Enabling the Media industry with 5G: the 5G-MEDIA pilot cases

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***Abstract*— Media-based applications are amongst the most demanding services in terms of bandwidth and latency to enable high audio-visual quality and interactivity. The goal of the 5G-MEDIA project is to develop an integrated programmable platform consisting of a Service Development Kit (SDK) facilitating the development, testing and emulation of media services and a Service Virtualization Platform (SVP), enabling the deployment and operation of media services on 5G networks by leveraging the principles of Network Function Virtualisation (NFV) and Software Defined Network (SDN). The platform offers an advanced cognitive management environment for the provisioning of network services and media-related applications, which directly link their lifecycle management with user experience as well as optimization of infrastructure resource utilization. Another innovation of the 5G-MEDIA project is the integration of serverless computing with media intensive applications in 5G networks, increasing cost effectiveness of operation and simplifying development and deployment time. The aim of this paper is to illustrate how the 5G-MEDIA platform is being validated through three media pilot cases: immersive Virtual Reality 3D gaming application, remote production of broadcast content, and dynamically adaptive Content Delivery Networks (CDNs) for the intelligent distribution of Ultra-High Definition (UHD) content.**

Keywords—Network Function Virtualization, edge-cloud, management and operation framework, 5G networks for media applications, Ultra High Definition, Content Delivery Network, Virtual Reality, Smart Production, Broadcasting

I. INTRODUCTION

This paper presents the novel Service Virtualization Platform (SVP) architecture [1][2] based on NFV [3] and SDN that facilitates the development, deployment and operation of media services on 5G networks and its deployment and validation in the context of the three pilot cases. The components of the 5G-MEDIA architecture are presented in Section II. Section III presents how the 5G-MEDIA platform is validated against three pilot cases on different infrastructure provided by the 5G-MEDIA consortium partners.

II. THE 5G-MEDIA HIGH-LEVEL ARCHITECTURE

The 5G-MEDIA Service Virtualization Platform (SVP) is built upon the Open Source MANO (OSM) [4] NFV-MANO and, within the 5G-MEDIA project, two new Virtualized Infrastructure Manager (VIMs) are provided, in addition to those supported by OSM, i.e. the Function as a Service (FaaS) VIM [5], which enables the use of the so-called FaaS concept and the OpenNebula VIM. The 5G-MEDIA high-level architecture (Fig. 1) includes: i) a Software Development Kit (SDK), ii) the 5G App and Service Catalogue and iii) the Media Service MAPE (Monitoring-Analyse-Planning-Execute).

