Study on Use-Cases of Open Source Management and Orchestration Framework in 5G Projects

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***Abstract* — Open Source Management and Orchestration (OSM) is an European Telecommunications Standards Institute (ETSI) hosted project supporting the development of Open Source Network Function Virtualization (NFV) Management and Orchestration (MANO) software stack aligned with ETSI NFV. This short paper is focused on the introduction of OSM and studies some real use cases on the market and in the same time brings out a new possible use case in order to evidence its flexibility. The paper will prepare future work of the authors, to migrate from a previous approach based on only Service programming and orchestration for virtualized software networks (SONATA) framework, to the more comprehensive OSM. A comparison between OSM and SONATA is provided here.**

Keywords — Network Function Virtualization; Software Defined Networking; Cloud computing; Open Source Mano; SONATA; Orchestration; Use case

I. INTRODUCTION

Telecommunication infrastructures include a large range of specific technologies from specialized domains such as radio, access, transport, and core and (virtualized) data center networks. Designing, deploying and operating end-to-end (E2E) services on top of the above infrastructure are commonly manual and long processes performed via traditional Operation Support Systems (OSS) resulting in long lead times (weeks or months) until effective service delivery [1]. Moreover, the involved workflows are commonly hampered by infrastructures strongly coupled to physical topologies and hardware-specific constraints.

Technological advances under the ages of Software Defined Networking (SDN) [2] in cooperation with Network Function Virtualization (NFV) bring new ways in which network operators can create, deploy, and manage their services. SDN and NFV, as well as cloud/edge computing support the introduction of novel services, and systems while meeting specific requirements and objectives (e.g., a customer requesting a specific network service). Altogether, the process shall be timely, consistent, secure, and lead to cost reduction due to automation and virtualization. We refer to Network Service Orchestration (NSO) as the automated management and control processes involved in services deployment and operations performed mainly by telecommunication operators and service providers [3].

However, to realize this paradigm, there is a need to model the E2E service and have the ability to abstract and automate the control of physical and virtual resources delivering the service. The coordinated set of activities behind such process is commonly referred to as orchestration.

In this paper, a new orchestration framework has been studied and used, i.e., Open Source MANO (OSM). The reason for this is that a previous framework SONATA and project itself is today considered as a part of entire OSM; it is not going to be treated alone anymore in the future, but as an integrated part of OSM.

OSM is an ETSI-hosted open source community delivering a production-quality MANO stack for NFV, capable of consuming openly published information models, available to everyone, suitable for all Virtualized Network Functions (VNFs), operationally significant and Virtual Infrastructure Management (VIM)-independent. OSM is aligned to NFV Industry Specification Group (ISG) information models while providing first-hand feedback based on its implementation experience [4]. The first release of OSM was in October 2016 and in December 2019 they unveiled the latest release (Release SEVEN).

The main purpose of this paper is to introduce OSM, compare it with SONATA framework from previous papers, present some specific use cases in order to understand the capabilities of the framework. Future work will test the OSM scalability properties and capabilities for using it to develop and test some custom VNFs from previous papers along with developing Network Services (NSs) with OSM and OpenStack.

The paper is organized as follows: Section I is introduction. Section II is an overview of related work and architecture of OSM framework and a short parallel with SONATA framework. Section III introduces use cases. Section IV presents conclusions and future work.

II. RELATED WORK AND SHORT PARALLEL BETWEEN OSM AND SONATA

This section presents a selective view on some related work dedicated to service development and orchestration in virtualized networks and its relation to OSM architecture, when applicable and introduces SONATA which is part of OSM.

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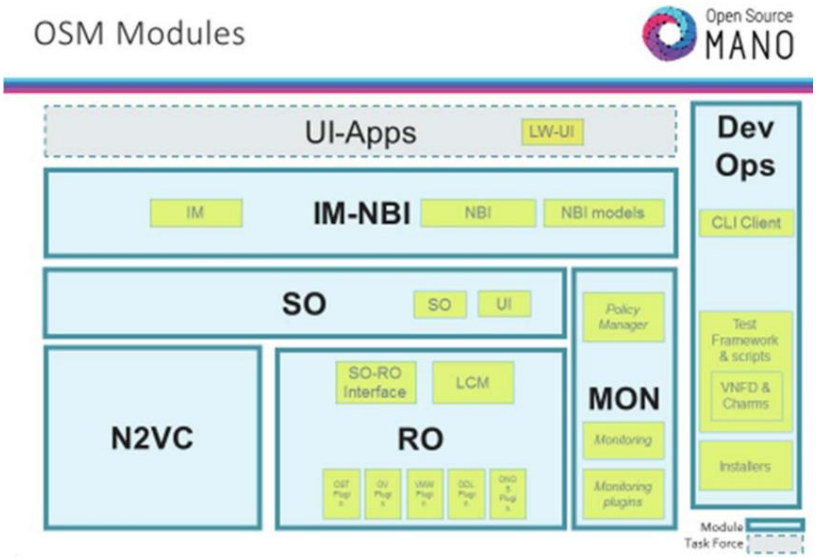

