Introducing Terrestrial Satellite Resource Orchestration Layer

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ABSTRACT
Satellite communications is an essential building block of 5G technology to ensure delivery of 5G promises such as ubiquitous connectivity, enhance mobile broadband (eMBB) and massive machine type communication (mMTC). Service providers require seamless connectivity between terrestrial and satellite system, considering the best transport options available according to bandwidth, latency, network conditions and other application-specific requirements. The interworking between terrestrial and satellite is well recognized and promoted in the standardization bodies like 3GPP and ETSI. Full integration foresees coexistence of satellite system, with the radio networks (core and access) as well as computational resources expanded from the core to the network edge. A suite of orchestration of heterogeneous resources is fundamental enabler to realize this vision. This paper focuses on the management and orchestration of heterogeneous resource integrated with MANO-like framework for rapid provisioning of network services. The proposed architecture provides a user-friendly single point of interaction for all stakeholders in the ecosystem, i.e. terrestrial and satellite operators as well as 5G vertical providers, where they can launch and manage end-to-end 5G services. The system allows easy integration of multiple applications (e.g. virtual 5G Core, virtual caching, etc.) as well as solutions provided by radio and satellite vendors (e.g. satellite gateway, small cells, etc.).
Keywords: orchestration, NFV, SDN, 5G, satellite, wireless networks, MEC.

1. INTRODUCTION

Convergence of various telecommunication technologies is a key enabler to deliver 5G promises, such as ubiquitous solution featuring aspects like extraordinarily high speeds and capacity [1]. Seamless integration of satellite communication (SatCom) [2, 3] into 5G networks aims to deliver 5G access everywhere. Although, the idea of having satellite connectivity as backhauling solution along with terrestrial system is not new, 5G calls for more advanced integration at different levels.

In the traditional way, the actual process of launching and managing a complex service requires huge amount of manual operations and processes. Such a complex and manual intervention prevents the end to end service provisioning and lifecycle management. It increases risk of human errors and reduces the satellite and terrestrial services business desirability. To improve the situation, this work focuses on ensuring seamless integration of SatCom in 5G networks at orchestration layer and it presents a proposal for a terrestrial and satellite resource coordination solution, called TALENT. TALENT is a solution proposed to tackle this problem. TALENT is a management layer sit on top of the MANO frameworks with comprehensive view over all available resources and services. The paper is organized as follows: Section 2 introduces the overall TALENT architecture. Section 3 details TALENT operation. Section 4 concludes the paper.

2. TALENT ARCHITECTURE

TALENT is a coordination tool, which provides end to end services over satellite domain, radio system, cloud and Mobile Edge Computing (MEC) resources [4]. It provides a single and easy to use point of interaction for all stakeholders involved in the ecosystem, such as terrestrial and satellite operators as well as different 5G verticals. TALENT is completely in-line with 3GPP and ETSI definition, extending them towards satellite systems. The original idea of TALENT is based on the definition of hierarchical and distributed orchestration [5], where an overarching orchestrator is able to manage and coordinate several independent domains (satellite, radio and cloud). We assume, at each domain, there exist a domain manager (DM) able to work with resources of the domain. In this sense TALENT becomes a light, scalable and efficient solution agnostic to elements of domains coming from various vendors.

Having these objectives in mind and based on the frameworks suggested by ETSI MANO [6] and 3GPP SA5 [7], this work proposes an extension towards satellite integration at the management and orchestration level, to build a multi-tier orchestration stack over a heterogeneous environment. As shown in Figure 1, the first release of TALENT supports satellite and cloud/edge domains, interworking with each other to deliver end to end services. Next release will follow [8] in order to introduce radio domain to the TALENT (more detail can be find in [4]). The internal components of TALENT are detailed below:

- **Northbound REST API:** This is the main entry point for different actors such as operators and verticals. It also provides an abstraction layer, which exposes a well-defined set of functions serving