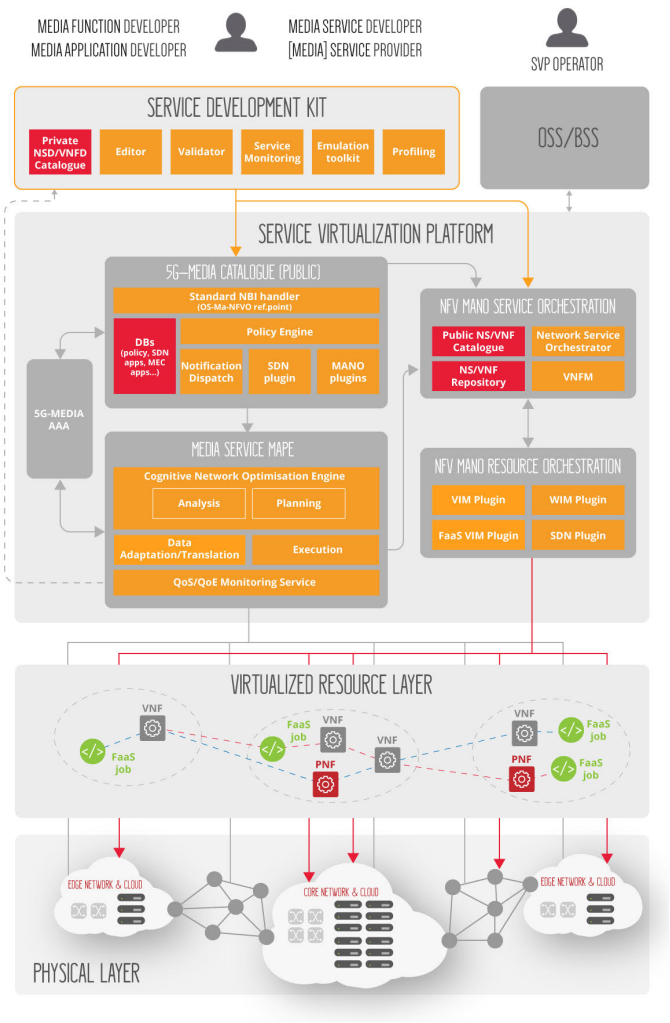

Fig. 1. 5G-MEDIA high-level architecture

A. Service Development Kit

The 5G-MEDIA SDK [6] supports the development of new media applications and services assisting the function, application and service development, emulation, testing and validation process, prior to the deployment phase and allows the use of lightweight virtualization through Docker and unikernels; it provides an all-in-one environment to validate Network Service Descriptors, to emulate network services, to onboard NS in the NFV catalogue and finally instantiate it on a specific NFVI/VIM through the SVP. In addition, the 5G-MEDIA SDK allows FaaS Emulation using Lean OpenWhisk (Lean OW) [7] and FaaS CLI Tools allow media application developers (NS developers) to leverage the FaaS programming model and quickly develop and evaluate value added code while relieving them from the infrastructure management concerns and it offers CLI tools for unikernels, to enable unikernel development, providing improved security, smaller footprint and consequent faster boot time. Finally, it provides a VNF/NS Emulation toolkit including service profiling and monitoring tools that allows doing load testing on a media application (profiling) and provides visualization of pre-defined performance metrics (monitoring). This allows media application developers to test and verify their applications functionality, debug and fine-tune them before deploying to a production environment.

B. 5G App and Service Catalogue

The 5G App and Service Catalogue is placed between the SDK and the MANO components. The catalogue is designed to be NFV MANO platform-agnostic in terms of formats and syntax for NS descriptors and VNF Package information model. The catalogue uses a novel generalized and extendible format for representing NSs and VNFs, and it is capable to onboard NFV service elements as well as Mobile Edge Cloud (MEC) media applications and services and other virtual applications such as SDN applications, and functions implementing the FaaS paradigm.

C. Media Service MAPE

A key component of the SVP is the Media Service MAPE mechanism, which provides the intelligence behind the MANO to allow it to dynamically manage and provide infrastructure resources for the deployed media services according to observed changes in user demand patterns, availability and performance of network and computational resources. In particular, QoE Monitoring collects data from running NSs/VNFs and the SDN controller in the underlying NFVIs and shares data with the Cognitive Network Optimizer (CNO) through a distributed message queue based on Apache Kafka. The CNO employs statistical analysis based on machine learning and optimization techniques for classifying network and computational resource service status, predicting/forecasting future resource conditions, and triggering corrective actions for the running NSs. Its machine learning engine is based around algorithms for data dimensionality reduction, feature selection/extraction, traffic classification, anomaly detection, performance degradation detection and demand prediction.

III. The 5G-MEDIA Pilot Cases

The 5G-MEDIA platform is validated against three pilot cases on different infrastructure provided by the 5G-MEDIA consortium partners.

A. Immersive Media and Virtual Reality

Tele-Immersive (TI) applications are immersive media network-based applications that enable the multi-party real-time interaction of users located in different parts of the globe, by placing them inside a shared virtual world. TI applications produce a large volume of heterogeneous data, thus, creating a challenging networking scenario. This use case [8] (Fig. 2) requires high bandwidth (next-gen immersive 3D media), low latency streams between the players (establish the needed interaction) and smooth playback for the spectators.

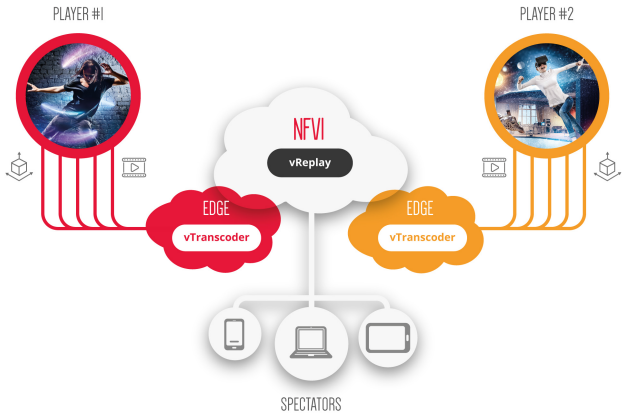

Fig. 2. Immersive Media and Virtual Reality pilot case

Within the scope of 5G-Media, this use case will demonstrate a network aware media application development through the deployment of media specific VNFs (e.g. transcoders), as well as showcase the potential of a FaaS application development model with specific VNFs being instantiated based on trigger/rule logic (e.g. replay generation) that increases modularity and overall offers more efficient architectural design. The Cognitive Network Optimiser will be involved in configuring the quality of the transcoder based on the network resources availability. The machine learning aspects of the smart engine will be used to forecast traffic demand and adjust quality in the current network conditions.

B. Smart Production and User-generated content

Due to the steadily rising cost pressure, broadcasters are looking for new, low-cost and time-saving production methods, which include participatory and user-generated media archives in the production, also known under the term smart production.

