**APP NOTES**

# CloudCO-APPN-007 - SDN-based FANS service

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# 1 Summary/Objective

This application note establishes a Fixed Access Network Sharing service provided by an Infrastructure Provider (InP) via a fixed access CloudCO Domain architecture.

Section 6.1.1.1 of TR-384 indicates that the support of multiple tenants occurs via the E2E Service Orchestrator (SO) interacting with the same CloudCO Domain Orchestrator (CCO DO). Though the E2E SO is outside the CCO scope, it is worthwhile for a multi-tenancy service like FANS to make hypothesis about how/what interactions take place between the E2E SO and the CCO DO via the (FANS) NB API.

The FANS service is provided to a set of Virtual Network Operators (VNOs) by allocating to each of them access network resources available in the Cloud CO domain.

Each VNO takes control of logically and administratively separated L2 virtual Access Nodes presented as a whole access network asset on top of which to manage and operate, in an independent way, the services offered to the end customers.

The FANS service is achieved via the SDN enabled programmability available in the Cloud CO Domain, the capabilities in the Access SDN Manager & Controller and the Broadband Access Abstraction (BAA) layer functionalities and interfaces.

Main interactions among Cloud CO entities for the creation and activation of the FANS service are provided herein.

# 2 Assumptions and Preconditions

The following bullets narrow down the AppNote scope and technical/deployment variables to allow an easier description of the foreseen solution.

They are not necessarily prescriptive and some of them may be extended to widen the applicability of the AppNote.

The InP Cloud CO Domain instance is already fully bootstrapped.

The InP Cloud CO Domain consists of access network resources (for simplicity physical OLTs operating on a PON based FTTH architecture).

The CCO DO exposes to the VNOs (Service Tenants) a NB API that fulfill the FANS framework as agreed between the InP and the Service Tenants. This is realized by giving to VNOs the ability to connect to the FANS NB API of the CCO per the following options:

1. segregated and secured VNO Management System (MS) instances provided by the InP and accessed via e.g. service-client applications

2. each VNO has its own flavour of MS in terms of FCAPS management and flow control

3. a mix of the above

4. Regardless of the source of the VNO MS, this element shall support the standard FANS NB API.

Note: as discussed also at the 1Q18 meeting, having VNO Management System instances facilitate by the InP and accessed via remote clients through a VPN connection is just one way of exposing the NB API for FANS services. As mentioned CloudCO-APPN-006 , each tenant may have its own Management System, though in this case the verifications exercised on received commands by the CCO DO and Access SDN Manager & Controller (see below) are essential. Regardless of who provides the VNO MS, this system shall comply with the standard NB API specified for the CloudCO

In essence, there is a separation of interests, roles and responsibilities among CloudCO Provider (InP) and Service Tenants (VNOs) that administratively and technically is reflected by the deployed M&C elements and the operational interfaces that connect them.

Each VNO MS instance is dedicated to a VNO (e.g. VNOA) and accesses via the CCO NB API to:

• a geographical map of the access network resources (i.e. mainly a map of the deployed OLTs and ODN PONs location - e.g. street address - and the number of uplink interfaces)

• a L2-based service interface to configure and manage the OLTs logical resources

Note: the concepts of network map and of an L2 service based interface are schematically recalled in the two figures at the bottom of this AppNote.

The CCO DO, exposes also its resources to the OSS layer of a Network Operation Tenant (i.e. one or more InP departments).

# 3 Description of the System

A VNO who accesses the E2E SO has its own configuration view because of its specific service models, compared to other tenants.

The VNO MS, residing inside the E2E SO, sends L2 service requests to Access SDN Manager & Controller via the FANS API exposed by the CCO DO.

- The CCO DO verifies that the received L2 service request fulfills the profiles offered by the InP per the FANS framework, the existing commercial agreements with that specific VNO and resource accessibility/availability.
- Then the CCO DO passes the request to the Access SDN Manager & Controller to create/configure the selected L2 resources on the target OLT via the transcoding table in the Port Mapper.
- The Access SDN Manager & Controller verifies if the received request can be accomplished based on technological and traffic-engineering logics and if so it identifies the appropriate L1 profile to get to a full blown L1&L2 configuration. Then the Access SDN Manager & Controller sends the L1&L2 configuration to the BAA layer.
- The BAA layer updates its local representation of the target OLT and, if this latter is reachable, it issues via its SBI the appropriate vendor-specific commands.

The Access SDN Manager & Controller updates the OLT representation of logical L2 resources assigned to the VNO (i.e. the vOLTA representation exposed to VNO AMS).

The CCO DO updates, if needed, the transcoding table of the Port Mapper.

- Depending on the successful or unsuccessful result of the L2 service request at the CCO DO or Access M&C a positive or negative notification is sent to VNO MS.

The L2-based service interface (i.e. the FANS NB API aka Os-Ma-ccodo per TR-384 nomenclature) exposed to the VNOs via the MS application allows access to, at least, the attributes listed below.

## Remark about the nature of the FANS NB API exposed to VNOs

The parameters set below expresses a FANS service based on a pure L2 abstraction of the shared AN resources that enables VNOs to consume such parameters quite granularly.

