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Northbound API Specification and Graphical Interface (Iteration II)

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Abstract

The current document is the outcome of the second iteration of Task 8.1. The task aims at providing the One Stop API solution for the complete SliceNet ecosystem. In this second iteration the task has evolved based on the functional requirements and operation principles of the Management, Orchestration and Control sub-planes and the way these can be processed under the principles defined in the first iteration of the task. The current document summarises the workflows and UI functionalities implemented by the OSA artifacts in the context of the task and are under integration within the SliceNet platform.

[End of abstract]

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Executive summary

The second iteration of Task 8.1 provided the implementation of the front end design views for the different business roles as well as the backend services of the One Stop API that interact with the SliceNet Orchestration and Management components. The last phase of the task has focused on aligning OSA developments and workflows with the actual implementation details of the aforementioned components as these have been clarified in the corresponding deliverables.

One Stop API implementation evolved along two main functional axes. On the one hand, OSA had to address the dashboard views of the different roles and support their requirements with respect to catalogue maintenance and offering exposure to overlaying roles. On the other hand, OSA had to provide the bonding logic between domain offerings and the instantiation process and inventory information maintenance. In the context of the first functional axis, OSA followed a bottom approach as presented in the Design Views chapter (3), whereas the second axis involves workflows that are driven in a top down manner as described in the Operation Views and Workflows chapter (4).

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Abbreviations

API	Application Programming Interface
BBU	Base Band Unit
CN	Core Network
CP	Control Plane
CPS	Control Plane Service
CQI	Channel Quality Indicator
CQI	Channel Quality Indicator
CSP	Communication Service Providers
DECOR	Dedicated Core Network
DSP	Digital Service Provider
E2E	End-to-End
EPC	Evolved Packet Core
ETSI	European Telecommunications Standards Institute
ID	Identifier
IDE	Integrated Development Environment
IETF	Internet Engineering Task Force
IMSI	International Mobile Subscriber Identity
KPI	Key Performance Indicator
LCM	Lifecycle Management
MANO	Management and Orchestration
ME	Mobile Edge
MEC	Mobile/Multi-access Edge Computing
MEO	Mobile Edge Orchestrator
NE	Network Element
NEF	Network Exposure Function
NF	Network Function
NFV	Network Function Virtualisation
NFVI	NFV Infrastructure
NS	Network Service; Network Slice
NSS	Network Subslice
NSaaS	Network Slice as a Service
NSD	Network Service Descriptor
NSEP	Network Slice Provider
NSI	Network Slice Instance

NSP	Network Service Provider
NSSAI	Network Slice Selection Assistance Information
NST	Network Slice Template
NSST	Network Slice Sub-network Template
OAM	Operations, administration and maintenance
OSS	Operations Support System
P&P	Plug & Play
PNF	Physical network Function
PoP	Point-of-Presence
QoE	Quality of Experience
QoS	Quality of Service
RAN	Radio Access Network
REST	Representational State Transfer
RO	Resource Orchestrator
RRH	Remote Radio Head
SBA	Service Based Architecture
SBI	Service Based Interface
SDN	Software Defined Networks
SDO	Standards Developing Organization
SLA	Service Level Agreement
SliceNet	End-to-End Cognitive Network Slicing and Slice Management Framework in Virtualized Multi-Domain, Multi-Tenant 5G Networks
SW	Software
SS-O	Slice Service Orchestrator
UC	Use Case
UE	User Equipment
URI	Uniform Resource Identifiers
VM	Virtual Machine
VNF	Virtual Network Function
VNFD	VNF Descriptors
VNFFG	VNF Forwarding Graphs
WG	Working Group

1 Introduction

The second iteration of Task 8.1 delivers the design views for the different business roles as well as the backed services that provide support in the context of both the design and provisioning phases where OSA backend services implement, where required, the gluing logic and workflows to allow for automated instantiation of the FCAPS artifacts along the orchestration workflows for the support of the management aspects of the slices as described in the WP6 deliverables.

Therefore the current document is organised as follows:

- Chapter 2 presents the relation of OSA with respect to the rest of the SliceNet architecture and particularly with the business domains and additionally, it provides a functional decomposition of the OSA components and their relation with major components of the SliceNet subplanes.
- Chapter 3 presents the OSA design views for the three different roles (NSP, DSP, Vertical) through the corresponding dashboards as these have been clarified with in relation to the SliceNet components with which interaction is required. The related workflows detailing the steps of information retrieval and storage are also presented.
- Chapter 4 provides the details of the operation views exposed to the Verticals as supported by the P&P modules as well as the NSP and DSP operation views as supported by the Data Lake components. Additionally, the workflows that activate the artifacts that provide the linking of information between DSP and NSP Data Lakes, as well as those that activate the NSP domain FCAPS artifacts are presented.
- Chapter 5 lists the JavaScript packages and libraries that have been used in the implementation.

2 One Stop API Architecture

SliceNet has considered, since the early design phases, the fact that the flexibility offered by 5G technologies and practices will definitely have an impact on the redefinition of the business roles that for the previous generations were centred on two key types of relationships: those between Mobile Network Operators (MNOs) and their subscribers, and those between MNOs (e.g., roaming, RAN sharing) ([2]). Although, the preliminary separation of roles ([3]) assumes that a single entity can play several roles, the functional separation of operations alone is able to drive equally the segregation of business domains. In this way, the business ecosystem can benefit from the flexibility offered by the plethora of suppliers to allow either new services to evolve or end users receive offerings tailored to their needs. SliceNet elaborated (D8.1 [8]) on the related functional aspects of a preliminary business role separation during the first iteration of the current task (T8.1) in which a qualitative approach on the One Stop API was documented. Among others, a fundamental requirement was also expressed to address the ownership of the OSA Services. According to this requirement, OSA cannot be owned by single business domain, at least one of those domains that are interacting in the context of the producer-consumer relationships. In this context and taking also into account the fact that (D8.1 [8]) SliceNet aims at producing a management space that replaces the traditional proprietary BSS/OSS frameworks of nowadays telecommunication system, at least for the domain resources that are committed to multi-domain slicing, OSA is delivered as an additional business role aiming at allowing the different provider roles to properly apply the domain definitions and exposure options that are required for end to end multidomain slicing. Contrary to the other three main SliceNet roles, OSA is evolving vertically to cater for the needs of the different players both in design and operation phases. In this context, OSA backend service maintains role specific views by aggregating information from different domains. For example, DSP view is supported by information collected from the registered NSPs.

2.1 Overall Topology

OSA builds on top of the assumption that multidomain slicing is supported within each administrative domain by the installation and operation of the components delivered by SliceNet. This assumption eliminates the need for applying any complex practices with respect to trust establishment and security management as far as the interaction among SliceNet components is concerned as these are operating according to their envisaged role.

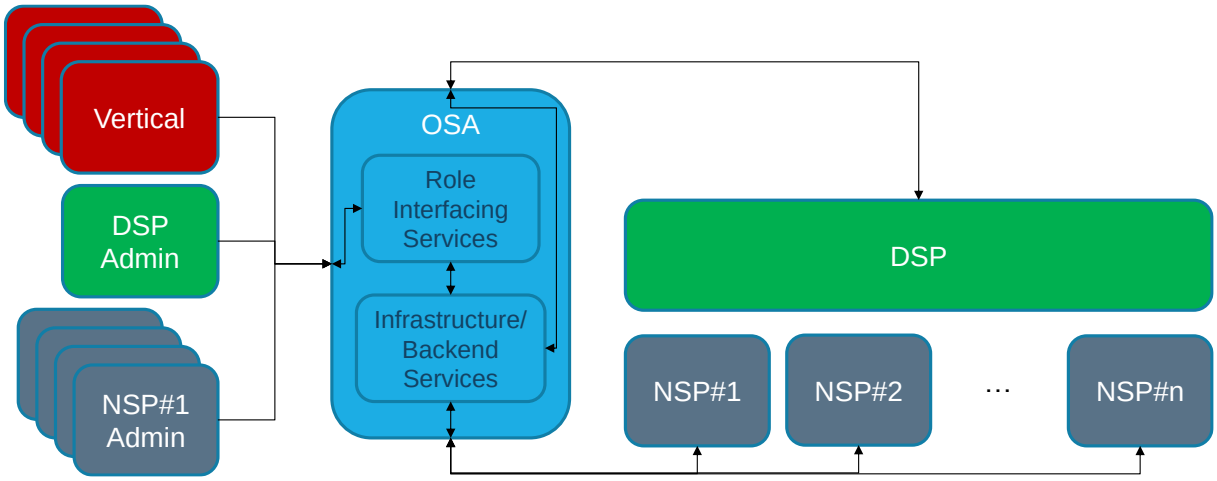

Figure 1: OSA Overall Topology

OSA acts as web-based interface for all the user accounts relating to the three different roles (Figure 1). Depending on the identity of the authenticated user, the provided UI presents the options with which the user is entitled and within the administrative domain with which it is related. The UI

elements are presenting the role specific view of the information OSA is processing and forwarding to the view components. This information can be collected from and maintained in:

- a single domain as in the case of an NSP or a vertical
- more than one domains as in the case of DSP

Information repositories per domain are organised in the context of catalogues (available options to be used) and inventories (instances of artifacts that have been activated) as far as the design and management views are concerned, whereas operational views are based on the utilisation of domain Data Lake content (D6.6 [4], D6.7 [5]). In the case of Verticals, operational views are exposed via the P&P options that the vertical has selected to activate (D4.1 [10]).

OSA installation assumes available connectivity to the domains offering slicing resources and particularly to the catalogue, inventory, Data Lake and orchestration components of DSP and NSPs, via appropriate networking practices (e.g. VPNs). In this context, vertical, NSP and DSP account management is considered as an offline administrative process that is reflected to the OSA user repository by the addition of the appropriate user records that will allow OSA to properly apply the information management between the UI elements and the backend endpoints.

User records are structured as follows:

Field Name	**Description**	**Applicability per Role**		
		NSP	DSP	Vertical
name	Business name	√	√	√
user	User name to be used for authentication	√	√	√
password	User password to be used for authentication	√	√	√
Data Lake IP	IP address of the TICK stack for supporting administrative metric views	√	√	
Inventory	MongoDB endpoint for storing Monitoring, Actuation descriptors (D6.6 [4], D6.7 [5]) and also association of descriptors with NFs	√	√	
Catalogue	MySQL endpoint for activation of FCAPS artifacts (D6.6 [4], D6.7 [5]) or P&P backend exposure options	√	√	
SS-O Endpoint	Slice orchestrator endpoint for NSS, NS listing and VSB, VSD, VSI management (D7.1 [6])	√	√	

OSM Endpoint	Used for listing of available Network Services (NS) and VNF entries (D7.1 [6])	√		
P&P Endpoint	Used for listing of available P&P options		√	
Location information	Used for allowing NSPs to indicate areas that its eNodeBs are covering or Verticals to register the wider area its interest	√		√

For each user account registered with OSA the corresponding connections to the foreseen endpoints are activated and utilised when information exchange is required.

2.2 Functional Architecture

The implementation of the One Stop API has aligned with the exposure approaches that have been followed in Control, Management and Orchestration subplanes of the SliceNet architecture. Therefore, OSA functionalities both in terms of design and operation phases require that its building blocks interact with the components of the SliceNet subplanes for exchanging information either for support of each role's design views or for activation of the required slice provisioning and support workflows. A detailed view of the OSA interconnections with the rest of the SliceNet components as well as a breakdown of OSA internal modules is presented in the following diagram (Figure 2).

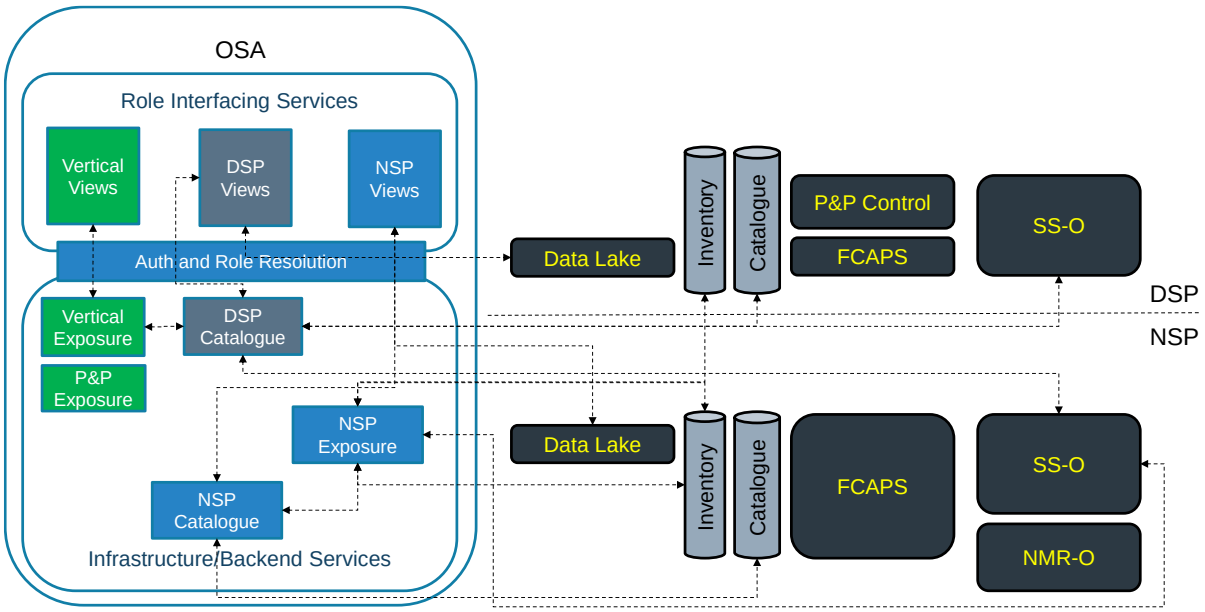

Figure 2: OSA Functional Architecture

The building blocks identified in the above functional architecture are:

- Authentication and Role resolution functions: authenticate the user and identify the views and the connection to the proper backend functions
- Vertical Views: the UI artifacts that interact with the Vertical Exposure functions
- Vertical Exposure functions: interact with the DSP catalogue services for customising the views of the information exchanged with the DSP SS-O and the P&P, QoE, Cognitive catalogue
- P&P Exposure functions: provide the backend support for the P&P options that are intended to be utilised as vertical input endpoints

- DSP Views: interact with the DSP Catalogue services for maintaining the DSP catalogue information and expose the slice runtime views from the Data Lake content
- DSP Catalogue services: retrieve information from the NSP SS-O for exposing the NSP offerings to the DSP design views
- NSP Views: interact with the NSP Catalogue service for maintaining FCAPS offerings as well as associate these with the slice templates
- NSP Catalogue service: supports the viewing and maintenance of the NSP offerings
- NSP Exposure service: maintains the correspondence between DSP and NSP inventory information to allow the automation of the FCAPS Framework

3 Design Views

OSA resolves the role of the user that is authenticated via the login process (Figure 3) based on the registered domain and vertical accounts. The identified role is thereafter provided with a number of views relating to its business domain for the maintenance of its catalogue and inventory information.

