ONAP

OPEN NETWORK AUTOMATION PLATFORM

ONAP E2E Network Slicing

Technical Overview

Providing End-to-end 5G Network Slicing Capability

OVERVIEW:

- Tenants and network operators can order slice-based services
- Enables network slice creation as well as reuse
- Supports many of the slice lifecycle management operations

CURRENT CHALLENGES:

- Use case diversity in 5G necessitates Network Slicing
- Shaping the network to cater to industry verticals requirements while optimizing cost
- Simple interface to request network slices by non-telecom users by providing service requirements

SOLUTION:

- ONAP Frankfurt provides basic capabilities for Network Slice Orchestration
- Supports Network Slice lifecycle operations of E2E Slice Design and Creation, Activation, Deactivation and Termination
- Provides 3GPP-defined Communication Service Management Function (CSMF) and Network Slice Management Function (NSMF) functionality within ONAP
- Supports E2E Slice design including design of Communication Service, Service Profile, and Network Slice Template (NST)
- Supports selection of suitable NST and suitable Network Slice Instance (NSI), covering the scenario of new NSI creation by providing suitable slice profile
- Interacts with an external Core Network Slice Sub-net Management Function (NSSMF)

Overview

Network Slicing is one of the key features of 5G. The essence of Network Slicing is to be able to effectively cater to of a diverse set of use case categories and customers in an optimal manner. 5G is expected to fulfill the requirements of a wide variety of use cases including urban mobile broadband, massive machine-type communications, and ultra-reliable low latency communications.

Further, 5G should be able to meet the QoS and quality of experience of different consumers, and industry verticals including connected home, autonomous vehicles, smart cities, remote healthcare, in-stadium experience, rural broadband, factory automation, and smart enterprises. Each of these categories have a different set of performance requirements (e.g., latency, throughput, reliability, availability, etc.) and characteristics (e.g., mobility, security, resource sharing level, etc.). End-to-end Network Slicing enables addressing these in an optimal manner through sharing of resources and shaping the network dynamically to meet the demands of various services. This, in turn, saves significant CAPEX and OPEX for the communication service provider. Further slice orchestration functionality is another enabler for network automation and shall play an important role in quick service roll-outs, as well as service assurance and SLA adherence, leading to an improved end user experience.

An End-to-End (E2E) Network Slice consists of RAN, Transport, and Core network slice sub-nets, with each of these subnets possibly consisting of further subnets, for example, RAN subnet decomposed further into fronthaul, mid haul, and RAN Network Functions.

The objective of this use case is to realize End-to-end 5G Network Slicing using ONAP. An End-to-end Network Slice consists of RAN (Radio Access Network), Transport Network (TN), and Core Network (CN) slice sub-nets. This use case intends to demonstrate the modeling, orchestration (life cycle and resources) and assurance of a network slice which are implemented in alignment with relevant standards. The key highlights of this use case include:

- Modular architecture providing building blocks and flexibility under various deployment scenarios
- Functionality aligned with 3GPP and other relevant standards such as ETSI and IETF.
- Interfaces and APIs aligned with relevant standards (3GPP, IETF, ETSI, TM Forum, etc.) while enabling easy customization through use of appropriate plug-ins. This would enable easier interoperability of

slice management functions realized within ONAP with 3rd party slice management functions, as well as northbound and southbound systems.

- Taking a step-by-step approach to realizing different architectural options in an extendable manner.
- Providing flexibility in network slice selection by providing an option of manual intervention, as well as abstracting the network internals as needed.
- The use case implementation team is composed of service providers, software and hardware vendors, solution providers, and system integrators thereby taking into consideration different perspectives and requirements.

This use case is a multi-release effort in ONAP with the first steps taken in the Frankfurt release. It will continue to expand in scope both in breadth and depth, and along the journey it shall also align with updates to the relevant standards which are also currently evolving. This use case shall also collaborate with other open initiatives such as O-RAN to enable wider adoption and use.

In the Frankfurt release, this use case covers the following aspects:

- E2E Network Slice design
- E2E Network Slice creation and activation, deactivation, and termination
- Selection of appropriate Network Slice instance and mapping it to a service
- Selection of appropriate core network slice subnet instance
- Interfacing with an external entity to create a new core network slice sub-net instance or to map an existing network slice instance to a network slice instance

It also takes the first step towards alignment with relevant standard bodies (e.g., 3GPP, ETSI, TM Forum) w.r.to both interfaces, information models as well as functional aspects.