Indeed, the actual set of parameters exposed at the FANS NB API as well as their degree of abstraction of their representation on the VNO MS depends on the technical, commercial and/or regulatory agreements of each deployment environment.

For example, with regard to the set below, one may envision:

- a deeper and more granular access including also physical layer parameters (e.g. mapping or even configuring of T-CONT, handling of DBA parameters, relaying of ONT authentication information) which, along with a higher degree of management, entails more complexity/responsibility in the configuration of the shared AN resource on the part of the VNO.

OR, going towards the other direction,

- an even more abstract exposure of L2 parameters belonging to a pre-defined set of service profiles that the InP, based on its knowledge and upon concertation with VNOs, configures and exposes via the FANS NB API. This offers to VNOs a lower degree of management but also less complexity in consuming their portion of the AN resource.

Regardless of the degree of layer-depth and service-abstraction of the FANS NB API, the technical solution requires the support of separation of roles and of accessed resource-sets ( role-based/responsibility-separation property), at least at the level of the Access SDN Manager & Controller. This is to allow a secure and segregated interaction to the VNOs and to grant instead a full management, control, orchestration and administration to the InP.

At the uplink port (V ref. point) of a target OLT: Configuration

– # of VNO dedicated VLANs (likely in the form of S-VLANs in a Q-in-Q scheme)

– S-VLAN Downlink/Uplink bandwidths (guaranteed/peak/...)

– per S-VLAN priority

– per S-VLAN Id (may be assigned by the InP rather than arbitrarily chosen by the VNO)

– per S-VLAN L2 PM commands

– per S-VLAN L2 alarm reporting commands

– ...

### Parameters configurable per each S-VLAN:

– # of C-VLANs

– per C-VLAN Downlink/Uplink bandwidths (guaranteed/peak/...)

– per C-VLAN priority

– per C-VLAN Id

– per C-VLAN L2 PM commands

– per C-VLAN L2 alarm reporting commands

– ...

### Monitoring

– OLT status

– Monitoring of all the above parameters

– per S-VLAN trunk status

– per S-VLAN L2 PM counters

– per S-VLAN L2 alarms

– per C-VLAN L2 PM counters
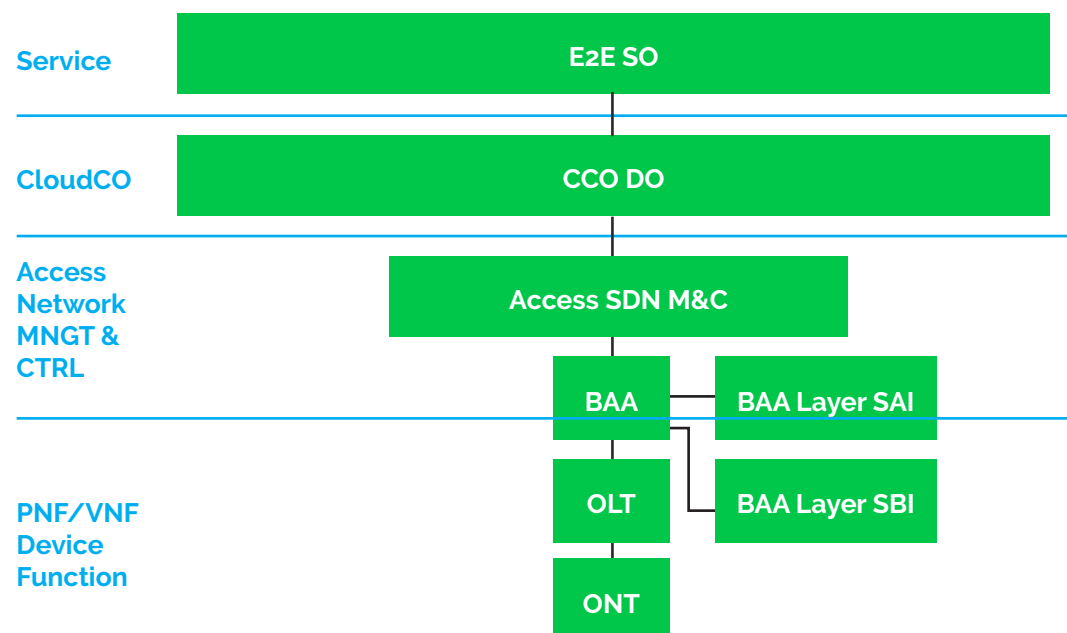
– per C-VLAN L2 alarms

– ...

### At an ONT (U ref. point) at a PON tree end of a target OLT:

### Configuration

– # of VLANs

– per-VLAN mapping to specific "VNO VLAN" on specific OLT uplink port

– per-VLAN DS/US bandwidths (guaranteed/peak/...)

– per-VLAN priority

– per-VLAN Id

– per-VLAN L2 PM commands

– per-VLAN L2 alarm reporting commands

– ...

