

Experimental Validation of Network Slicing Management for Vertical Applications on Multimedia Real-Time Communications over a Packet/Optical Network

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ABSTRACT

This paper presents the experimental validation of a vertical application on multimedia real-time communications use case in which its services are managed by a network slice manager. The network slice manager has been developed in the 5GTANGO project for the SONATA NFV Service Platform. It used to partition the 5G network and dynamically deploy network slices with quality of service (QoS). Network slices exist in parallel and isolated for the different tenants (e.g., vertical industries) in order to deliver the tenant-specific requirements (e.g., latency, bandwidth).

The network slice manager has been experimentally validated in the multimedia real-time communications pilot deployed in the 5GTANGO project, considering the development and instantiation of two network slices with different QoS.

Keywords: 5G, Network Slicing, NFV, 3GPP, Real-Time Communications.

1. INTRODUCTION

In the last years, one of the hot topics discussed around the NFV service platforms is the possibility to manage their network resources by creating small and independent pieces (called slices) of network virtual resources (with different objectives) co-existing and isolated over the same physical network. Keeping this concept in mind and using the definition made by the 3GPP [1], a **Network Slice** is a set of network functions/services (NF/NS) linked one to another with the aim to allow the operator of the network infrastructure to offer multiple and different network services (web or ftp services, real-time communications, etc.) over the same physical resources.

In comparison to the previous work [2], the current version of the Network Slice Manager aims to be more complete creating the relationships among instantiated NS and so, to generate more complete applications to offer to the user. Moreover, and equally important, there is a new feature that focuses on having a more efficient usage of the instantiated NSs by allowing them to be shared among Network Slices.

This paper is organized as follows. Section 2 introduces the concepts of Network Slicing with the main slice features that a Network Slice Manager should be able to manage. Section 3 presents the design of the proposed Network Slice Manager (as part of the Sonata Service Platform developed during the 5GTANGO project), by describing its internal architecture and the relationship with the other components and the data model defining a network slice. Section 4 describes the Multimedia Real-Time Communications environment test used to prove our network slicer, together with the results obtained from the developed tests. Finally, we conclude the paper.

2. NETWORK SLICING

As its definition describes, the idea of a network slice is essentially to provide as a single element, a set of individual services or functions [1]. Each one of these services/functions can probably work on its own, but joining them allows the NFV orchestrator (NFV-O) a more efficient and easier way to manage its network resources (through their virtualization), and the final user a better performance on the requested services (each slice is seen as a logical and independent network from the other slices that meets a requested QoS).

To manage the concept of a network slice, the usage of two data objects is necessary. On one side, the Network Slice Template (NST), the descriptor defining the set of services/functions to be instantiated. On the other side, the Network Slice Instance (NSI), the descriptor containing the information of all the instantiated services (based on the NST).

2.1 Features

Based on the documentation presented by the multiple organizations (ETSI, 3GPP, etc.) a Network Slice manager should have the following features:

- **Services Management:** The basic element within a network slice. By creating a list of IDs referencing to all the desired services, the user can instantiate/terminate all the services within the NST by sending one single request and let the slice manager to do the rest.
- **Quality of Service (Slice):** The services in use are expected to give a certain quality of their performance. Multiple ideas are being described on how to add Quality of Service (QoS) at Network Slice level. In a further section, the way the 5GTANGO project aims to relate QoS to Network Slices and Services is presented.
- **Service Composition:** It is necessary to allow traffic between the Virtual Machines (VMs) hosting each one of the NSs by linking them through internal networks of a Virtualized Infrastructure Manager (VIM), which is the owner and manager of the available virtual resources to instantiate the NSs. Similar to what it is done within the NFs composing a NS, we used the idea of Virtual Link (VL) also at a slice level.
- **Service Sharing:** Even though each slice is independent from the other slices, we cannot forget that one of the objectives of SDN/NFV is to improve the network resource efficiency. To do so, slices can share NSs among them (if defined in the NST) and this means to reuse an already existing and used resource of the network, which allows to avoid to spend unused resources (for a new equal service instantiation) that could be requested for other usages.

3. 5GTANGO NETWORK SLICE MANAGER

As described in section 1, our Network Slice Manager, based on the 3GPP technical specification [1] and presented in a previous work [2]), has evolved from a very simple manager capable of instantiating a set of NSs without any link among them, to a new version with the previously presented features subsection (2.1), allowing a more efficient management of the VIM resources and allowing more complex NSs relationships.

Internally speaking, the architecture keeps the same structure presented in [2] with some differences. The internal communications between the Network Slice Manager and the central SONATA NFV SP [3] component (called Gatekeeper) have been improved to be asynchronous, allowing the user to create multiple slices in parallel without the necessity of waiting for previous slice to be ready before instantiating another slice. The other important improvement is the update of the data models defining our descriptors (NST and NSI) in order to include the two new presented features.

