Innovative TV Broadcasting-related Media Use Case in 5G-Crosshaul H2020 Project

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Abstract: **Video is expected to contribute ~70% of all the mobile traffic by 2018. Content media distribution is expected to be the dominant contributor to the mobile data traffic demand, therefore being more and more present in everyday life communications, anywhere, any time and in end-user multi-device environments. In this paper a Broadcast application aims to provide a solution for TV broadcasting and multicasting services utilizing the 5G-Crosshaul architecture, running as an OTT service.**

Keywords: Broadcasting, SDN, NFV, OTT service, 5G

1 INTRODUCTION

The 5G-Crossshaul project [1] aims at developing an adaptive and cost-efficient solution for the 5G transport network, integrating both fronthaul and backhaul segments. The envisioned solution requires a fully integrated and unified management of fronthaul/backhaul resources in a sharable, scalable and flexible way. The control and management of such an integrated transport network, namely 5G-Crosshaul, will be based on the SDN principles and architecture defined by the Open Networking Foundation (ONF) [2] and will adopt Network Function Virtualisation (NFV) [3] concepts and mechanisms as well as aligned with the ETSI Management and Orchestration (MANO) architecture [3] as a specific means to offer a subset of the aforementioned services of network, cloud and storage. The controller plane, namely the 5G-Crosshaul Control Infrastructure (XCI), is composed of a hierarchy of network and cloud controllers, together with orchestration and management entities for Virtual Network Functions (VNFs). The controllers will be in charge of allocating, controlling and configuring resources within the underlying network, computing and storage infrastructure in order to offer services in an optimal and efficient manner. The XCI interacts with the data plane entities via a Southbound interface (SBI) and offers a Northbound Interface (NBI) through which the appropriate resource abstractions are exposed to applications. A design principle of both the 5G-Crosshaul XCI and support applications is that their seamless applicability to both physical or virtual infrastructures, while allowing support for resource sharing and multi-tenancy to improve cost-efficiency. The innovations brought by these applications will enable a system-wide resource optimization of power consumption, infrastructure utilization and cost, to create QoS-enabled unified transport services between network endpoints, i.e., 5G Points of Attachment (5GPoAs) and core network elements. Main project objective is to leverage state-of-the-art SDN/NFV architectures and enhance them so as to maximize the compatibility and integration of the system design with the existing standard frameworks and reference specifications.

This paper presents one of the 5G-Crosshaul applications that use the services offered by the XCI in order to extend and complement it, by providing transport services offering context-aware resource optimization to manage network, computing and storage resources operating physical or virtual resources and enabling infrastructure sharing and multi-tenancy. In order to effectively design this application, its interaction with the Crosshaul control plane need to be properly defined, taking into account the application requirements in terms of information to be collected and the required operations to be performed on the infrastructure.

First of all, brief presentation of 5G-Crosshaul architecture will be made, highlighting the functional role of the one of the 5G-Crosshaul applications that use the services offered by the referred XCI: the TV Broadcast Application developed as part of the Over-The-Top (OTT) service use case.

Then, the selected 5G-Crosshaul application will be described. A TV broadcasting/multicasting service is offered starting from the content of a live-source (e.g., a football match), which is processed till be finally transcoded to the objective format and bit rate (e.g., image resolution, scan format, etc.) and injected into the 5G-Crosshaul network. The TVBA deploys media transmission, live video broadcast over the 5G-Crosshaul infrastructure with focus on minimising both the cost and the spectrum consumption of the next generation TV.

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Innovative and business-oriented novel experimentation of connected media technology validated within the 5G-Crosshaul project will be thus presented.

2 5G-Crosshaul Architecture Concept

Figure 1 illustrates the Crosshaul architecture concept, which has three layers [4]. The lowest layer corresponds to the overlay of all infrastructure layers. The middle layer represents one of the key concepts of the Crosshaul vision: the integration of the different technologies (for both fronthaul and backhaul) in a common packet-switched network based on technology abstraction, and a unified data and control plane.

