Efficient Streaming in Future Internet

Theodore ZAHARIADIS[a,1], Ahola JARI[b], Roberta FRACCHIA[c], Federico ALVAREZ[d]
Thierry FILOCHE[e], Harilaos KOUMARAS[f]
[a] *Synelixis Solutions Ltd, 10 Farmakidou Av. 34100, Chalkida, Greece*
[b] *VTT, Finland*
[c] *Thales, France*
[d] *UPM, Madrid, Spain*
[e] *Thomson, France*
[f] *Democritos, Greece*

Abstract. The Future Internet is not envisaged to be simply a faster way to go online. What is expected to fundamentally change the way that people use the Internet is the ability to produce, and seamlessly deliver and share their own multimedia content. In this paper, we introduce and analyse innovative architecture components to offer media scalable content delivery, increasing the robustness, enriching the PQoS and protecting the content from unauthorized access over heterogeneous physical architecture and P2P logical overlay network topologies. Technology pillars in which the system is based are described: i.e. Multi-layered/Multi-viewed content coding, Multi-source/multi-network streaming & adaptation, content protection and lightweight asset management.

Keywords. Multi-layered/Multi-viewed content coding, SVC/MVC, MDC, Multi-source/multi-network streaming & adaptation

Introduction

The Future Internet is expected to fundamentally change the way that people use the Internet is the ability to produce, and seamlessly deliver and share their own multimedia content. We expect that in a few years everyone will be multimedia content producer (by publishing digital pictures, video recordings, smart home surveillance, etc.), multimedia content mediator (by storing/forwarding streaming content) and multimedia content consumer (digital television, video on demand, mobile broadcasting and alike). In this context, we consider the Future Internet as a dynamic and distributed environment, that enables new services and seamless, scalable and trusted multimedia content delivery, increasing the robustness and resiliency, enriching the PQoS both within the network and/or at the end-user terminal, while protecting the content from unauthorized access over heterogeneous physical architecture and overlay network topologies.

The first step to introduce seamless content distribution is to take advantage of the sufficient uplink capacity that most access technologies typically offer. Individuals may operate as content creators and service providers by distributing their personal content including but not limited to video streams. Moreover, novel “follow me” like services may be introduced, where the home-based equipment may operate as service mediator

[1] Corresponding Author.

and content forwarder and a subscriber may consume personalised streaming services, properly adapted to network characteristics/conditions and his mobile phone/PDA capabilities, while on the move.

However, the major envisaged potential of the Future Internet is shown in Figure 1 by introducing trusted Peer-to-Peer (P2P) overlay topologies and cloud computing in the broadband, heterogeneous architecture. This is also compatible with the increasing and expanding WiFi community networks architectures. In this case, services may be offered not only by centrally located media streaming servers, but by groups of end-user devices, acting as distributed content repositories. Given content protection and management is in place, network operators and service providers may offer value-added streaming services with remarkable PQoS, while avoiding the nightmare of network scaling and the expenses in network infrastructure upgrades, as the content (at least the most popular one) and the network resources (traffic load) may be distributed and thus balanced to a large number of peers. Moreover, individuals may produce their own (real-time) content and make it publicly available to a larger audience, without having to rely on a specific, expensive networking infrastructure. In this environment, video streaming scalability, resilience and PQoS may be exponentially increased, as not only multiple-networks, but also multiple-sources may stream video segments, enriching the content on-the-fly either at the network and/or at the end-user terminal.

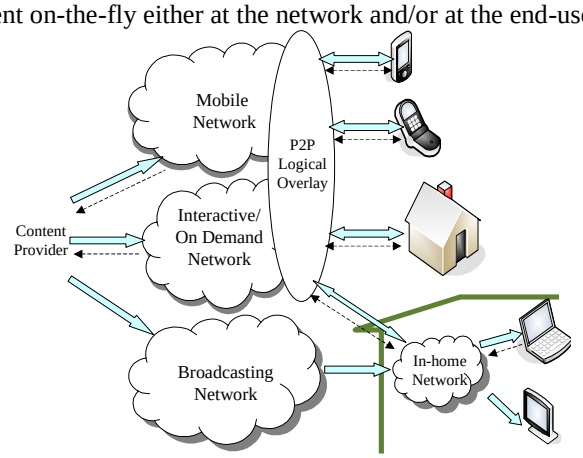

Figure 1: The proposed Future Internet logical network architecture

In order to realize the above service provisioning scenarios, a number of issues have to be considered and tackled. Advanced scalable and multiview video coding, knowledge of the network conditions, innovative cross layer optimization, real-time service adaptation, on-the fly PQoS enrichment, content protection are some of the issues that have to be solved. In this paper, we highlight and analyse the main pillars and introduce technologies and solutions that could be applied in the envisaged seamless content delivery in the Future Internet network evolution.