3.1 Data Models

Our new data models for the NST [7] and NSI [8] descriptors were updated to define the relationship among the services composing a network slice and to define which one of them could be shared among multiple slices.

The first main improvement is the addition of the already existing concept of Virtual Link Descriptor (VLD) within NST and NSI. Thanks to the VLD, we are able to define how the different Network Services are linked one to another in order to send the traffic to the following function and, finally, to make all the necessary functionalities to work as one single slice.

The second important improvement is a new parameter added within the NST to define whether the services could be shared among network slices. While in the NST this parameter simply specifies if a service is shared or not, the management of the shared services is done with the NSIs; when a shared service is instantiated, the Network Slice manager will check if that service can be shared or not. If it is shared, it will check if there is an already existing instance of that same service and if it does, copy its information from the original NSI descriptor to the new NSI. In case, it does not exist any shared service instance, then, it simply creates a new service instance as done until now. On the other side, when termination of a shared service is requested, the Network Slice Manager must check if there is another network slice using that instantiation and only terminate it, if the current terminating network slice is the last one using that shared service instance.

Finally, the NSI was also updated to have more detailed information about each one of its service instantiations.

4. MULTIMEDIA REAL-TIME COMMUNICATIONS PILOT

Among all the 5GTANGO pilots defined in [5], this paper presents and provides an evaluation of the use case in which the concept of Network Slicing has been used.

4.1 Use Case Description

This use case provides a real-time communication suite using network slices with the aim to provide flexibility when deploying different Quality of Services (QoSs) over the same physical network. The idea is to create two equal network slices as **Error! Reference source not found.** shows. Both network slices will have the same exact service but each network slice with a different QoS. By doing this, the operator of the physical resources will be able to create multiple network slices and manage them by fulfilling QoS requirements requested by the different users.

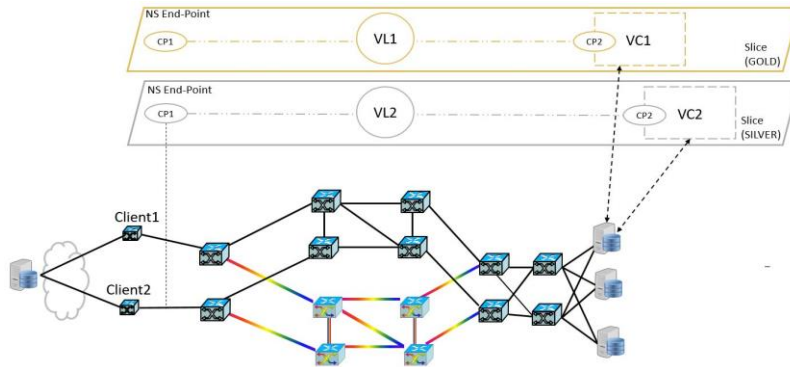


Figure 1 - Diagram of the network slices over the architecture.

4.2 Network Service Architecture

The composition of the network service that provides real-time communications service is the following. Five Virtual Network Functions (VNFs) compose our real-time Network Service ([4] [5]):

- **Reverse Proxy (VNF-RP):** VNF composed by an Nginx with the goal to receive all the HTTP and WebSocket traffic coming from the Internet. Besides, it includes a central monitoring system built with Simple Networking Management Protocol (SNMP).
- **WebRTC Application Controller (VNF-WAC):** It includes the Sippo Server and the Signaling Server (QSS) in charge of the WebRTC communication. Besides, it includes an SNMP service used to monitor user data, such as the user registrations.
- **Backend Services (VNF-BS):** Composed by a MongoDB database and RabbitMQ. It will be accessible for all the VNFs requiring of these services.
- **Dispatcher (VNF-DS):** It asks for media rooms to create the multimedia sessions. Any new Media Server added to the system will register against the Dispatcher so that it can be eligible to create new rooms.
- **Media Server (MS-VNF):** Composed by a Janus and a Wrapper in charge of receiving and relaying the media during the videoconferences. Furthermore, it includes an SNMP service used to monitor network parameters (bandwidth, jitter and packet loss) affecting the QoS of the communication.