The different architectural options, and the scope of Frankfurt release are illustrated in Figure 1.

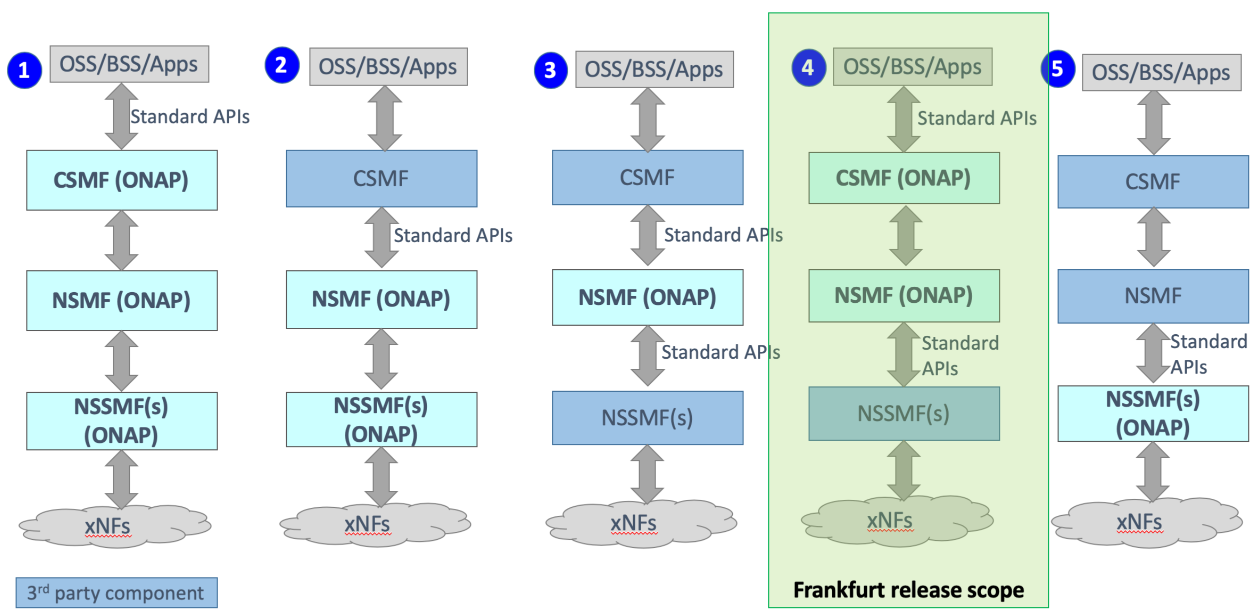

Figure 1: Architectural Options and Scope of ONAP Frankfurt Release

Problem Statement

IUse case diversity and the need to address various industry vertical requirements necessitates Network Slicing. The following challenges exist in the realization of Network Slicing:

- A simple user interface for non-telecom users (tenants, slice consumers) to request network slices by just providing service requirements
- A framework for network slicing design that aligns with service and resource models
- Providing the appropriate network slice as required for the service, including creation of a new slice or reuse of a suitable existing slice, based on the user request, and active network slice inventory
- Dynamic network slice orchestration to effectively cater to the needs of services in an optimal manner
- Mechanism to intervene in the automatic network slice selection process to ensure correctness

Requirements

The problem statement discussed above can be translated into the following high-level requirements:

- Communication Service and Network Slice Design (aligning with 3GPP where relevant)
  - Design of communication service template (to capture service requirements from user
  - Design of Service Profile
  - Design of Network Slice Template (NST)
  - Onboarding of Network Slice Subnet Template (NSST)\
- Network Slice allocation
  - Generate a new S-NSSAI
  - Determine the slice characteristics and requirements needed to support the service requested by the user
  - Based on user input on sharing the resources to be used for the service with other users/ services:
    - Sharing not allowed: Determine the properties (slice profiles of the sub-nets) of a new slice to be created
    - Sharing allowed: Determine a suitable existing network slice instance for reuse, if none exists or not suitable, then determine the properties (slice profiles of the sub-nets) of a new slice to be created

- Network Slice creation/update
- New slice to be created: Create a new network slice by triggering the (external) NSSMF
- Existing slice to be reused: Instruct the (external) NSSMF to map the new
- Service and Network Slice activation
- Network Slice de-allocation

Solution

The Open Network Automation Platform (ONAP) project is an open source project that provides a platform for designing, implementing, and managing different kinds of network services. ONAP enables service orchestration including automated life cycle management and resource orchestration of services. It has a robust service design framework, and orchestration includes FCAPS functionality, ETSI specified Management and Orchestration (MANO) layer functionality, and the ability to manage and control Software Defined networks—both IP and optical. It is also focused on management of software-defined Radio Access Network (RAN).