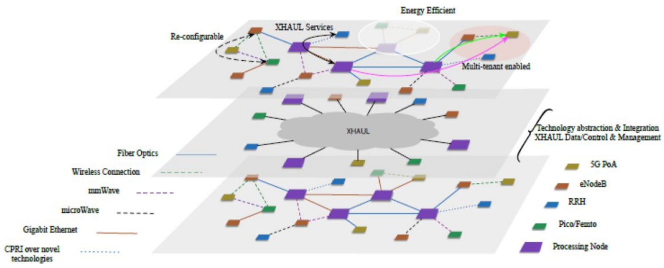

Figure 1: 5G-Crosshaul Architecture Concept

The uppermost layer presents the applications layer envisioned on top of the Crosshaul infrastructure in order to support the features related to:

- Re-configurability to cope with the level of demand expected from 5G Points of Attachment (5GPoAs) and to allocate resources in a dynamic way, moving resources from areas where they are not needed to busier areas.
- Energy efficiency through techniques that reduce the energy consumption of the different Crosshaul elements, combined with the joint optimization of RAN and Crosshaul resources by dynamic de-activation or decommissioning of scarcely used network portions.
- Multi-tenant operation to enable a generalized sharing and more efficient utilization of the underlying resources, not only at the Crosshaul infrastructure level but also allowing operators and Over-the-Top (OTT) companies to quickly deploy services within the Crosshaul platform such as Video On Demand, high-definition video conferencing, TV broadcasting/multicasting, Content Delivery Networks and cloud services.

The controller plane, namely the 5G-Crosshaul Control Infrastructure (XCI), integrates SDN principles control in ETSI/NFV MANO architecture [3]. XCI is composed of a hierarchy of network and cloud controllers, together with orchestration and management entities for Virtual Network Functions (VNFs). The controllers will be in charge of allocating, controlling, and configuring resources within the underlying network, computing and storage infrastructure in order to offer services in an optimal and efficient manner. The XCI interacts with the data plane entities via a Southbound interface (SBI) and offers a Northbound Interface (NBI) through which the appropriate resource abstractions are exposed to applications.

The data plane needs to allow the integration of heterogeneous technologies for the fronthaul and backhaul links into a common packet based network. In the data plane, 5G-Crosshaul network Forwarding Elements (XFEs) interconnect a broad set of novel technologies building in effect a flexible packet-based network with high diversity. A unified, versatile frame format and the corresponding protocol suite will transport Crosshaul data over heterogeneous technologies that may span from fiber optics to wireless mmWave for instance. Crosshaul data plane is also comprised of 5G-Crosshaul Processing Units (XPUs) that are in charge of carrying out the bulk of operations in Crosshaul. These operations shall support C-RAN, thus hosting Base Band Unit (BBU), but also 5GPoA functionalities and a heterogeneous set of services like the TVBA presented in this paper.

3 TV Broadcasting Application

TV broadcasting and mobile broadband are undoubtedly essential parts of today's society. Both of them are now facing tremendous challenges to cope with the future demands.

Video is expected to contribute ~70% of all the mobile traffic by 2018. Content distribution is expected to be the dominant contributor to the mobile data traffic demand, therefore content media distribution is being more and more present in everyday life communications, anywhere, any time and in end-user multi-device environments. It is widely accepted that people expect more features from their TV experience than just watching linear broadcast programmes. The consumption is moving towards on-demand services so that anyone can watch the content whenever they like. Consumers want to watch TV anytime, anywhere and regardless of the device type. And quality is going further very quickly, in most European countries people have become accustomed to high-definition TV and are now expecting even Ultra HD quality.

The Broadcast application (TVBA) aims to provide a solution for TV broadcasting and multicasting services utilizing the 5G-Crosshaul architecture, running as an OTT service. This is the case in which service providers share the 5G-Crosshaul network to reach their remote customers. In this use case, tenants of the 5G-Crosshaul operate in agnostic manner over the underlying infrastructure which they do not require to control directly.

More specifically, a TV broadcasting/multicasting service is offered starting from the content of a live-source (e.g., football match), which is processed till be finally transcoded to the objective format and bit rate (e.g., image resolution, scan format, etc.) and injected into the 5G-Crosshaul network. The TVBA deploys media transmission, live video broadcast over the 5G-Crosshaul infrastructure with focus on minimising both the cost and the spectrum consumption of the next generation TV.