### Monitoring

– ONT status

– Monitoring of all the above parameters

– per-VLAN trunk status

– L2 PM counters

– L2 alarms

– ...

| | |
|---|---|
| **Service** | **E2E SO** |
| **CloudCO** | **CCO DO** |
| **Access Network MNGT & CTRL** | **Access SDN M&C** |
| | **BAA** — **BAA Layer SAI** |
| **PNF/VNF Device Function** | **OLT** — **BAA Layer SBI** |
| | **ONT** |

**NOTE:** as explained at the 1Q18 meeting, this figure shows a CCO system mainly based on an pure SDN chain down to the "end Access Network Functions". This does not aim to deny the presence of some NFVI and related management and orchestration components. Still for an access-only application like FANS, all Data Plane Access Functions are supposed to stay in the PNFs (this is the outcome of the Access Node decomposition analysis in section 5.2.6 of TR-384.

The CCO DO, Access SDN M&C and BAA layer are indeed sw modules that run over hosts but these processes, once instantiate and bootstrapped in a given point in time, have not the typical cloud native lifecycle of Data Plane VNFs.

# 4 Components

| Component Framework Name | Component Description |
|---|---|
| **CCO DO** | Cloud Co Domain Orchestrator: TR-384, WT-411. |
| | Exposes the NB API per the agreed FANS framework and the Port Mapper transcoding. |
| **Access SDN M&C** | Access SDN Access SDN Manager and Controller: TR-384, WT-411, WT-413 Provides SDN Management and Control of the OLTs via the BAA layer and propagates OLTs map and status to the upper layers. |
| | This element can also manage VNFs in the access segment. |
| **BAA** | Broadband Access Abstraction layer: TR-384, WT-411, WT-413, WT-xxx (placeholder for BAA layer spec) |
| | Adapts and abstracts the management and control of the OLTs. |
| **OLT** | OLT Access PNF |
| **ONT** | ONT Access PNF |

# 5 Actors

| Actor Name | Actor Description | Actions at CCO Perimeter (CCO DO NBI, User action) |
|---|---|---|
| **Infrastructure Provider (InP)** | InP is the owner of a physical access network infrastructure and provides L2-based FANS service to a set of VNOs while exercising Network Operation activities via its OSSes. | See Actor Description |
| **Virtual Network Operator(s) (VNOs)** | VNOs are the users of the FANS services as a virtual access network facility to provide retail services to their end customers. | See Actor Description |

# 6 Interactions

## 6.1    Interaction 1: VNO Network Creation

1. T
1. o      The CCO DO exposes to the VNO MS a network map of OLTs consistently with the VNO requested OLT list and a L2-based service interface to configure and manage the OLTs logical resources.
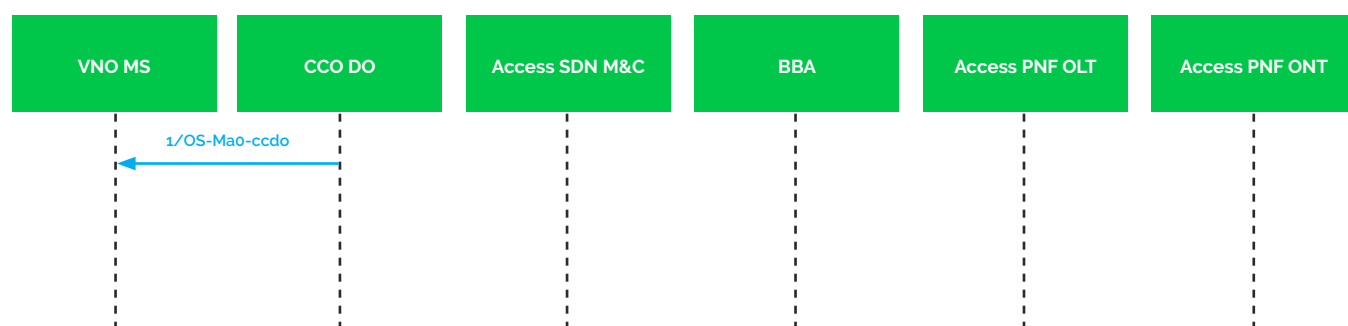


## 6.2    Interaction 2: VNO OLT Uplink L2 Service Creation

1. 1The CCO DO receives a OLT Uplink L2 servicerequest from the VNO MS (in the E2E SO) via the L2-based service NB API.
   NOTE: as mentioned at the 1Q18 meeting, the requests highlighted in bold in Interaction 2, here, and 3 and 5 follow all the same flow diagram in passing through the involved blocks down to the OLT.
2. The CCO DO verifies that the request fulfills the profiles offered by the InP per the FANS framework, the existing commercial agreements with that specific VNO and resource accessibility/availability.
   The CCO DO passes the request to the Access SDN Manager & Controller to create/configure the selected L2 resources on the target OLT via the transcoding table in the Port Mapper.
3. The CCO DO sends a negative notification to the VNO MS if the L2 service request cannot be fulfilled.
4. The Access SDN Manager & Controller verifies if the received request can be accomplished based on technological and traffic-engineering logics and if so it identifies the appropriate L1 profile to get to a full blown L1&L2 configuration.
   The Access SDN Manager & Controller sends the L1&L2 configuration to the BAA layer.
5. The Access SDN Manager & Controller sends, through the CCO DO, a negative notification to the VNO MS if the L2 service request cannot be fulfilled.
6. The BAA layer updates its local representation of the target OLT and, if this latter is reachable, it issues via its SBI the appropriate vendorâ€'specific commands.
7. The BAA layer notifies to the Access SDN Manager & Controller that the command has been fullfilled(or it is pending --- not reflected in the bullets and diagram below).
8. The Access SDN Manager & Controller sends to the CCO DO a positive notification.