The Frankfurt release of ONAP introduced the Network Slice orchestration functionality. It includes two of the three 3GPP-specified Network Slice Management functions, namely Communication Service Management Function and the Network Slice Management Function, and an (external) interface to the third one, namely Network Slice Sub-net management function for the 5G core sub-net.

With this functionality, an end-to-end Network Slice Instance (NSI) containing a suitable core Network Slice Sub-net Instance (NSSI) can be allocated to fulfill a service's requirements. Based on the service requirements, and the currently active network slice and slice sub-net instances, it could involve both reuse of existing NSI, or creation of a new NSI, wherein the creation of a new NSI could involve reuse of an existing core NSSI or creation of a new core NSSI. The allocated NSI and NSSI are then presented to the operator for confirmation that the choice is indeed appropriate or if any modifications are required. This functionality enables creation of services which can run on network slices.

This is the first yet significant step towards realizing full-fledged end-to-end network slice orchestration functionality covering all network segments, as well as the entire life cycle management and resource orchestration of slices and slice sub-nets.

Implementation Details

The design of communication services to run on network slices is done by using the existing ONAP design constructs such as allotted resources. The steps for creating an eMBB network slice template and a service that can run on it is illustrated below.

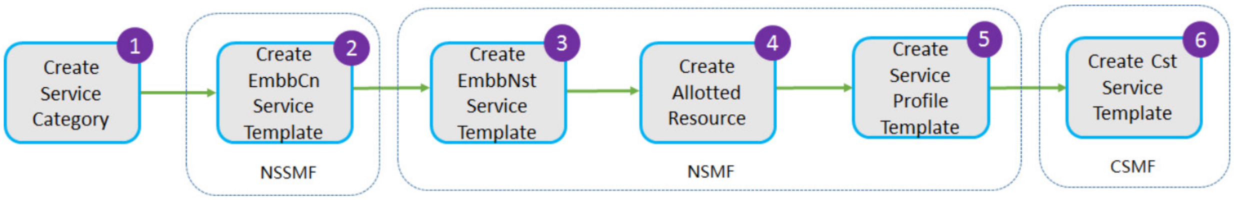

Figure 2: Design-time actions

Further details on this can be found here: https://wiki.onap.org/display/DW/Design+Service+Templates.

The run-time actions for instantiating a new service that runs on a network slice is depicted in Figure 3 below.