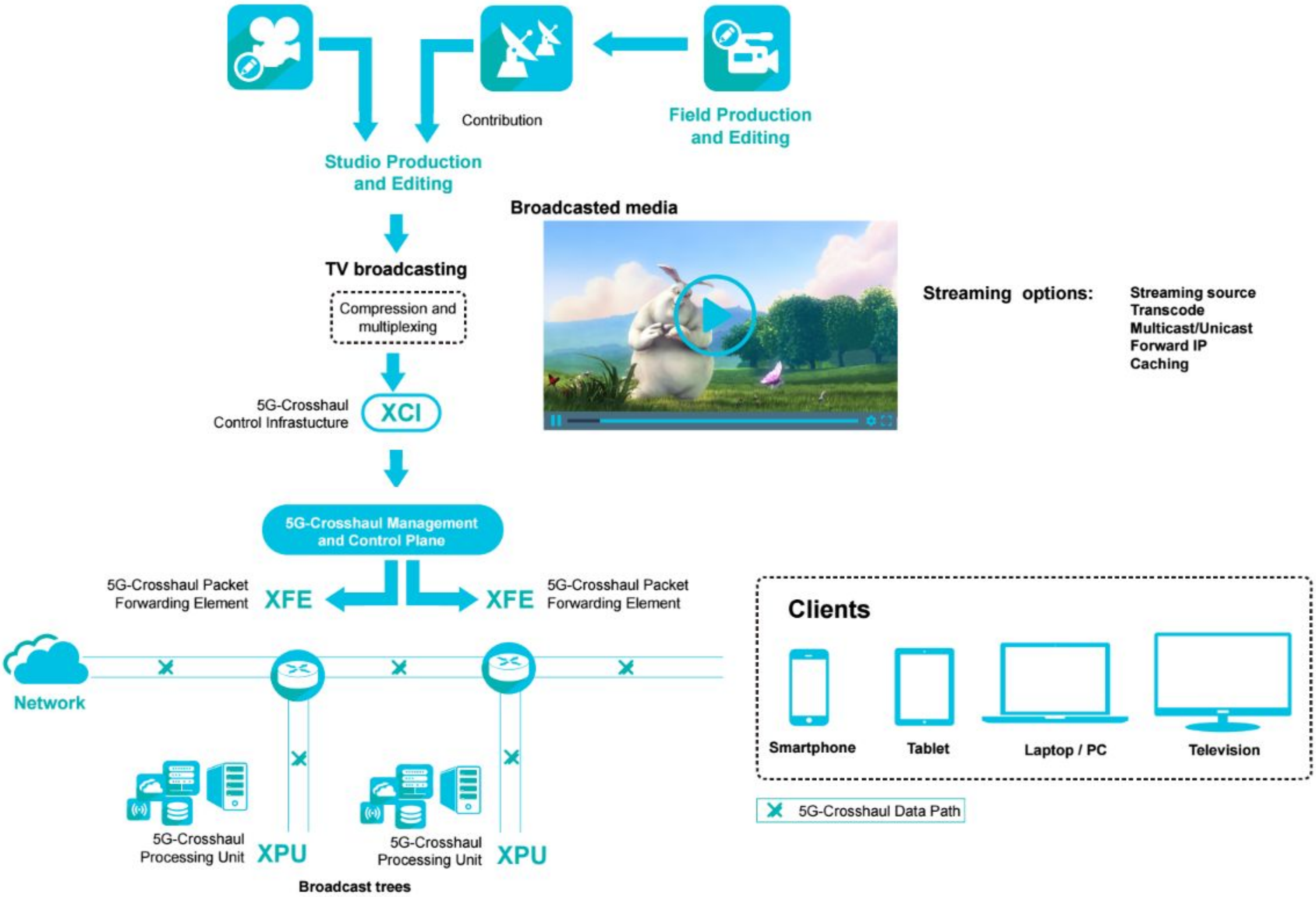

Figure 2: 5G-Crosshaul Architecture Concept

3.1 TVBA Functionality

The trends of on-demand, mobile, and Ultra HD quality impose formidable challenges for TV and the delivery network of the future to be coped for 5G-Crosshaul. And the application proposed in this paper aims to provide a solution for broadcasting built upon 5G-Crosshaul framework.

