Self-restoring video user experience in 5G networks based on a cognitive network management framework
Salva-Garcia, Pablo; Alcaraz-Calero, Jose M.; Wang, Qi; Barros Weiss, Maria; Gavras, Anastasius

Published: 18/06/2019

Document Version
Peer reviewed version

Link to publication on the UWS Academic Portal

Citation for published version (APA):
Self-restoring video user experience in 5G networks based on a cognitive network management framework
Salva-Garcia, Pablo; Alcaraz-Calero, Jose M.; Wang, Qi; Barros, Maria; Gavras, Anastasius

Published: 18/06/2019

Document Version
Peer reviewed version

Link to publication on the UWS Academic Portal

Citation for published version (APA):

General rights
Copyright and moral rights for the publications made accessible in the UWS Academic Portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy
If you believe that this document breaches copyright please contact pure@uws.ac.uk providing details, and we will remove access to the work immediately and investigate your claim.

Download date: 12 Feb 2021
Self-Restoring Video User Experience in 5G Networks Based on a Cognitive Network Management Framework

Pablo Salva-Garcia*, Jose M. Alcaraz-Calero*, Qi Wang† Maria Barros† and Anastasius Gavras†
University of the West of Scotland, United Kingdom
†Eurescom GmbH, Germany

Abstract—Video applications such as streaming are expected to dominate the traffic of the incoming Fifth generation (5G) networks. It is essential for 5G service video providers and/or network operators to provide assurances for both the overall status of the network and the quality of their video transmissions in order to meet the final users’ expectations. In this contribution, we propose a video optimisation scheme which is implemented as a Virtualised Network Function (VNF), which in turn, facilitates its on-demand deployment in a flexible way in response to an intelligent analysis of the current network traffic conditions. We leverage a cognitive network management framework to analyse both network status metrics and video stream requirements to evaluate if any optimisation action is required. The testing and evaluation focus on the functional tests and scalability evaluation of the proposed scheme. Moreover, the bandwidth saving is assessed to demonstrate the significant benefit in traffic reduction for a 5G system that adopts the proposed approach.

Keywords—5G; Artificial Intelligence; Video.

I. INTRODUCTION

Video applications trend to dominate the traffic over the coming years [1]. In fact, High Definition (HD) and Ultra High Definition (UHD) services have been gaining growing popularity and are foreseen as main driving applications in 5G networks. Video services are generating continuously heavy traffic load to the network and leading to congestion and thus overall performance downgrading in the 5G system. Besides, virtualised 5G networks impose a complex network protocol stack to isolate and differentiate network traffic at different layers, to what is known as Network Overlays. Such complexity plus the fact of using the latest video codec (e.g., H.265/HEVC) and its scalable extension SHVC [2] makes extremely difficult to find a video tool able to deal with all such requirements. Therefore, it is essential to design and develop a new video optimiser that is capable of parsing the 5G traffic and processing the video traffic encoded by the latest codec, likewise, it is also fundamental to make an intelligent analysis of the current state of the network to provide autonomous self-optimization capabilities. This research focuses on the scalability of the proposed video optimiser approach by deploying instances of the service as a response to an alarm of a possible downgrading of the video quality.

II. DESIGN

This section lists of requirements of both the video optimiser and the management layer as well as its architectural components. Furthermore, we present the methodology that provides the methods and procedures used in this research study.

Video Optimizer: Video optimiser is able to work with the new generation video codec and to inspect trough different overlay network layers existing in virtualised 5G networks; The VNF where video optimiser is deployed has to be instantiated on-demand when a downgrading in the quality of any video flow is detected (mainly due when impairments in the network); System should minimise the negative impact on the user’s perceived quality for video applications and should mitigate network congestion by maximizing bandwidth saving; System should also cope with scalability aspects when thousands of users are using a video streaming service; The application of video optimisation requires direct communication within the upper layers of the cognitive framework in order to autonomously apply user video policies when congestion is detected.

This research makes use of an ETSI MANO [3] compliant management framework and architectural components (Figure 1) required for providing self-optimisation capabilities following the Self-Organising Networking (SON) principles to automatically adapt video flows over a multi-tenant 5G network data path. In summary, it uses a VNF Orchestrator for orchestrating the deployment of different VNFs, VNF Management for having control of the life cycle of the VNFs managed in the infrastructure, and a Virtual Infrastructure Manager (VIM) for the management of the physical and virtual resources of the infrastructure (compute, storage and networking).

Cognitive Framework: The cognitive framework has a policy engine to define quality of service agreements; The framework Monitor information coming from the network sensing pipeline, Analyzes such information in order to determine if the network is congested and led to a Decision Maker that will decide what type of video optimization need to be done. The Planner module will then refine the decision providing an implementable and ordered plan to enforce such decision. Such optimization plan will then be orchestrated by the ETSI MANO Orchestrator. The framework has a network sensing layer providing both network metrics and also per-flow video metrics. It also has a resource and network flow inventory with an updated list of physical and logical hardware equipment, network flows and services. The framework has also a network actuation later providing adaptation capabilities over the video flows.

This study presents a realistic scenario where a cognitive network management framework is used to detect congestion problems in the data plane and subsequently deciding on a specific action to be taken to mitigate the impact of such problem in the final user’s video quality perception. The framework relies on a cognitive intent-based algorithm to calculate, based on the current state of the network condition and the specific video flow bitrate requirements, a parameter called Congestion Index (CI). CI is calculated as the maximum bitrate that a specific video flow is going to reach, divided by the current available bandwidth in the network (As shown in Equation 1). Both subjective and objective video metrics gathered from our previous work in [4], have provided the network congestion limits where users perceive a degradation of video quality. Such limits are called Quality Index (QI). Therefore, the periodically CI calculation produced by the Analyzer is mapped within those QI boundaries to provide QoE quality degradation alerts.
As can be seen in Figure 2, at the end of the transmission about 2,981MBytes (close to 3GBytes) has been saved. From the network point of view, congestion has been mitigated; from the users’ point of view, the perceived quality remained stable since there is no uncontrolled packet loss but just a downgrading of the video resolution under imperceptible boundaries for the human eye in smartphone devices.