9. The CCO DO updates the OLT representation of logical L2 resources assigned to the VNO (i.e. the vOLTA representation exposed to VNOA MS) sends to the VNO MS a positive notification (only when the command is fulfilled)
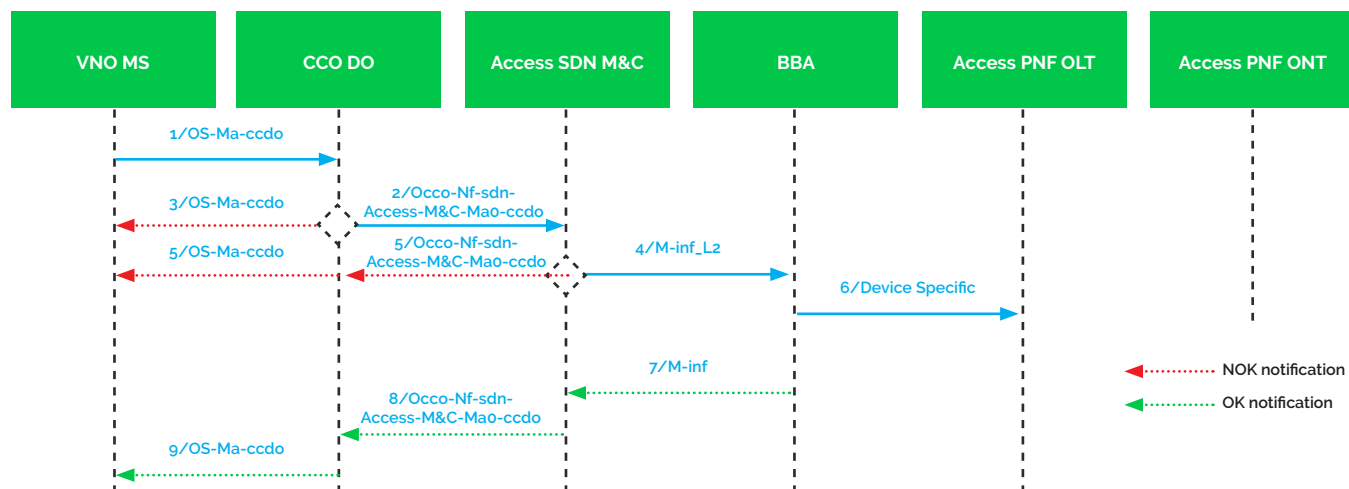


## 6.3    Interaction 3: VNO ONT L2 Service Creation

1. The CCO DO receives a ONT L2 service request from the VNO MS (in the E2E SO) via the L2-based service NB API.

Same steps from 2 to 9 as per Interaction 2: VNO OLT Uplink L2 Service Creation.

Same ladder diagram as per Interaction 2: VNO OLT Uplink L2 Service Creation.

## 6.4

## 6.5    Interaction 4: VNO ONT activation

1. Upon physical connection of the ONT (hypothesis: provided/installed by InP) to the PON termination point at the VNO's Customer premises, the ONT is switched-on and a L1 communication link between to the OLT and the ONT is established via ONT authentication mechanism (hypothesis: BAA assisted | simplification not to be taken for real deployments: the ONT is recognized without any check, e.g. Serial Number).
2. The BAA layer configures, via the OLT, the ONT with the L2 service requested by the VNO.
3. The BAA layer notifies to the Access SDN Manager & Controller that the L2 service configuration command has been fullfilled.
4. The Access SDN Manager & Controller sends to the CCO DO a positive notification on ONT L2 service configuration.
5. The CCO DO updates the OLT representation of logical L2 resources assigned to the VNO (i.e. the vOLT Arepresentation exposed to VNO AMS).
   The CCO DO sends to the VNO MS a positive notification on the fulfillment of the L2 service request.