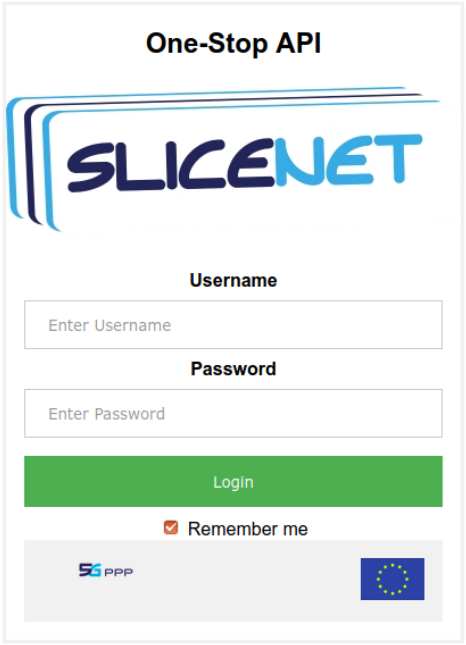

Figure 3: OSA Login Screen

3.1 NSP Views

The main aspect of the NSP View provided by OSA regards the association of the capabilities of the domain technology specific resources with the offerings exposed towards DSPs in the form of the Network Slice and Network Slice Subnet Templates (NST and NSST) D7.1 [6]. According to this approach, the templates are listing, among others, the monitoring and actuation capabilities that a DSP may require for the design and delivery of higher level service aspects that, in turn, will be made available as selectable options to the Verticals. According to the design of SliceNet control (D4.3 [9]) and management (D6.6 [4], D6.7 [5]) planes, actuation options refer to the options provided either by the Control Plane Services (CPS) on top of the deployed technology adaptors, or by the Slice Orchestrator (SS-O at NSP level) and the NFV, MEC and RAN Orchestrator (NMR-O) D7.1 [6], whereas the monitoring options are subject to the activation of the appropriate FCAPS descriptors that aim at providing an adaptation over the technology related information retrieval endpoints of the NSP domain. Finally, the NSP View is also allowing for the definition of the geographical areas where the offered network services can be provided.

3.1.1 Capabilities Descriptors

Actuation and monitoring capabilities are registered in the form of manually (no tool provided) prepared JSON documents (D6.6 [4], D6.7 [5]). The content of the descriptors embeds the technical knowledge regarding the technology artifacts of the NSP domain, which requires the involvement of the domains experts or administrators. The NSP OSA View provides the dashboard options to administer these descriptors and their maintenance in the appropriate document database.

3.1.1.1 Actuation Descriptors

Actuation descriptors are managed through OSA NSP Dashboard (Figure 4) via the related NSP account. OSA persists these descriptors in the FCAPS inventory of the NSP admin that is using the dashboard. New entries and modifications are applied directly on the JSON structures (Figure 5). The details provided in the summary view are based on the fields of the JSON Structure and relate with the identification, name, type and description of the actuation. The actuation descriptors relate with the Control Plane Services that are available in a specific NSP domain and are subject to be activated in the context of the instantiation of a Slice Template.

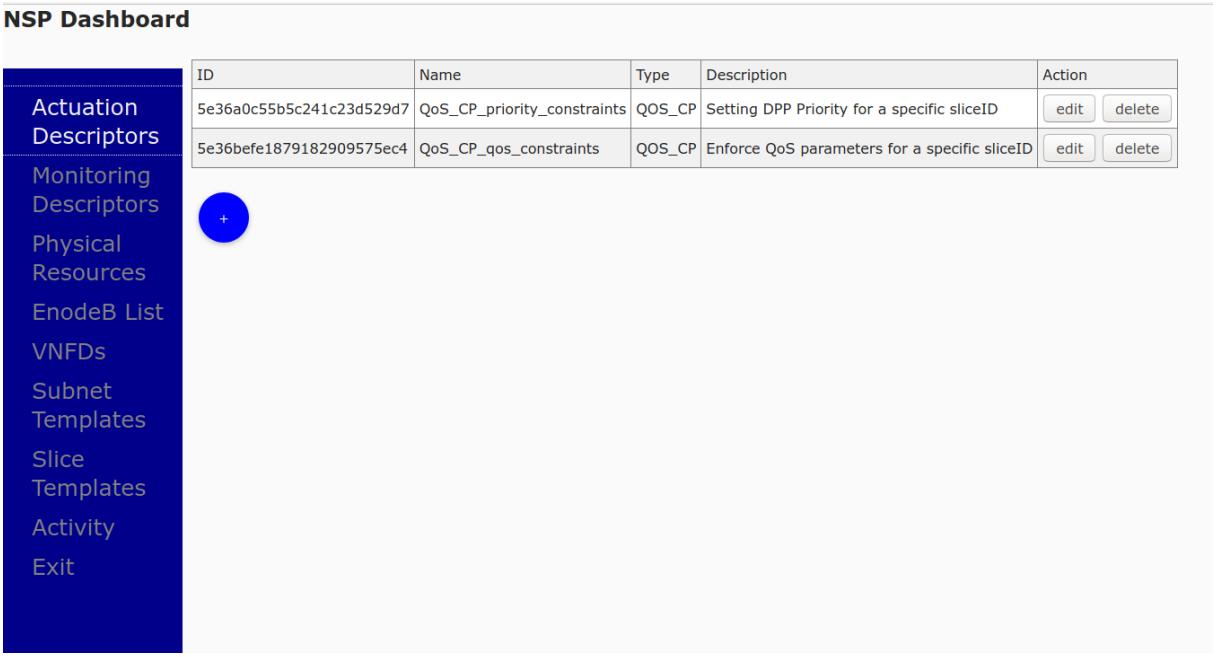

Figure 4: OSA NSP Dashboard – Actuation Descriptors

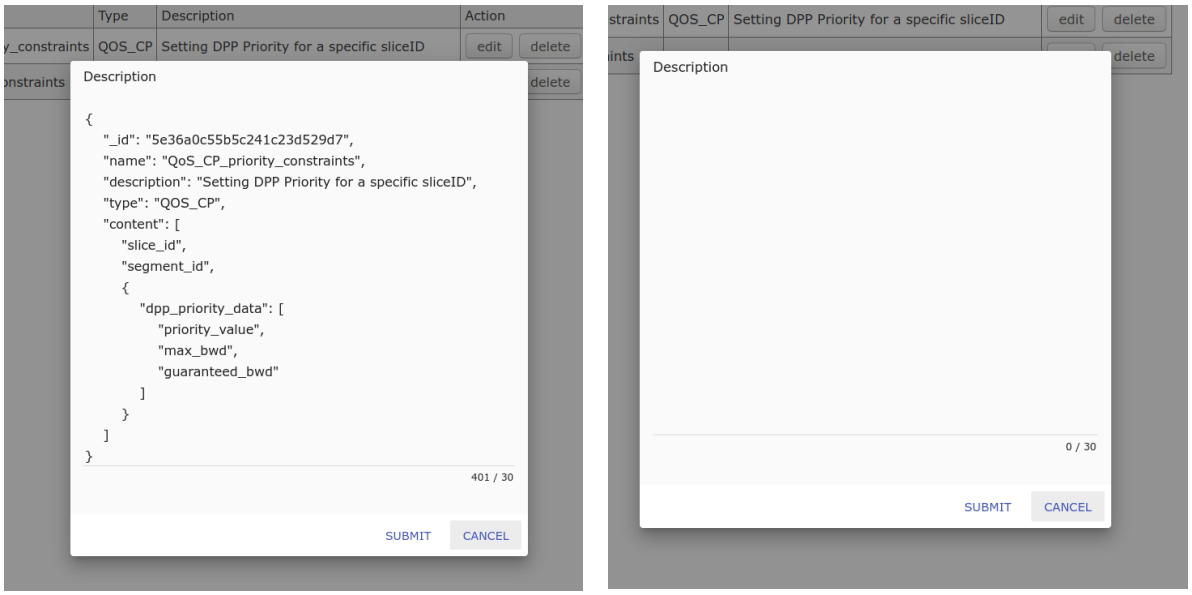

Figure 5: OSA NSP Dashboard – Actuations Editors

3.1.1.2 Monitoring Descriptors

Monitoring descriptors are also managed through OSA NSP Dashboard (Figure 6) on behalf of the logged in NSP account. Monitoring descriptors are persisted in the same FCAPS inventory used also for the Actuation descriptors. Editing is applied again directly on the JSON structures (Figure 7). In the case of monitoring descriptors, the counters, which are contained in the exportable fraction towards the DSP, are listed. Monitoring descriptors are instantiated in the context of the operation of the FCAPS framework (D6.6 [4]).

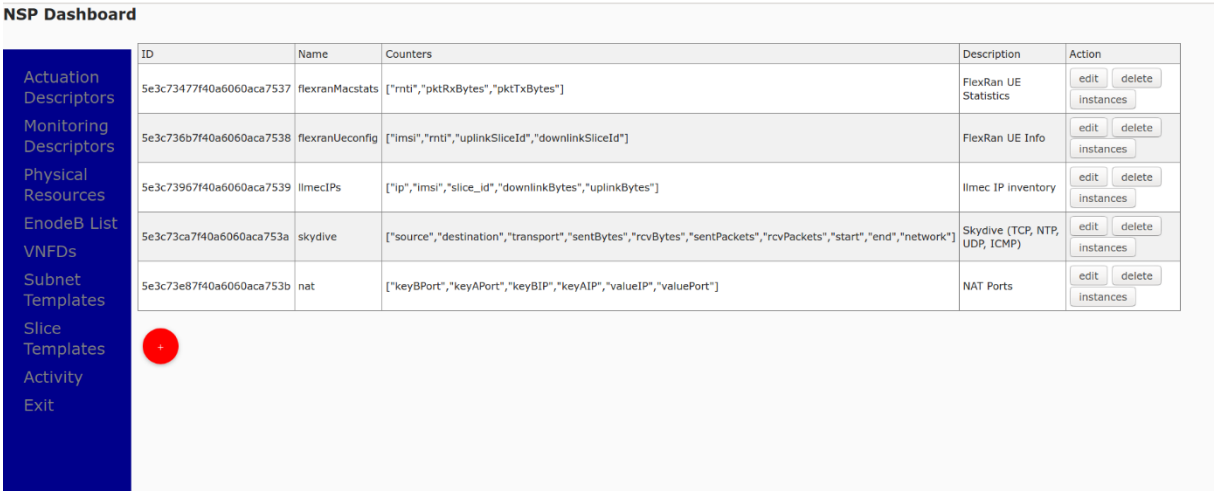

Figure 6: OSA NSP Dashboard –Monitoring Descriptors

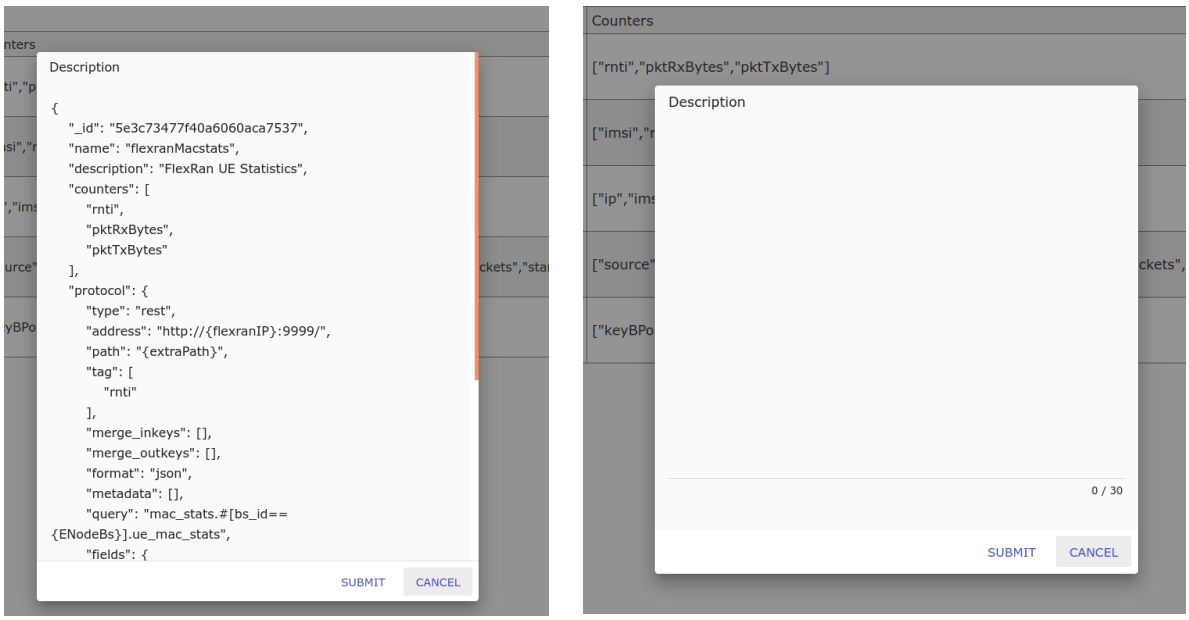

Figure 7: OSA NSP Dashboard – Monitoring Editors

3.1.2 Physical/Single Instance Resources Catalogue

Having available a set of monitoring and actuation descriptors that embody the technology specific knowledge of the NSP domain, the NSP admin is able to associate (Figure 8) these options with the physical resources that may be utilised in the context of the operation of a slice. In the context of NSP domain, physical resources are those artifacts that are not subject to virtualisation or dynamic deployment. Through this association, the first part for supporting the concept of NSP offerings is

completed. Thereafter, the offerings relating to the physical resources are subject to be utilised in the context of the synthesis of NSSTs and NSTs.