Figure 1 OSM Release Four Architecture Progression [4]

OSM is innately a modular and model driven architecture (Figure 1) and has evolved steadily to adopt cloud native design principals. The OSM community adopted rapidly this modularity, given its better fit to the growing functionality and answer to the need of efficient operation.

In the Release 4, the community rationalized the network to VNF Configuration (N2VC) module and the VNF.

Configuration and Abstraction Task Force to support rapid progress on the VNF configuration functionality. The Information Model and Northbound API were combined under one module ensuring model/interface harmony in the system and to support a growing demand for vendor/user different options.

The following OSM architectural entities (Figure 1) are shortly described below.

IM-NBI contains the information model and northbound interface.

The *Service Orchestrator (SO)* is responsible for E2E service orchestration and provisioning. The SO stores the VNF definitions and Network Services (NS) catalogs, manages workflow of the service deployment and can query the status of already deployed services. OSM integrates the rift.io orchestration engine as an SO [5].

The *Resource Orchestrator (RO)* is used to provision services and it orchestrates the resources necessary to compose a service over a particular IaaS provider in a given location. The RO component can deploy networking services over OpenStack, VMware, and OpenVIM. The SO and RO components can be jointly mapped to the NFVO entity in the ETSI MANO architecture [5].

UI-Apps module refers to the new lightweight graphic user interface (GUI) of OSM.

The *DevOps* module controls the Continuous Integration (CI) / Continuous Development (CD) pipeline optimizing the release process for the developers.

The *Network Service to VNF Communication (N2VC)* Module is responsible for the plugin framework between the SO and the VNF Configuration and Abstraction (VCA) layer [6].

The *VNF Configuration and Abstraction (VCA)* layer is responsible for enabling configurations, actions and notifications to/from the VNFs and/or Element Managers. When backed by Juju, it provides the facility to create generic or specific indirect-mode Virtualized Network Functions Managements (VNFMs), via charms that can support the interface the VNF/EM chooses to export [6]. Juju is an open source modeling tool, composed of a controller, models, and charms, for operating software in the cloud. A charm is a collection of actions and hooks that encapsulate the operational logic of an application.

The *Monitoring Module (MON)* should mostly be considered as a tool for driving monitoring configuration updates to the external monitoring tool and as a conduit for steering actionable events into the Service Orchestrator. These actionable events may be either directly triggered by running NS/VNFs or deduced by the external monitoring tools. Apache Kafka was used as the Monitoring Module message bus implementation. It is a fault-tolerant message passing system that supports a publish-subscribe model that aligns with the Monitoring Module's architecture. Messages sent to or received from the Monitoring Module core will be passed via the message bus for both internal and external components of monitoring. Apache Kafka "topics" and "partitions" are used to segregate messages to MON [6].

SONATA is the acronym name of an EU-funded project who developed an NFV platform, which offers to service developers or operator an ecosystem for managing the full lifecycle of a network service [7].

It consists of three main modules:

- *Service Development Kit (SDK)* which represents a set of models and tools that can be used to develop and test NS and VNFs.
- *Service Platform (SP)* which is responsible in orchestrating the network resources by providing a MANO framework.