Finally, there are two more components to keep in mind that are needed for the NFV-O to manage the network service: a) **Function Specific manager (FSM):** It allows the VNFs to modify their internal functions configuration; and b) **Service Specific Manager (SSM):** It allows the VNFs to extend their own information with data from the other VNFs or simply know about the others VNFs existence and location.

```
name: "GOLD_CommunicationsPilot_NST"
description: "NST for the communication pilot with GOLD QoS."
vendor: "5gtango"
version: "2.0"
sliceServices:
  - servID: "f51543f1-b9e4-405c-9a20-d121d7c42a20"
    servname: "Videoconference"
    slaID: "1d7a0223-dbf7-43a4-9dd6-25136e138d96"
QoS_5qi_value: 3
notificationTypes: "NstOnboardingNotification"
onboardingState: "ENABLED"
operationalState: "ENABLED"
usageState: "NOT_IN_USE"
userDefinedData: ""
```

Figure 2 - NST with GOLD QoS level assigned.

4.3 Network Slice and Quality of Service

As the pilot deals not only with services but, moreover, with a testbed emulating a real network, it has to consider the QoS at different levels. At a link level, the idea is to use bandwidth and delay parameters. However, it is at Network Slice level where it becomes interesting, as the idea is to fulfil the QoS of the Network Slice specifying explicit requirements for each NS.

Within the NST, there is a parameter called “5QI” which maps from one single value to a set of 5G QoS characteristics and it was described by the 3GPP [6] as one of the parameters to define 5G QoS. Our proposition is to define this value within the NST and give the responsibility to fulfil the global network slice requirements to each one of the NS by assigning them a Service Level Agreement (SLA) that will be monitored by the *Sonata SP* Monitoring Manager component.

At this point and keeping in mind all the previous information, it is possible to present one of the two NST descriptors used in our tests. A single NS with an associated SLA to fulfil the QoS requirements defined in the 5QI parameter composes the NST in **Error! Reference source not found.** This is the NST with higher QoS (GOLD) and it has a 5QI value equal to 3, which maps to the requirements in the second row of Table 1 while the first row are the requirements assigned to the other NST with a lower QoS requirements (5QI value equal to 2).

| 5QI Value | Resource Type | Default Priority level | Packet Delay Budget | Packer Error Rate | Default Max. Data Burst Volume | Default Av. Window |
|-----------|---------------|------------------------|---------------------|-------------------|--------------------------------|--------------------|
| 2 | GBR | 40 | 150ms | 10^{-3} | N/A | 2000ms |
| 3 | GBR | 30 | 50ms | 10^{-3} | N/A | 2000ms |

Table 1 - 5QI selected requirements for the NST.

4.4 Test Description and Results

In our test, it was possible to deploy both NSTs over the architecture in **Error! Reference source not found.** and perform a call in which two users were sharing their own desktops as real-time video through webcam devices.

During the videoconference sessions, several measures of bitrate and packet loss were measured for both audio (Figure 3I) and video (Figure 3II). By looking at the measures, it can be seen that the service reached the desired performance and the values met the expectations, showing just a marginal packet loss of 2.0 packages until the moment this information was taken. This value is considered negligible for the videoconference service. Besides, the audio bitrate remains by a stable value of 25 kbps for outgoing and incoming directions and, the video bitrate remains stable at 300 kbps for outgoing directions. The peaks observed are due to the different types of frame used in the VP8 video flow.

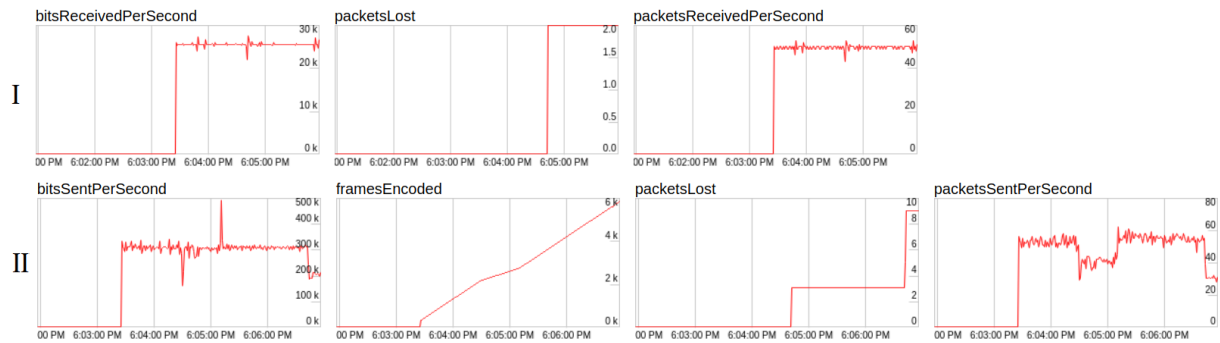


Figure 3 – Audio (I) and Video (II) Results

5. CONCLUSIONS

This paper presents the concept of distributing the responsibility to fulfil the assigned QoS requirements of a Network Slice, down to the NS level among all services composing a Network Slice by using a real-time communications service.

ACKNOWLEDGEMENTS

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