Paper

# Utilization of the Software-Defined Networking Approach in a Model of a 3DTV Service

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**Abstract—In article a new concept concerning multimedia service modeling of stereoscopic motion pictures distribution is depicted. Presented conceptual model utilizes functionality approach supported by a Software-defined Networking (SDN) architecture. The core elements composing the proposed 3D television service are stated, depicting internal arrangement of a modern 3DTV service. Moreover, investigated examples of a functional utilization of the SDN approach in a 3DTV service model realization reveal key improvements towards greater flexibility and efficiency in heterogeneous users environment.**

***Keywords—3DTV service, SDN, Software-defined Networking, streaming architecture.***

## 1. Introduction

Nowadays, intense visual data information exchange is observed. It has to be instantaneous, fast and reliable. In case of contemporary telco market, the focus is put on the telecommunication services delivering high definition quality audiovisual content. Deployed multimedia data processing systems support variety of transferring (distribution) modes. They include real time transmission of live video streams, content on demand features, i.e., Video on Demand (VoD) as far as originated from social networking, forms of prosumer like videos (prosumer, by definition is a service user that not only consumes the content but also produces video materials of its own). In order to keep the service away from an instantaneous market disapproval, from the point of view of the delivered multimedia stream, one has to guarantee appropriate Quality of Service or Experience model (QoS, QoE).

Elaborating on the domain of current telecommunication services, one shall acquire the analysis and forecasts included in the Cisco Visual Networking Index annual report [1]. Therein depicted (Internet Video section) are the researched trends and directions concerning global network congestion schemes. It is delivered, that in the category of the Web-based video applications and video related user activities, the overall, worldwide IP traffic will grow annually in an average of 29% (study was performed for the period of 2012–2017). What is more, extended forecasts provided by the considered report, depict the overall, global IP traffic share. It is indicated that the data transmitted within the multimedia related network activities will contribute, by the year 2017, to nearly 80% of total global IP traffic. Therefore, what follows is the value of the audiovisual data traffic (volume), which by means of Cisco VNI report is evaluated to be in the range of 53 thousands of petabytes (PB) per month. Thus, it is of the upmost importance to consider such a significant value of video related IP traffic, while introducing a new range of functionalities and enablers in refreshed, redesigned network architectures for telecommunication services.

Progressing towards multimedia services of a stereoscopic television (3DTV), investigated projections presented in [2], [3] reveal the extent of intensity of relevant activities in the considered domain of telecommunication services. By means of Compound Annual Growth Rate – CAGR coefficient, the Cisco Visual Networking Index: Forecast and Methodology, 2011–2016 report presents the overall behavior of selected multimedia services. In case of a 3D Video on Demand telecommunication product, the forecasted value of CAGR index reaches 105%. Thus, one can perceive the extent and the behavior of this dedicated service traffic growth, which in the considered case results in a global increase from 2 to 74 PB per month (specific data is included in Table 1).

Table 1
Global consumer managed IP traffic – 3D VoD service

| Year | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | CAGR |
|---|---|---|---|---|---|---|---|
| Traffic [PB/month] | 2 | 5 | 11 | 20 | 38 | 47 | 105% |

Expanding the domain of topic related forecasts, as it is presented by DisplaySearch of NPD Group company in [3], the CAGR factor representing the increase of end user devices being 3D playback enabled, reaches 75%. Depicted amongst the Table 2 are the numerical values of projected 3D display sales in the considered time interval, between the years 2010 and 2018. Notable is the fact that nearly 200 million devices, i.e., mobile displays, 3DTV sets, etc. will be ready to present stereoscopic content to their users. Another study delivered by the NPD Group shows that in the 2012 the total market share (saturation) of 3D compatible displays over the total number of shipped screen devices was over 25%. Depicted by means of Table 3 are the saturation levels reflecting LCDs market composition.

