E2E Network Slicing use case overview

Participants: CMCC, Wipro, Huawei, AT&T, IBM, LTTS, DT, TIM, QCT, Amdocs, Tech Mahindra, Reliance Jio, Tencent, China Telecom

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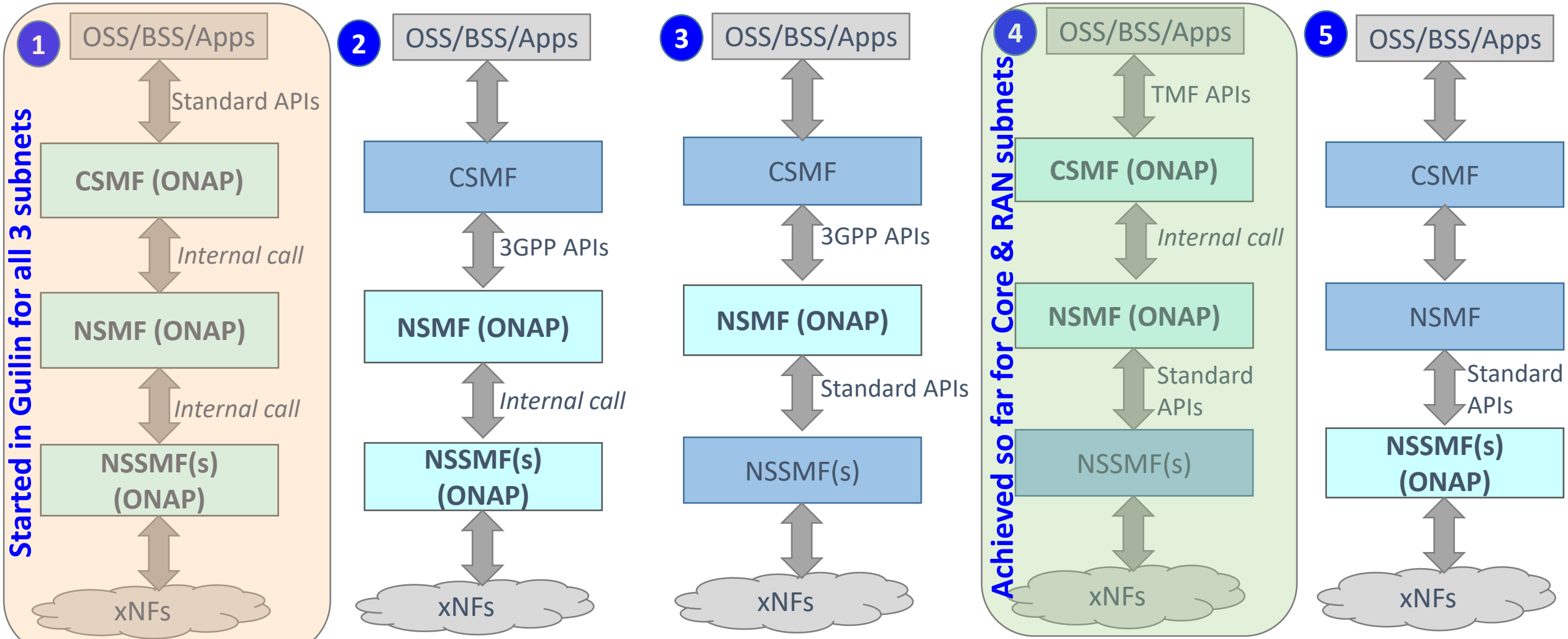
3GPP Slice Management Functions (3GPP-defined)

Management Function	Key tasks
Communication Service Management Function (CSMF)	• Responsible for translating the communication service-related requirement to network slice related requirements. • Communicate with Network Slice Management Function (NSMF).
Network Slice Management Function (NSMF)	• Responsible for management and orchestration of Network Slice Instances (NSIs). • Derive network slice subnet related requirements from network slice related requirements. • Communicate with the Network Slice Subnet Management Function (NSSMF) and Communication Service Management Function.
Network Slice Sub-net Management Function (NSSMF)	• Responsible for management and orchestration of Network Slice Sub-net Instances (NSSIs). • Communicate with the NSMF.

Ref.: 3GPP

ONAP-based Slice Management Overall Architecture Choices

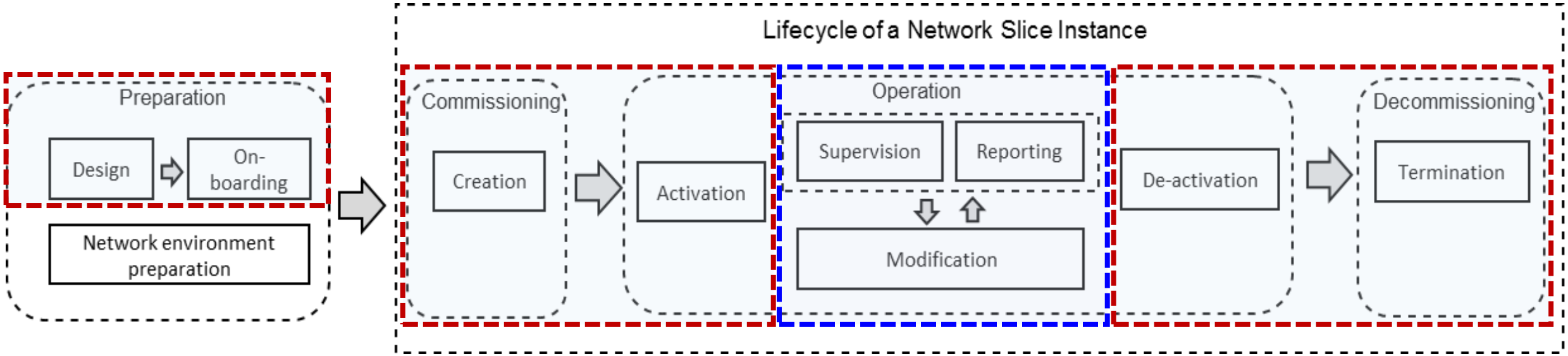


3rd party component

In H-release, we will mainly continue with enhancements for Scenario 1, and address a few gaps in Scenario 4.

ONAP-based Slice Management - NSI Life Cycle view

Objective: Demonstrate e2e slice design, instantiation and operation, including RAN, core and transport slice sub-nets.



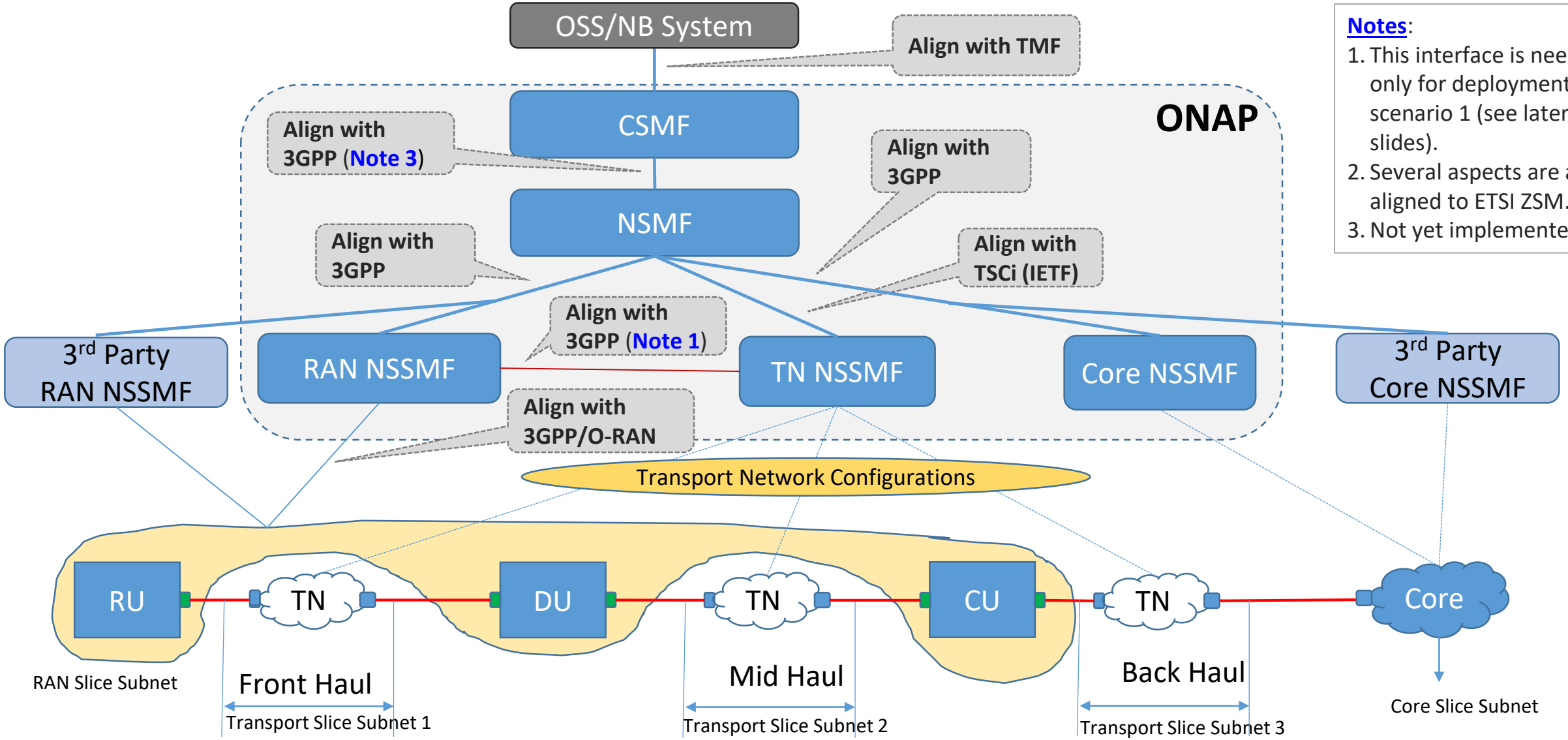
Ref.: 3GPP TS 28.530

Frankfurt/Guilin scope

Focus area for Honolulu for new functionality

- **Design and pre-provision**: Creation of necessary slice/slice sub-net templates.
- **Instantiation/Configuration, Activation/Deactivation and deallocation/termination** of NSIs, including its constituent NSSIs (RAN, Core and Transport).

E2E Network Slicing: Architecture & Interfaces

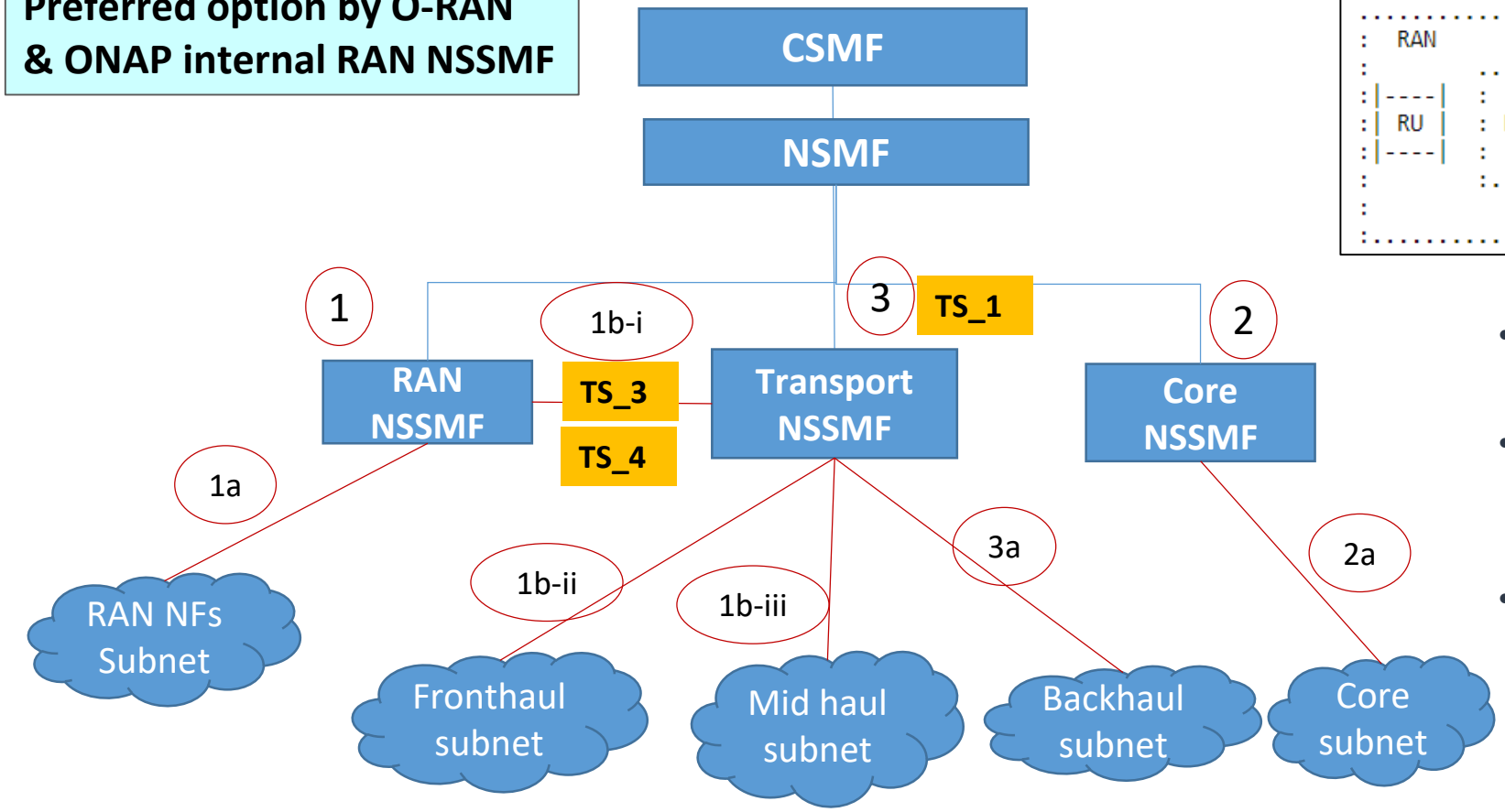


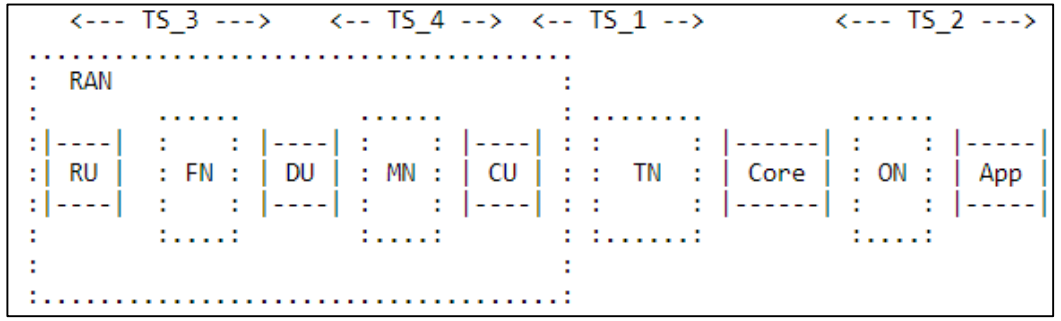
Notes:

