Extended Abstract: Quality Probe for Testing Multimedia Content in 5G Networks

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Abstract - With the growth of Internet traffic and the deployment of 5G networks, the evaluation of technology for video streaming over the Internet needs to be assessed. Users demand more efficient algorithms that taking into account the state of the network assure the requirements in terms of quality and allow them to enjoy the contents, which have gradually more resolution and definition than years ago. For this purpose, it is important to create a "probe" for video quality analysis, which checks the correct video transmission through the network avoiding undesirable effects in the multimedia content. In absence of a reference to compare the video transmitted with the original video, an algorithm based on video quality metrics is able to assess the transmission and, consequently, to improve the Quality of Experience of the users, needs to be implemented. The metrics are based in the detection of freezing frames, artefacts, colour errors and packet losses through the analysis of the video sequence. 5G network architecture, based on novel virtualization architectures, such as Software-Defined Networking (SDN) and Network Function Virtualization (NFV) allows the nodes in the network to improve the distribution capabilities of the multimedia network in case of transmission errors. The algorithm of the Quality Probe is designed to assess the quality and, in case of finding a descent on it, trigger an alarm to the broadcaster. The probe has been tested with a database that considers this type of errors, with successful results.

Index Terms - 5G Networks, Video Quality Assessment, Multimedia, Virtualization, SDN, NFV, Artefacts, QoE, Streaming, Probes.

INTRODUCTION

The trends in video content transmission impose challenges for broadcast and delivery networks, with the expansion of Video on Demand (VoD), mobility and Ultra HD [1]. Users demand triple A (Any device, Anytime, Anywhere) services in ubiquitous networks for accessing their favourite multimedia contents. For this purpose, the fifth generation of mobile technology (5G) is positioned to address the demands and business contexts of 2020 and beyond, but the amount of traffic generated require evolved techniques to control the media flows.

Software-Defined Networking (SDN) [2] and Network Functions Virtualization (NFV) [3] provide an interesting opportunity in the transformation of broadcast, contribution and content distribution in 5G networks [4]. The applications and services based on NFV and SDN are expected to schedule, coordinate, and control media flows across broadcast and contribution in 5G-network infrastructures.

The limitations of bandwidth in the networks leads to video bitrate oscillation and undesirable behaviour that impact negatively the viewing experience [5]. For that reason, it is necessary to design and implement a SDN-based application that receives the video for evaluating the Quality of Experience (QoE) in the network [6]. The building block in charge of that evaluation is referred as "quality probe". The probe enables the analysis of video through Video Quality Assessment (VQA) techniques, in order to improve the experience, because the visual metrics offer an instant assessment in the network that facilitate the control of impairments caused by the transmission system.

OBJECTIVES AND ENVIRONMENT

The work here presented has been developed as part of a TV Broadcast Application (TVBA). This application aims at developing an adaptive and cost-efficient solution for the 5G transport network, which makes available a ubiquitous infrastructure integrating network, compute and storage resources. Featuring SDN and NFV, it enables a flexible programmability of the infrastructure and a dynamic allocation of functions on top of it. It adopts mechanisms aligned with the ETSI Management and Orchestration (MANO) architecture as a specific means to offer the aforementioned network, cloud computing and storage. Meaning that it requires intelligent mechanisms of TV distribution to minimize the impact of high bandwidth and demand variability. Furthermore, NFV allows an effective provision of TV services by different providers over the same infrastructure, providing economies of scale.

In order to minimize both the cost and the spectrum consumption, thus optimizing transmission, the application needs to be able to reconfigure the virtual infrastructure, attending to QoS and QoE evaluations. Under these premises it creates a structure which provides transport services offering context-aware resource optimization and management of the network. Therefore, the objectives of the network's quality probe implemented are derived from those previous premises and comprise measuring a QoE value through VQA techniques at any given point in the network and communicating its results to the TVBA in order to enable bandwidth, routing and quality adaptation control, all over the 5G broadcast network, for service provision.

Monitoring information regarding the network infrastructure, the QoS/QoE associated and the control of network performance are some of the capabilities involved in the system, in order to provide the necessary resources in the form of computing power and storage for video.

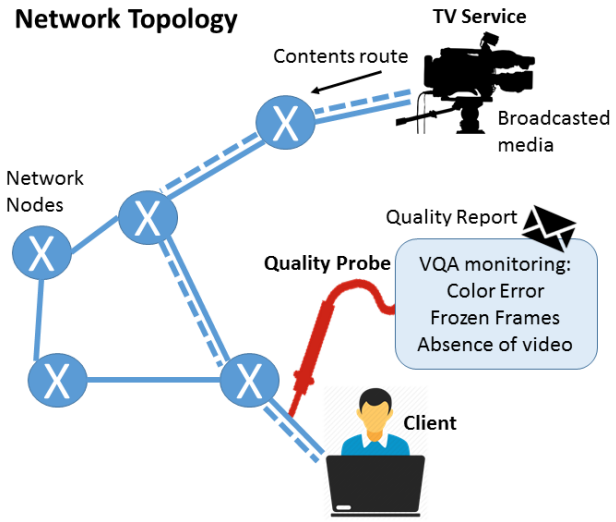

FIGURE 1. QUALITY PROBE IN NETWORK ARCHITECTURE

The quality probe is instantiated as a Virtual Network Function (VNF) within the 5G network and orchestrated by the NFVO (NFV Orchestrator) used by the TVBA. After monitoring video transmitted through the network, the quality probe communicates with the TVBA providing the quality information of the network so that the TVBA can take decisions for the service establishment and operation. This communication is exchanged using REST API and JSON messages to send Quality Reports, including data of the video quality evaluation and VQA monitoring, as seen in Figure 1. More specifically, the application offers Broadcast-as-a-Service, using the 5G network as a facility for management of the instantiation, deployment and provision of the involved resources. The target is to optimize the content delivery ensuring the best viewing experience with the lowest possible delay offered to the users.