Table 2
Worldwide forecast for 3D display sales

| Year | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|---|---|---|---|---|---|---|---|---|---|
| 3D Display Units [M] | 3 | 11 | 20 | 40 | 71 | 88 | 113 | 143 | 196 |

Table 3
3D TV share of global LCD TV panel shipments

| Year | 2011 | | | 2012 | | | |
|---|---|---|---|---|---|---|---|
| Quarter | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| Share [%] | 9.4 | 11.9 | 14.2 | 15.2 | 21.0 | 23.5 | 25.7 |

Aforementioned projections and forecasts deliver significant data, especially those shaping the overall behavior of 3DTV domain, necessary to include while developing and designing of the appropriate mechanisms for the telecommunication service of stereoscopic data transmission. The motivation for an appropriate modeling of a service is supported by the overwhelming numerical values representing forecasted IP traffic volumes required for an efficient service implementation, while the extent of the total number of 3D compatible devices uncovers the scope of widespread service possibilities.

## 2. 3DTV Service Characteristic

In this section the basics concerning 3DTV service architectural layout are covered, thus one can perceive the general characteristic of the generic service layout. Presented on the schematic diagram within the Fig. 1 are the fundamental elements contributing to the general 3DTV service architecture. Base blocks and relations identified among the considered figure indicate 5 blocks representing separate pillars of the service, listed in a following manner: customer of a service (End User), the Internet Service Provider (ISP), data processing center (Data Center), audiovisual content providers (Content Providers) and an extra block of External Service Provider. The most bottom entity of the Fig. 1 represents so called OTT providers (Over The Top) that expand the basic service offer with a value added functionalities or content.

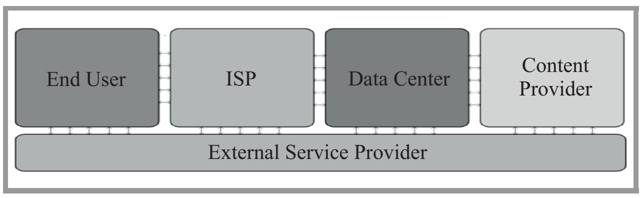


*Fig. 1.* Generic layout of a 3DTV service.

Nevertheless, the original shape and performance of the service is determined by the joint relation between End User and ISP pillars. Audiovisual content delivery based on that relationship determines the original and attainable levels of QoS or QoE. Moreover, performing monitoring (sensing, probing) over this pair of blocks shall lead towards selection of natural set of parameters describing the quality of the transmitted video content. However, one shall also incorporate such an approach whenever networking capabilities are limited and modification or transcoding of the multimedia data is necessary to balance the provisioned agreements.

Following the interactive path of content, all of the effective multimedia stream processing takes place in the Data Center entity, triggering the Content Providers and External Service Provider bodies to adjust. Furthermore, to keep the overall flexibility of the service, one shall consider supporting heterogeneity over the End User terminals. Not only is the video stream dependent upon the final presentation device but also on a type of a technique utilized to create the 3D perception. Amongst the popular approaches, one can enlist autostereoscopic and filtering methods, where in the latter case active (shutter) and passive (polarization) modes are distinguishable.

In order to complete the investigation of the 3DTV service characteristic, it is necessary to focus on the video stream features, as they are essential in the content driven multimedia service. Depicted by means of Table 4 are the crucial parameters describing stereoscopic 3DTV video streams.

Table 4
Fundamental video stream parameters utilized inside a 3DTV service

| Parameter | Description |
|---|---|
| Image resolution | Depends on a subscribed version of a service (HD/SD) and utilized user's end device. It describes only a single stream resolution, not to confuse with the compound stereoscopic pair. |
| 3D format | Defined as a composition of a pair of frames, might be of a dual settings: video frames positioned one aside another or one over another, respectively for left and right sensor of Human Visual System. |
| Stream format | Determines the attributes of utilized video stream coder along with specific profiling of selected standardization. |
| Bitrate | Reflects access network capabilities, may be adaptively selected depending on a subscribed version of a service. |
| Framerate | Depends on the utilized end device's capabilities. Exemplary values stated for a single video stream. |

The common outcome of the analysis of parameters described in previously mentioned juxtaposition leads to the intermediate conclusion that the generic 3DTV video stream shall possess a multilevel flexibility. As it concerns the stage of modeling of a service, this criterion shall be understood as a video stream's property of scalability and adaptivity. What is more, projected model of a 3DTV service implies that the network and environmental conditions behave dynamically and change over time. In order to maintain such a video stream flexibility one shall approach realization of this feature with separate flows multiplicity, carrying essential visual data sequences. Thus, a logically coherent video content asset is transported over the parallel set of data flows, what in fact enables extended (and also adjustable) QoS control. Moreover, a specific set of primitive parameters describing basic video units may be obtained, improving streaming capabilities with respect to the flexibility criterion. Figure 2 presents multisession transmission mode of a MVC stereoscopic video stream.