1. This interface is needed only for deployment scenario 1 (see later slides).
2. Several aspects are also aligned to ETSI ZSM.
3. Not yet implemented

RAN & Transport Slicing: Scenario 1

Preferred option by O-RAN & ONAP internal RAN NSSMF



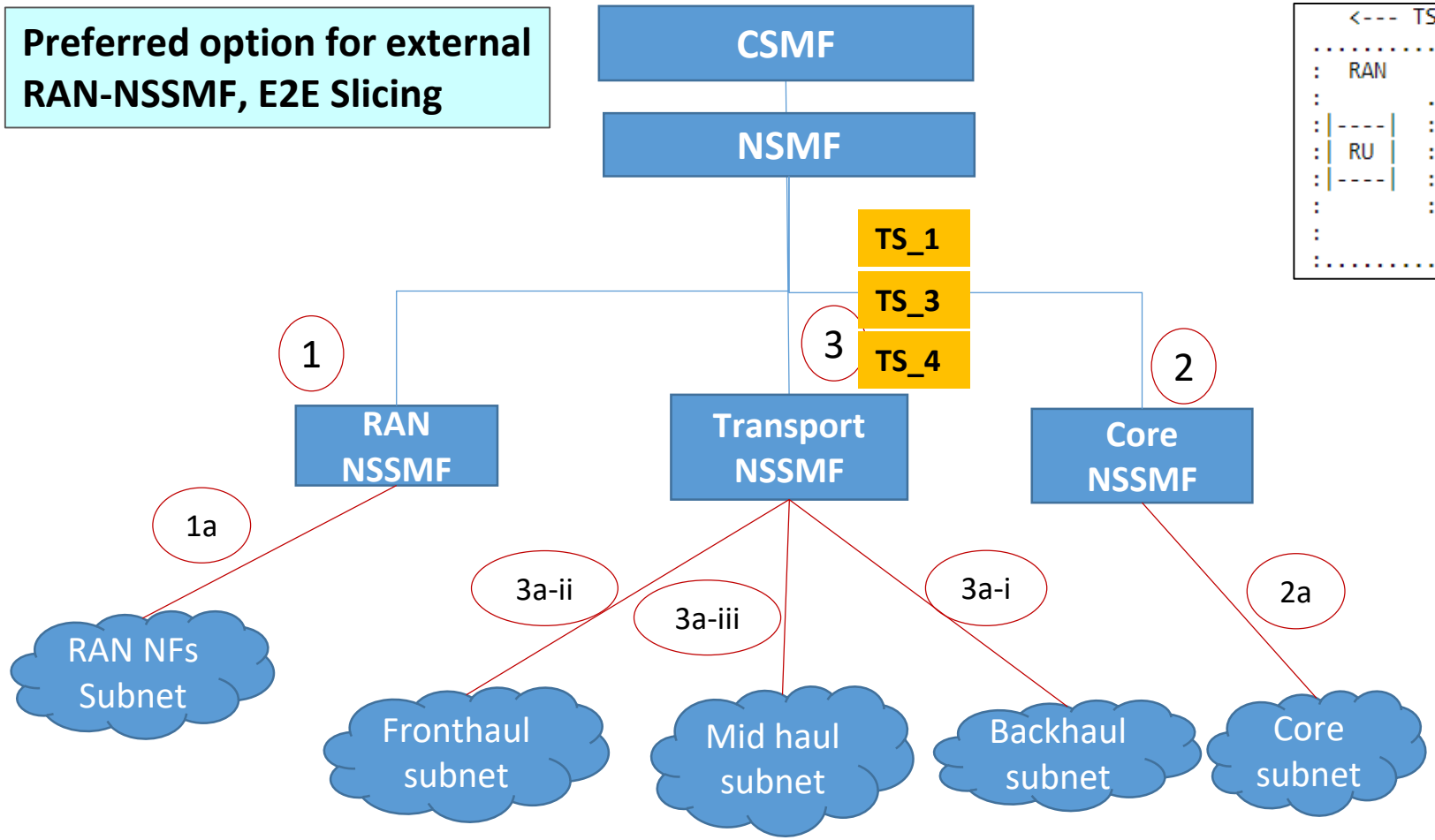


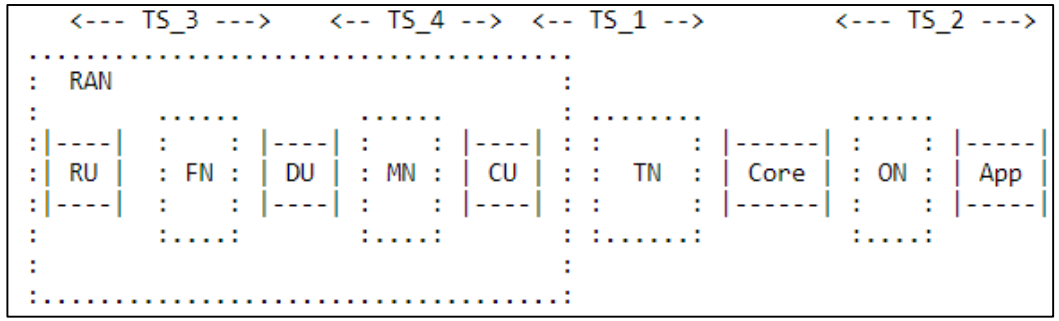
- TS_1 is backhaul transport slice; TS_3, fronthaul; TS_4, midhaul.
- TN MD (T-NSSMF) receives TS_1 from NSMF (step 3), and TS_3 and TS_4 from RAN NSSMF (step 1b-i).
- TN MD then configures backhaul (3a), fronthaul (1b-ii), and midhaul (1b-iii), respectively.

- **RAN NSSMF shall be responsible for determination of Slice Profile of FH, MH and RAN NFs.**
- **RAN NSSMF shall be responsible for entire RAN subnet comprising FH and MH (stitching together, CL actions, etc.)**

RAN & Transport Slicing: Scenario 2

Preferred option for external RAN-NSSMF, E2E Slicing

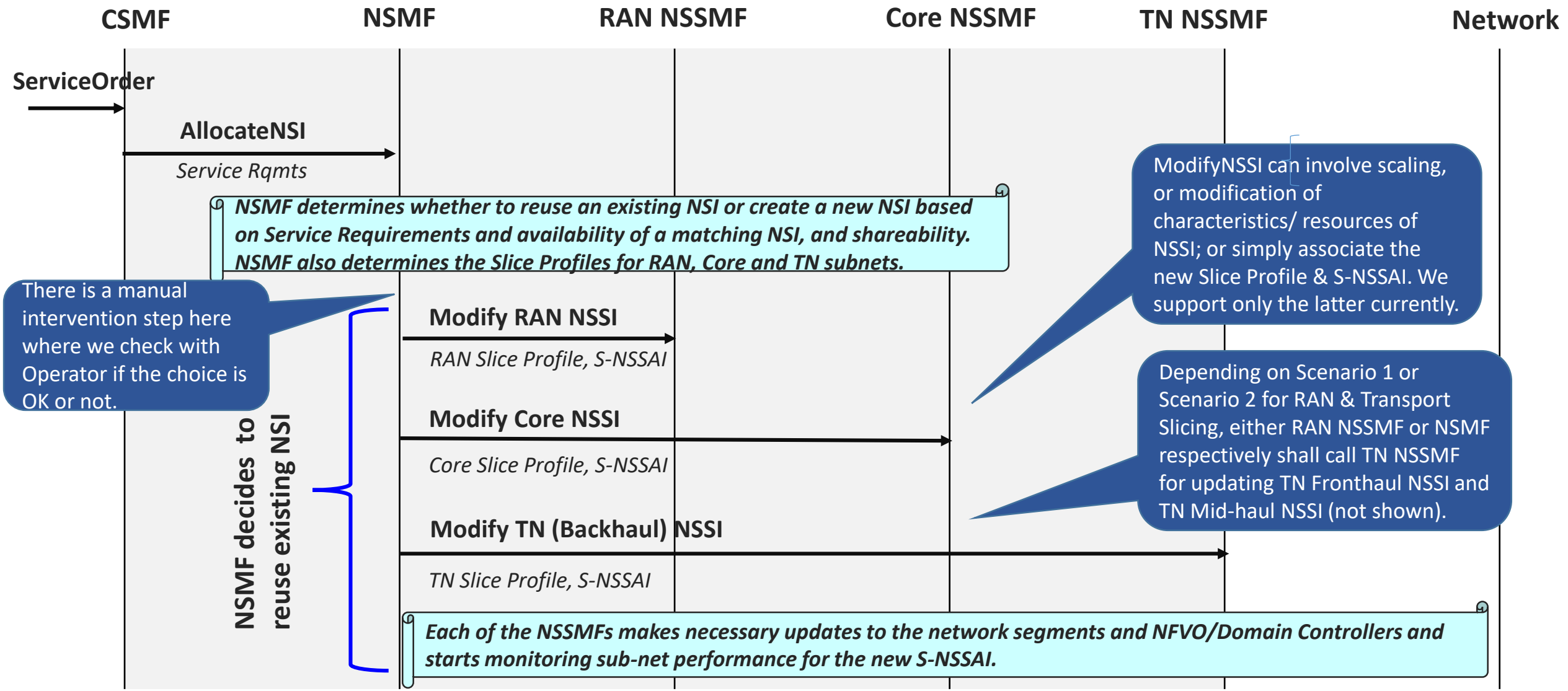




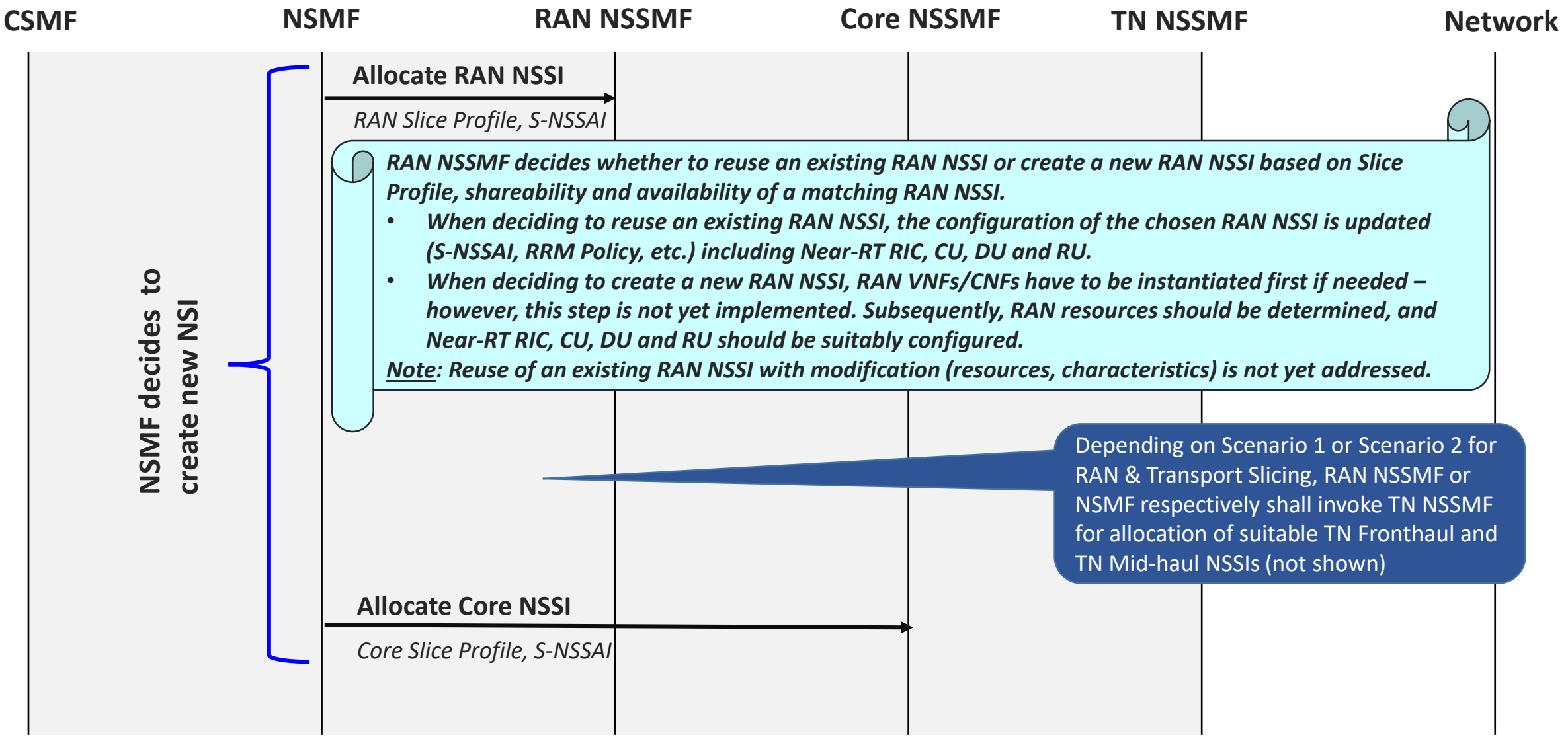
- TS_1 is backhaul transport slice; TS_3, fronthaul; TS_4, midhaul.
- TN MD (T-NSSMF) receives TS_1, TS_3 and TS_4 from NSMF (step 3).
- TN MD then configures backhaul (3a-i), fronthaul (3a-ii), and midhaul (3a-iii), respectively.