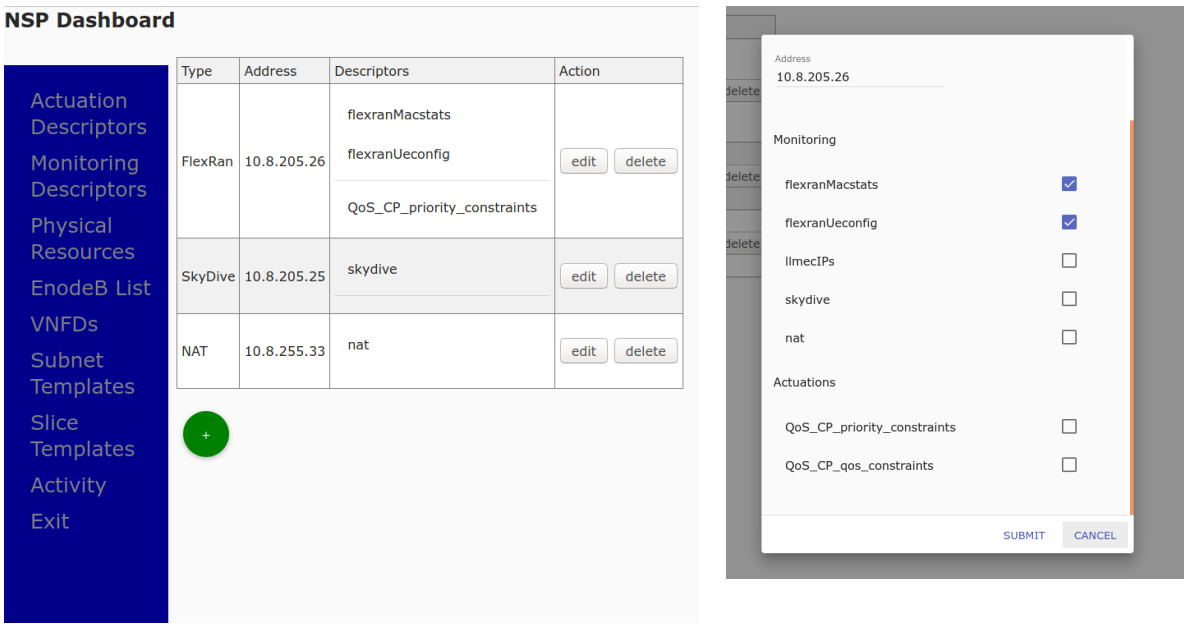

Figure 8: OSA NSP Dashboard – PNF Records and Editor

3.1.3 Virtual Resources Catalogue

Virtual functions can be also associated with monitoring and actuation options, as in the case of physical resources. Therefore, a similar UI control has been implemented to allow VNFs to be linked with such features. VNFs are subject to be onboarded/managed via the corresponding MANO (e.g. OSM) framework of the NSP domain. The OSA support focuses on the monitoring and actuation annotation that complements the operational features of the virtual functions with aspects that allow for enhanced FCAPS (based on QoE, cognitive and vertical oriented (P&P)).

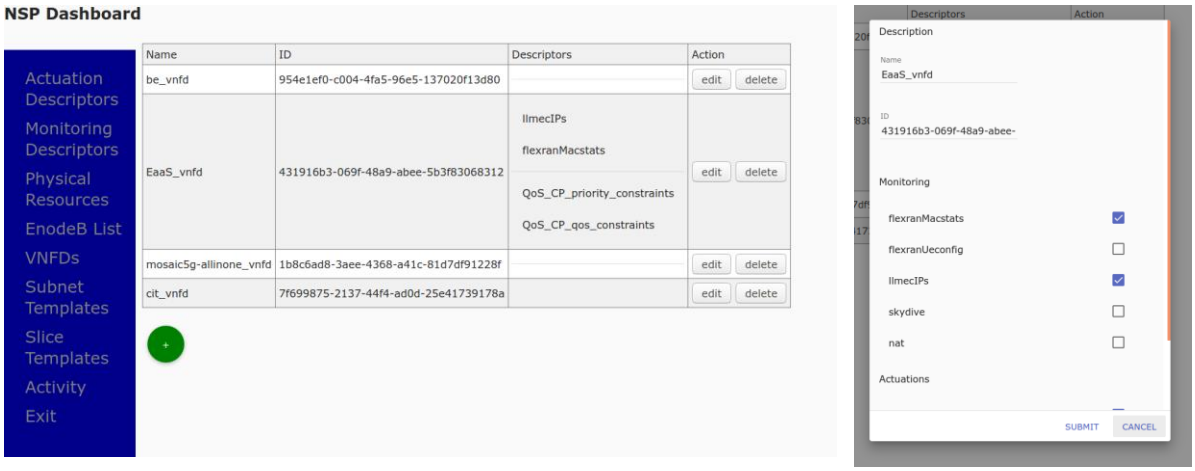

Figure 9: OSA NSP Dashboard – VNF Records and Editor

The list of available VNFs are collected from the MANO-OSM platform of the NSP domain. The association of the monitoring and actuation options are maintained separately in the document database allocated in the NSP domain. The steps performed via the OSA UI and Backend services is displayed in the following workflow (Figure 10).

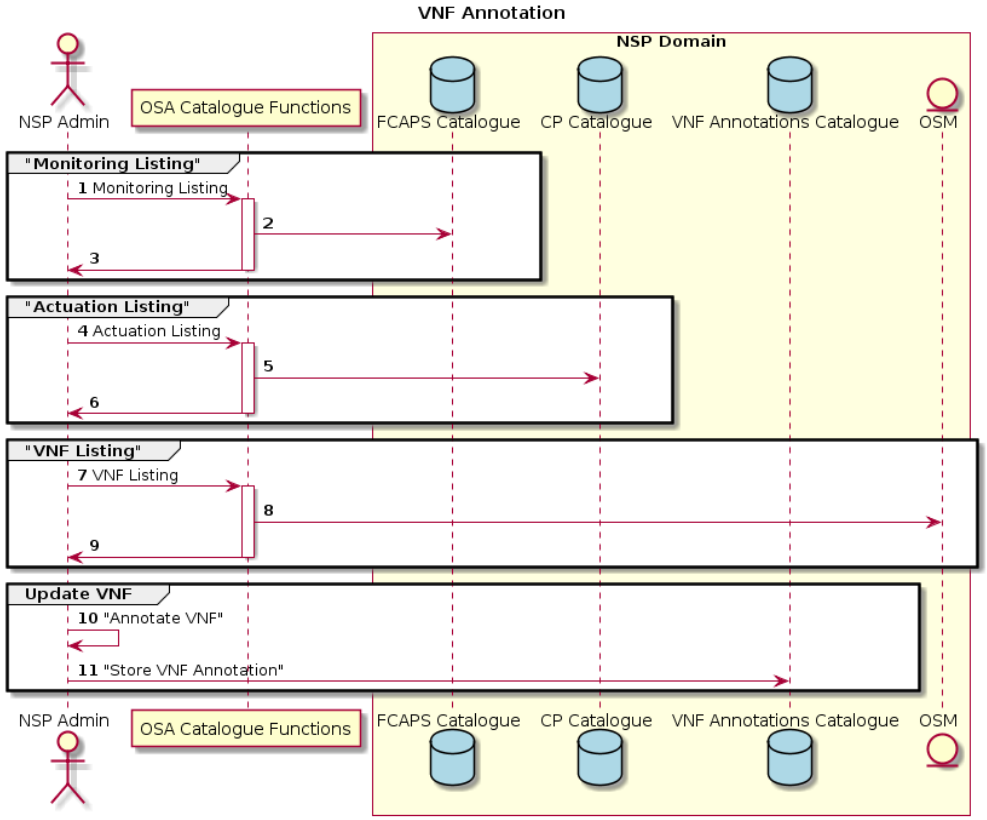

Figure 10: VNF Annotation Workflow

3.1.4 Network Slice Subnet Templates

The Slice orchestrator (SS-O) (D7.1 [6]) at the NSP level administers Network Slice Subnet Templates (NSSTs) that may be referring to the virtualised Network Services composed by VNFs. In this case, the association of VNFs with actuation and monitoring capabilities, which is applied via the OSA features presented in 3.1.3, suffices for extracting the kpiList and actuationList details in the Network Slice Subnet Template (D7.1 [6]) model. In case, however, NSSTs relate with physical (or singleton) functions (e.g. RAN subnet), OSA offers a Subnet Template management feature (Figure 11) to associate the NSSTs with the corresponding monitoring and actuation options available so that the related kpiList and actuationList properties are properly completed. In the example presented in Figure 11, the RAN slice subnet is subject to be annotated with monitoring options via the linking with the physical (FlexRan) function. Contrariwise, the Core component does not require such annotation as its relation with the particular VNF can be used to resolve the monitoring and actuation options it supports (3.1.3). For the RAN slice subnet, the monitoring and actuation options that have been linked with the selected physical function are extracted and used to submit the modified NSST to the SS-O. OSA retrieves the NSST list for a specific NSP domain from the SS-O API.

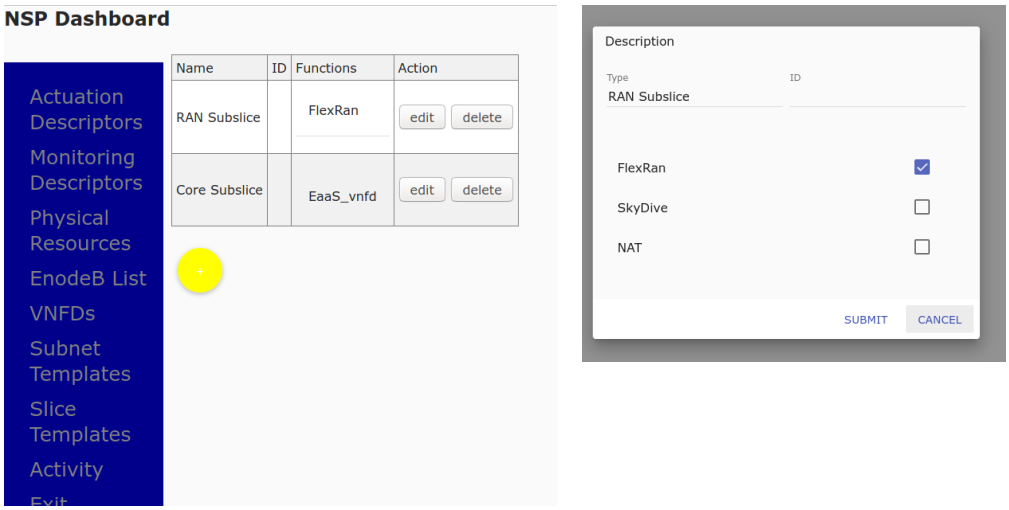

Figure 11: OSA NSP Dashboard – NSST List and Editor

The overall workflow for updating the NSST records on the SS-O is presented in Figure 12.

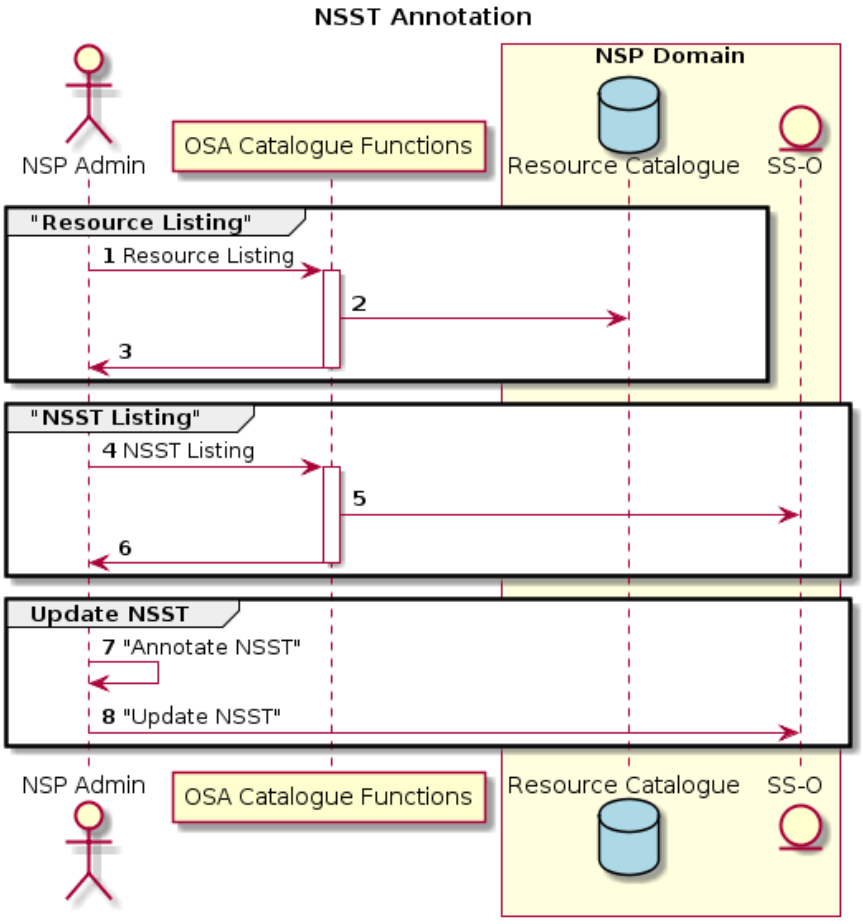

Figure 12: NSST Annotation Workflow

3.1.5 Network Slice Templates

The Network Slice Template (NST) regards a higher level aggregation of NSSTs that is made available from an NSP domain (D7.1 [6]) to one or more DSPs. Typically, the NST is associated with all the features contained in the referenced NSSTs. Additionally, an NST can be also associated with any physical resources relating to monitoring options and with actuations that are subject to Control Plane services (CPSs) (Figure 13). OSA retrieves the NST list for a specific NSP domain from the SS-O APIs. The association with CPSs and physical resources is used to augment the NST entries to be sent to the SS-O.