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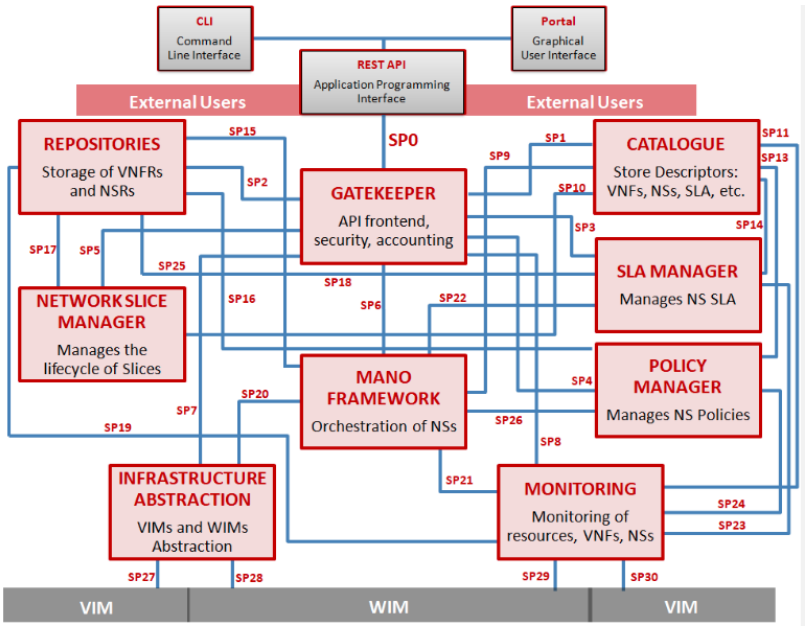

Figure 2 SONATA Service Platform Architecture [9]

- *Validation and Verification (V&V)* Platform Service which automatically manages the testing of services.

SONATA is in a direct relationship with OSM due to the integration of SONATA's emulator from the SDK module into OSM DevOps which was part of OSM Release THREE. This emulator assures an easier integration with MANO stacks due to its APIs, which resemble with the APIs offered by OpenStack [8]. Looking at Figure 2, the following components are shortly presented:

The Service Platform which may be considered as an alternative to OSM, consists of a Gatekeeper, Management and Orchestration Framework, Slice Manager, Infrastructure Abstraction, Catalogue, Repository, Policy Manager, SLA Manager, Monitoring Manager and a Portal.

Gatekeeper ensures that the Application Programming Interfaces (APIs) from the Service Platform are available to authorized users.

MANO Framework is managing the lifecycle of the Network Service active instances. It is the most important component from the Service Platform.

Network Slice Manager controls the deployment of multiple and isolated Network Services grouped in a Network Slice.

Infrastructure Abstraction is responsible of creating a unified management of all available infrastructures.

The *Catalogue* contains Virtual Network Functions (VNFs), Network Services (NS), Network Slice Templates (NSTs), etc.

Repository stores information from Network Service and Network Slice instances.

Policy Manager ensures the management of the policies used in Network Service instances.

Service Level Agreement (SLA) Manager works like a plugin and it is responsible for the lifecycle management of the SLA during the entire Network Service lifecycle.

Monitoring Manager collects data and displays the metrics through an interface.

The *Portal* is the front-end component which ensures the access to the Service Platform through an user interface.

As it was described, SONATA looks more like an OSM contributor than a competitor, having different components which are already compatible with OSM framework or which are easy to integrate. They already started a collaboration from OSM's third release (which was already stated above).

More than this short introduction and comparison, here are some pending and future works between SONATA and OSM.

SONATA is also playing a central role in a white paper that OSM is currently writing about "Experience with NFV architecture, interfaces and information models". A type of scenario is where the operator wants to cooperate with another operator to deliver the network service. For instance, it may devolve provision of the infrastructure, or of a specialist VNF, to another operator. The implication is that OSM needs an architecture that allows to orchestrate orchestrators and SONATA project contributes for this through its MANO framework. Another type of scenario involves modification to a network service, say 'video delivery'. The internal operation of the service may vary according to the specific device type, content source and so on – hence the network service may consist of an initial firewall that steers a request into the appropriate chain of VNFs. In the SONATA project, the development of their pilots is helping OSM to explore and sort out some of these scenarios.