- **NSMF shall be responsible for determination of Slice Profile of FH, MH and RAN NFs.**
- **NSMF shall be responsible for stitching together e2e slice including FH and MH.**

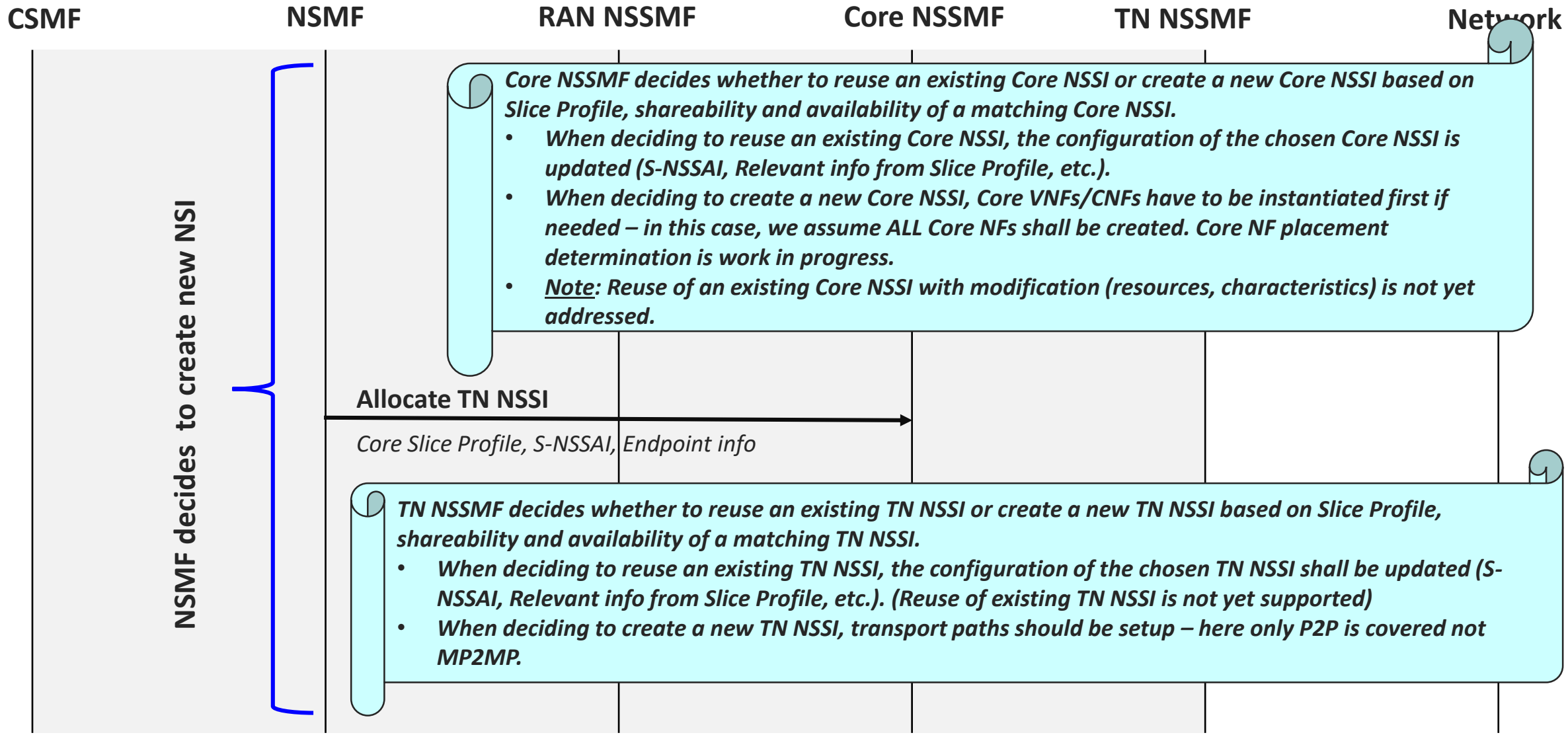
High-level flow for Allocating a Slice



High-level flow for Allocating a Slice



High-level flow for Allocating a Slice

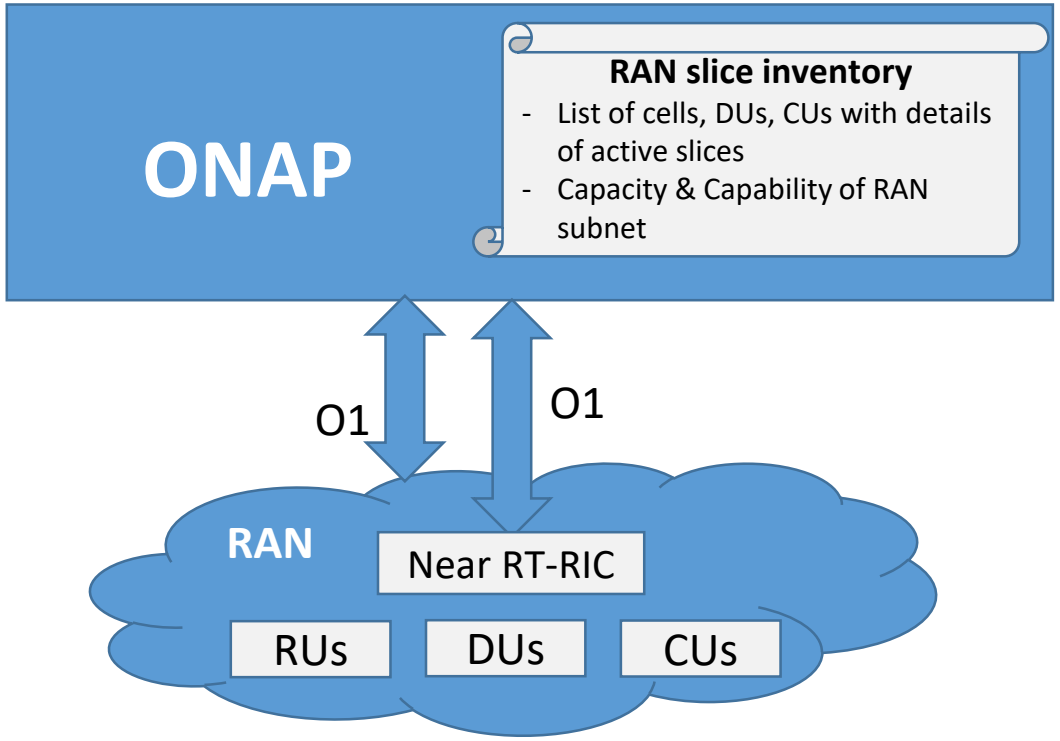


RAN Slicing – Current Implementation

- Select RAN NSSI, determine RAN slice sub-net resources and then configure the RAN slice sub-net including allocation of ‘resources’ for a slice sub-net instance and configuration of RAN for a slice sub-net instance (including cell configuration)
- Consume necessary PM/FM info from RAN, for simple Closed Loop Actions/Intelligent Slicing
- Re-configure/re-allocate RAN resources

Assumptions

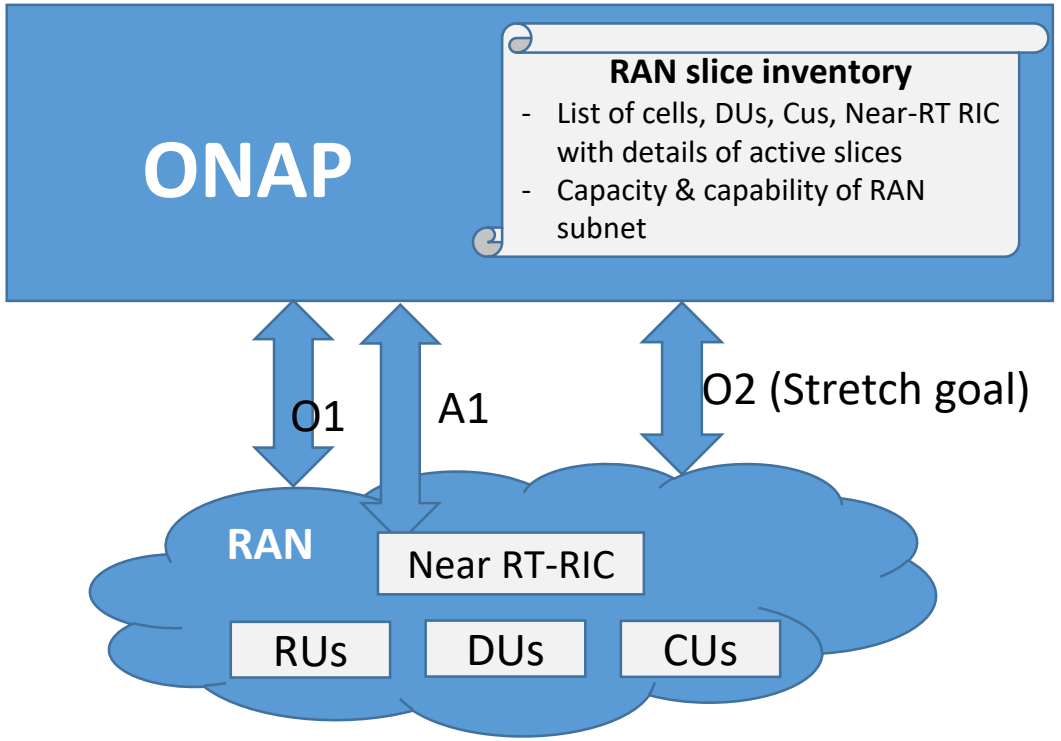
- All RAN xNFs are created and pre-configured
- Config DB is assumed to contain cell details including PNF mapping, etc.
- Southbound interface from SDN-C (R) will be netconf for CM, and VES for FM/PM. For FM/PM we will align with O-RAN/3GPP.



Note: O2 interface not considered in scope for RAN Slicing, as the RAN xNFs are assumed to be pre-instantiated as part of the preparation phase.