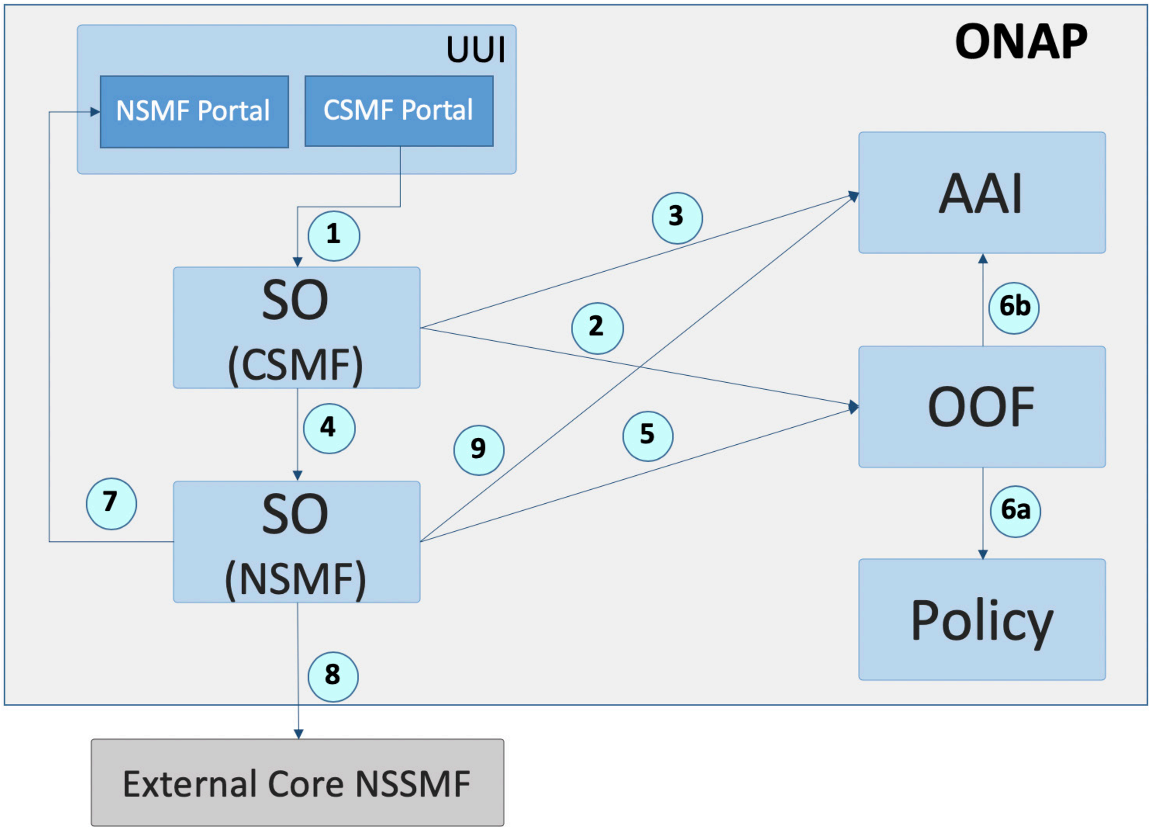

Figure 3: Simplified illustration of steps in service instantiation

The steps in Figure 3 are explained below:

1. The slice consumer requests a communication service with relevant inputs on the service's characteristics and performance requirements via the CSMF portal in UUI.
2. The CSMF portal sends a request to SO acting as CSMF denoted as SO (CSMF). SO (CSMF) converts the communication service request into a Service Profile and triggers OOF for providing a suitable Network Slice Template (NST).
3. SO (CSMF) updates AAI with the communication service details. OOF provides the suitable NST back to SO.
4. SO (CSMF) then triggers SO (NSMF) for allocating a suitable NSI.
5. SO (NSMF) triggers OOF for selecting a suitable NSI/NSSI.
6. OOF checks Policy inputs and existing inventory in steps 6a and 6b respectively, and then selects the suitable NSI and provides it to SO (NSMF). In case no suitable NSI exists but there is a suitable (core) NSSI, then SO provides the details of the suitable (core) NSSI for reusing it when creating the new NSI. If the service request required a non-shared service to be instantiated or if no suitable NSSIs exist, OOF returns the Slice Profile to SO asking it to create a new core NSSI and NSI.
7. SO (NSMF) shares details of the selection made by OOF with NSMF Portal in UUI for the operator to check and make any modifications if needed.
8. SO (NSMF) triggers External Core NSSMF for instantiating/updating the core NSSI.
9. SO (NSMF) then updates the AAI inventory with the slice details.

Let us take a look at the implementation done in various components to realize the above functionality.

User interface (CSMF Portal and NSMF Portal)

The user interface (UUI) provides the following functionality:

(a) CSMF portal: The customers fill the create communication service form in CSMF portal to create a network service that uses a slice, and then they can see the created network service in the list, and execute operations of activating, deactivating or terminating the network service

(b) NSMF portal: This consists of:

- Slicing Task management in which network operators can find all the slicing tasks created by customers in CSMF component and executing proper operations according to different task status. This is also used to verify and modify slice options suggested by OOF if needed.
- Slicing Resource management which provide the functions of displaying and processing the existing NS, NSI and NSSI.