*Behavior beyond the CCO boundaries: upon receipt of this notification the VNO is able to deliver the service to the end customer. Such a notification might be accompanied by a monitoring report testifying the establishment of the requested L2 service.*
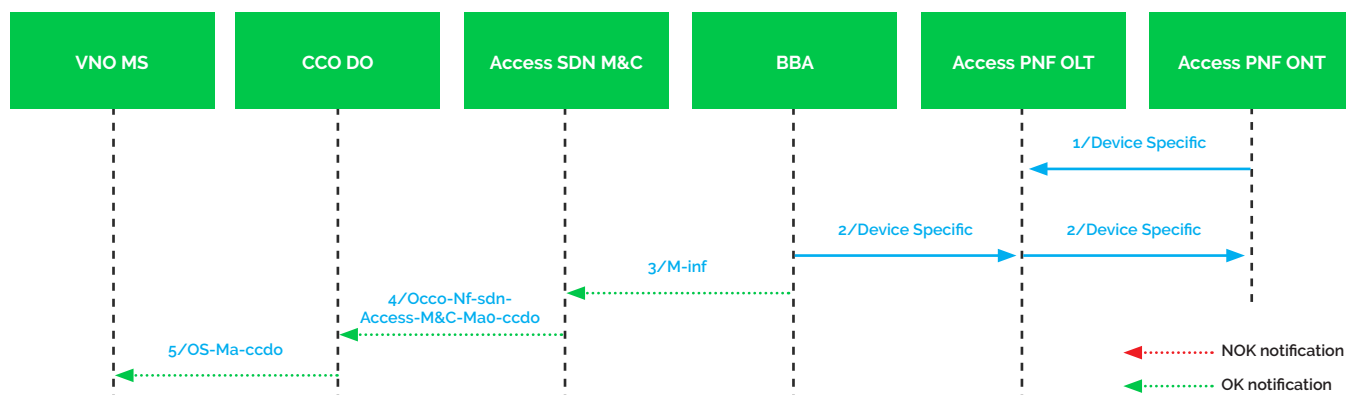
## 6.6  Interaction 5: VNO ONT L2 Performance Monitoring

1. The CCO DO receives a ONT L2 performance monitoringrequest from the VNO MS (in the E2E SO) via the L2-based service NB API.
   Same steps from 2 to 9 as per Interaction 2: VNO OLT Uplink L2 Service Creation.Same ladder diagram as per Interaction 2: VNO OLT Uplink L2 Service Creation.

2. The ONT sends to the OLT the measured PM counters at the configured collection frequency.

3. The OLT sends the PM counters to the BAA layer which adapts them to the standard DM.

4. The BAA layer sends the standard-format PM counters to the Access SDN Manager & Controller which stores them.

5. The Access SDN Manager & Controller sends the collected PM counters the CCO DO.

6. The CCO DO makes the collected PM counters available to VNO MS via the OLT representation of logical L2 resources assigned to the VNO (i.e. the vOLT A representation exposed to VNOA MS).
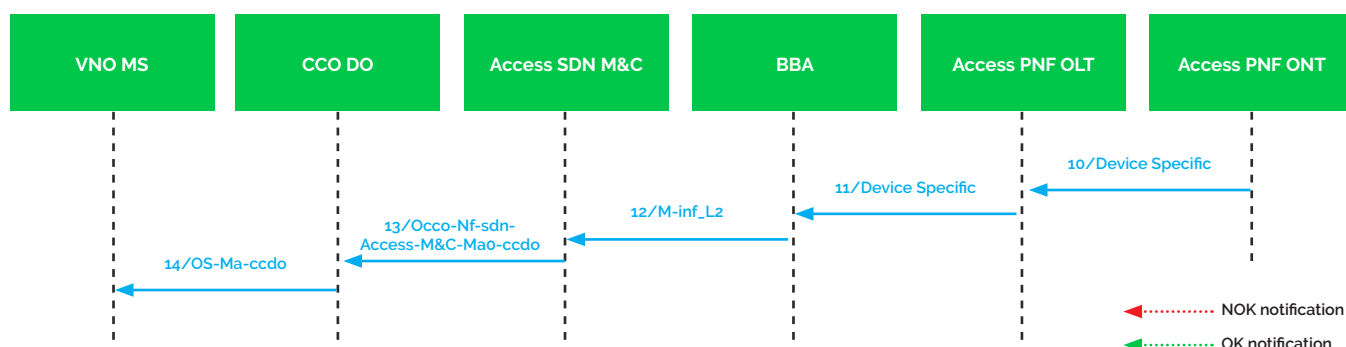


## 6.7  Interaction 6: Customer Migration

A VNOA's customer wants to migrate its services to VNOB. Since both VNOs terminating on the same target OLT, there is no need for manual intervention on the target OLT because the physical port which the customer is connected to remains the same after the migration.

1. The CCO DO receives a " Customer Migration" request in the form of a " Customer-J release" from VNOA MS and "Customer-J activation and ONT L2 Service Creation" from VNOB MS.

NOTE: the above interaction is illustrative, not prescriptive, of the way the involved actors may interact to communicate the migration of a customer from one VNO to another.

In this case it is assumed that administratively the "migration procedure" requires that both involved VNOs issue a command about the same customer (release vs activation). Furthermore, it is assumed that the customer activation [administrative command] is issued together with the ONT configuration [operational command] that allows to reprovision the customer over the new connectivity to avoid/minimize service downtime.

**2.** The CCO DO, once received all relevant communications per the agreed "migration procedure", updates the transcoding table of the Port Mapper.

The CCO DO updates the OLT representation of logical L2 resources assigned to VNOs by:

- removing Customer-J termination from VNOA's manageable resources and sends to VNOA MS a positive notification of the customer release command.

- adding Customer-J termination to VNOB's manageable resources and sends to VNOB MS a positive notification of the customer activation command.

At this point the customer is administratively released from VNOA and activated for VNOB. No configuration over the OLT and ONT has taken place yet affecting the Data Plane.