RAN Slicing: Next Steps

- **Instantiate RAN NFs, RAN "service" and perform initial configuration** (O2 is a stretch goal) **as part of slice allocation actions**
- **Support end-point related enhancements for E2E Slicing and RAN<->TN interactions**
- **Map RAN Slice Profile to each Near-RT RIC-level configuration (also align with RRM Policy)**
- **Support A1 interface for Closed Loop and AI/ML based config update guidance**
- **Consume necessary PM/FM info from RAN, for Closed Loop Actions/Intelligent Slicing**
- **Appropriately configure/re-configure RAN resources (dependency on O-RAN models)**
- Appropriate RAN resource determination is a stretch goal

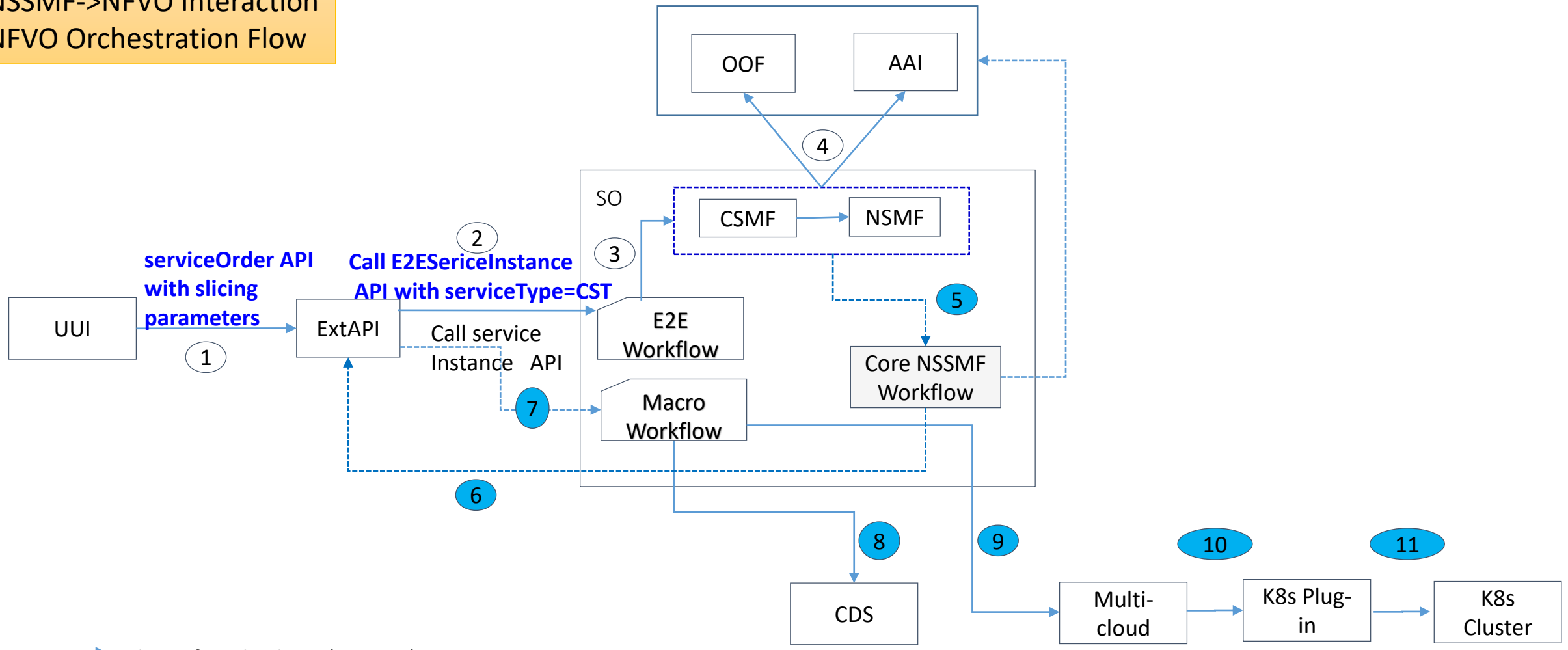


Notes

1. O2 interface is considered as a stretch goal for RAN Slicing
2. Alignment with O-RAN information models to be considered in scope.
3. **Only a part of the CPS impacts may be considered in this release.**
4. TA <-> Cell mapping inventory to reside in C&PS/Config DB

Core Slicing: Creation of new Core NSSI

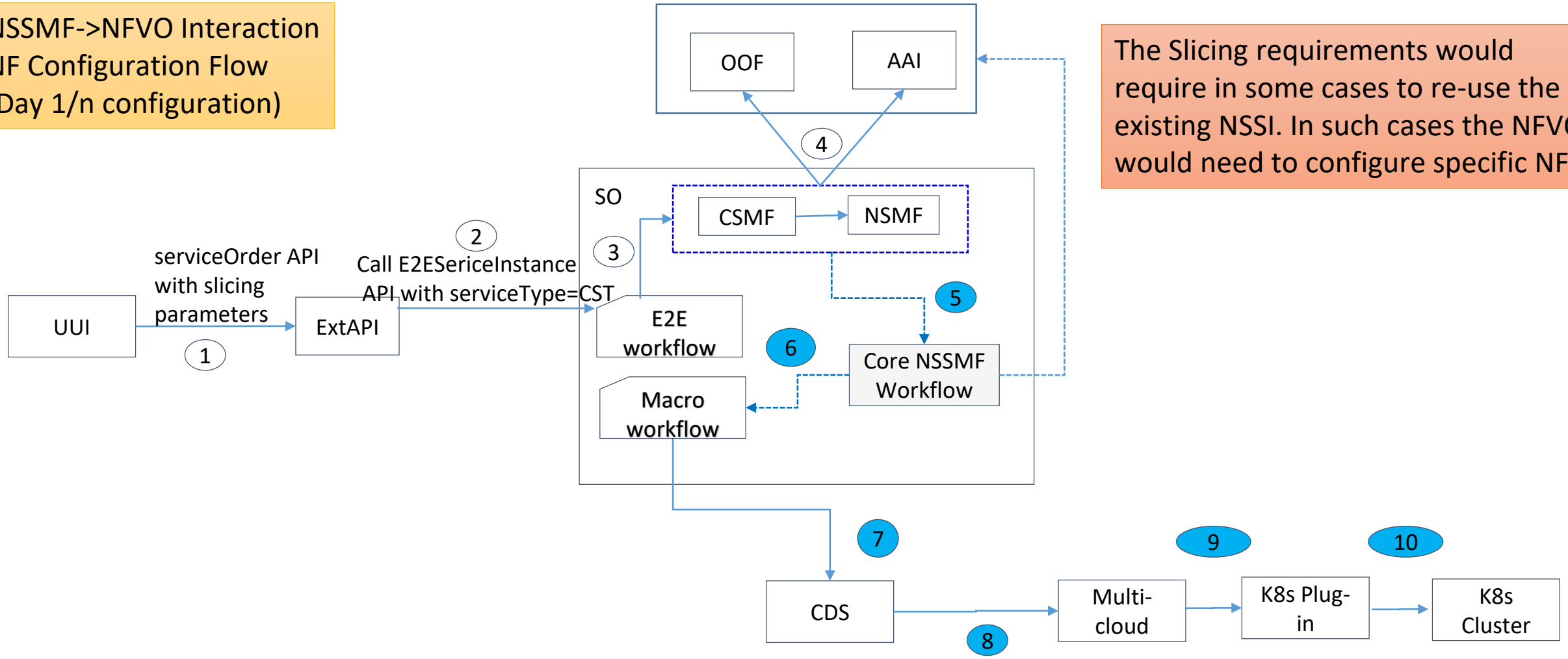
NSSMF->NFVO Interaction
NFVO Orchestration Flow



Solution based on ONAP Frankfurt release features

Core Slicing: Reuse existing Core NSSI

NSSMF->NFVO Interaction
NF Configuration Flow
(Day 1/n configuration)



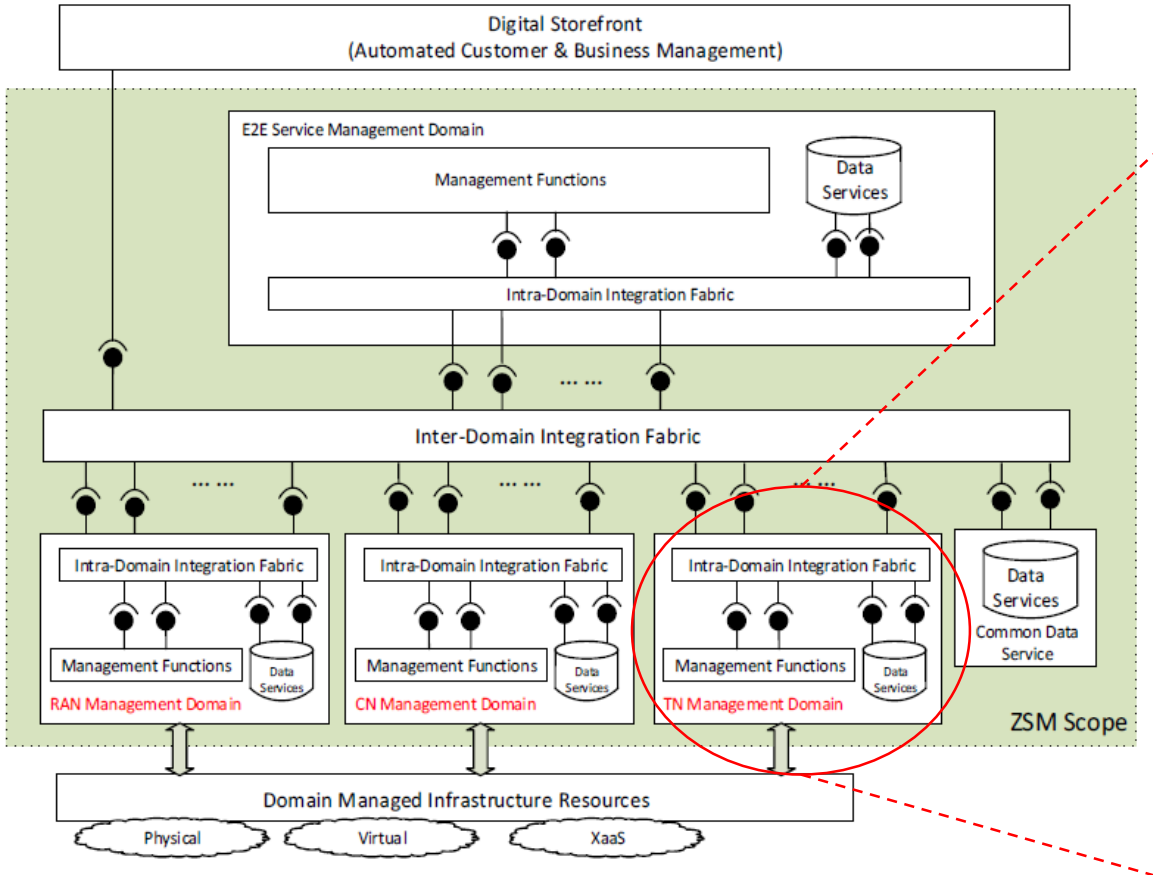
The Slicing requirements would require in some cases to re-use the existing NSSI. In such cases the NFVO would need to configure specific NFs.

Solution based on ONAP Frankfurt release features

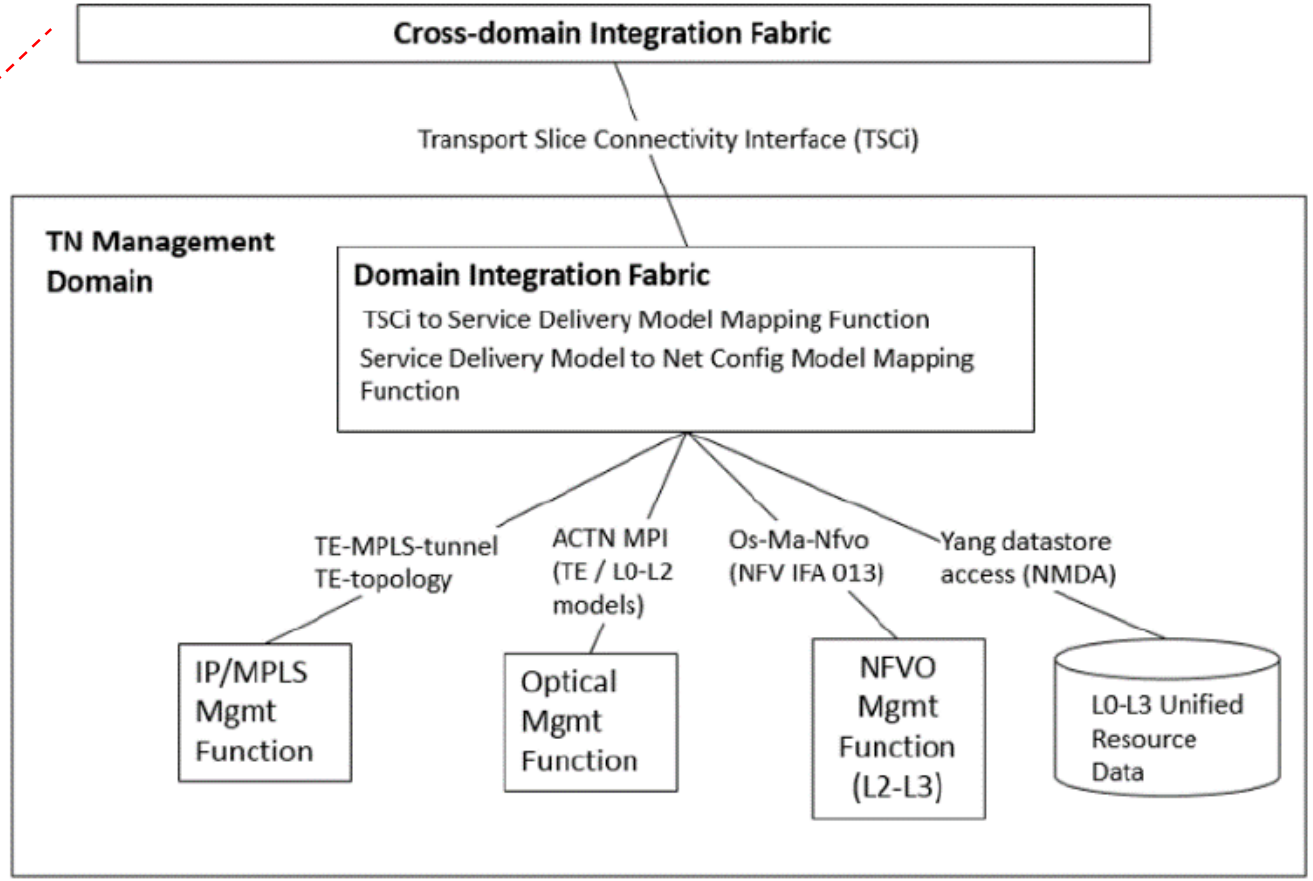
Core Slicing: Next Steps

- **Enhance the configuration of the Core NFs beyond basic aspects such as S-NSSAI.**
- **Determine placement of Core NFs during Core NSSI instantiation**
- **During new Core NSSI creation, consider some Core NFs being reused while others are instantiated newly – this may also have modeling implications.**