Service Orchestrator (SO)

In SO, there are separate BPMN workflows for CSMF and NSMF. CSMF workflow processes the service request that comes from CSMF portal (UUI) and saves the order information into a communication service instance in AAI. CSMF workflow sends network slice request to NSMF workflow, and NSMF then creates service profile, NSI, and NSSI. Service profile is a logical concept which exists only in AAI—it contains two AAI instances, one is a profile instance that will hold the slice parameters, and the other is a service instance which will be used to organize the NSI. NSI is also a service instance in AAI which will be used to organize NSSI. NSSI is the actual entity which will be created by NSSMF and an AAI service instance will also be created to represent NSSI in an ONAP context. NSI and NSSI can both be shared.

SO queries OOF for slice template selection and then slice instance selection. In response to slice instance selection query, OOF may return an existing slice instance or may recommend SO to create a new slice instance. A new process called Orchestration Task is created to manage recalibration of NSI&NSSI selection with manual intervention by the operator via NSMF Portal in UUI. A new NSSMF adapter in SO interacts with external NSSMF for NSSI orchestration. SO also provides Service activation, deactivation and service termination functionalities, for which the SO (CSMF) and SO (NSMF) are involved.

ONAP Optimization Framework (OOF)

- OOF is invoked by SO for Network Slice Template (NST) selection, and NSI/NSSI selection. In case of NSI/NSSI selection, as described earlier, OOF may return:
- Existing NSI, if the service request indicates it is shareable and if a suitable NSI exists
- Existing NSSI, if the service request indicates it is shareable, no suitable NSI exists and a suitable NSSI exists
- Slice profile, if the if the service request indicates it is non-shareable or no suitable NSI or NSSI exists.

External API (ExtAPI)

A new value "CST" for the serviceType attribute in the TMF 641 based Service Order API has been introduced. The relatedParty attribute in the Service Order is set according to the Customer, where relatedParty.id will map to the AAI "global-customer-id" in the "customer" object. The serviceSpecification.id is to be set to the UUID of the CST from SDC (i.e., this is the template for the Service we are ordering from CSMF). The action field will be set to "add" to indicate creation of a new service instance. Upon sending a POST with the JSON body to /{api_url}/nbi/api/v4/serviceOrder/, ExtAPI will generate a Service Order ID and send it in the response—this ID can be used to track the order. ExtAPI will then invoke SO's API for creating the service. This is a step towards standardizing the external interfaces for slice orchestration.

Active & Available Inventory (A&AI)

A&AI module has 3 new nodes (Communication-service-profile, Service-profile and Slice-profile), modified service-instance nodes, added 3 new nodes as new attributes of service-instance node. To map to SDC templates (Communication Service Template/Service Profile Template/NST/NSST), run-time instances of this use case have Communication Service Instance/Service Profile Instance/NSI/NSSI. To align with ONAP's model-driven approach, this use case reuses "service-instance" for all run-time instances. The relationship between service-instances use the existing attribute "relationship-list" or "allotted-resources". Communication-service-profile holds the original requirement of Communication-service-instance, such as latency, data-rate, and mobility-level. Service-profile holds the slice parameter info of Service-profile-instance. Slice-profile holds the slice sub-net parameter info of different network domain NSSIs, such as (Radio) Access Network (AN), Transport Network (TN), and Core Network (CN) NSSI.

A&AI provides query APIs to CSMF and NSMF, such as:

- Query Communication-service-instances/Service-profile-instances/NSI/NSSI
- Query Service-profile-instance by specified Communication-service-instance
- Query NSI by specified Service-profile-instance, query NSSI by specified NSSI

A&AI also supply creation APIs to SO, such as:

- Create Communication-service-profile/Service-profile/Slice-profile
- Create relationship between service-instances

Summary

Network Slicing in 5G is taking off in real-world deployments and is on the cusp of playing a key role in catering to the needs of industry verticals apart from the traditional mobile broadband service needs in an optimal manner. The scope of this use case and the functionality implemented in Frankfurt is an important first step towards realizing end-to-end network slicing.

As this use case continues to evolve in the upcoming releases in both breadth, i.e., covering all network segments, adopting standard external interfaces and enabling different architecture options, as well as depth, i.e., implement the entire lifecycle of slice orchestration, slice and service assurance, it shall become one of the differentiating features from an ONAP platform perspective. This shall provide immense value to CSPs in providing robust and flexible slice orchestration capabilities, as well as in decreasing the time-to-market to offer differentiated capabilities and features with regard to Network Slicing.

Resources

E2E Network Slicing wiki page

https://wiki.onap.org/x/eRdIB

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