1. Proposed Network Architecture Innovations

Advanced coding schemes like Scalable Video Coding (SVC), Multi-View Coding (MVC), Multi-Description Coding (MDC) will facilitate video distribution with enriched QoS, especially in case of high-end multi-modal terminals able to receive and reconstruct multiple video streams segments (i.e. layers, views, descriptions). However,

home terminals or low-cost mobile terminals may be only capable for decoding at a particular bit-rate or may be only feasible to correctly display up to a particular image resolution. Thus, in order to meet all proposed innovative features, the media delivery service architecture should be content aware and have knowledge of the access technologies as well as to the utilised end-user device capabilities and characteristics. The Future Internet network architecture has to provide the relative adaptation functionalities to seamlessly support the majority of terminals. It should be able to support terminal mobility, including service continuity, between different (radio) access technologies, or maintaining and supporting the same capabilities of access control (authentication, authorization), privacy and charging when moving between different (radio) access technologies. IP service continuity should be maintained, i.e. the network should hide the impact of mobility events to the end user and the IP application(s), i.e. the service can continue without user intervention or special application support to mask the effects of a mobility event.

In case of building a service architecture upon the described variety of access networks, it is desirable to have as much information and adaptation at the lower layers (up to the network layer) as possible, along with scalability functionality coming with the media codec. Certain functions such as content caching in the network, content adaptation and cross-layer optimization would certainly need knowledge of the network conditions/characteristics. In order to overcome this problem, wherever applicable in the proposed Future Internet architecture, we introduce intelligent media/ network aware entities. These could be both new nodes of the foreseen network architecture or enhanced nodes. In the first case, we propose two MANE types: a) streaming Home Media Gateway (sHMG), located at the edge of the extended home environment and b) streaming Network Media Gateway (sNMG) at the edge of the 3GPP Service Architecture Evolution (SAE) (Figure 2). In the second case, the content provider and the different network point of access could collect feedbacks from the clients and implement the cross-layer adaptation process.

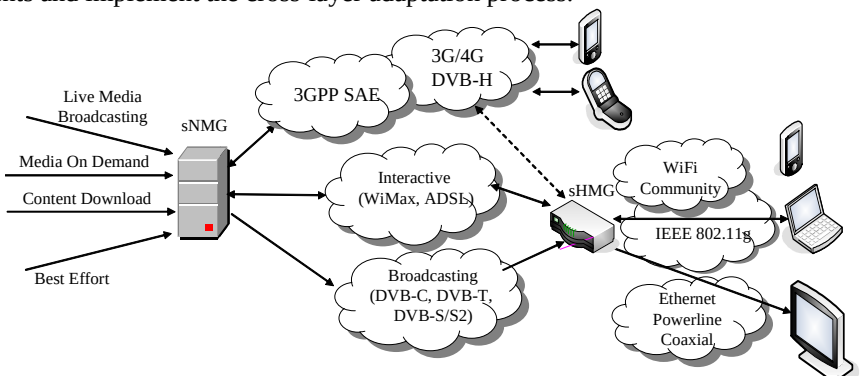

Figure 2: Proposed Content Delivery Network Architecture

The proposed MANE nodes will support the intelligent, seamless content distribution. They will offer functions like network and terminal awareness, content enrichment and content protection. In the longer term, they may be integrated on Internet Multimedia Systems (IMS) as define by ETSI TISPAN. They will offer multimedia storage, dynamic content adaptation and enriched PQoS by dynamically combining multiple multimedia content layers from various sources. Moreover, as they will have knowledge of the underlined networks, they will provide information on the

network conditions/characteristics, which will be utilised by the Cross Layer Control (CLC) mechanism and adapt the multimedia streams to the next network in the delivery path. This will be extremely important in case of a low bandwidth, but guaranteed QoS mobile networks and in the broadband, but best effort P2P topologies.

2. Key Technology Pillars and Trends

For the introduction of novel services and new business models, including efficient, resilient, enriched Perceived QoS (PQoS) and seamless content delivery over the future Internet, apart from the network architecture, we expect that key-content pillars should be introduced. Some of them are summarized in this section:

- ***Multi-layered/Multi-view personalised content coding.*** In order to maximize video portability, scalability and error resilience across a number of heterogeneous terminals, we propose the H.264 Scalable Video Coding (SVC) as the major encoding standard. The concept of Multi View Coding (MVC) is to allow for different views of video streaming without drastically increasing the data rate for the media delivery.

- ***Multiple Description Coding (MDC).*** Future Internet should provide for inherited mechanisms for resilient content distribution. One method that could be applied is the Multi Desription Coding (MDC) approach.

- ***P2P video streaming.*** The Future Internet should address P2P challenging topics including: a) peer retrieval optimization and b) application of proper coding techniques. Another important topic will be the distribution of multiple views over a P2P overlay and optimization of the visual quality and PQoS via exploitation of advanced source coding techniques (SVC, MVC, MDC).

- **Cross Layer Control (CLC) and Optimisation.** Existing CLC provide significant improvements in the PQoS under specific networking and transmission conditions. However, none is directly applicable to the Future Internet concept, as the terminal will not necessarily know the actual physical layer infrastructure. Especially in the case of P2P topologies, the physical infrastructure may even be an arbitrary, timely varying combination of links belonging to different networks. The Future Internet should define a cross-layer scheme that will face the network and terminal heterogeneity and take advantage of the coding and delivery schemes by proposing a network abstraction mechanism, able to model the underlined end-to-end path, describe the functional dependencies and determine the optimum adaptation of the resources.

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