Transport Slicing: Adopting ZSM 003 architecture and IETF models

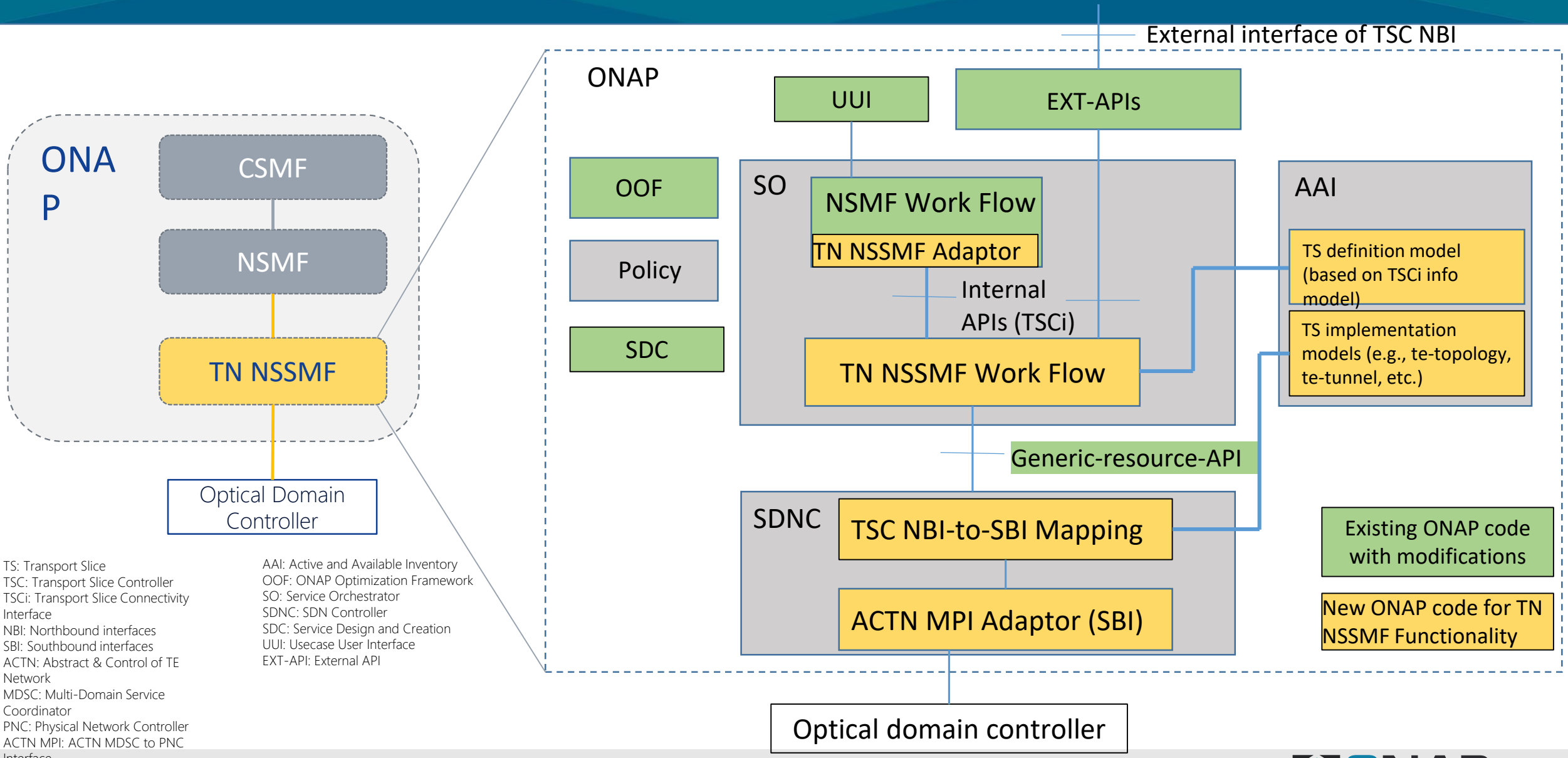


ETSI ZSM E2E Network Slicing Architecture



Logical View of the IETF Transport Slicing Solution

Transport Slicing: Implementation on ONAP

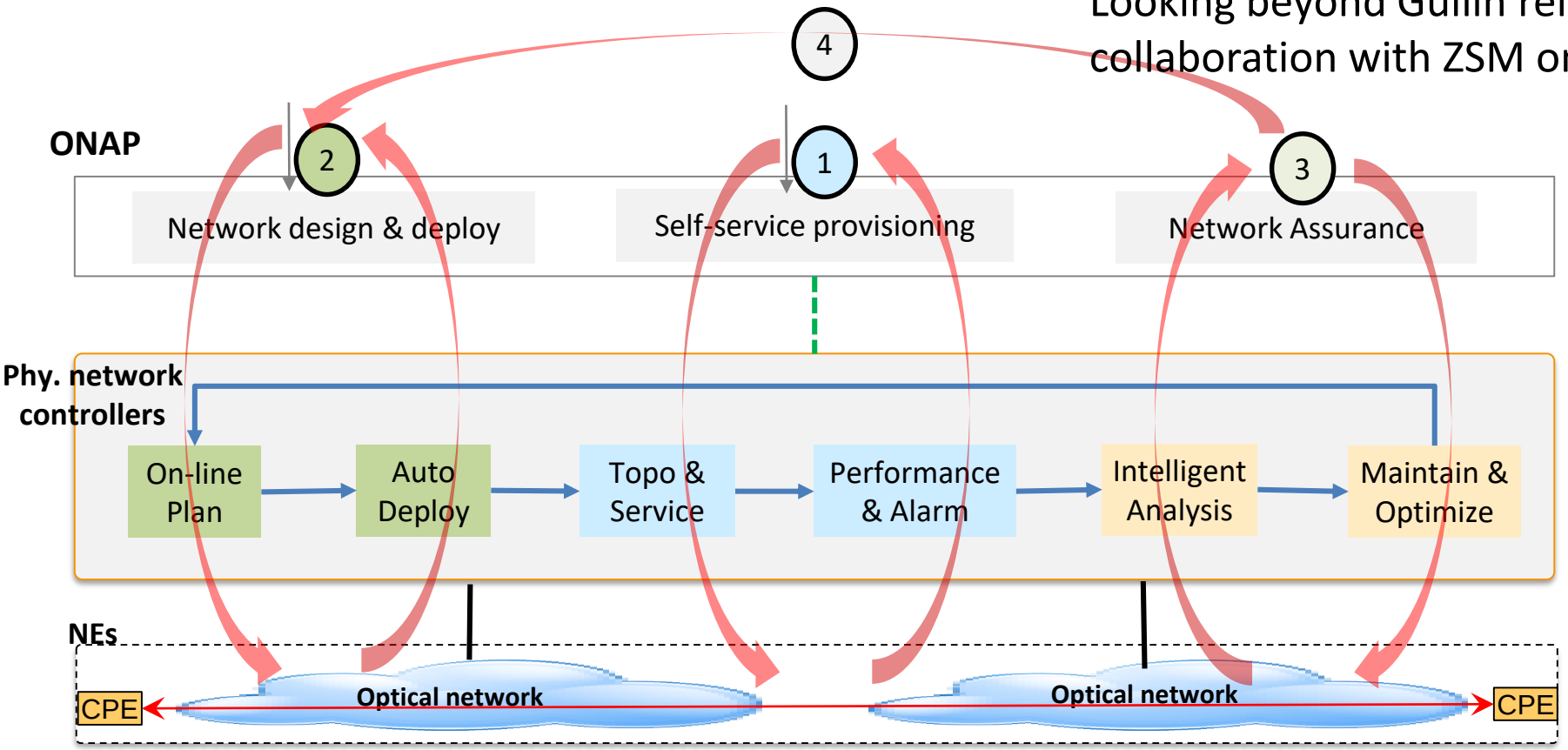


TS: Transport Slice
TSC: Transport Slice Controller
TSCi: Transport Slice Connectivity Interface
NBI: Northbound interfaces
SBI: Southbound interfaces
ACTN: Abstract & Control of TE Network
MDSC: Multi-Domain Service Coordinator
PNC: Physical Network Controller
ACTN MPI: ACTN MDSC to PNC Interface

AAI: Active and Available Inventory
OOF: ONAP Optimization Framework
SO: Service Orchestrator
SDNC: SDN Controller
SDC: Service Design and Creation
UUI: Usecase User Interface
EXT-API: External API

Transport Slicing future roadmap: Closed-loop Automation

Looking beyond Guilin release, we are looking for further collaboration with ZSM on closed-loop automation.



Four Types of Closed-loop Automation

① Service provisioning and activation:
- Days ➔ Minutes

② Network planning and deployment:
- Weeks ➔ Days

③ Network troubleshooting and restoration:
- Hours ➔ Minutes

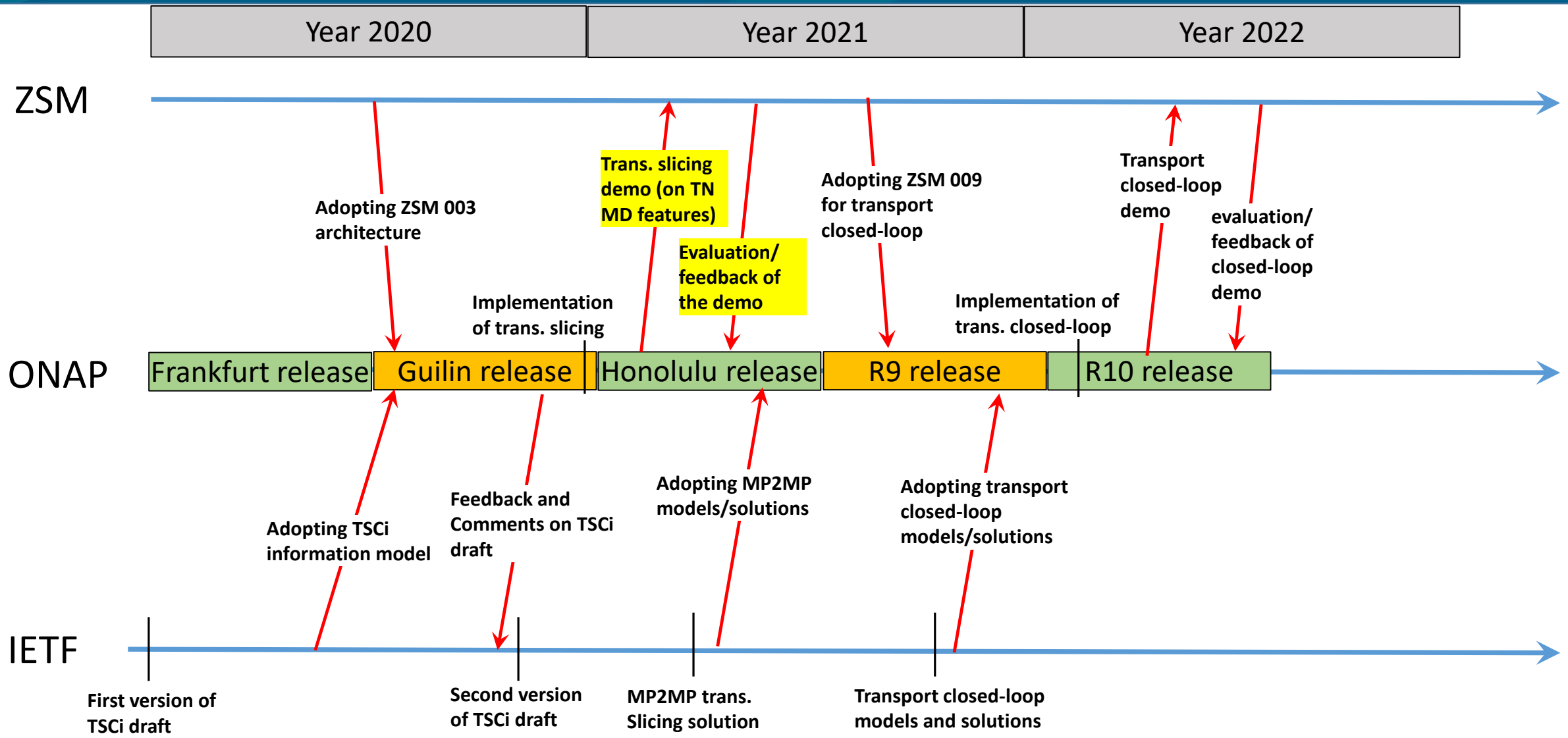
④ Traffic prediction based auto network planning:
- Months ➔ weeks