The operational part of VNOB's command (i.e. ONT L2 Service Creation) will then take place with the same steps of Interaction 3: VNO ONT L2 Service Creation. The only difference being that with the ONT already connected, in step 6 of Interaction 3, the BAA configures both the OLT and, via the OLT itself, the ONT (see red circle in the ladder diagram). Then Interaction 4: VNO ONT activation has to be applied for configuring the new service profiles at the ONT level.

The steps related to ONT service configuration are note reported explicitly as bullets but just copied from Interaction 3: VNO ONT L2 Service Creation, with the same numbering, in the ladder diagram below.
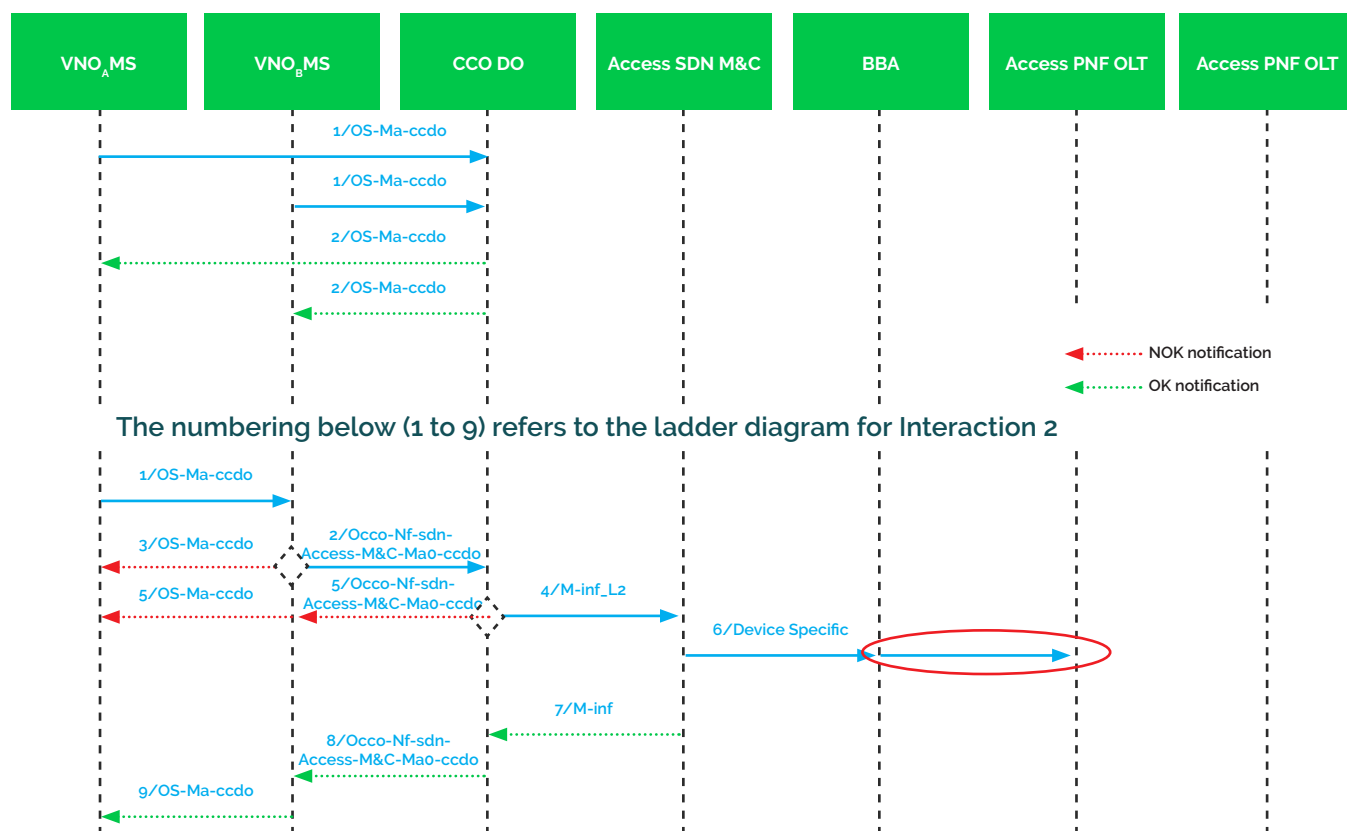
# 7 Success Criteria