As part of the functionality provided, TVBA application provides a set of functions for content media management (including head-end injection) and routing by means of the selection of the most suitable physical or virtual nodes for very low latency delivery.

The focus is on minimizing both the cost and the spectrum consumption of the next generation TV and broadcast-like content delivery that will be capable of addressing the future needs of European citizens:

- Media/TV broadcasting & multicasting services utilizing the 5G-Crosshaul architecture
- Providing a good alternative to classical broadcasting networks, with an additional ability to mix with other media content not coming from the broadcasted TV using the same network with a controlled quality and offered as a Broadcast-as-a-service
- Useful to demonstrate the feasibility of 5G-Crosshaul objectives such as Crosshaul-integrated (control/planning) applications
- Increase cost-effectiveness of transport technologies for media distribution

The TV Broadcast Application functions are presented below:

- TV-Headend configuration
- Media workflow managing and monitoring
- Request-routing algorithms: adaptive, considering the current system condition to select a replica server for content delivery.
- Metrics: load, congestion, location…
- QoE metrics for the service

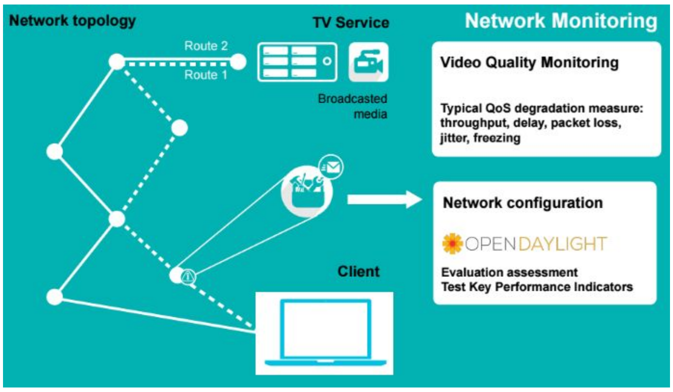

Figure 3: TVBA Functional view

BA benefits from XCI services (i.e. Resource Manager) to deploy media transmission over the 5G-Crosshaul infrastructure, and not requiring direct access to the resources and controllers. BA should communicate with XCI manager and provide the information needed for the service establishment and operation. The TVBA offers broadcast as a service, taking the 5G-Crosshaul network as a facility for management of the construction, deployment and provision of the involved resources. The target is to optimize the content delivery and make sure a real-time delivery with the lowest possible delay is offered to the users.

The interface requirements defined by the TVBA application to be fulfilled by XCI NBI are related to the broadcast service information deployment (provision of APIs for service invocation) and the network-based NBI functionalities. Monitoring information regarding the network infrastructure or on the QoS deployed, control of performance and the related notifications are some of the capabilities involved. Indeed, in order to meet the QoS traffic requirements of the OTT, it is sufficient to provide resources in the form of computing power and storage, and routes allocated over the most adequate technologies, amongst the available ones.

4 PRELIMINARY RESULTS

The 5TONIC-Madrid site will host the first TV Broadcast tests within 5G-Crosshaul. The objective is to verify the improved capacities of the 5G network for deploying high-demanding video services. These trials will be analyzed to measure the improvements 5G-Crosshaul integration will provide.

Visiona will provide its head-end solution for video play-out. It will be connected with the XFE (entry point) to inject the video flow into the network. Optimum routing inside 5TONIC-Madrid site to build the broadcast tree (point to multipoint deployment) will be achieved and, then, a quality probe to get the service metrics (quality assessment) will be integrated.

The first achievement is the first version of Visiona's TV head-end for the video injection and service configuration. A graphic interface has been developed for the control of the system. The video stream provided is fully-compatible with DVB and IPTV.

The TV head-end has been used as real-time video source for carrying out the first tests of content distribution within Crosshaul network.