- **2021：New CPE online and deployment (and auto service activation)**

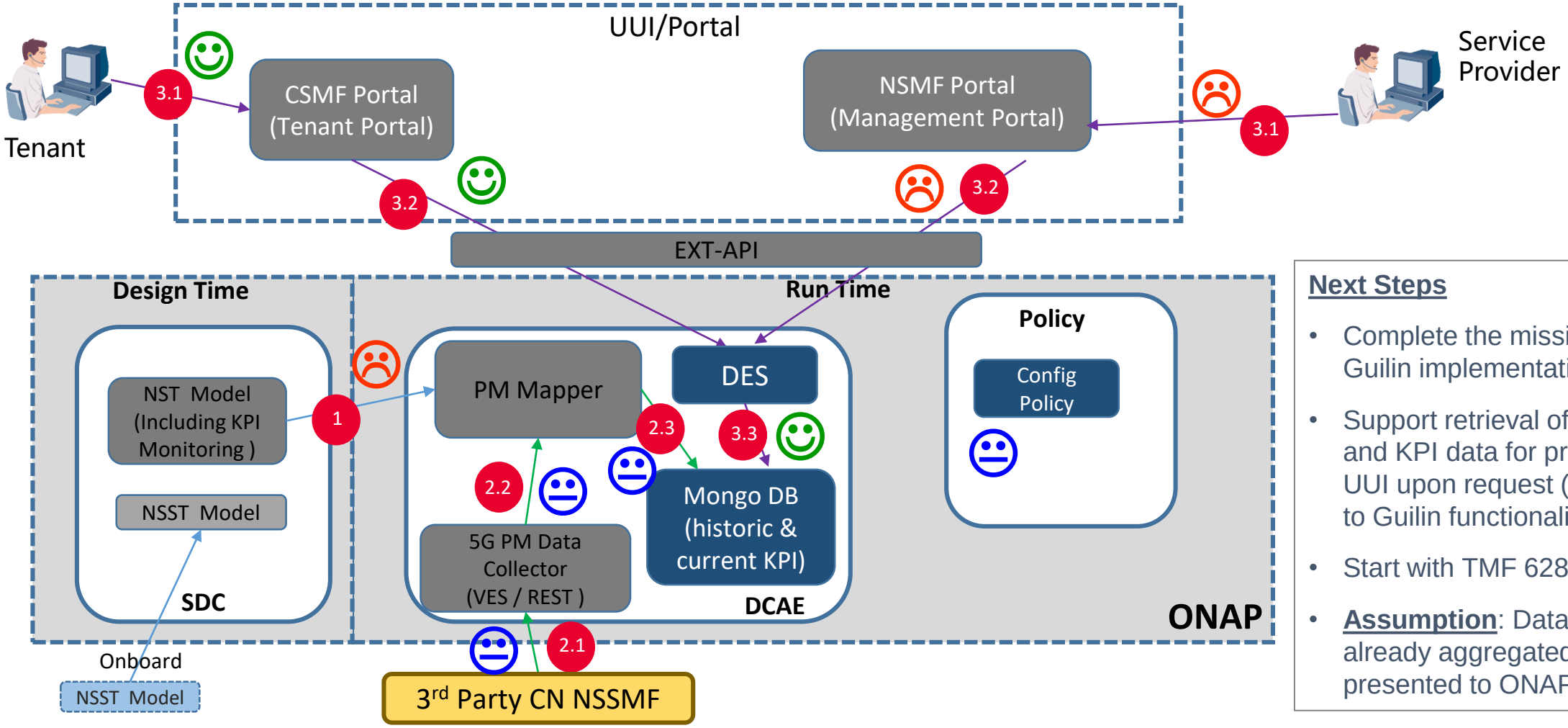
- **2018：L2 service**
- **2019：L1 service**
- **2020：Transport Slicing**

- **2022+：Network performance prediction based service disruption prevention**

Transport Slicing future roadmap: ONAP, ZSM, IETF collaboration



KPI Monitoring

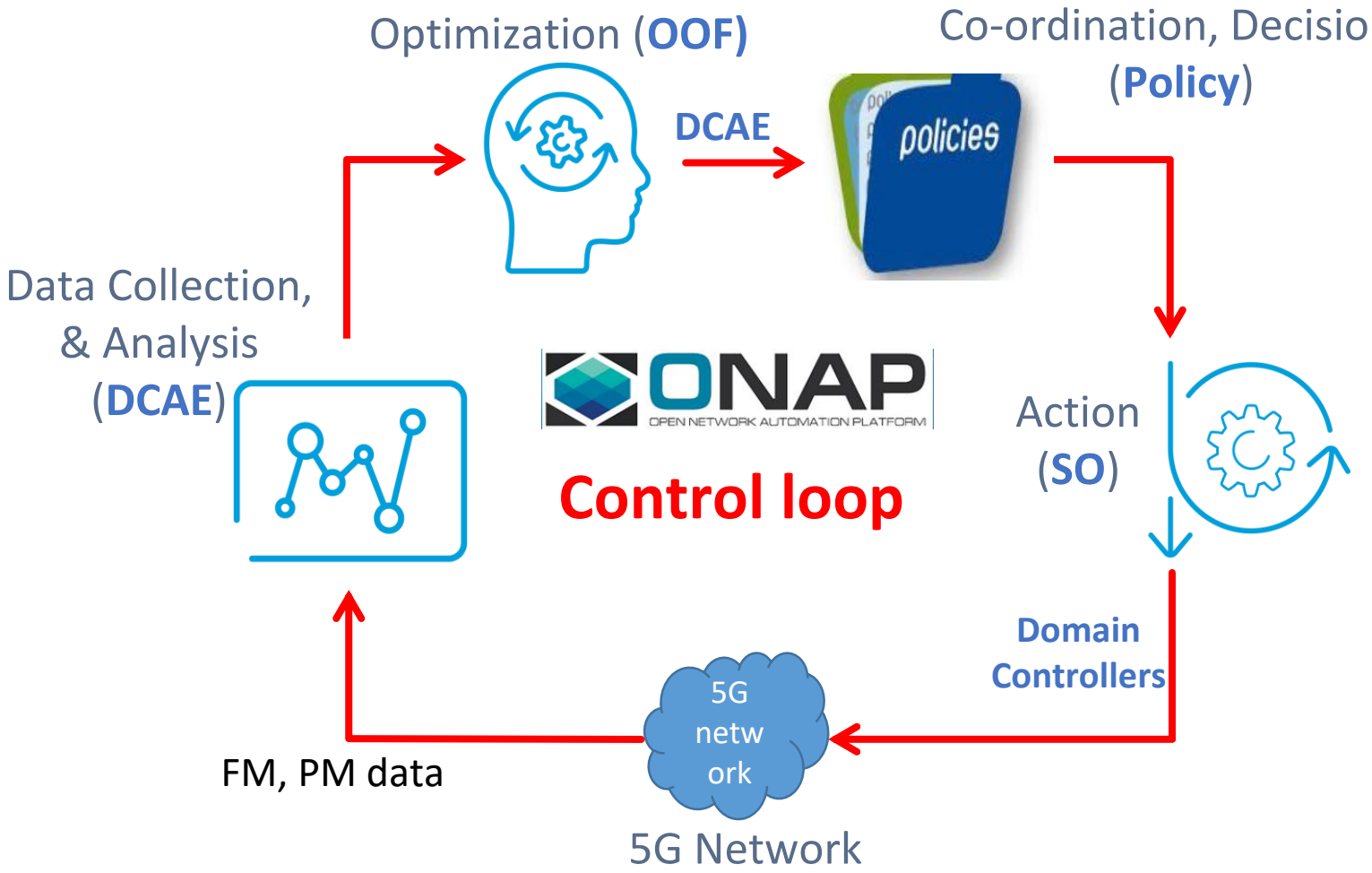


Next Steps

- Complete the missing parts of Guilin implementation.
- Support retrieval of historic PM and KPI data for presentation to UUI upon request (enhancements to Guilin functionality).
- Start with TMF 628 API support.
- **Assumption**: Data from NFs is already aggregated and then presented to ONAP.

Done | Partially done | Not done | Enhancement | New for this use case

Closed Loop: Overview



- Leverage the SON ⇔ Control Loop (CL) framework in ONAP
- Based on PM/FM data, analyze NSI/NSSI traffic patterns, KPI adherence, and resource occupancy in NSI/NSSI
- Based on analysis, trigger OOF for NSI resource optimization/re-allocation to guarantee KPI adherence and optimal use of resources
- Perform necessary resource adjustments via SO and Domain Controllers (modify NSI/NSSI/S-NSSAI mapping/etc.)

Closed Loop: Roadmap

Use data (e.g., QoE data, network data, etc.) from various sources as input and do analysis based on AI algorithms to obtain network capabilities that can match the SLA of tenants, and then dynamically adjust the service capabilities of network slices while using optimal resources. It mainly consists of the following three scenarios:

1 Commissioning-Initial resource Assignment

Determine the initial resource assignment and configuration for a new slice by intelligent analysis based on SLA requirement. For e.g.:

1. Determine the resources in each domain especially for RAN
2. Guarantee the existed slices SLA when creating a new slice

Not for Honolulu

2 Runtime-monitoring

Evaluate the SLA fulfillment and **real time monitor QoE based on the QoE model** trained by ML algorithms.

The QoE model is used to describe the relationship between **the QoE collected from AFs** and the **KPIs produced by ONAP** or **network data from Core & RAN NFs**.

The QoE model is mainly used in measuring and predicting QoE.

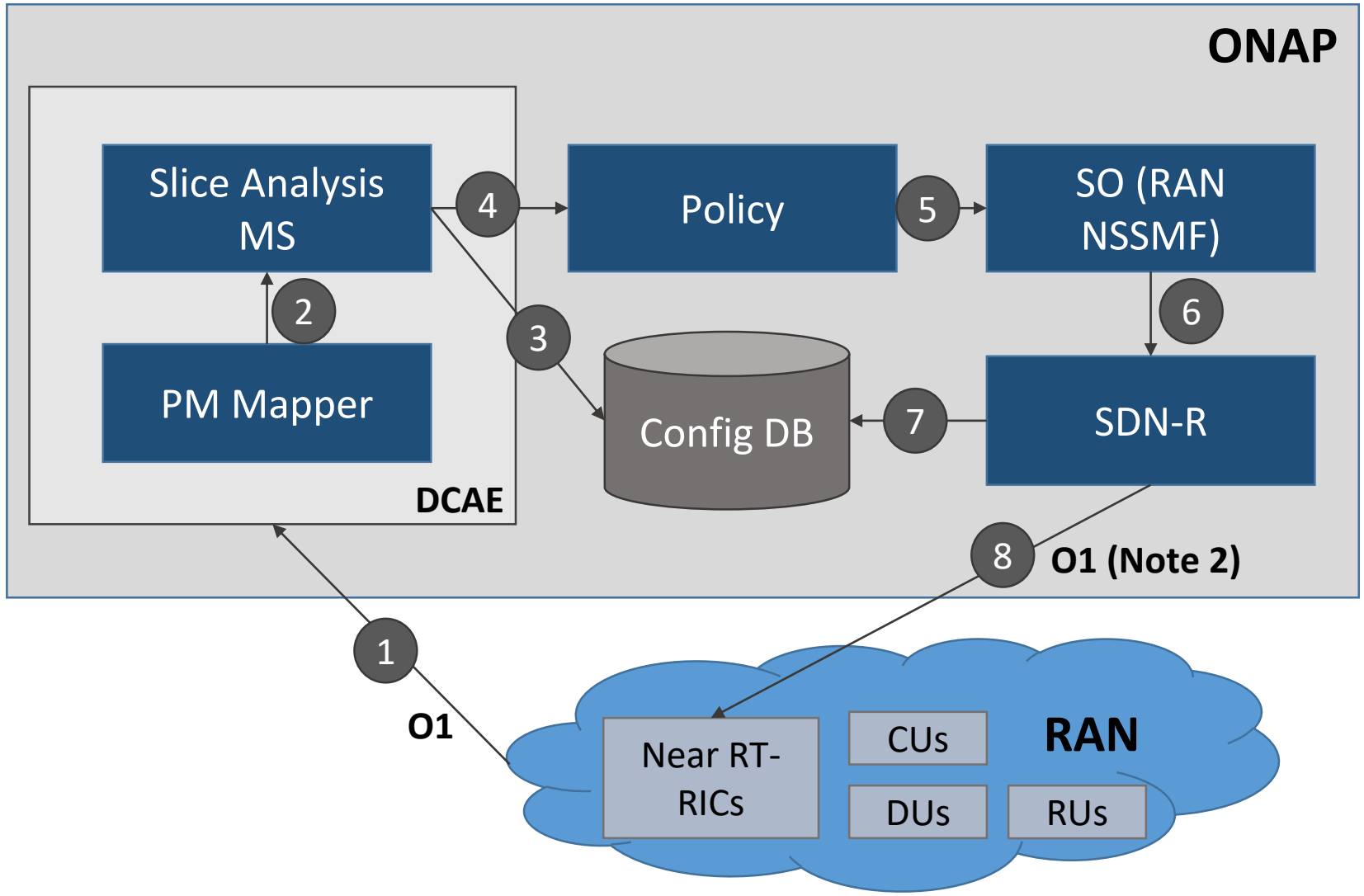
KPI Monitoring for Honolulu
QoE Monitoring is beyond Honolulu

3 Closed-loop Update

Considering the limited resource and changing condition like the Signal to Noise Ratio and users on the slice, the initial resource configuration may not be able to satisfy the slice SLA during the lifecycle of the slice. **ONAP can adjust or update the resource configuration of the slice in a close loop way triggered by the analysis of SLA fulfillment.**
SLA fulfillment is evaluated based on the analysis of QoE info and KPIs.