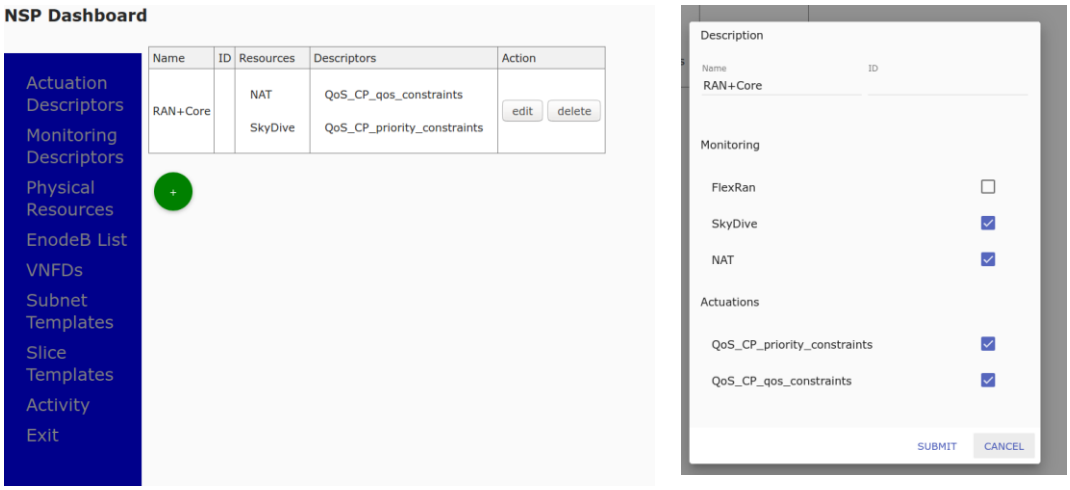

Figure 13: OSA NSP Dashboard – NST List and Editor

The overall workflow of NST Annotation with monitoring and actuation options is presented in Figure 14.

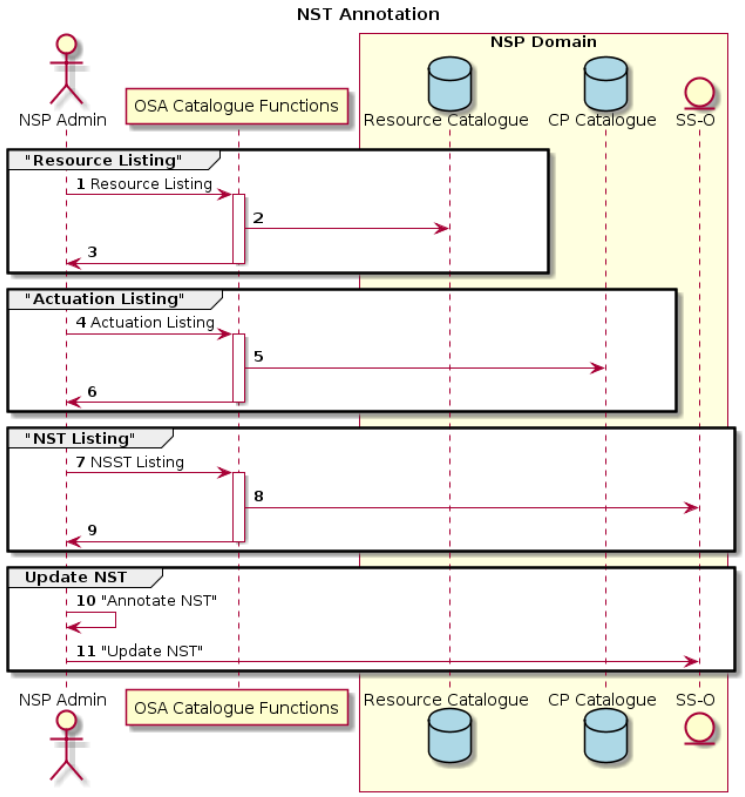

Figure 14: NST Annotation Workflow

3.1.6 NSP Coverage Area

One of the main parts of the NSP domain that is exposed by an NSP is the geographical locations where its access network can be used for delivering connectivity to vertical equipment. OSA provides support for the registration of the areas in association to the eNodeB equipment that is operated and made available for access network slicing. This feature is provided by a map-enabled UI element that allows the NSP Admin to identify installation locations (Figure 15). Selection on the map records a point and highlights the area around. The locations registered per NSP are subject to be processed during slice orchestration in the DSP workflows according to the locations a vertical is indicating as important for slice coverage.

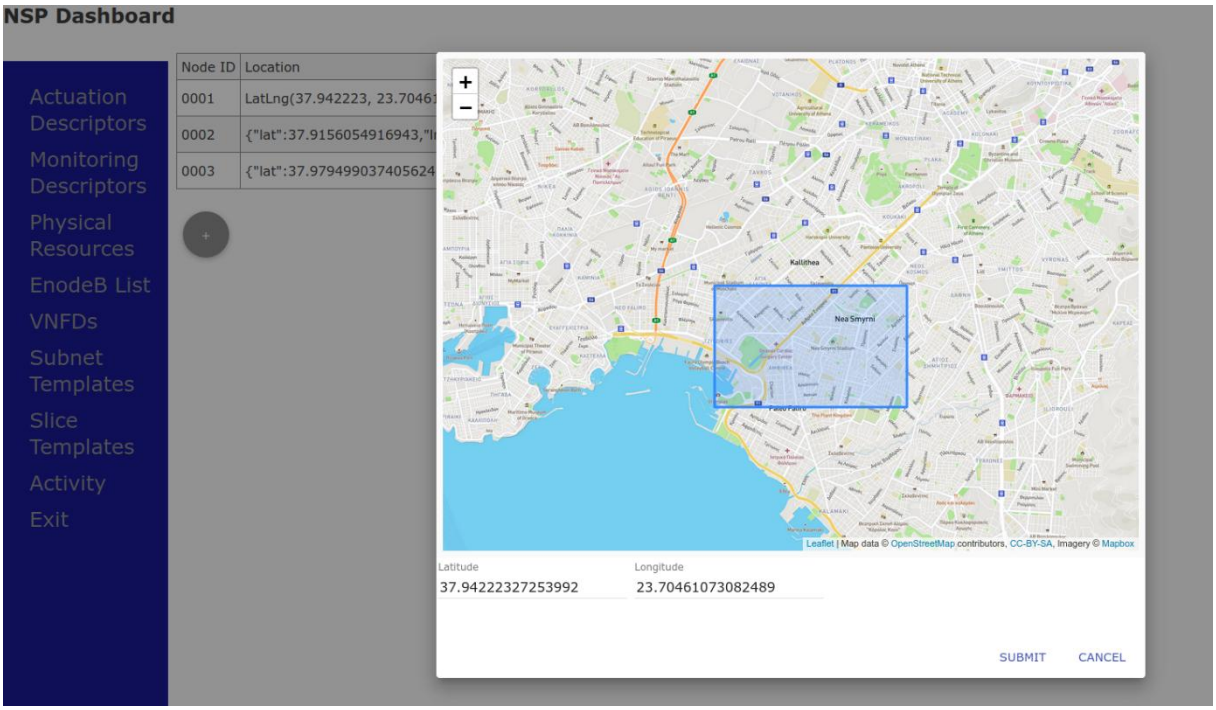

Figure 15: OSA NSP Dashboard – eNodeB Location Support

3.2 DSP Views

DSP is operating on top of a number of NSPs. According to the SliceNet orchestration principles (D7.1 [6]), the DSP is creating Virtual Service Blueprints to be selected by Verticals on the basis of the available NSSTs and NSTs that the NSP domains are exposing. The exposed templates embed information regarding the supported monitoring and actuation options as described in the previous section regarding the NSP Views of the OSA. Monitoring and actuation options are subject to interdomain FCAPS management as described in D6.7 [5] which is implemented in the context of Cognitive, QoE and P&P operation. Therefore, OSA has to support the association of the implemented Cognitive, QoE and P&P modules with their dependencies on monitoring and actuation options, which are made available through the NST and NSST records provided by the various NSPs. Obviously, the resolution of dependencies during orchestration of end-to-end slice provisioning and runtime operation is affecting, along with other aspects such as geographical coverage, the NSP selection by the SS-O.

The three types of the interdomain FCAPS modules (P&P, Cognitive, QoE) realise the DSP business offerings aiming at high level management of slices for supporting communications with adequate performance and guaranteed stability across NSPs. These offerings require their own development cycle which evolves on top of the availability of monitoring and actuation options. OSA exposes a

summary of such options (Figure 16) as extracted from NSTs and NSSTs enumerated across NSP domains so that DSP developers can consult such catalogues before implementing (or adapting) their artifacts.

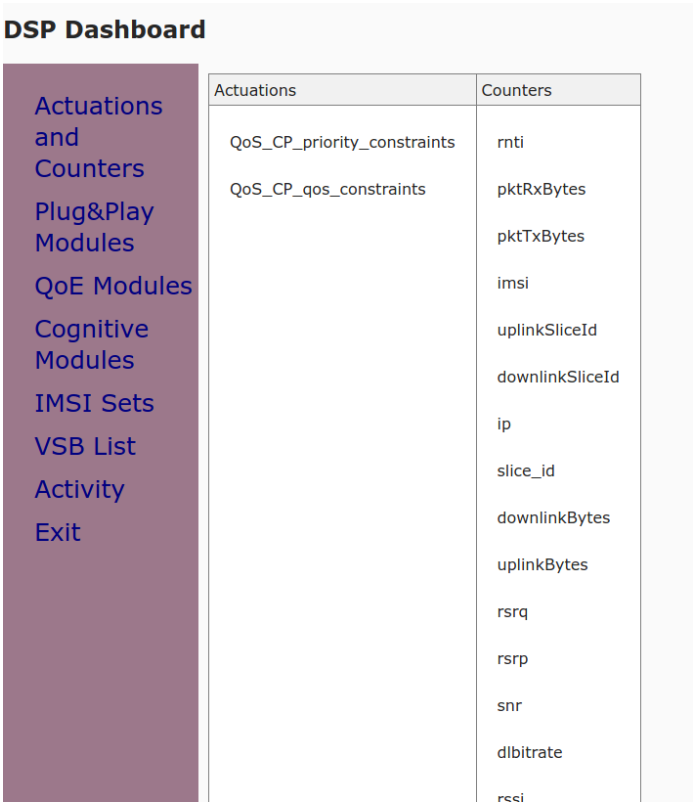

Figure 16: OSA DSP Dashboard – Counter and Actuation Listing

The information listed can be used by DSP developers to implement their modules assuming the presence of the metrics of interest in the DSP Data Lake and the support of the actuations via the orchestration sub-plane. Overall, the following workflow indicates the above approach.

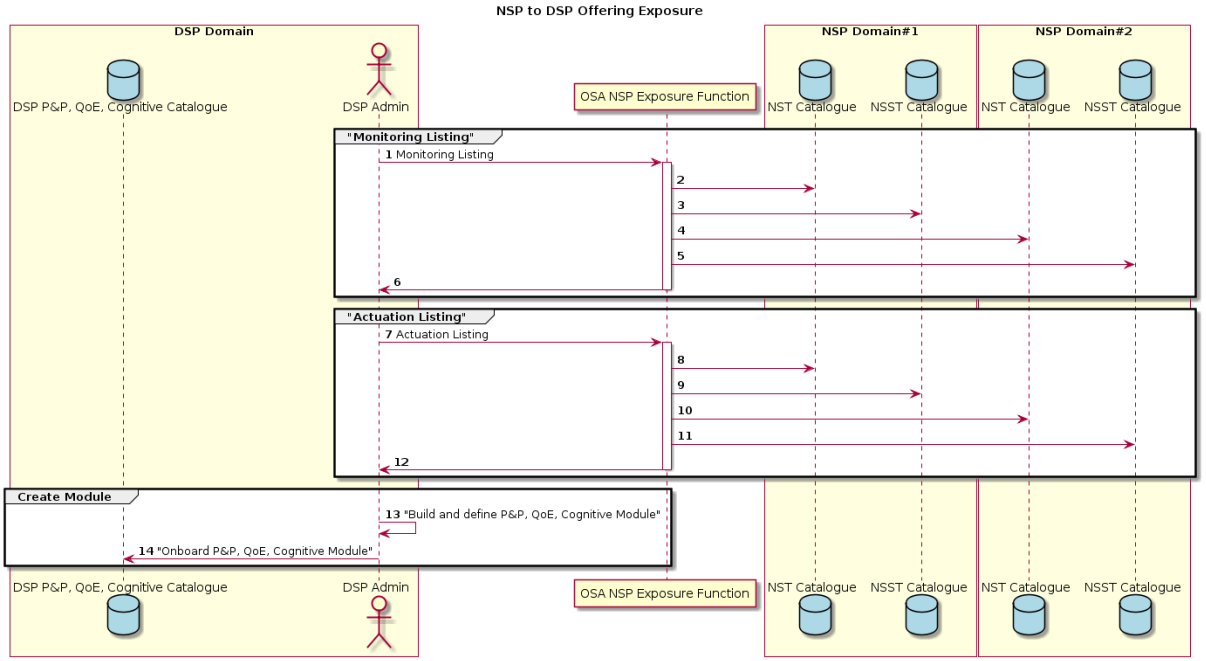

Figure 17: OSA DSP Dashboard – Monitoring and Actuation inspection for the development of P&P, QoE and Cognitive modules

Step	Description
1	DSP requests monitoring counter listing
2, 3, 4, 5	OSA queries NST and NSST Catalogue Endpoints of the SS-O of the available NSPs for identifying the available counters that have been linked with the registered templates
6	OSA returns the available counters across all domains
7	DSP requests actuations listing
8, 9, 10, 11	OSA queries NST and NSST Catalogue Endpoints of the SS-O of the available NSPs for identifying the available actuations that have been linked with the registered templates
12	OSA returns the available actuations across all domains
13	DSP Developer designs and builds QoE, P&P and Cognitive Modules
14	The modules created are annotated and the information is made available to be used during slice provisioning

3.2.1 P&P, Cognitive and QoE Annotation

Once the modules are available and onboarded, the DSP can associate these with the counters and actuations that were considered in the design phase. This is done via the appropriate OSA DSP views (Figure 18, Figure 19, Figure 20) and annotation editors (Figure 21, Figure 22, Figure 23) of these modules.