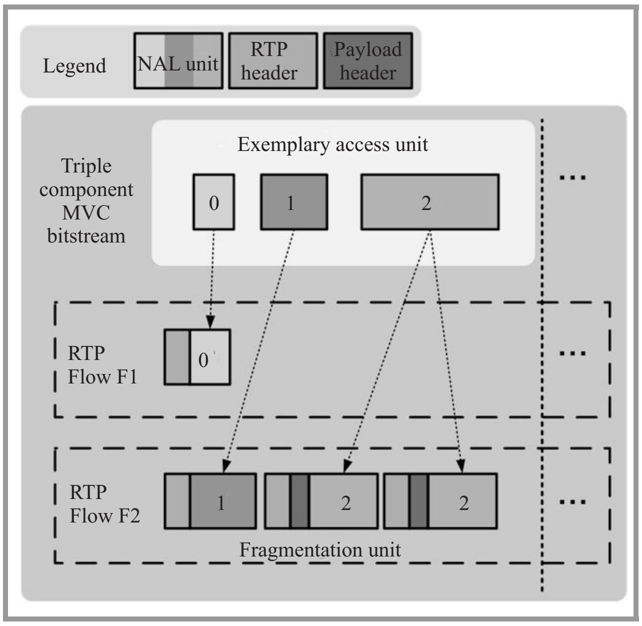


***Fig. 2.*** MVC stereoscopic stream in multisession transmission mode.

Advanced support of a selected QoS mechanism may be realized by means of an initial video stream unit slicing (Access unit module in Fig. 2). A single video content is therefore represented with graded quality streams or may be prioritized accordingly to the proclaimed routine or policy preventing from the severe quality degradation. It also works with an implementation of mechanisms enabling switching between different video streams of a single (logical) multimedia asset with respect to the triggering event, i.e. user's transition between 3DTV service eligible terminals.

Depicted within the Fig. 2 is the scenario of a triple component unit Network Abstraction Layer (NAL) [4] which is orchestrated into a two, separate, manageable network flows. This basic feature is developed over the standard, classical 2D High Definition H.264 codec specification [5]. Worth noticing is the fact of native support of Real-time Transport Protocol (RTP) as an effective transport layer protocol.

## 3. Software-Defined Networking Architecture

Introducing the concept of a Software-defined Networking architecture [6] it is essential to present the modification that the networking plane has undergone. Conversely to the classical network approach, where multiplicity of layers (i.e., from physical towards application) is vertically merged within a single device, an SDN concept delivers the idea of specific separation of considered stack's planes. The crude significance of a Software-defined Networking architecture is an inherent division into a Control and Data (Forwarding) Planes. Since, control (management) functionalities over data flows and actual data transferring (payload traffic) are logically and physically (in a specific cases) separated. Elaborating on, contemporary network units implement both functionalities (Control and Forwarding) at once, where in case of the SDN approach, the management module of a device is lifted upwards into an unified abstraction plane called Control Plane. Moreover, what follows, is that the network management function may be performed from a single controller unit. Thus, a vast improvement with respect to the classical networking approach is clearly visible, namely efficient resource utilization and simplified reconfiguration of networks.