Closed loop control triggered by RAN KPI monitoring for Honolulu

Closed Loop Scenario

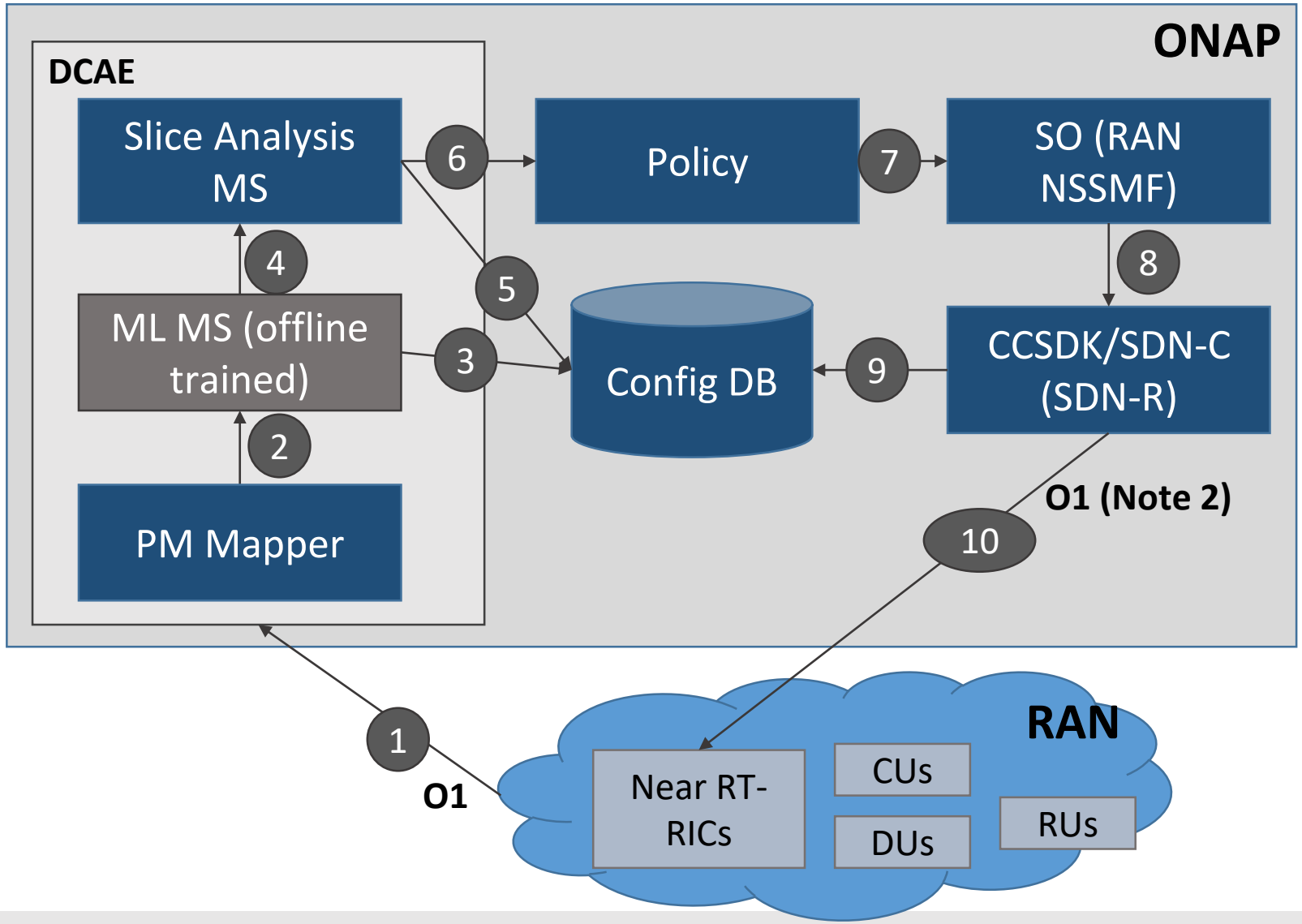


- The PM data collected from RAN in Step 1 is DL/UL PRB used for data traffic.
- The configuration update determined by Slice Analysis MS and triggering Policy in Step 4 is slice specific throughput guidance for Near-RT coverage area (i.e., at Near-RT RIC level).

Notes

1. DFC and VES Collector are not shown in the flow but are used.
2. **Step 8 is over O1, it will eventually be over A1.**
3. Config DB which contains RAN config info is not an official ONAP component. This will be implemented as part of C&PS in H-release and beyond.

ML-based Closed Loop



- The PM data collected from RAN in Step 1 is PDU sessions requested, setup successfully & failures.
- The configuration update determined by ML MS and triggering Slice Analysis MS in Step 3 is slice specific maxNumberofConns for each cell (i.e., cell level for each S-NSSAI).

Notes

1. DFC and VES Collector are not shown in the flow but are used.
2. **Step 10 is over O1, it will eventually be over A1.**
3. ML MS is onboarded to DCAE, but not an official ONAP component. Later we will onboard using Acumos DCAE adaptor.
4. Config DB which contains RAN config info is not an official ONAP component. This will be implemented as part of C&PS in H-release and beyond.

To be considered/in progress

- Interaction with NSSF and other Control Plane functions
- Interaction with NWDAF for Slice Analytics
- Federated Slicing, roaming scenarios
- Stitching together an e2e slice in Control and Forwarding plane (work in progress)
- RAN NF instantiation, Core NF placement (work in progress)
- Appropriate resource allocation (RAN, Core and Transport)
- Capacity and resource occupancy of existing slices
- Slice modification during service request, or for cross-slice resource optimization

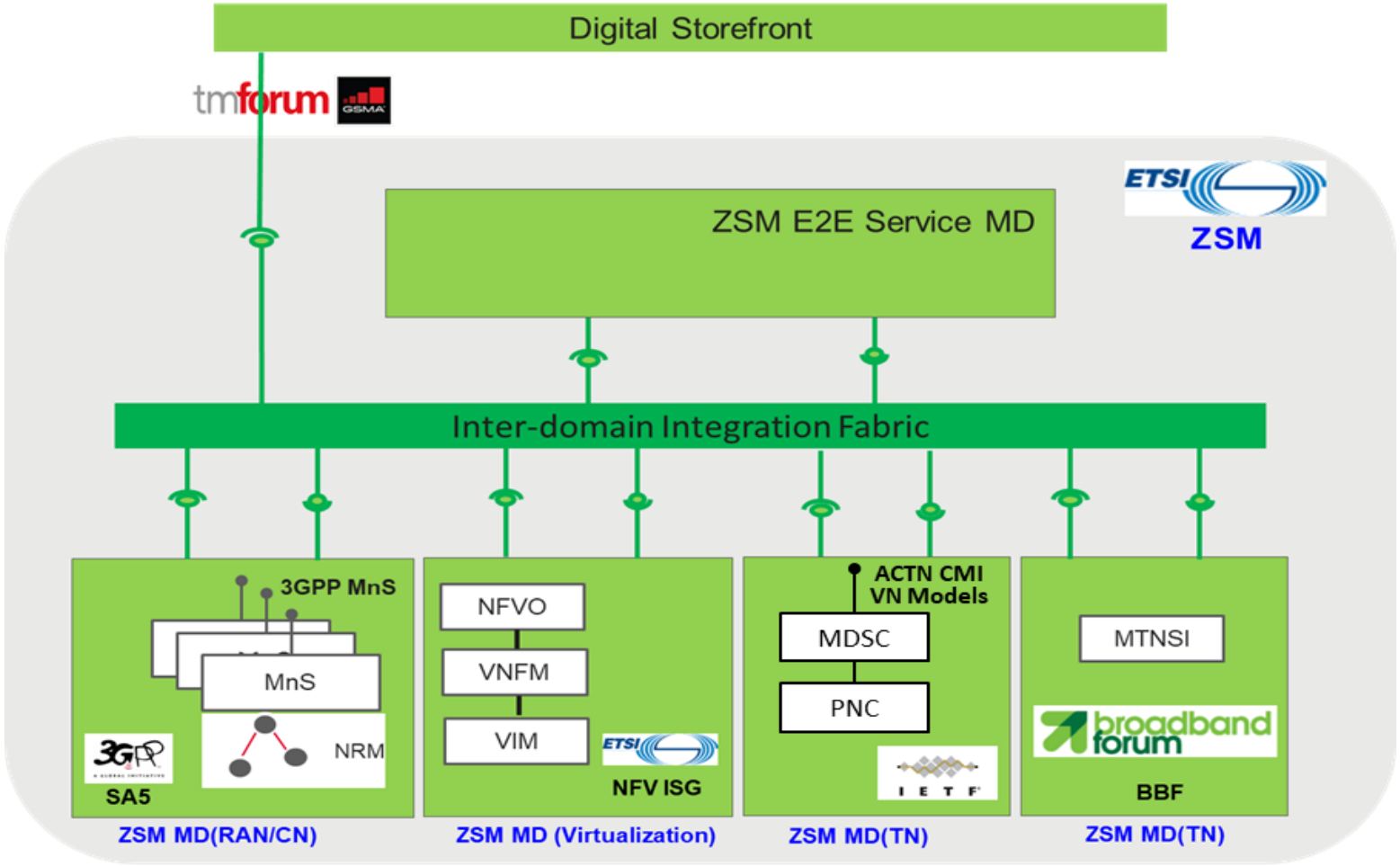
Gaps in Standards & ONAP realization

- **Gaps in Standards**
  - Specifications for stitching together an E2E Network Slice (endpoints, etc.)
  - 1:1 mapping between NSI and top-most NSSI
  - API specifications between the xSMFs
  - Elaboration of Slice Profile per domain (RAN, Core and Transport)
  - Specification of security requirements (logical level, infra level, transport, control plane, etc.)
- **Gaps in ONAP realization**
  - Fast release cycles, so limited functionality is implemented for each release
  - Lacking reference on the Configuration of NFs in Core and RAN to establish real traffic on a slice
  - Modeling of RAN and Core is still not matured
  - Functions such as slice modification, NSI/NSSI selection based on resource occupancy is still in early stages
  - In early stages for automated assurance of slice KPIs/SLAs

ONAP
OPEN NETWORK AUTOMATION PLATFORM

ETSI ZSM & E2E Network Slicing

ZSM collaboration and alignment with other SDOs



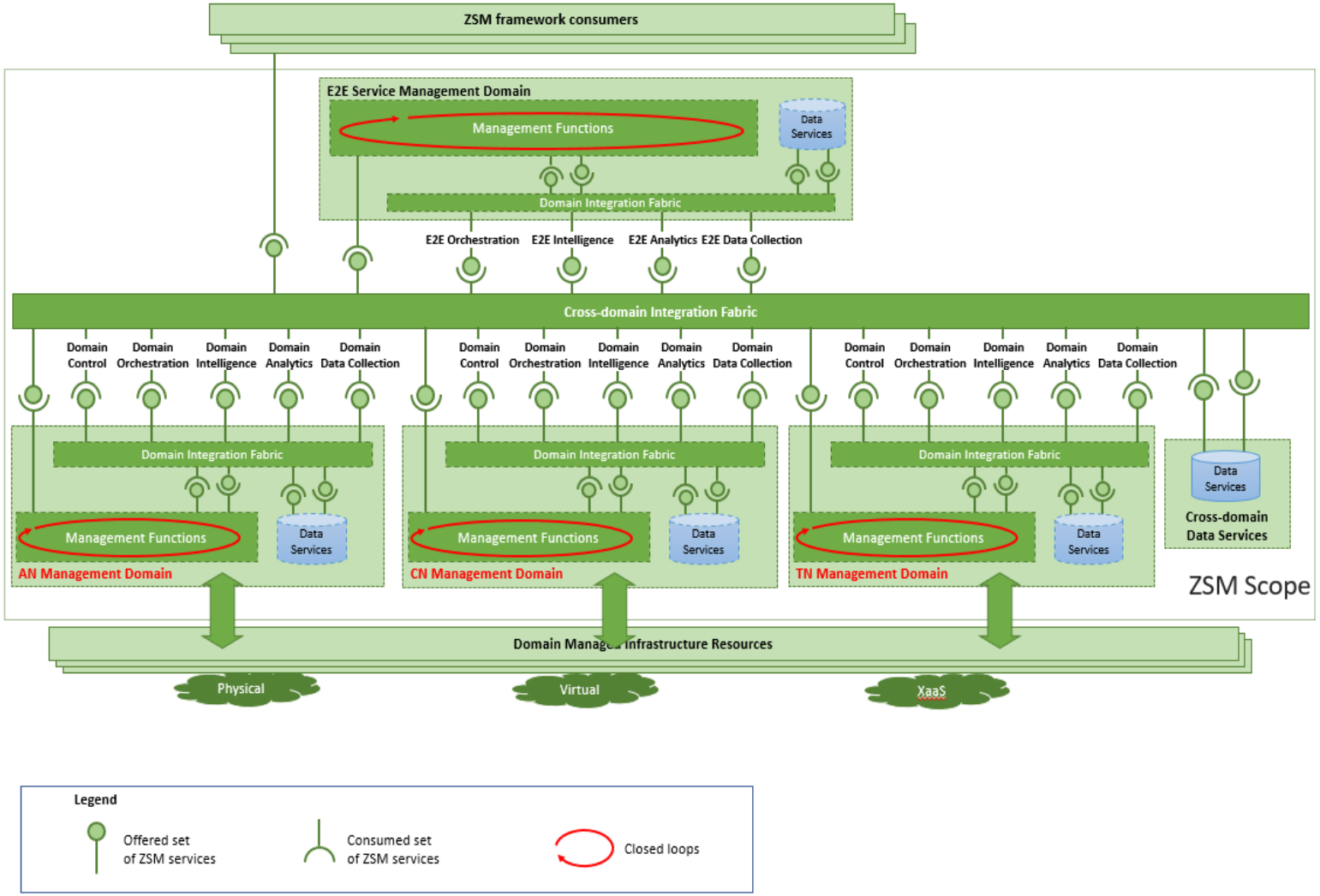
- ZSM stiches related work from different SDOs (e.g., TMF, 3GPP, IETF, BBF, etc.) and provides a federated solution.
- In other words, ZSM is a platform which integrates different standards and produces a unified and implementable solution, from which the ONAP network slicing use case may benefit.