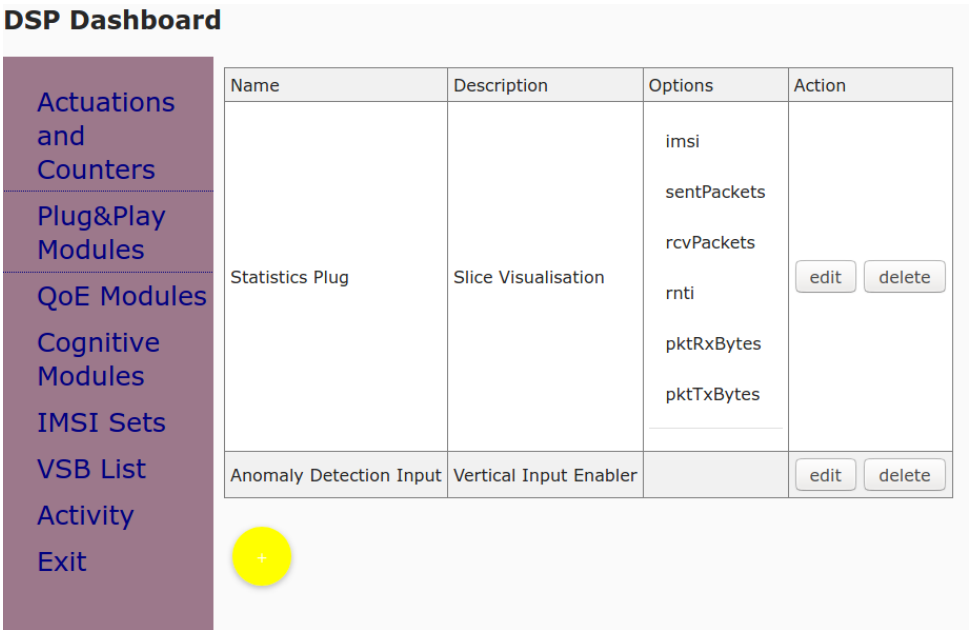

Figure 18: OSA DSP Dashboard – P&P Module List

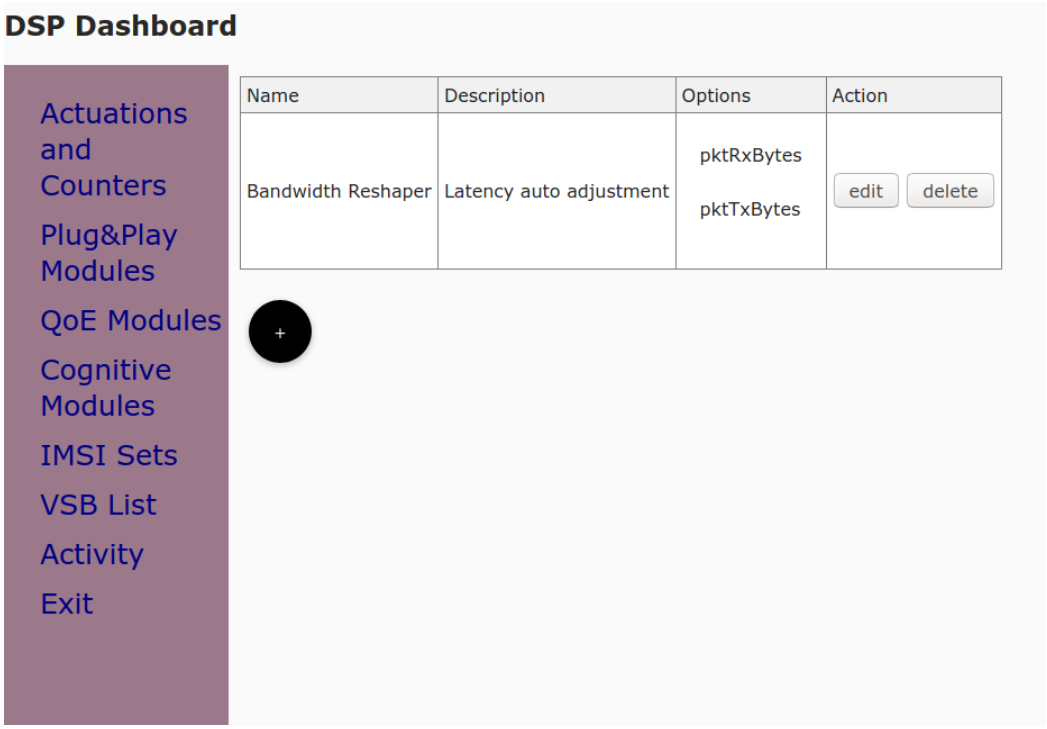

Figure 19: OSA DSP Dashboard – QoE Module List

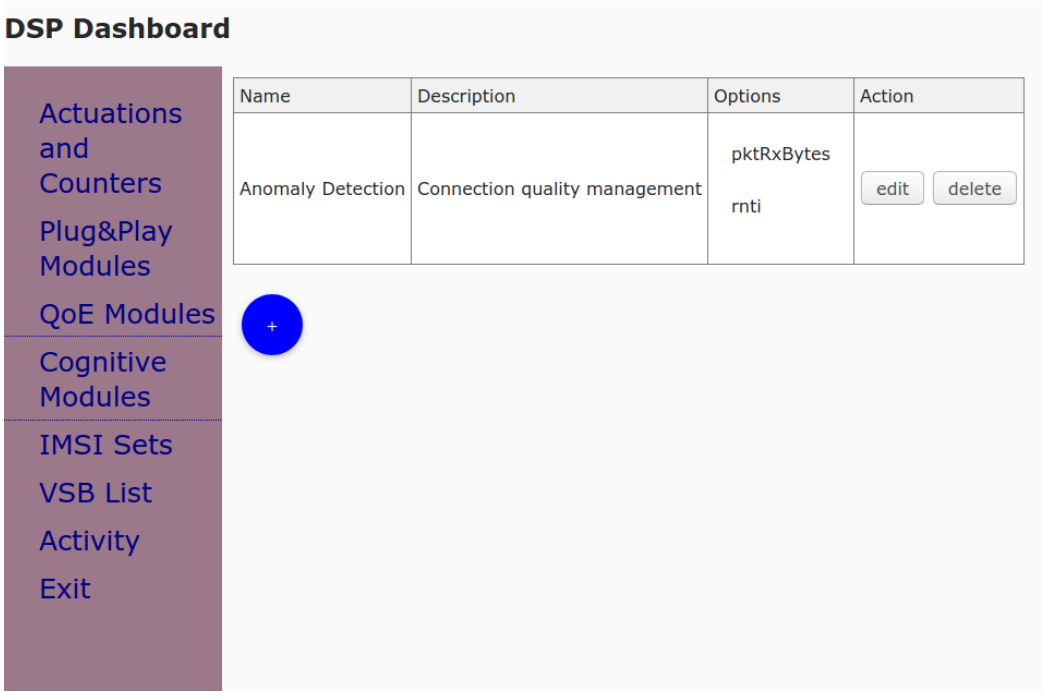

Figure 20: OSA DSP Dashboard – Cognitive Module List

The *Description* field provides the option to be exposed to verticals for selection through the VSB processing.

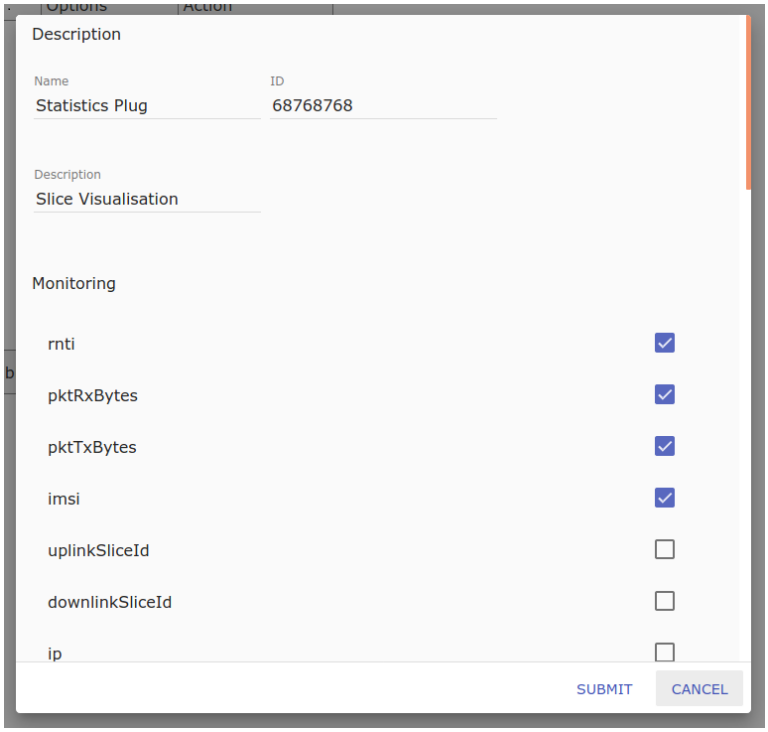

Figure 21: OSA DSP Dashboard – P&P annotation editor

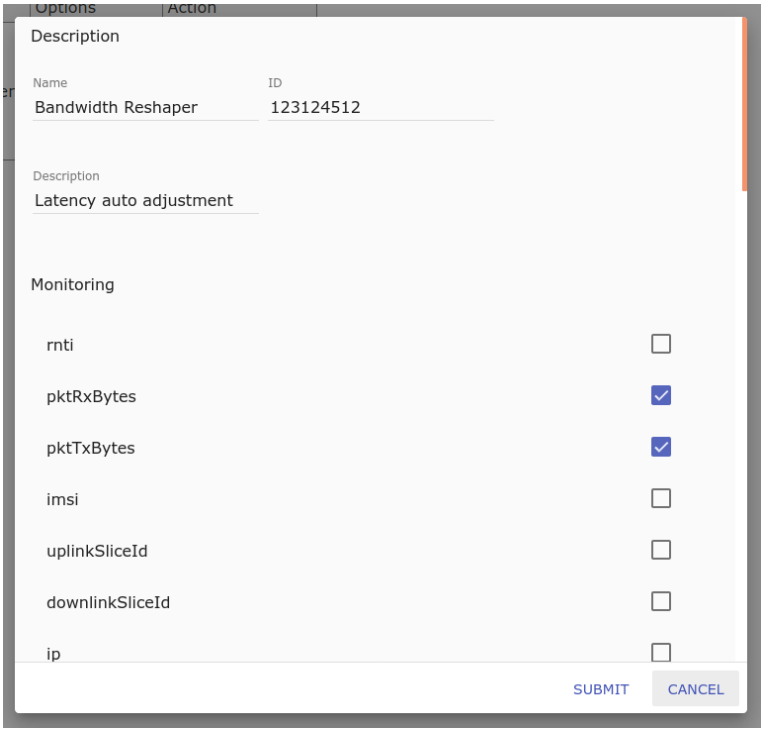

Figure 22: OSA DSP Dashboard –QoE annotation editor

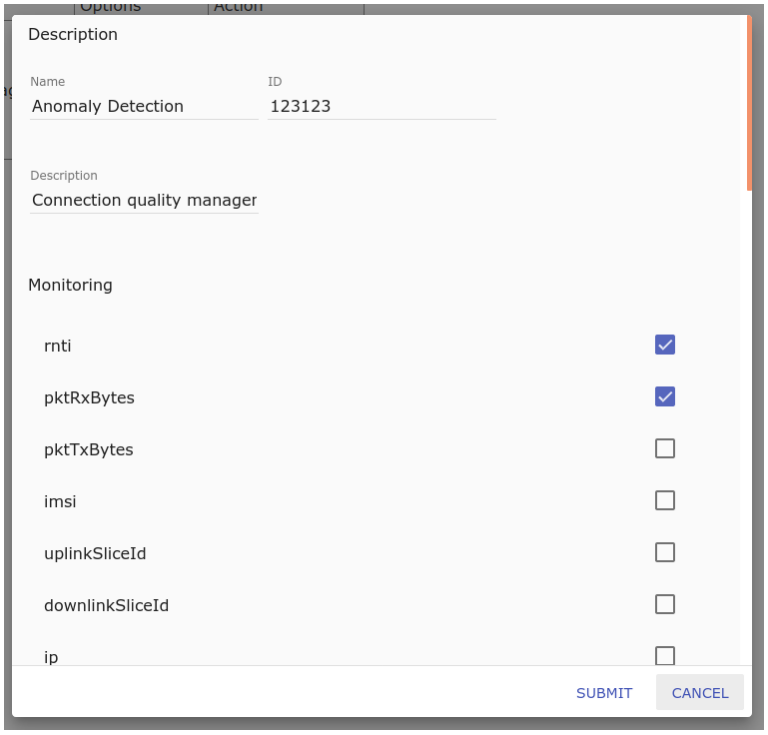

Figure 23: OSA DSP Dashboard – Cognitive annotation editor

The outcome of the P&P, QoE and Cognitive modules annotation processing is maintained in a document database to be used by SS-O during NSP selection. This enumeration and annotation process corresponds to the last step of the workflow presented in the previous paragraph (Figure 17).

3.2.2 Vertical Service Blueprint Annotation

The offerings provided by the DSP to the verticals consist of the Vertical Service Blueprints (D7.1 [6]) and are subject to be customised according to vertical business interest. From OSA perspective, within the DSP management context, VSBs are subject to be annotated with P&P, Cognitive and QoE aspects that provide the added value management options with which the DSP enhances the slice offerings. OSA enumerates (Figure 24) the available VSBs from the DSP SS-O endpoint (D7.1 [6]) and allows the DSP admin to include any of the P&P, Cognitive and QoE aspects that are available for selection by the Vertical along with any other parameterisation required (Figure 25).