**Interaction 1:**

**1.** VNOs can access to the OLTs network map per the list agreed with the Inp

**Interaction 2:**

**1.** L2 resources of the target OLT uplink are configured and allocated per VNO request

**2.** InP's full network view and VNO's scoped network view are updated per the above configuration


**Interaction 3:**

**1.** L2 resources of the target ONT are configured and allocated per VNO request

**2.** InP's full network view and VNO's scoped network view are updated per the above configuration


**Interaction 4:**

**1.** L1 and L2 connectivity is established between the ONT and the OLT's uplink interface

**2.** A notification is generated on the VNO MS


**Interaction 5:**

**1.** L2 PM collection is carried out as configured

**2.** Collected L2 PM counters are reported and stored in the Access Manager & Controller

**3.** Collected L2 PM counters are made availbale to the VNO MS
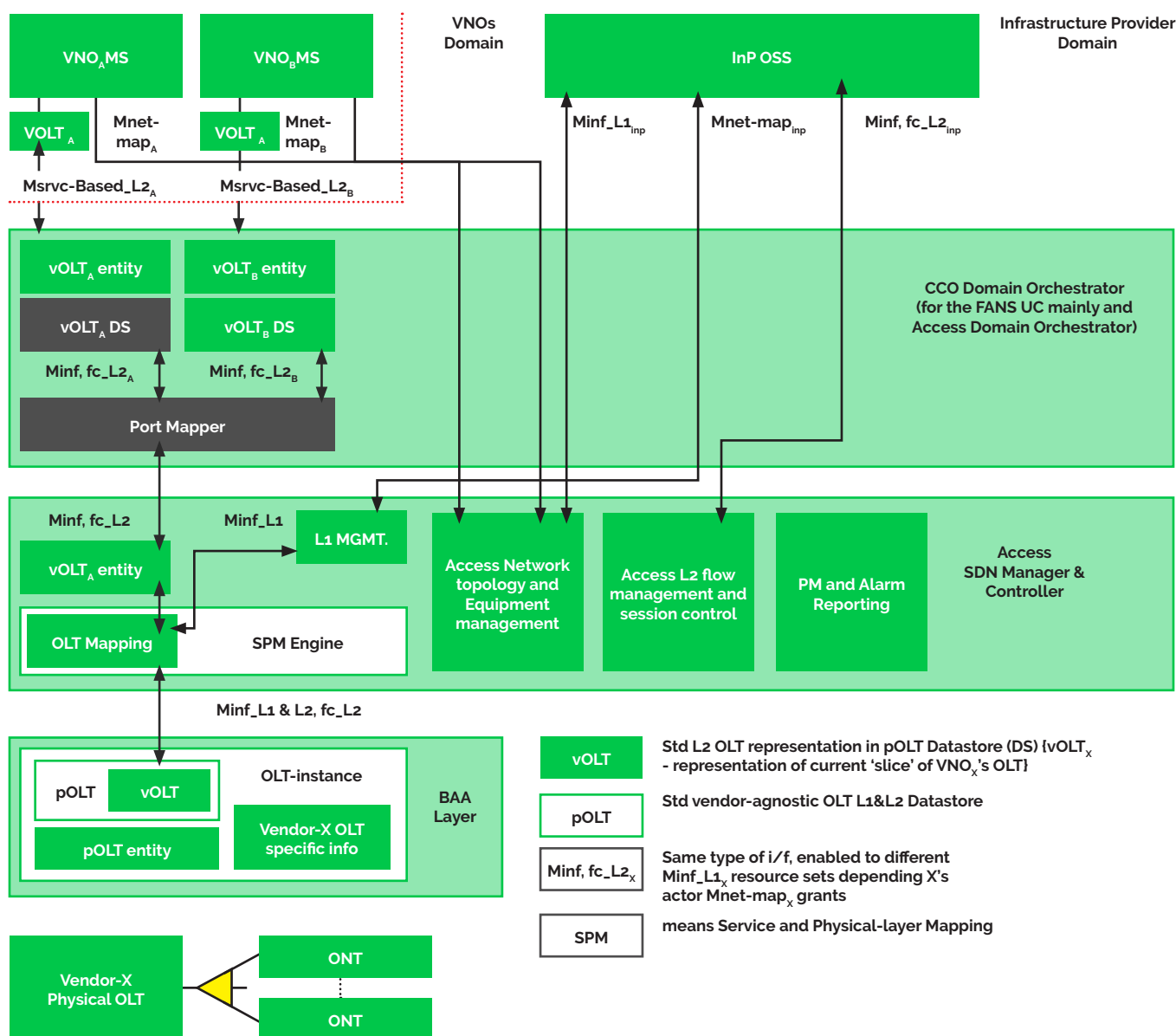
**Interaction 6:**