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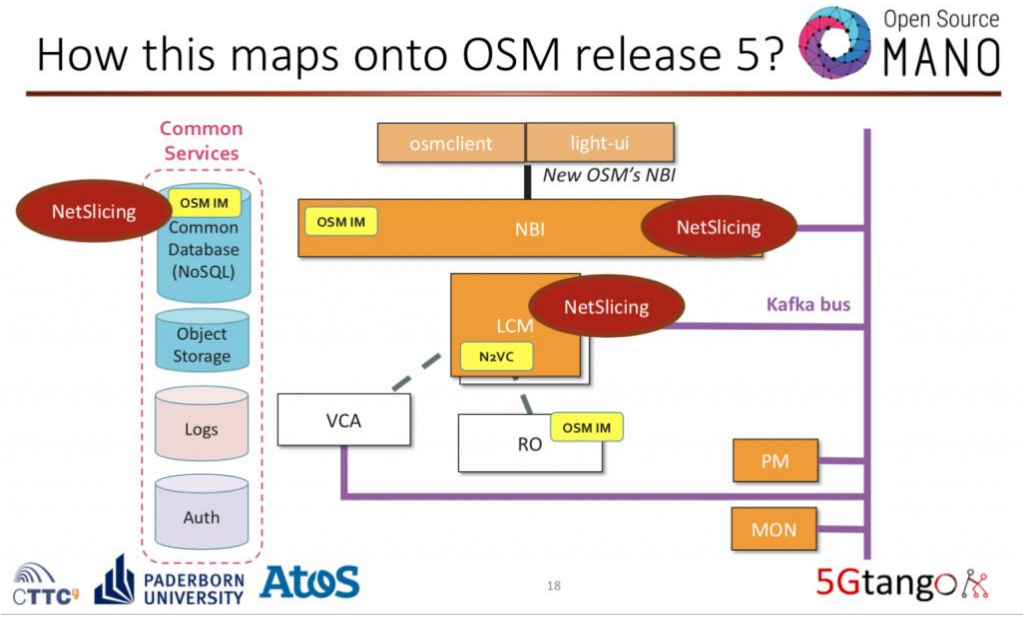

Figure 3 5GTango (SONATA) in OSM [10]

Regarding future work, there is 5GTANGO (the 5th SONATA Release) which is going to take the opportunity of the 7th OSM Hackfest to demonstrate the use of the standalone 5GTANGO V&V platform in an OSM environment. GTANGO has developed a unique V&V approach. V&V stands for verification and validation and aims at ensuring that a software application behaves according to its specification (verification) and users' needs (validation). The 5GTANGO V&V environment is a multi-MANO (targeting SONATA, OSM, ONAP) standalone test environment which streamlines the complete test chain: definition of reusable test plans across NS, reporting from the Service Platform with advanced analytics and reusable probes. Packaged with the 5GTANGO SDK, it becomes part of the developers' continuous integration (CI) framework. [14]

III. USE CASES FOR OSM NETWORK FUNCTION VIRTUALIZATION

Network function virtualization proposes an architecture that allows operators to virtualize network functions in a high-performing, elastic and automated way. Most of the early use cases are related to mobile networks in a move towards fifth generation (5G) technology and most implementations aim to have OpenStack as a Virtualization Infrastructure Manager (VIM), complemented with NFV orchestration platforms like the open source projects Open Source MANO (OSM) and Open Networking Automation Platform (ONAP.)

OSM can reach common goals for global service providers, leading IT/cloud players and VNF providers, but also for 5G research projects.

These 5G projects which use OSM to implement NVF MANO orchestration are very important for OSM community. Here are below, some examples of 5G projects and how OSM contributes to them:

- *5GTango* [10]: In the context of OSM, this project has contributed with a VIM emulator, advanced NFV packages formats, network slicing and many automation efforts.

- *Metro-Haul* [11]: is intended to build a smart optical metro infrastructure able to support traffic from different 5G access networks. OSM is the orchestrator in Metro-Haul, it deploys, manages and orchestrates the network services across disaggregated datacenters. It deploys VNFs across multiple datacenters in a network service; it creates L2 VLANs over the underlying network infrastructure.

There are also other 5G-oriented projects which use OSM (Matilda, 5GCity, 5G-MEDIA, 5G-TRANSFORMER).

The objective of this paper is to bring new functionalities and use cases from OSM which can be used for 5G over NFV and its application on the market in general. In order to bring new ideas, a study of the actual use cases of OSM has been done. The conclusion is that OSM is used in:

- Multi-site orchestration over disaggregated optical networks
- Urban radio infrastructure
- Media content distribution in core and edge cloud
- Computing resources management in multi-point of presence scenarios.

Next, this paper proposes an OSM approach for an Internet of Vehicles (IoV) schema in Figure [4].