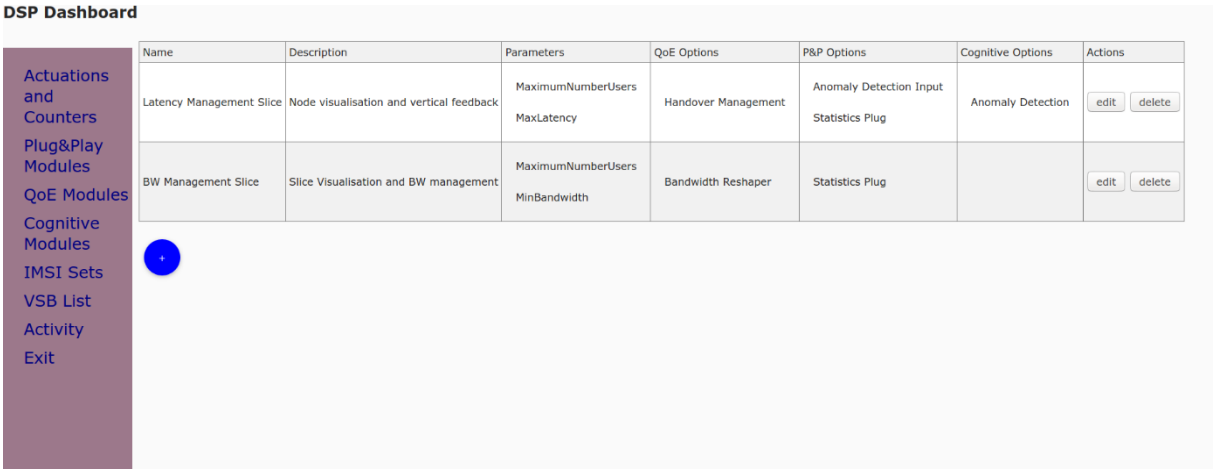

Figure 24: OSA DSP Dashboard – VSB List

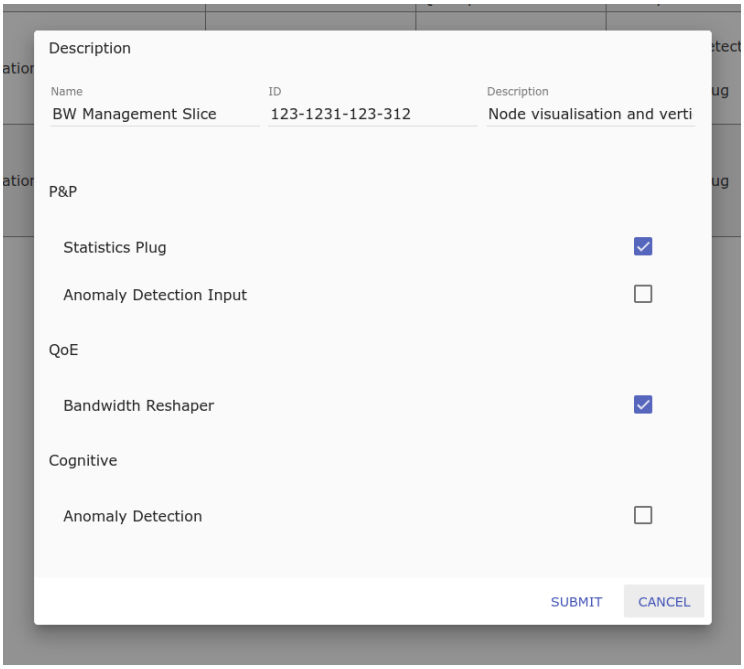

Figure 25: OSA DSP Dashboard – VSB Editor

The following workflow (Figure 26) presents the steps involved for the VSB annotation with the P&P, QoE and Cognitive options to be selected by the verticals.

Step	Description
1	DSP requests P&P, QoE and Cognitive options
2	OSA queries the DSP Catalogue
3	DSP Admin (UI) is provided with the available options
4	DSP Admin (UI) requests VSB listing
5	OSA queries the SS-O endpoint
6	DSP Admin (UI) is provided with the VSB list
7	DSP Admin selects P&P, QoE and Cognitive options to be made available for a VSB
8	Updated information is submitted
9	OSA delivers the update request to the SS-O

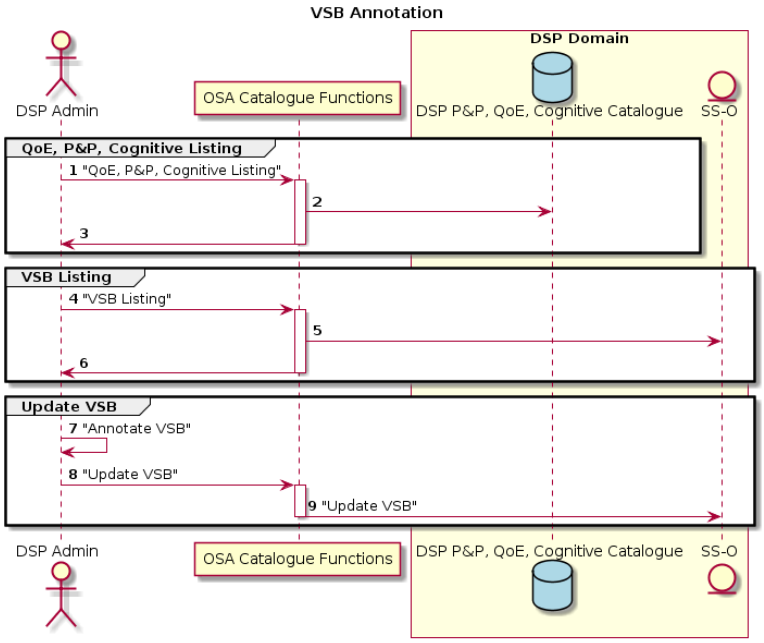

Figure 26: VSB Annotation with P&P, QoE and Cognitive Options

3.3 Vertical Views

A user, the role of which is identified as Vertical, is presented with the Virtual Service Blueprints that the DSP is providing to select for ordering the slice(s) that are required for its business purposes. According to the principles of SliceNet orchestration sub-plane, a Vertical should personalise the VSB to create the Vertical Service Descriptors (VSD) that can thereafter instantiate.

The overall workflow from VSB listing to slice request is presented below (Figure 27).

Step	Description
1	The Vertical (UI) queries for the VSBs that the DSP is providing
2	OSA resolves the VSB listing from the SS-O
3	The list of VSBs is sent to the UI
4	A VSB is customised (management options selection and parameter completion)
5	The customised VSB is posted for the creation of VSD
6	OSA applies the Vertical identifier and forwards the request for VSD creation to the SS-O
7	The Vertical collects the list with the VSD entries
8	OSA queries the SS-O for the identified vertical's VSDs
9	The VSD list is sent to the UI
10	A VSD entry is modified with respect to required coverage area related information and vertical input options via P&P backend exposure (4.1.2)

11	The modified VSD is sent to OSA
12	OSA applies vertical identity and forwards the request to the SS-O
13	The Vertical requests the set with VSD entries
14	OSA queries the SS-O for the identified vertical's VSDs
15	The VSD list is sent to the UI
16	A VSD is selected for instantiation
17	Vertical identity is applied by OSA and the request is sent to the SS-O
18	SS-O provides VSI identifier
19	VSI list is updated on the UI

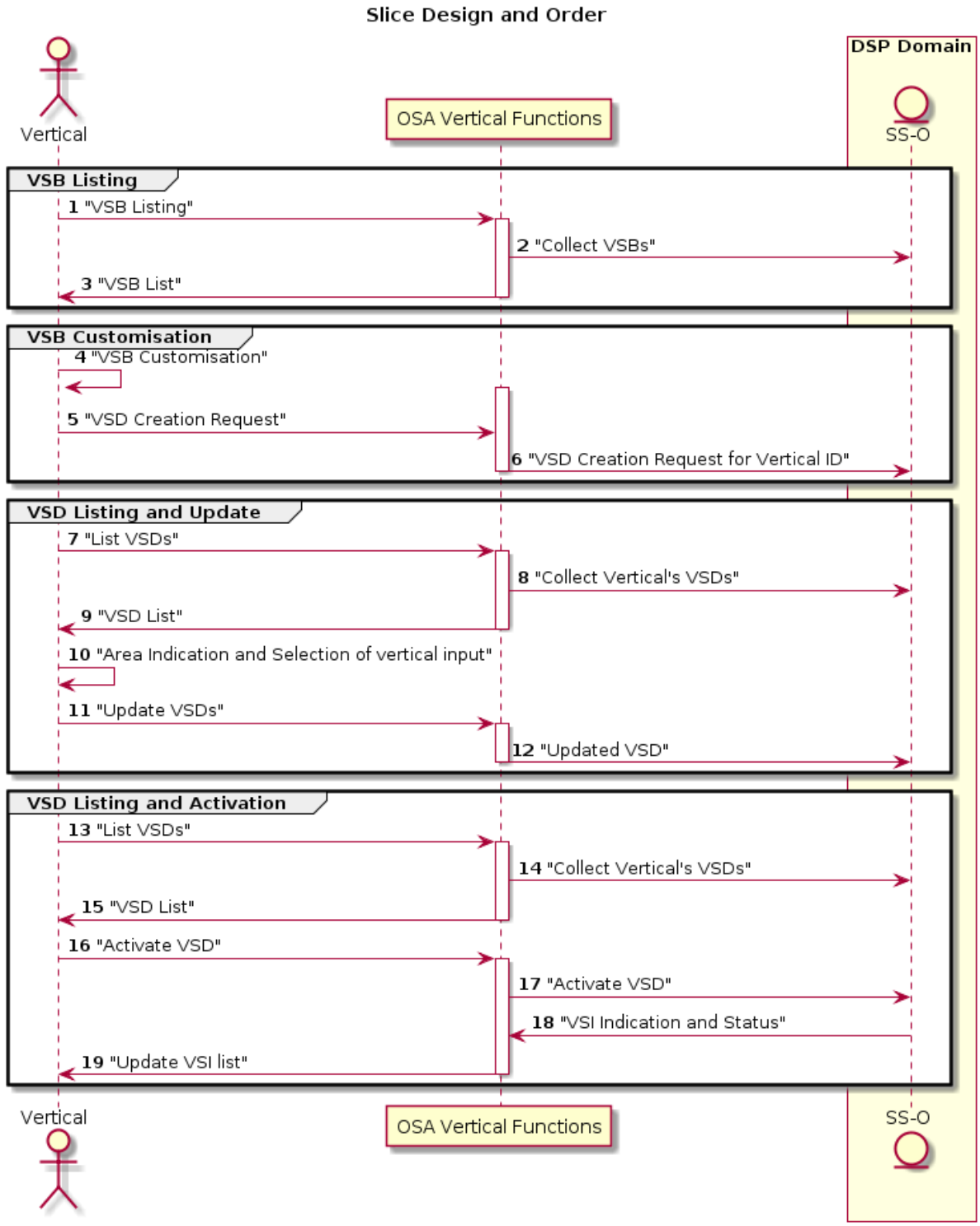

Figure 27: Vertical Slice Order

3.3.1 Virtual Service Blueprints View

OSA identifies the Vertical role and collects from the DSP SS-O the VSB records that are available for the Verticals. The information collected is adapted to present a Vertical oriented view (Figure 28) that is focusing on the name, description, customisation parameters and management options. The

management options are relating to the P&P, Cognitive and QoE options that have been linked with the VSB and are presented via their description field that is aimed to be service oriented defined.

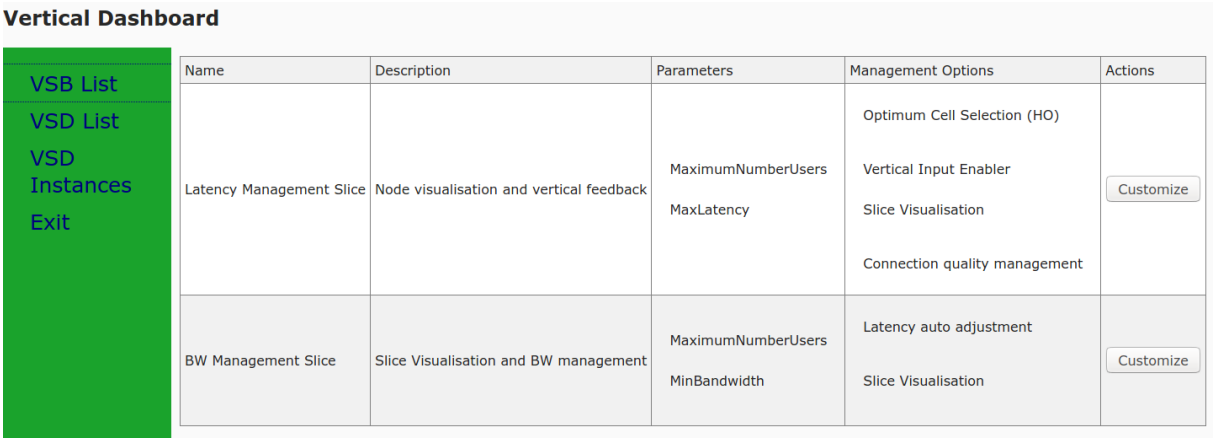

Figure 28: Vertical view – VSB Listing

By selecting the customisation option of the VSB, the user is provided with the editing options (Figure 29) that include the name and description of the designed VSD as well as the parameter definition controls and the management options that may be of interest for the Vertical. Submission of the customisation options lead to the creation of the VSD (D7.1 [6]) at the SS-O.

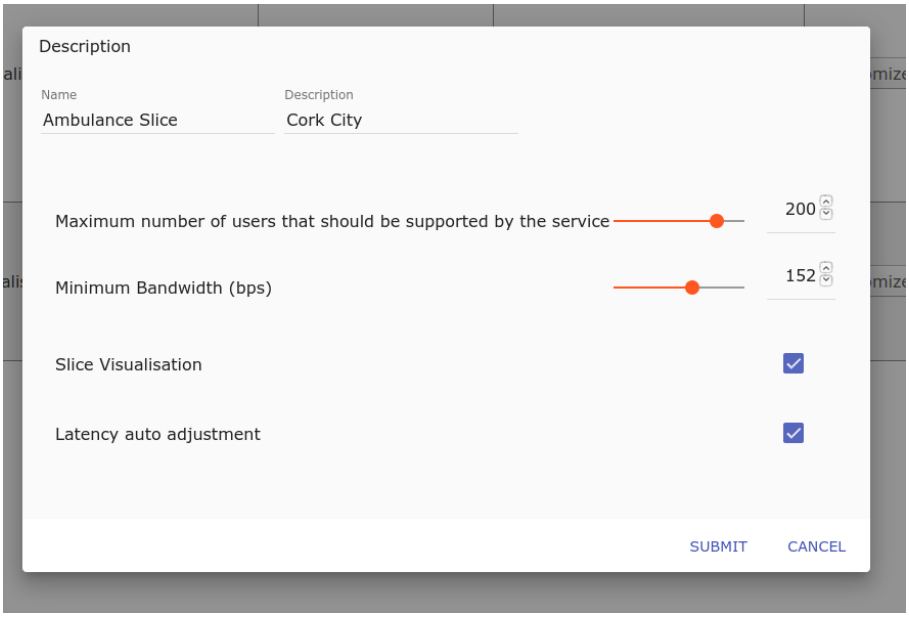

Figure 29: Vertical view – VSB Customisation

3.3.2 Virtual Service Descriptors View

The VSDs created via the VSB customisation option are made available on the OSA on a dedicated view (Figure 30). The previously selected customisation options can be modified only as far as the parameters are concerned. The management options related to P&P are listed to allow the Vertical indicate any requirement for activation of backend endpoints that will be made available for vertical input, as it is elaborated later (4.1.2), towards the management sub-system to trigger optimisation workflows. Additionally, the VSD modification provides the vertical with the option to indicate specific areas where it requires that the instantiated slice should provide coverage (Figure 31).