VIDEO QUALITY ASSESSMENT (VQA)

The quality probe implements VQA metrics for evaluating the quality of multimedia contents in the network.

- Colour errors. This metric is based on the detection of artificial colours occurred by effect of colour space transformations in the video sequence when the network generates transmission errors or packet losses.
- Frozen frames. This metric is based on the detection of frozen or black frames when the frame is repeated in time by the effect of an error transmission.
- Absence of video. The node stops streaming video through the network or there is an interruption of the service and the user is not receiving frames.

The following example shows the JSON message corresponding to a Quality Report returned to the TVBA through the management network, for assuring the quality in the system. The JSON contains no errors detected in the video.

{ "jsonfile": "streaming-22_05_2017-16:02:30.json",
"framesDefinedToAnalyze": "250",
"startTime": "22_05_2017-16:02:09",
"endTime": "22_05_2017-16:02:30",
"processTime": "12.000000seconds.",
"namefile": "http://192.168.0.xxx/mjpg/video.mjpg",
"localFileOrStreaming": "Streaming",
"widthFrame": "640", "heightFrame": "480",
"fpsVideo": "25.00", "numFramesVideo": "0.000000",
"numFramesReadFromVideo": "250",
"errorFreezing": "0",
"numFreezingFrames": "0", "valueFreezingFrames": "0",
"errorNoVideo": "0", "errorPacketLoss": "0",
"errorColor": "0",
"numErrorColor": "0", "valueErrorColor": "0",
"errorGlobal": "0"}

TESTS AND RESULTS

For evaluating the "probe", test sequences included in ReTRiEVED database [7] were used, because those video sequences contain the most common artefacts in network video streaming, such as freezing frames, colour error or packet losses.

The application was first tested with sequences contained in local files. A second test battery used the same sequences but streamed to the network, simulating a conventional transmission of video.

- Sequences with frozen frames
- Sequences with error caused by throughput (example in Figure 2), packet losses and jitter.
- Absence of frames when streaming video through the network.

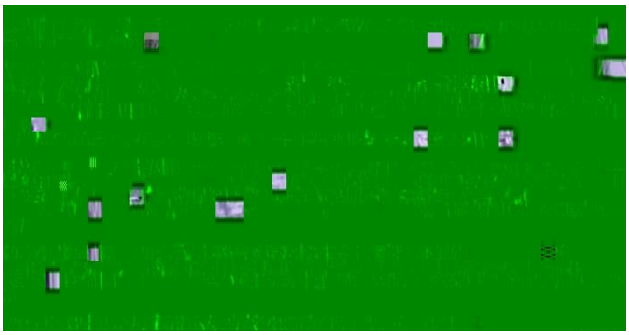

FIGURE 2. EXAMPLE OF SEQUENCE "CROWDRUN" (1.R.512.TS) WITH ERRORS CAUSED BY THROUGHPUT

As part of the TVBA system for 5G networks the quality probe, instantiated as a VNF, has been tested in a reduced environment with 6 switches and 3 compute units. For the tests the TVBA was scheduled to launch the quality probe every 2 minutes in order to detect QoS/QoE errors from broadcaster to client in an acceptable time. The quality probe was configured to analyze 250 frames of the video streamed. Under those conditions, the average processing time of quality probe is 12 seconds and the time needed to detect a quality issue depends strongly on the scheduling time to start the quality probe, being the maximum time 132 seconds and the minimum time 12 seconds. Self-healing of the system once a quality issue has been detected takes around 500ms to provision a new the service for the users over a new path.

These results are highly dependent on both scheduling times for testing and number of frames to analyse using the quality probe so further optimization would reduce even more that time.

CONCLUSIONS

Video Quality Assessment enables the analysis of the network state, determining the necessity of providing better quality to the system and the resubmission of low quality video, meaning the convergence between content delivery and 5G networks. The metrics developed for detecting the absence of video, colour distortions or frozen frames compose a first approximation to the model that trends expect to be the future 5G multimedia distribution content.

First tests highlight the necessity of developing intelligent nodes that are ready to detect common transmission errors to improve the efficiency of 5G networks and increase the users' satisfaction.

The TVBA and its quality probe service demonstrates the necessity of standardization and deployment of intelligent network nodes that automatically adapt to the 5G network conditions with the objective of improving video transmission, with the enhancement of users' viewing quality.

ACKNOWLEDGEMENTS

This work has been partially supported by the EU project "5G Crosshaul: The 5G Integrated fronthaul/backhaul" (grant no. 671598) within the H2020 program [8].

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