In 5G MEDIA it is planned [9] to overcome these limitations by leveraging new options for more flexible, ad-hoc and cost-effective production workflows by replacing dedicated lines and hardware equipment with software functions (VNFs) facilitating

(semi-) automated smart production in remote locations (Fig. 3). Virtualised and flexible media services will reduce complexity for the user and ensure operational reliability (QoE). Within 5G-MEDIA, the Cognitive Network Optimiser will be validated to configure the compression levels of the virtualized Compression Engine in a dynamic manner considering the quality profiles set by the broadcaster and the availability of network resources.

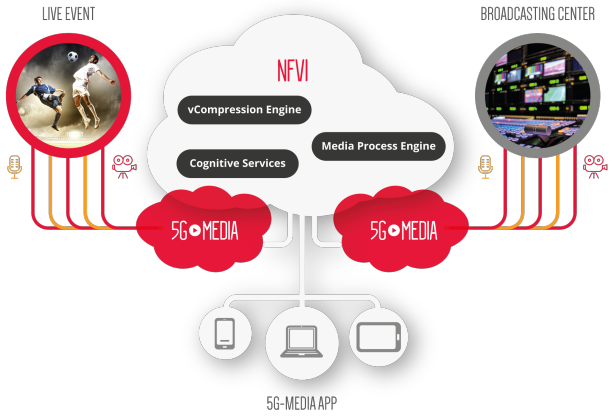

Fig. 3. Smart Production and User-generated content pilot case

C. *Ultra High Definition over Content Delivery Network*

Main purpose of this use case is to test access streaming of UHD media services through various personal devices, both fixed and mobile, while the user is on the move in the 5G network. The focus is on how UHD contents by a Media Service Provider (MSP) can serve users on the go and how the MSP can build media distribution service chains made of software defined media functions to properly serve users attached to the 5G network. This use case [10] (Fig. 4) shows the orchestrating the lifecycle of service chains between an origin streaming server containing the UHD contents in various transcoded formats and the edge of the 5G network where media caches are to be dynamically instantiated to serve mobile devices. The target of this use case is to provide personalised view angles, with the possibility to compose UHD streams and move personal media while on the go. Key to the realisation of the use case is the possibility to implement high bandwidth streams between the streaming service (origin, replicas, transcoder and viewpoint servers) and users, in a flexible and dynamic way through the mechanisms of composition of virtualised network and media functions orchestrated by an NFV MANO layer. Within the context of 5G-MEDIA, the Cognitive Network Optimiser will adapt the media service chain related to the various media distribution flows based on end-to-end media quality control metrics and policies for scaling VNFs and optimising cache placement between the core and edge locations.

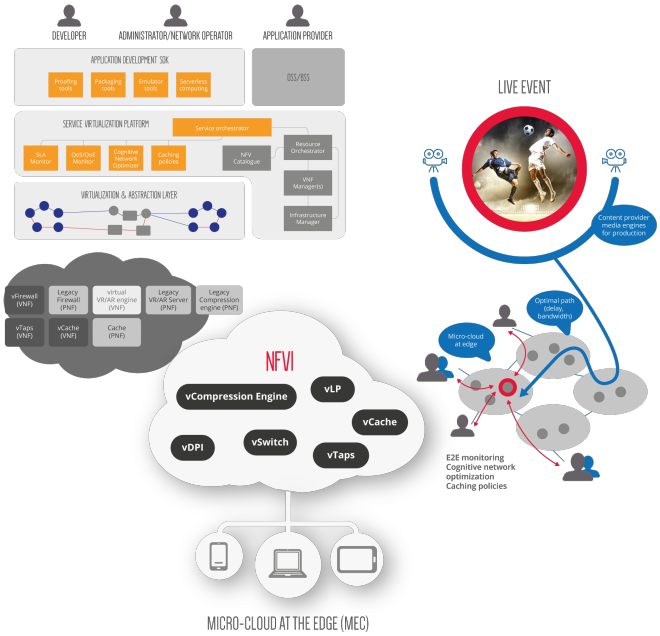

Fig. 4. Ultra High Definition over Content Delivery Network pliot case

IV. CONCLUSIONS

This paper presents how an ETSI NFV compliant architecture enables new possibilities to facilitate the development, deployment and operation of media services on top of the upcoming 5G networks, leveraging cutting-edge technologies and computing paradigm like: i) FaaS as a new form of container based PaaS able to provide significant cloud operational cost reduction thanks to a finer granularity of resource allocation, instantaneous elasticity and a finer granularity of billing; ii) ML-driven optimization techniques for the optimal configuration and operation of media NSs and iii) a catalogue as a functional element designed to be NFV MANO platform agnostic in terms of formats and syntax for NS descriptors and VNF Package information model. The proposed architecture is being validated against three media use cases: an immersive Virtual Reality 3D gaming application, the remote production of broadcast content incorporating user generated contents, and dynamically adaptive CDNs for the intelligent distribution of UHD content and first results have been provided in this paper. Extensions to the three use cases will be implemented and validated till 2019-Q4, spanning the applications to include support to mobility, higher data rates and instantiation of the needed NSs across different domains.

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