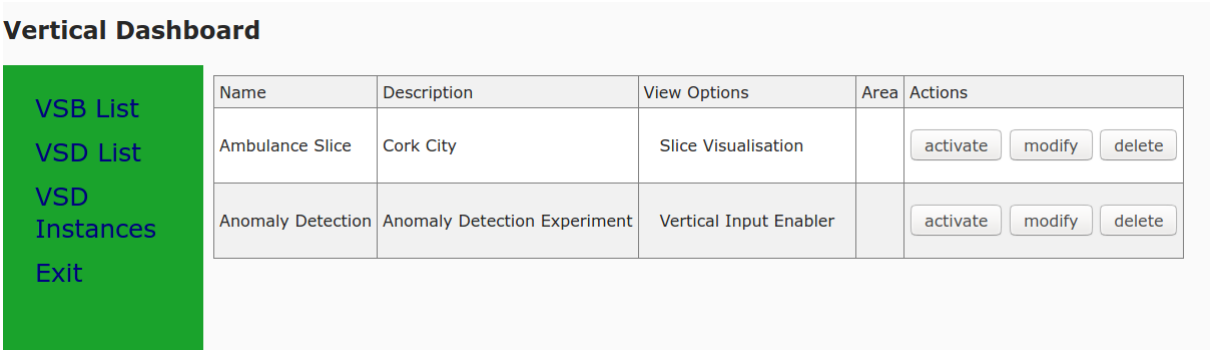

Figure 30: Vertical view – VSD List

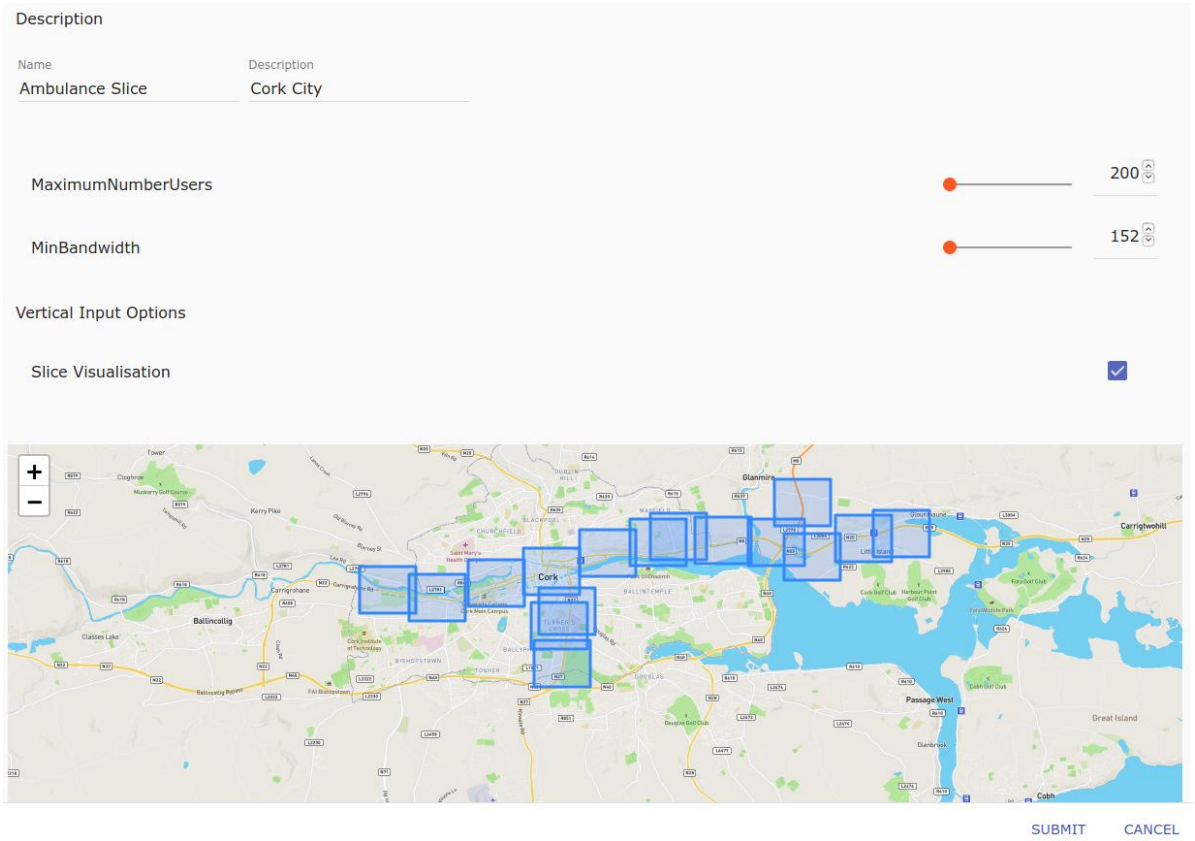

Figure 31: Vertical view – VSD Customisation

From the VSD list view (Figure 30), the Vertical user can activate a VSD. The request is forwarded to the SS-O endpoints along with the information about the identification of the requesting vertical (D7.1 [6]). This request triggers the creation of Vertical Service Instance (VSI).

3.3.3 Virtual Service Instances View

All the VSI records of the vertical are provided through the relevant view (Figure 32) from where they can be managed (deleted or modified). Newly created VSIs are presented with “pending” status. The information is updated periodically from the SS-O and when the status changes to ready, the P&P options that have been selected appear as hyperlinks (Figure 33) to be selected for providing the user with the operation view of the slice (Figure 34).

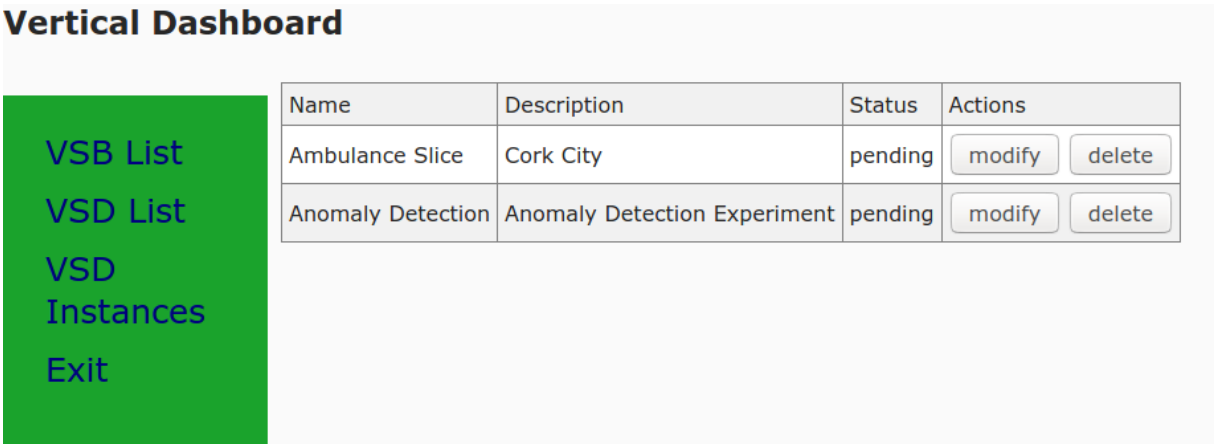

Figure 32: Vertical view – VSI List – pending status

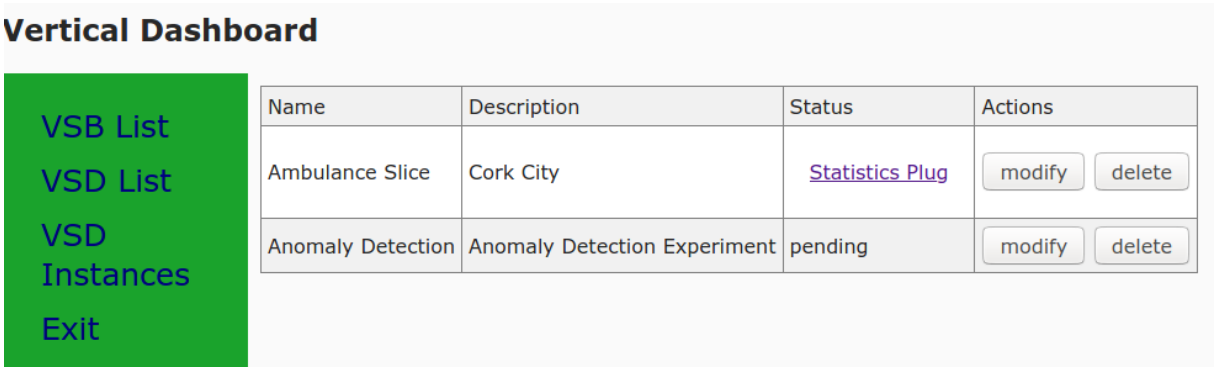

Figure 33: Vertical view – VSI List – activated status

4 Operation Views and Workflows

4.1 Vertical Views and Backend API

4.1.1 UI Exposure

Once a slice has been ordered and on condition that an exposure P&P plug has been associated, the vertical can use the relevant hyperlink from the VSI View (Figure 33) to launch the P&P related exposed view of the slice (Figure 34) and also reach the UI options for actuation (Figure 35) and monitoring.

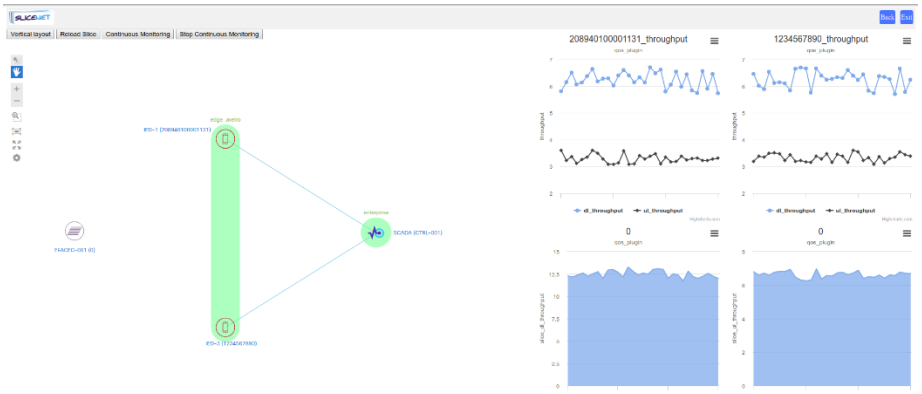

Figure 34: Vertical View

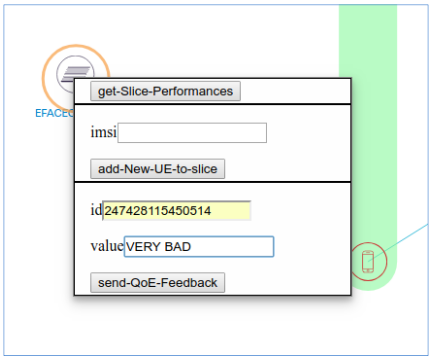

Figure 35: OSA Exposure of Actuation Option

The operational view exposure, according to P&P principles (D4.1 [10]), is aligned with the vertical (i.e. slice user) centric approach adopted by SliceNet that aims at abstracting technology and domain related enablers towards the provision of services tailored to the needs of the topmost user of the infrastructure. In this regard, the P&P has been designed on the basis of the provisioning of vertical oriented exposure of the delivered slice. This requires that specially crafted plugs are available that allow verticals to activate those related to their business. Each of the plugs provides a northbound exposure that fits the needs of the slice owner whereas it is able to process, in southbound, the platform specific information, which is maintained via the layered and multidomain FCAPS enablers.

4.1.2 Backend Exposure

Beyond the bottom-up approach for the delivery of slice specific metrics and due to the vertical centric approach, it was considered important to allow verticals to contribute to the Data Lake information for the exploitation of service metrics that the user endpoints are able to produce. In this regard, the vertical tailored UI view provided by P&P and OSA is augmented to create slice specific endpoints that expose the existing P&P options towards more automated (UI less) procedures to contribute to the slice segment of the DSP Data Lake and trigger cognitive and QoE functions via direct quantitative vertical feedback. OSA allows therefore slice owners to indicate which P&P functions should be

exposed as REST endpoints that can be invoked by metric and counter agents deployed in vertical UEs and collecting valuable metrics from the user domain.

This indication is enabled through the VSD View (3.3.2) and it is activated once the related P&P module is deployed. OSA operates a backend management service that enumerates the instantiated P&P modules in comparison with the VSD definitions per vertical and maintains accordingly the exposed endpoints.

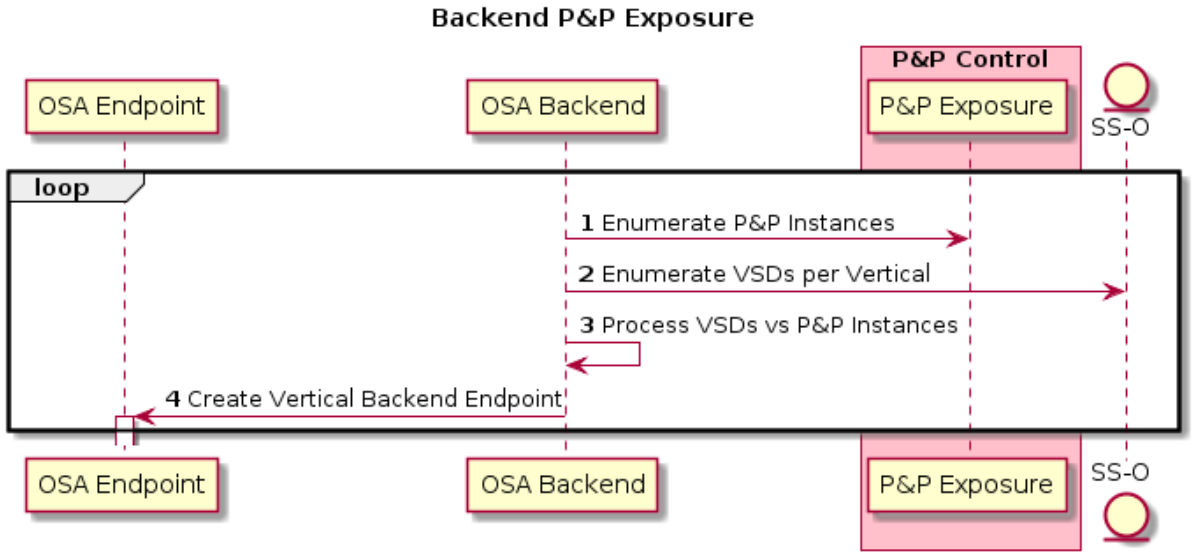

Figure 36: Exposure of Backend Endpoints for Vertical Input

4.2 DSP Views and Operation Workflows

4.2.1 NSP to DSP Data Lake Integration Workflow

As it has been described in sections 3.1 and 3.2, OSA allows NSPs to provide monitoring offerings via NST and NSSTs that thereafter are subject to be exploited by P&P, Cognitive and QoE modules. Depending on Vertical choices a number of these modules are activated in the context of each slice. During operation the activated modules rely on information that is available in the DSP Data Lake, which in turn has to be retrieved from the slice related NSPs (D6.7 [5]). This requires that the NSP FCAPS framework, and particularly the TAL Engine, has to be configured with the appropriate Exposure Rules that aim at configuring the merging of the information from the various measurement tables of the slice database in the NSP Data Lake, and the propagation of the merged information in the DSP domain dedicated Kafka bus topics. The steps followed are presented in the following workflow (Figure 37).