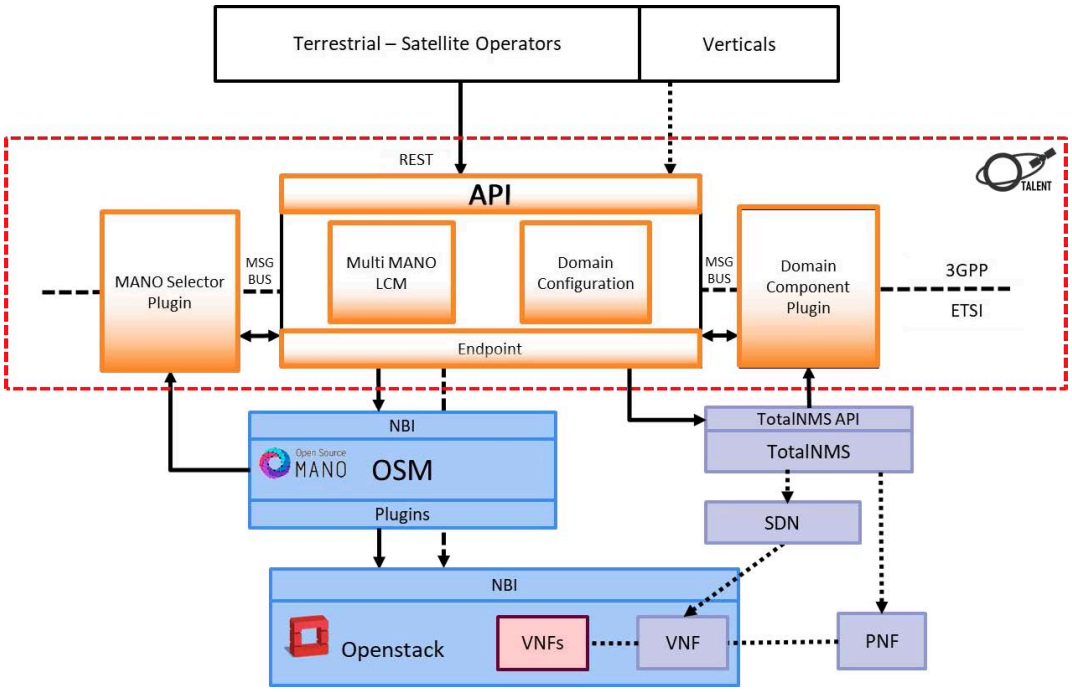

Figure 1. Validation use case.

different needs of operators and verticals (e.g. service instantiation, check service status, QoS monitoring, to name a few possibilities). TALENT API is a REST-based API, which feed the TALENT Graphical User Interface - GUI.

- **MANO Selector Plugin:** This module is a reference point where all the required information such as IP address, data model format, vendor and interaction procedures of the supported NFVOs (OSM, ONAP, etc.) and VIMs (OpenStack, OpenVIM, etc.) are kept. "MANO Selector Plugin" is responsible to registered all supported NFVOs and VIMs at the bootstrapping phase. This release supports OSM release 4 and 5, and OpenStack Queen. In the next releases, other NFVO (e.g. ONAP) and VIM (e.g. OpenVIM) solutions will be added to the TALENT.
- **Multi-MANO Lifecycle Manager:** This module is responsible to support NFVO and VIM clients, including their actual service and life-cycle management at the run-time phase. It use a template file to produce request with required attributes to the cloud/edge domains that registered to system. To manage all received requests, "Multi-MANO Lifecycle Manager" synchronizes with "MANO Selector Plugin" to load the required dependencies and interact with underlying NFVO and VIM solutions.
- **Domain Component Plugin:** It is a reference point to keep all the required information such as IP address, data model format and configuration settings of the supported satellite components. "Domain Component Plugin" is responsible to register all supported satellite components at the bootstrapping phase. TALENT will be loaded required dependencies and libraries to establish communication with underlying satellite solutions. Release 1 supports TotalNMS of Gilat [9]. Later, more vendors will be added to the TALENT.
- **Domain Configuration Module:** This module is responsible to support satellite clients including configuration and life-cycle management of supported solution at the run-time phase. Similar to "Multi-MANO Lifecycle Manager", it use a template file to produce request with required attributes to the satellite domains that registered to the system. To manage received requests, "Domain Configuration Module" synchronizes with the "Domain Component Plugin" in order to load the required dependencies and interact with underlying satellite solutions.

TALENT supports auto deployment practices. It means the user do not need to go through complex process to install TALENT. The following procedure are considered:

1. *System deployment*: TALENT supports auto deployment using container (docker-based). An ordinary container management tool for running multi-container applications can easily start-up the system and its components.
2. *System check*: each system component will register itself to an internal "Discovery" service, which controls activity status of each component and TALENT overall. This process runs when a TALENT freshly installed in a new system. Upon deployment of TALENT components from the docker container, all of them register themselves automatically to the "Discovery" service. The "Discovery" service creates a table with the name of component and its status [READY, UNKNOWN]. If the status

of all components change to READY and they are correctly link together, then TALENT endpoints become available (API and GUI).

3. OPERATION

TALENT has two main operational phases: bootstrapping and run-time. Bootstrapping consist of setting up the TALENT system to be ready for the proper operation over an infrastructure. It is a one-time process (every time the system starts from the fresh). The "MANO Selector Plugin" and "Domain Component Plugin" are loaded with proper inputs for the supported MANO and satellite solutions. These inputs later on will be used at the run-time phase. Run-time phase is responsible for execution of operational commands coming from different stakeholders. In principle, TALENT supports two categories of operational commands:

- Network Service-related commands: these are commands for life-cycle management of end to end connectivity and computational resources. TALENT eases the provisioning/termination of end to end services over satellite and terrestrial resources.
- 5G application-related commands: over the provision network services, TALENT is able to run and manage different 5G application.