Illustration of the relation between the scopes of ZSM and other groups (source: ZSM 003)

E2E Network Slicing Alignment with SDOs

Standards Body	Alignment Reference(s)
3GPP (Rel. 16)	○ TS 28.530 (Concepts, requirements) ○ TS 28.531 (Slice and Slice sub-net LCM) ○ TS 28.541 (Network Resource Models) ○ TS 23.501 (Procedures in Control Plane) ○ TS 28.552 and TS 28.554 (PM and KPIs)
TMF	○ TMF 641 (Service Order – CSMF NB) ○ TMF 628 (PM and KPI monitoring – just started)
ETSI	○ ZSM 002 ZSM Framework ○ ZSM 003 E2E Network Slicing Architecture ○ ZSM 009 Closed-loop Automation
IETF	○ draft-rokui-5g-ietf-network-slice-00 ○ draft-ietf-teas-actn-vn-yang ○ RFC 8795: YANG models for TE topologies
O-RAN	○ O1 (RAN Configuration, notifications, PM data) – in progress ○ O2 (not started yet) ○ A1 – just started ○ RAN architecture and functional split (Non-RT RIC, Near-RT RIC, SMO) – in progress

ZSM 003: Architectural Framework for E2E Network Slicing



- ZSM 003 provides a specification of E2E Network Slicing management solutions and related management interfaces
- Furthermore, it provides an architecture that identifies the components and specifies their functionalities and interfaces.
- It follows, therefore, that the solution to Transport Slicing (i.e., TN MD) is illustrated in the context of E2E network slicing.
- Thus, it is ideal to use ZSM 003 as the architectural framework for Transport Slicing.

ZSM architecture deployment example for network slicing management (source: ZSM 003)

ZSM 002: Design principles adopted by Transport Slicing

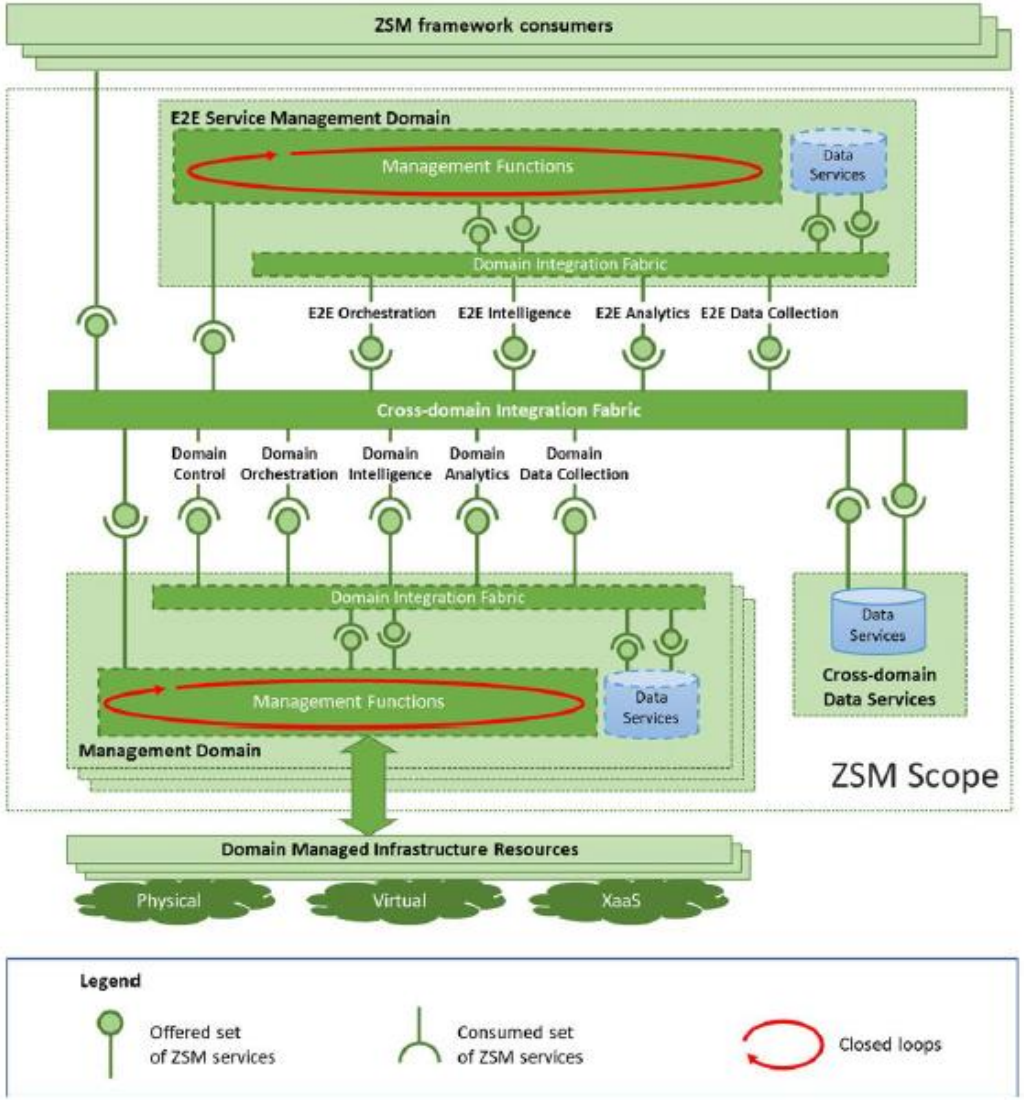


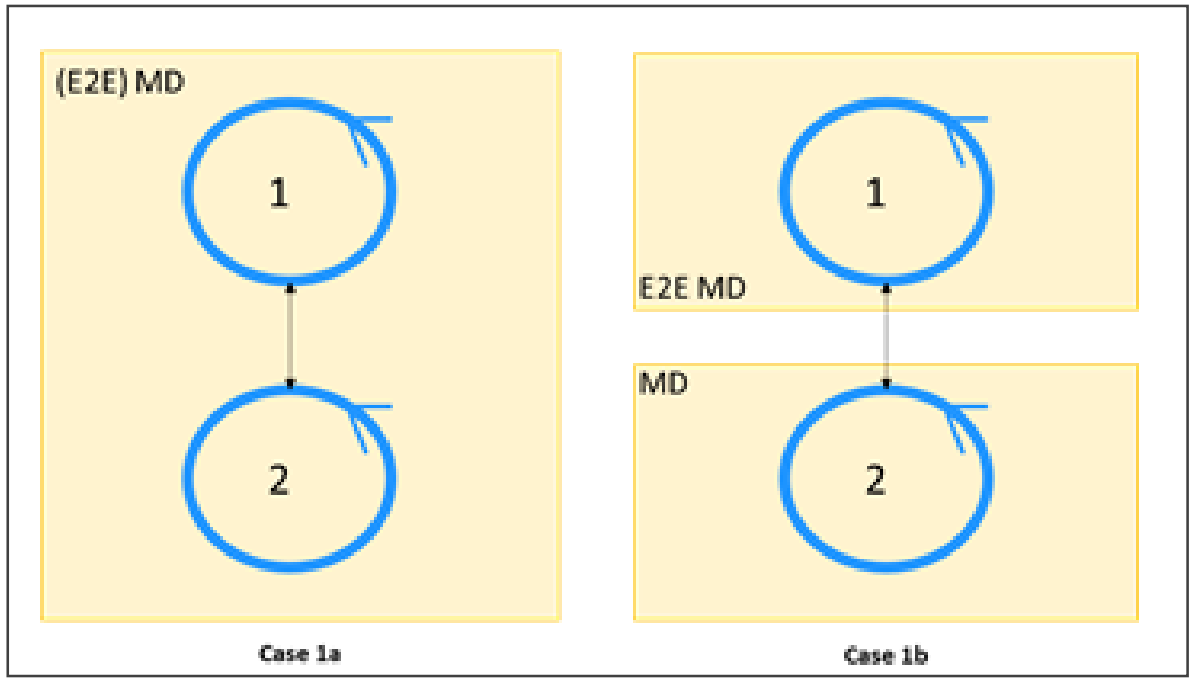
Figure 6.2-1: ZSM framework reference architecture

While ZSM 003 provides a specification for Transport Slicing functionality, as well as its interfaces, ZSM 002 provides the design principles on how to design such a solution (e.g., a management domain). Some of those principles are:

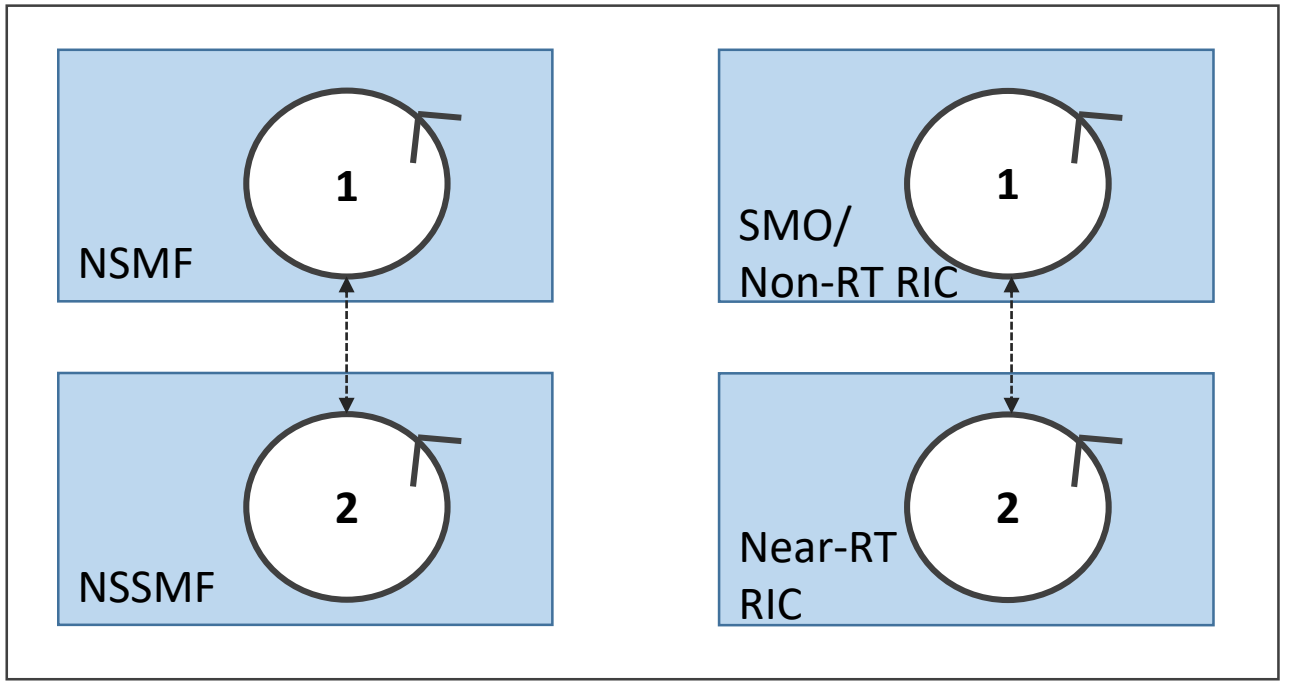
- **Model-driven, open interfaces**. models are independent from the implementation.
- **Separation of concerns**. Decoupling of management domains and E2E Service Management domain. Avoid monolithic systgems.
- **Intent-based interfaces**. Declarative interface. Hide complexity, technology, vendor-specific details away from user.
- **Designed for automation**. Zero-touch network.
- **Closed-loop management automation**.

ZSM 009: Closed Loop Automation

ETSI ZSM 009-1 Fig. 8.2.2-1 Hierarchical closed loops



Examples of Hierarchical Closed Loops in Slicing context



- In the Slicing context, Closed Loops can be hierarchical, and require co-ordination.
- In addition, co-ordination may also be required between Closed Loops across domains (peer-to-peer or hierarchical interaction), e.g., across NSSMFs managing different network segments.
  - Pre-action co-ordination, pre-action selection, pre-action conflict detection & post-action scope verification described in ZSM 009-1 are all relevant to Network Slicing.

Potential Areas to collaborate with ETSI ZSM

- **ONAP alignment with ZSM 003**
  - End-to-end network slice orchestration
- **ONAP alignment with ZSM 009**
  - Implementation of various Control Loops (with/without analytics and AI/ML) at NSMF (e2e network slice) and NSSMF (slice subnet) level
  - Concepts such as hierarchical Closed Loops (NSMF & NSSMFs, Non-RT RIC/SMO and Near-RT RIC) can be taken forward
  - Co-ordination of actions in hierarchical Closed Loops (e.g., NSMF and NSSMF), and in multi-domain Closed Loops
- **ONAP demo at ZSM**

References

- 3GPP TS 28.530 (Overview)
- 3GPP TS 28.531 (Management Procedures)
- 3GPP TS 28.541 (NRM)
- 3GPP TS 28.552, TS 28.554 (PM and KPIs)
- 3GPP TS 23.501 (Control Plane flows)
- ETSI ZSM 002, 003, 009
- https://wiki.onap.org/display/DW/E2E+Network+Slicing+Use+Case+in+R6+Frankfurt
- https://wiki.onap.org/display/DW/E2E+Network+Slicing+Use+Case+in+R7+Guilin
- https://wiki.onap.org/display/DW/R8+E2E+Network+Slicing+use+case

Thank You!