Step	Description
1	P&P, Cognitive or QoE modules are activated
2	OSA detects the activated modules
3	OSA collects the monitoring dependencies of the activated modules
4	Merging per NSP is calculated and the corresponding TAL Rules are generated (merging is applied on the basis of the merging fields included in the FCAPS descriptors D6.6 [4], D6.7[5])

5	TAL Rule including merging and exposure options is applied on the first NSP's domain TAL Engine
6	TAL Rule including only exposure options (monitoring data are provided from a single measurement table) is applied on the second NSP's domain TAL Engine

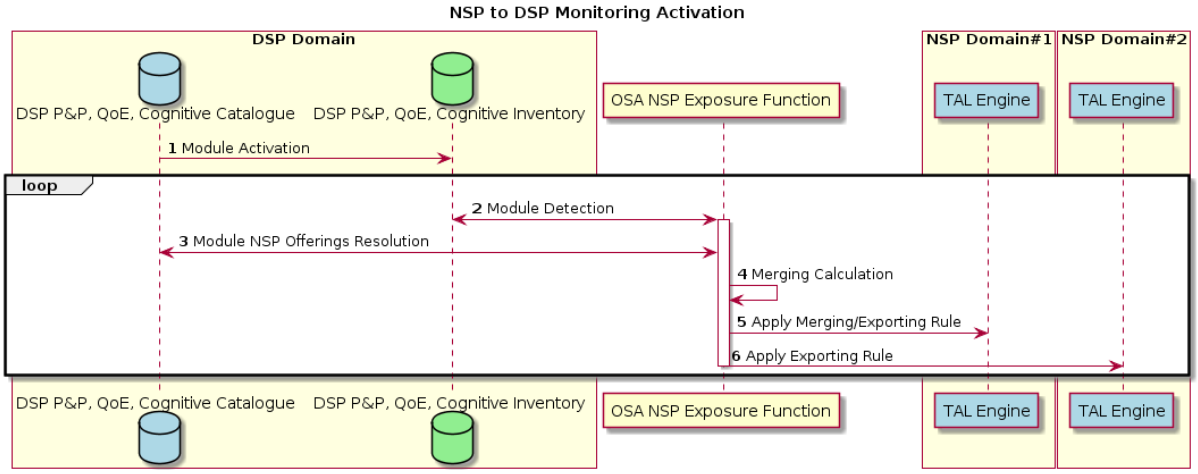

Figure 37: NSP to DSP Data Lake Rule Activation

4.2.2 DSP Data Lake View

All the monitoring information from all the slices, a DSP is providing to verticals, is stored in the InfluxDB of the TICK Stack deployed in the DSP domain (D6.7 [5]). OSA provides access to the Chronograf UI to the DSP admin slices so performance can be visualised (Figure 38).

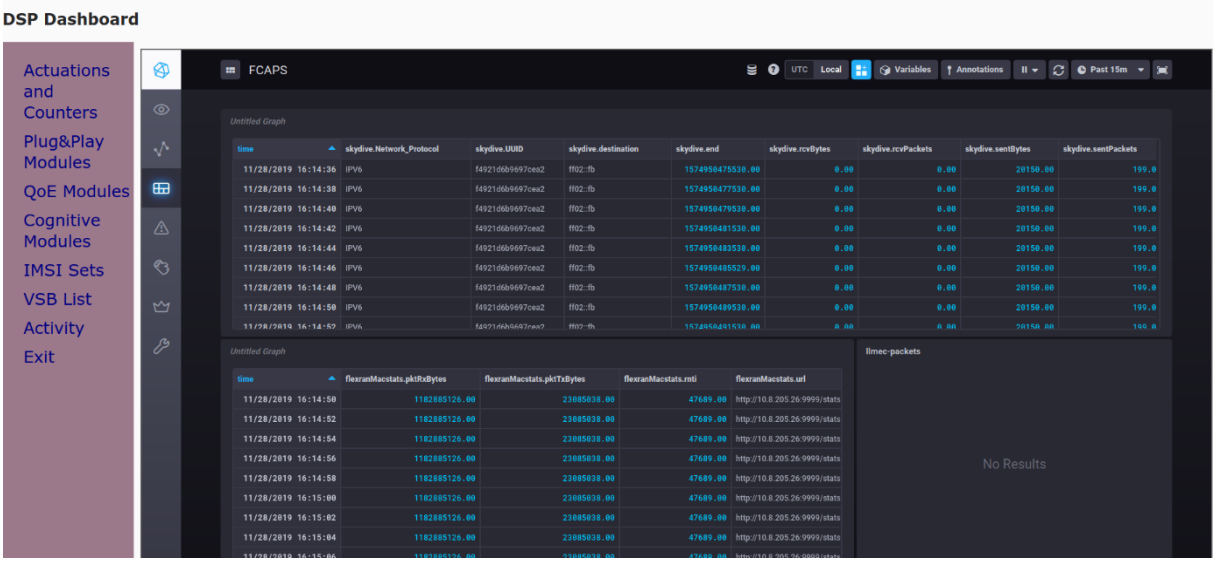

Figure 38: Chronograf UI for visualisation of the performance of the slices

4.3 NSP Views and Operation Workflows

4.3.1 FCAPS Integration Workflow

As in the case of DSP, where monitoring dependencies for the P&P, QoE and Cognitive modules is analysed and leads to the appropriate TAL Exposure Rules to allow the information flow from the NSP to DSP Data Lake, a similar automation is applied at the NSP level to activate FCAPS framework descriptors as onboarded through the related capabilities views (3.1.1). For this purpose, OSA monitors NSI and NSSI, and processes them on the basis of the correlated FCAPS capabilities. The related steps are indicated in the following workflow (Figure 39).

Step	Description
1	OSA detects NSI/NSSI entries
2	FCAPS dependencies are resolved
3	FCAPS parameters are listed so that they are resolved for the particular slice (D6.6 [4])
4	Parameters are resolved for the particular slice
5	Resolved parameters are stored to trigger FCAPS activation
6	FCAPS Manager detects inventory entries and maintains the appropriate Telegraf instances

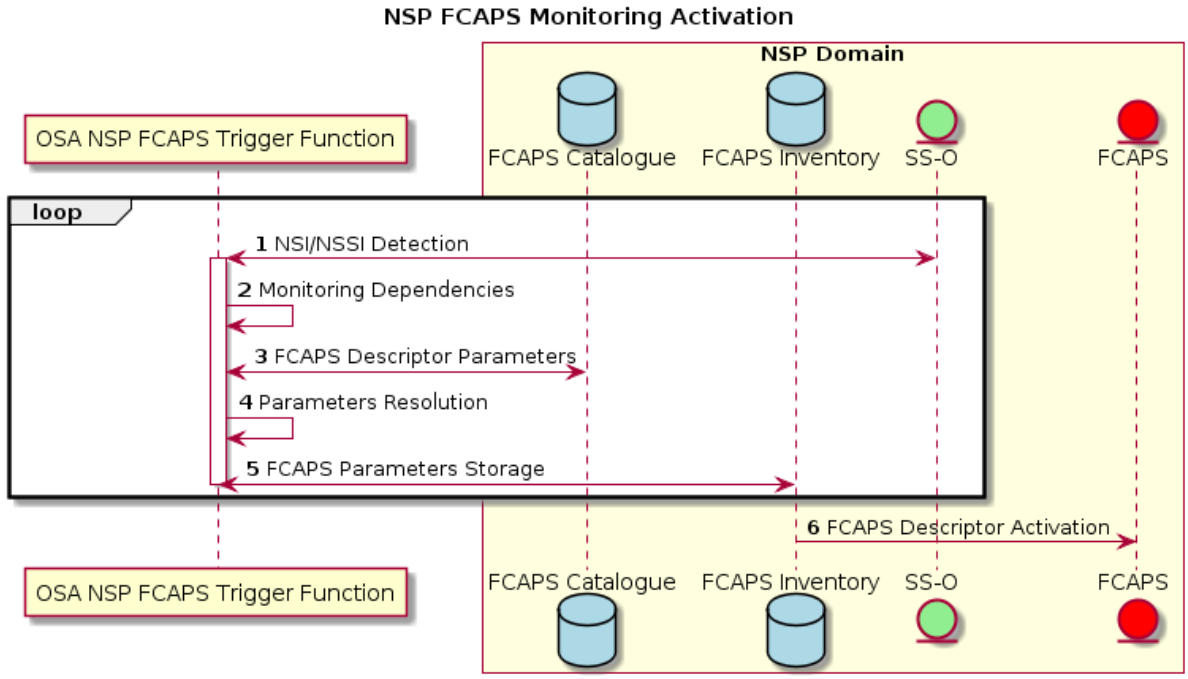

Figure 39: NSP FCAPS Artifacts Activation

4.3.2 NSP Data Lake View

Since NSP is using also TICK stack for the realisation of the Data Lake, NSP view is providing to the NSP admin the Chronograf UI based on the configured Data Lake for the NSP for visualisation of slice and/or slice subnet operation according to the FCAPS collected information (Figure 40).

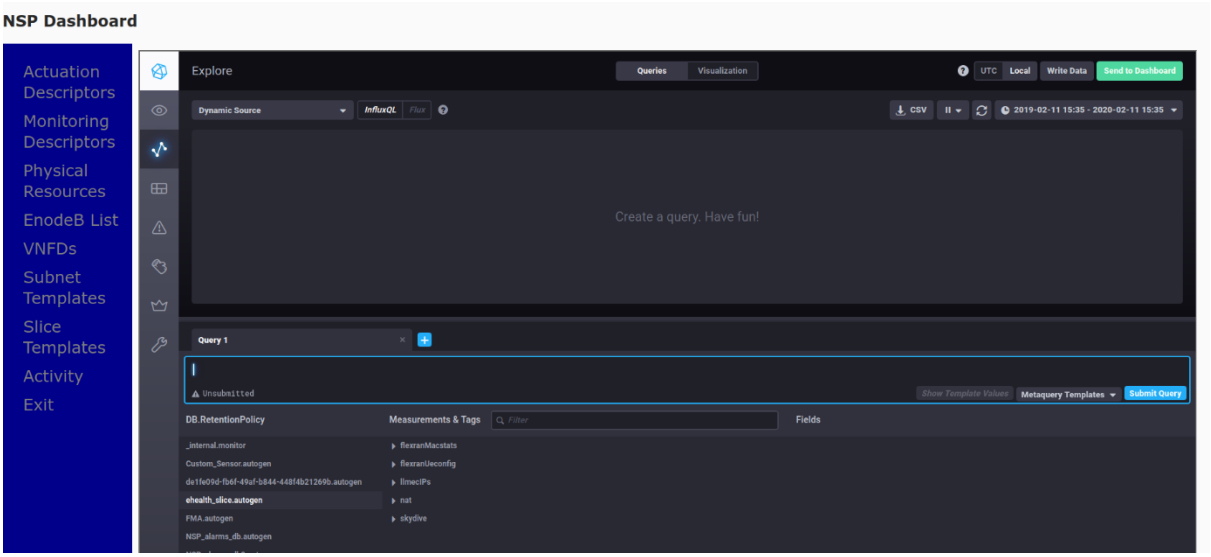

Figure 40: Chronograf UI for visualisation of the performance of the slice subnets

5 Implementation Details

OSA is implemented as set of Node.js (packages: express, body-parser, request, mongodb, mysql, passport-http, passport) applications for the backed operations. The following packages are utilised by the backend logic that has been implemented:

Package Name	Role	Reference
express	Web application framework	https://expressjs.com
body-parser	HTTP body parsing functionality	https://github.com/expressjs/body-parser
mongodb	MongoDB JavaScript driver	https://github.com/mongodb/node-mongodb-native
mysql	MySQL JavaScript driver	https://github.com/mysqljs/mysql
passport	Authentication Framework	http://www.passportjs.org/
passport-http	Library for Basic and Digest HTTP support on top of passport	https://github.com/jaredhanson/passport-http

Additionally, UI (browser elements) are created by use of the following libraries:

Package Name	Role	Reference
Angular.js	Model View Framework	https://angularjs.org/
Highcharts	Plotting support	https://www.highcharts.com/
NeXt UI	Topology visualisation	https://developer.cisco.com/codeexchange/github/repo/NeXt-UI/
Leaflet	Map Support	https://leafletjs.com/

6 Conclusions

One Stop API implementation has aligned with the Orchestration and FCAPS modules of the SliceNet platform as these have been the main elements that realise the layered approach in the context of the management procedures. It supports the three different roles through customised dashboard views that expose the catalogue and inventory information accordingly and additionally complements automation procedures by the appropriate processing of the catalogue and inventory information across business domains.

In the current phase OSA is being integrated in the three testbeds to support the envisaged Use Cases.

References

[1] https://slicenet.eu/ © SLICENET consortium 2017

[2] 3GPP TR 22.830: Feasibility Study on Business Role Models for Network Slicing

[3] 3GPP TR 28.801: Study on management and orchestration of network slicing for next generation network

[4] SliceNet, Deliverable 6.6, ”Single-Domain Slice FCAPS management,” 2019

[5] SliceNet, Deliverable 6.7, "Multi-Domain Slice FCAPS management," 2019

[6] SliceNet, Deliverable 7.1, “Cross-Plane Slice and Service Orchestrator,” 2019

[7] SliceNet, Deliverable 6.3, “Management for the Plug & Play Control Plane,” 2019

[8] SliceNet, Deliverable 8.1, “Northbound API Specification and Graphical Interface (Iteration I),” 2019

[9] SliceNet, Deliverable 4.3, “Network Slicing in Multi-tenant Virtualised Single-Domain Infrastructures,” 2018

[10] SliceNet, Deliverable D4.1, “Plug & Play Control Plane for Sliced Networks,” 2018

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