**1.** The customer migration is completed successfully and the customer can access to connectivity and services through VNOB network.
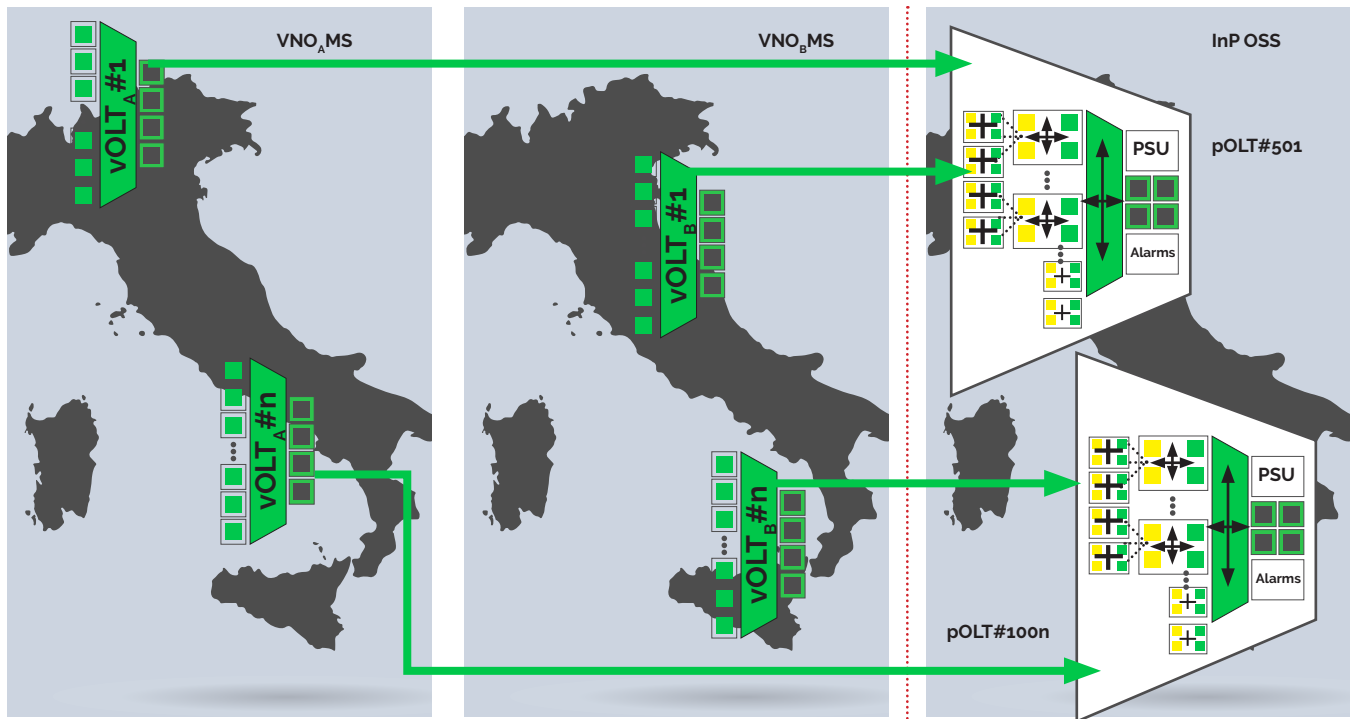
# 8 Appendix – Support figures

Disclaimer: this appendix is not part of the current AppNote template

The following figures provide a detailed view of functional elements the the authors consider necessary within each block of the System Description to implement the described interactions.

These are not prescriptive, however they are expected to help discussion and identification of actuall functionalities in real world solutions.

**VNOs Domain**

**Infrastructure Provider Domain**

$VNO_A MS$ | $VNO_B MS$ | InP OSS

$VOLT_A$ | Mnet-$map_A$ | $VOLT_A$ | Mnet-$map_B$

$Minf\_L1_{inp}$ | Mnet-$map_{inp}$ | Minf, $fc\_L2_{inp}$

Msrvc-Based_$L2_A$ | Msrvc-Based_$L2_B$

$vOLT_A$ entity | $vOLT_B$ entity

$vOLT_A$ DS | $vOLT_B$ DS

**CCO Domain Orchestrator (for the FANS UC mainly and Access Domain Orchestrator)**

Minf, $fc\_L2_A$ | Minf, $fc\_L2_B$

**Port Mapper**

Minf, fc_L2 | Minf_L1

$vOLT_A$ entity | L1 MGMT.

OLT Mapping | SPM Engine

**Access Network topology and Equipment management**

**Access L2 flow management and session control**

**PM and Alarm Reporting**

**Access SDN Manager & Controller**

Minf_L1 & L2, fc_L2

OLT-instance

pOLT | vOLT

pOLT entity | Vendor-X OLT specific info

**BAA Layer**

**Vendor-X Physical OLT** | ONT | ONT

vOLT — Std L2 OLT representation in pOLT Datastore (DS) {$vOLT_x$ - representation of current 'slice' of $VNO_x$'s OLT}

pOLT — Std vendor-agnostic OLT L1&L2 Datastore

Minf, $fc\_L2_x$ — Same type of i/f, enabled to different $Minf\_L1_x$ resource sets depending X's actor Mnet-$map_x$ grants

SPM — means Service and Physical-layer Mapping

VNO$_A$MS

VNO$_B$MS

InP OSS

vOLT$_A$ #1

vOLT$_B$ #1

vOLT$_A$ #n

vOLT$_B$ #n

PSU

Alarms

pOLT#501

PSU

Alarms

pOLT#100n

**Exposed per-VLAN L2 services on ONTs:**

· # of vLANs

· DS/US b/w

· priority

· Id

· L2 PM commands

· L2 alarm reporting

· ...

vOLT$_A$ #1
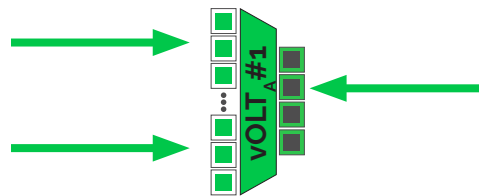
**VNOs/InP network maps and parameters exposed on FANS L2 service interfaces**

**Exposed per-VLAN L2 services on OLT uplink interfaces:**

· # of VNO vLANs

· Dlnk/Ulnk b/w

· priority

· Id

· L2 PM commands

· L2 alarm reporting

· ...

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