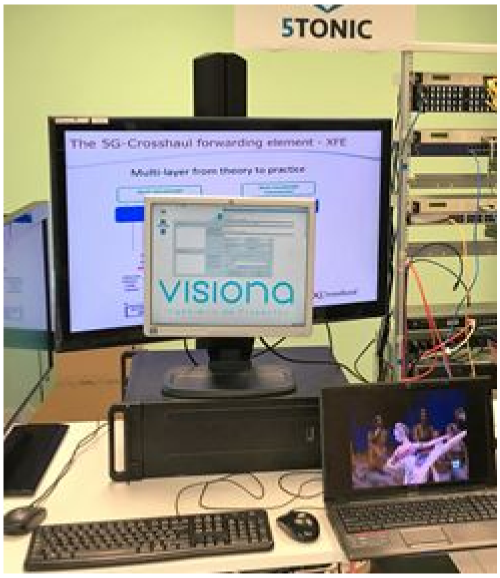

Figure 4: TV Head-End

Different tests have been deployed in the first year by integrating the head-end in the 5TONIC-Madrid site to analyse the feasibility of end-to-end high definition video distribution into the Crosshaul network. Service was successfully provided and the video was displayed in a webplayer in a laptop.

One of the tests was defined to compare the perceived QoS between the video service provided in Crosshaul and an equivalent DVB-T service.

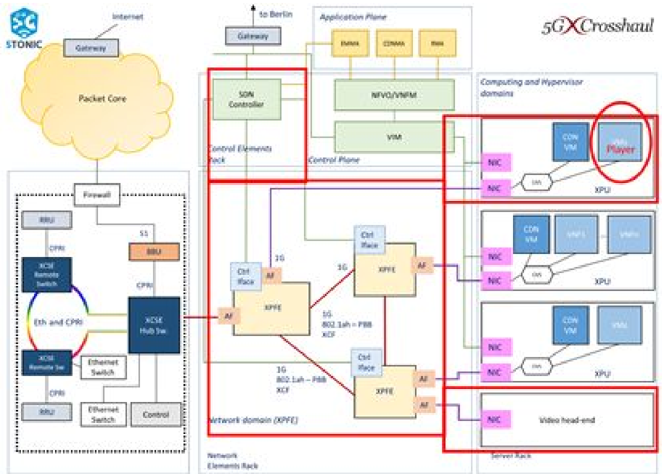

Figure 5: Video broadcasting demo in 5Tonic site

The same video services are provided in parallel through the Crosshaul network and a DVB infrastructure composed of a video play-out (laptop), USB to ASI converter, DVB-T modulator, and a USB DVB receptor (with its specific software running in a laptop).

The video quality was assessed by a panel of experts through subjective quality tests. The experts assessed the overall quality of the service and the noticeable difference between both services, the one provided through Crosshaul, and the DVB-based one. The video services were displayed in the 17" HD monitors of two equal laptops.

The first test got a mean score of 3.75 out of 5, that goes over the required quality threshold of 3. Jitter was the most annoying effect of the service, and should be improved in future works.

The second test got a score of 4.75 out of 5, so there was almost no difference at all between the two services in terms of video quality.

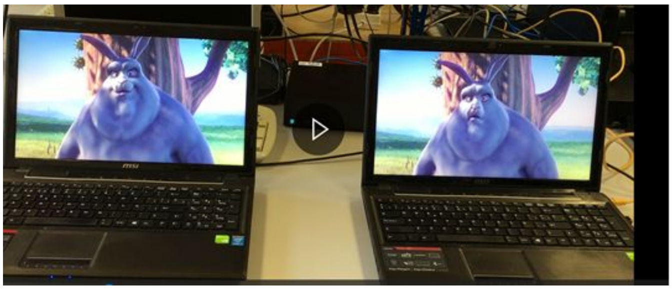

Figure 6: Video broadcasting comparison

5 CONCLUSIONS

In this paper we presented one of the applications within the 5G-Crosshaul project, in which key innovations to enable context-aware resource management and to provide system-wide optimization of the integrated fronthaul/backhaul transport network for 5G will be developed.

Ackowledgement

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