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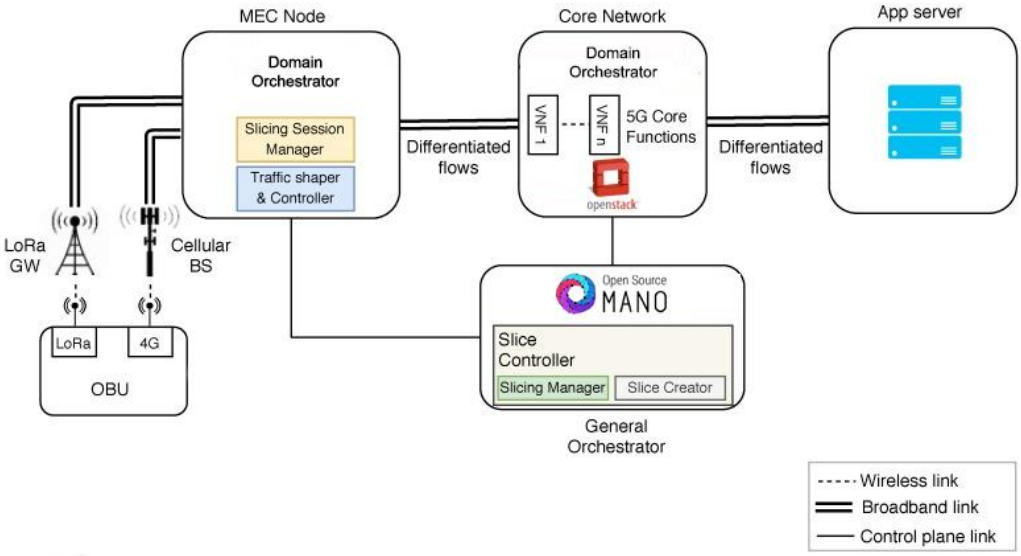

Figure 4 Implemented OSM slicing framework for vehicular applications. [13]

IoV is seen as a global network of vehicles enabled by various Wireless Access Technologies (WAT). It involves Internet and includes heterogeneous access networks. IoV can be seen a special use case of Internet of Things (IoT). IoV Target domains includes the basic vehicular services like vehicles driving and safety, but adds novel domains: traffic management, automobile production repair and vehicle insurance, road infrastructure construction and repair, logistics and transportation, etc.

IoV is a hot research domain exploiting the synergy between Cooperative Intelligent Transportation Systems (C-ITS) and the IoT, which can greatly benefit of the upcoming development of 5G technologies. [12]. The variety of end-devices, applications, and WATs in IoV calls for new networking schemes that assure the Quality of Service (QoS) demanded by the users. To this end, network slicing techniques (the slice is a dedicated, logical, isolated, virtual network sharing the same infrastructure with other slices) enable traffic differentiation with the aim of ensuring flow isolation, resource assignment, and network scalability. The development is based on a distributed Multi-Access Edge Computing (MEC) architecture, which provides flexibility for the dynamic placement of the Virtualized Network Functions (VNFs) in charge of managing network traffic. The solution is able to integrate heterogeneous radio technologies such as cellular networks and specific IoT communications with potential in the vehicular sector, creating isolated network slices without risking the Core Network (CN) scalability.

The proposal presents two orchestration tiers, complaint with ETSI NFV-Management and Orchestration (MANO):

The General Orchestrator (GO) and the Domain Orchestrator (Dos). The former is placed on the top of the system hierarchy in order to have control over the deployed slices. It consists of an OSM instance and of two micro-services in the form of VNFs: The Slicing Manager (SM) and the Slice Creator (SCr). The SM processes the slice-creation requests sent by the Slice Session Manager (SSM) placed in the MEC-node. When a request is received, the SM checks the requester subscription stored in the 5G CN's Unified Data Repository (UDR); this functionality is equivalent to the one described for the Network Slice Selection Function (NSSF) in [13].

IV. Conclusions and Future Work

Today, the OSM community is not only comprised of global service providers, leading IT/cloud players and VNF providers, but also many 5G research projects that are injecting more life, code and validation of the readiness of this NFV MANO implementation.

This study was necessary for the future work of the authors which are going to integrate OSM in the infrastructure and experiments. This integration represents an upgrade to the current infrastructure which was build using SONATA framework. After the upgrade, all experiments which were already done with SONATA will be recreated using the new infrastructure. Afterwards, new experiments containing new functionalities included in OSM will be started.

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