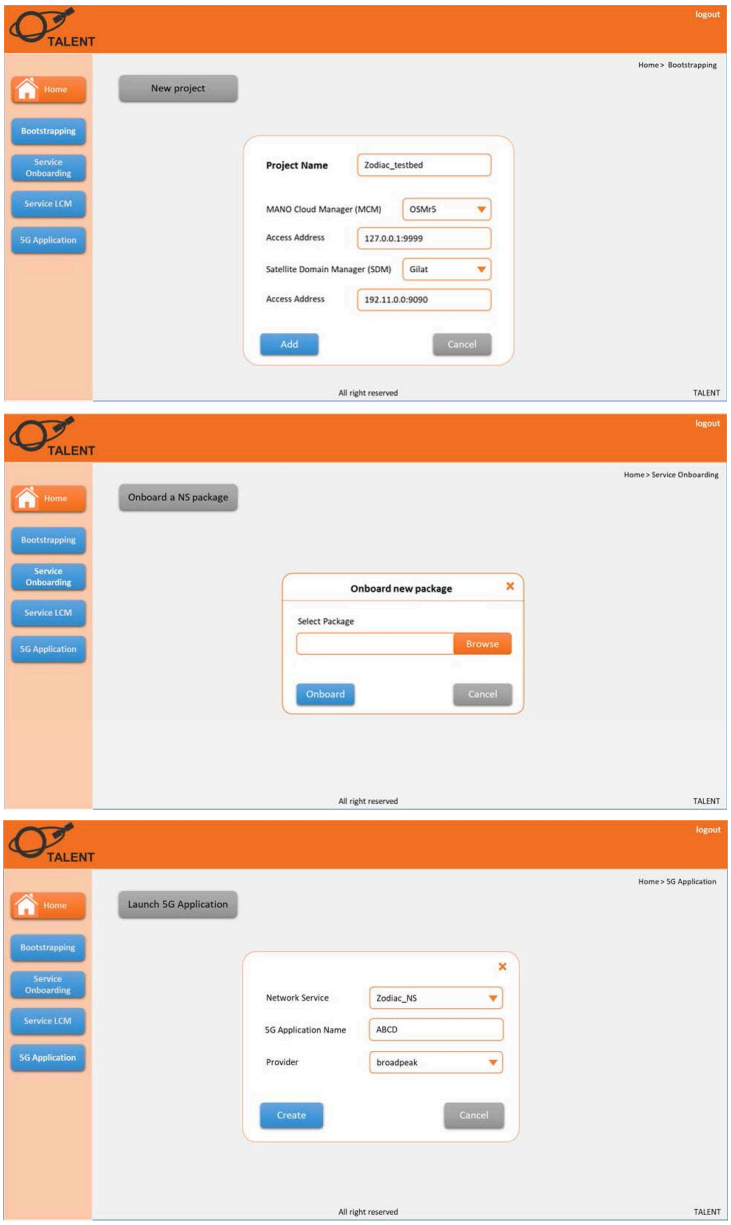

Figure 2. TALENT GUI.

As illustrated in Fig. 2, user triggers the operation by browsing to the bootstrapping page to define new project for provisioning network service on satellite and cloud/edge domains. To do so, user must provide information such as vendor (e.g. OSM, Gilat) and API information (e.g. IP address and port number) of MANO Cloud

Manager and Satellite Domain Manager to the system. Once the project is created, the bootstrapping phase is over.

The first step on the run-time phase is to upload TALENT's package, which includes TALENT index file, Network Service Descriptors (NSDs) and Virtual Network Function Descriptors (VNFDs). TALENT performs a set of actions on the uploaded package based on the package definition as follows:

1. Open received TALENT package file to analyse and categorize the information.
2. Check if the index file is included.
3. Parsing the index file to check which files are included in the package (cloud domain and satellite).
4. Retrieve Network Service (NS), Virtual Network Functions (VNFs) and Virtual Deployment Units (VDUs) information, including satellite elements.
5. Test deployed NS, VNFs and satellite elements.
6. Verify if the indicated descriptors are found in the TALENT package file.

Then a request corresponded to the MANO is forward to the OSM and another request correspond to the satellite domain forward to the TotalNMS, which start the service instantiation process. In the generic way, the MANO fetches the NSD; including VNFD from its catalogue, considering that the descriptor was already available in the catalogue and it sends the request to the VIM to deploy the new NS instance. Once the operation is complete from the VIM side, the MANO receives a confirmation message, and it sends a reply to the interface module, which will finally forward the message to the TALENT. In the same way, the TotalNMS fetches the configuration file in order to apply user request on underlying premises. Once the configuration applied, the TotalNMS sends a verification response to the TALENT.

Once the network set up is done, 5G application can use the created network service to offer an added value service. In this case, TALENT over the 5G application tap will allow the 5G application owner to select a proper network service and trigger starting of the service.

4. CONCLUSIONS

In this paper, we proposed a coordination solution for satellite and terrestrial systems from a single point of interaction. The proposed solution is completely in-line with 3GPP SA5 and ETSI standards, extending them towards the satellite integration. High-level architecture of the solution is clearly demonstrated internal components of the TALENT and their interaction to achieve three main goals: i) coordinating satellite, radio, cloud/edge resources from a single point; ii) being NFVO and vendor solution agnostic; iii) being user-friendly. TALENT is a work on progress and in the next release; it will be enhanced towards supporting new features, such as multi-tenancy.

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