An exemplary situation depicting the advances in such an approach, may be a case of singular path prioritizing, whenever each device contributing to the considered path had to be personally adjusted, what implied intensive administrative workloads. Herein, by means of a single controller (so called hypervisor unit), at one action call, required task is accomplished. In addition, available solution enables high reliability of control functionalities. Redundancy and hierarchical organization of the Control Plane lays a firm basis for the SDN architecture to support multimedia services, while the data transmission layer may still utilize effective carriage mechanisms. Architectural layout presented on the scheme from Fig. 3 depicts conceptual arrangement

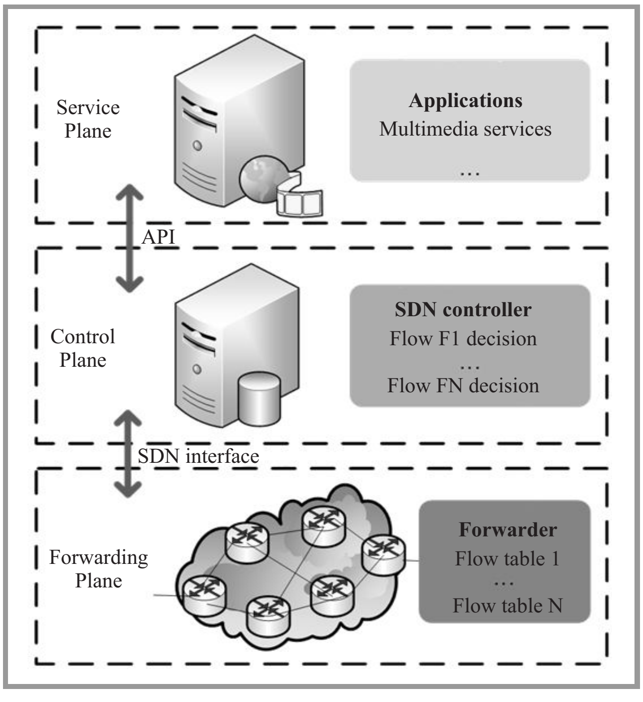


***Fig. 3.*** Layered architecture of an SDN model.

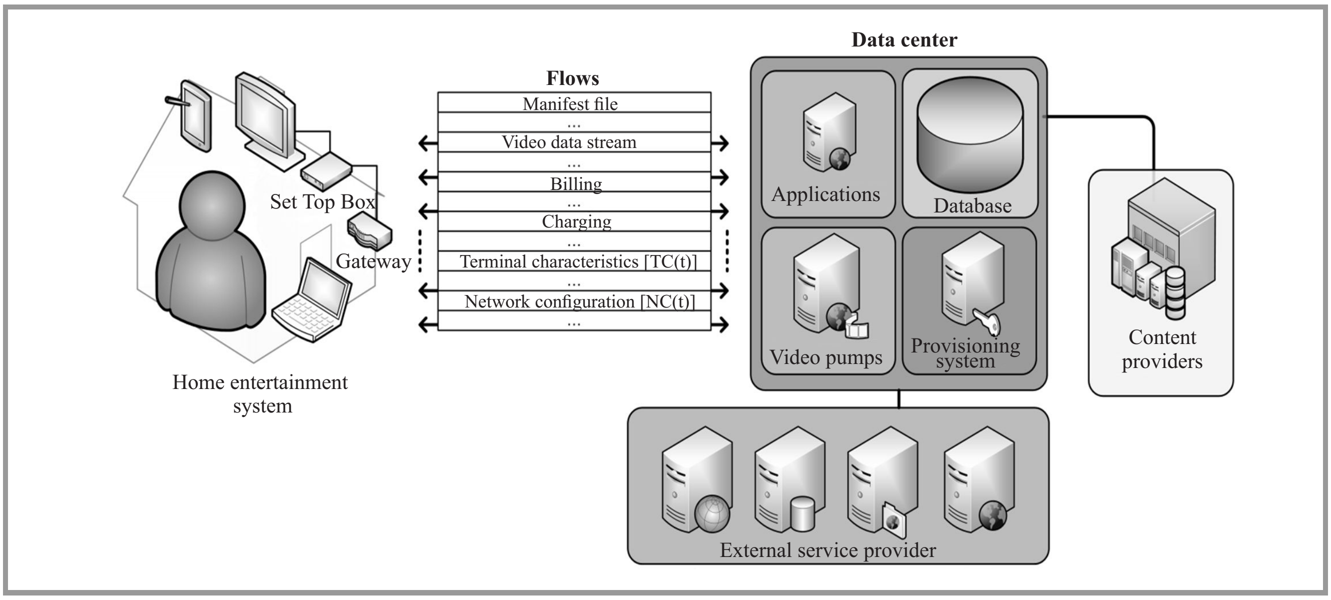


***Fig. 4.*** Compound model of a 3DTV service utilizing an SDN architecture approach.

of layers within the specific Software-defined Networking approach. It is composed of three separate layers, functionally responsible for (from bottom to the top): data transfer (Forwarding Plane), management (Control Plane) and application support (Service Plane).

The interconnection in-between aforementioned planes is performed by two significant interfaces: API and SDN Interface. Service Plane and controlling layer has a joint Application Programming Interface (API) that supports various functionalities, both in a form of an inbound, i.e. management systems, and outbound, i.e. external services scopes. It is a high level programming interface enabling developers to create a new set of services for the deployed system. In case of the SDN Interface connecting Forwarding Plane with the Control Plane, there exist several solutions to the realization of the interface. One can specify open and vendor dependent approaches. In the first case, interface is based on a community contribution model, i.e., OpenFlow [7], whereas in the latter manner, utilization of a commercial (closed) framework is chosen, i.e., Cisco onePK SDN package [8]. The common point of those solutions is the mode of operation, that is based on a network state reporting routines and on on-demand managed flow tables.

# 4. Model of a 3DTV Service with Use of an SDN Architecture

In the final stage, presenting the model of a 3DTV service based upon an SDN approach, aforementioned requirements, concerning both stereoscopic content as well as the 3DTV service characteristic are combined with the enhancements delivered by the improved network architecture given by the SDN solution. Schematic diagram presenting the compound model of a 3DTV service utilizing described features is illustrated within Fig. 4.

Depicted solution utilizes the model cooperation of five, main entities, revealing their insights and core built. From the point of view of the effective service creation, the part interconnecting Home Entertainment System with the Data Center or else the telecommunication service provider section is the inevitable layer. Appropriate information flow management enables creation of a network aware and optimized service solution. Flow dependent traffic regimes shall improve flexibility feature by creation of a set of policies and other QoS enablers defined upon heterogeneity of end user devices, i.e. singular flow for common set of video stream parametric constraints. Moreover, an administratively simplified and orchestration friendly model of a service becomes while using the SDN architecture key features. Furthermore, in the proposed model of a 3DTV service, one can define rules and actions per single flow setting, thus enabling increased scalability in the domain of stereoscopic video streams. The advantage of assigning different forwarding mechanisms for specific flows may prevent from abundant video quality corruption, as one can exclude essential key frames from being frequently damaged, i.e., by means of real-time resource reallocation, routing paths, etc.

Nonetheless, another improvement may be observed in the domain of Service Level Agreements management. Increased precision and effective resource reservation (utilization) leads to the optimized SLA rules and enables efficient adjustment of those. An additional feature delivered by the utilization of the SDN approach when designing a multimedia streaming service is a layered structure with an open API interfaces (as it was previously indicated), enhancing OTT functionalities and finally improving overall service attractiveness by value added features. Finally in the discussed service layout, the core structure supports direct end-to-end functionality and handling of a customer request from a single contact point, what should simplify the maintenance of the deployed service.

In order to complete the description of the functional model of a 3DTV service, let one perceive the system flows supporting previously discussed features:

- Manifest File (conveys video stream characteristic),
- Video Data Stream (multimedia data of an asset),
- Billing and Charging (basic IT functionalities),
- TC(t) flow (temporal characteristic of a terminal, defining primitives set essential for video stream preparation,
- NC(t) flow (temporal characteristic of a network resources, optimized for an extended QoS support).

## 5. Conclusions

The following paper covered selected insights out of the compound walkthrough of the process having presented the design of a 3DTV service with use of the SDN architecture approach. Indicated modeling steps followed the essentials and fundamentals of the efficient multimedia service creation.

Described core elements specification of the service, alongside the thorough 3DTV domain characteristic and broad selection of enhancements and advancements delivered by the Software-defined Networking scheme defined the scenario for a successful telecommunication service deployment. Finally, presented model of the 3DTV service supports increased reliability, flexibility of a video content and adaptive network resource allocation.

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