PoC Report

1 PoC Project Details

1.1 PoC Project Review

PoC Number:	4
PoC Project Name:	Autonomous network slice management
PoC Project Host:	DOCOMO Communications Lab., NTT Corp., NTT Communications, Corp., NTT DOCOMO, INC.
Short Description:	This PoC demonstrates the use-case of the autonomous network slice management. The use-case is based on ZSM framework reference architecture and implemented with the ZSM standards and NTT products. The PoC will demonstrate management services (defined in ZSM 002), network slice management (defined in ZSM 003) and cross-domain orchestration (defined in ZSM 008) on E2E management domain and TN, CN, DN management domain.
PoC Project Status :	Ongoing

1.2   PoC Team Members Review

	Organisation name	ISG ZSM participant (yes/no)	Contact (Email)	PoC Point of Contact (*)	Role (**)	PoC Components
1	DOCOMO Communications Lab.	yes	Wenjing Chen wenjing.chen.bv@nttdocomo.com Shinsaku Akiyama akiyamashi@nttdocomo.com	X	Research center	In charge of the study and implement to integrate all these products with the PoC scenarios and standard specification.
2	NTT Corp.	yes	Aki Fukuda aki.fukuda.cd@hco.ntt.co.jp Shiku Hirai shiku.hirai.uk@hco.ntt.co.jp Sho Kanemaru sho.kanemaru.pw@hco.ntt.co.jp Takayuki Nakamura takayuki.nakamura.gy@hco.ntt.co.jp Hiroki Baba hiroki.baba.zp@hco.ntt.co.jp		Research center	Take over the "Multi-layer Transport Provisioning Engine", "HANMOC", "ACPE", "APIO", vGW/SLG and router.
3	NTT Communications, Corp.	no	Shoji Hashimoto shoji.hashimoto@ntt.com Senri Hiraba s.hirabaru@ntt.com Haruki Takahashi haruki.takahashi@ntt.com		Network operator	Take over the "Qmonus" as a PaaS for the implementation of E2EO MD.
4	NTT DOCOMO, INC.	no	Taisuke Omoto omoto@nttdocomo.com Shinichi Isobe isobes@nttdocomo.com		Network operator	In charge of the study and implement to integrate all these products with the PoC scenarios and standard specification.
(*) Identify the PoC Point of Contact with an X. (**) The Role will be network/service provider, supplier, or other (universities, research centers, test labs, Open Source projects, integrators, etc…).						

All the PoC Team members listed above declare that the information in this report is conformant to their activities during the PoC Project.

1.3   PoC Project Scope Review

1.3.1   PoC Topics

Report the status of all the PoC Topics and Expected Contributions anticipated in the PoC Proposal

PoC Topic Code	PoC Topic Description	Related WI	Submitted Contribution link	Date	Status (*)
Cross-domain user-driven E2E services	Demonstration of the cross-domain orchestration and automation between the E2E MD and the TN, CN, DN MD	ZSM002, ZSM003 and ZSM008		Final May 2022	Ongoing
(*) Planned, On-going, Completed, delayed (new target date), Abandoned					

1.3.2   Other topics in scope

Report the status of all the additional PoC Topics and Contributions anticipated in the PoC Proposal.

PoC Topic Code	PoC Topic Description	Related WI	Submitted Contribution link	Date	Status (*)
(*) Planned, On-going, Completed, delayed (new target date), Abandoned					

1.4   PoC Project Milestones Review

PoC Milestone	Milestone description	Target Date	Additional Info	Completion Date
P.S	PoC Project Start	Jan 2022	Presented to ZSM members during ZSM#18-e and e-mail approved.	Mar. 3rd 2022
P.D1	PoC Demo 1	Mar 2022	Network slice instance creation based on ZSM002 ZSM framework with ZSM003 network slicing process and ZSM008 management service between E2E MD and MD.	Mar. 7th 2022
P.D2	PoC Demo 2	Mar 2022	Network slice instance deletion based on ZSM002 ZSM framework with ZSM003 network slicing process and ZSM008 management service between E2E MD and MD.	Mar. 7th 2022
P.C1	PoC Expected Contribution 1	Mar 2022	Contribution on the lessons from Demo 1 and Demo 2 (PoC_x_Interim_Report.doc)	During the ZSM-Interim#11e.
P.D3	PoC Demo 3	Apr 2022	Closed-loop automation due to the FM/PM notification related to ZSM002, ZSM003 and ZSM008.	
P.C2	PoC Expected Contribution 2	Apr 2022	Contribution on the lessons from Demo 3.	
P.R	PoC Report	May 2022		
P.E	PoC Project End	May 2022		

2   Additional information

We prefer to present the demonstrations at ZSM's meetings (planned for ZSM#19) and submit the contributions and report which include demo scenarios for public and ZSM members viewing in April and May.

We are also plan to present the demonstrations at ZSM workshop during Lay123 Event in April.

3 PoC Technical Details

3.1 PoC Overview

3.1.1 Use-case Description

In the 5G-era, with the introduction of network slicing and other techniques, the network will be complex and layered and require more advanced and diversified operation processes. It is an issue for operators to perform network operation with 5G services at the same level as conventional 3G and 4G services with existing human resource.

Furthermore, operators also need to consider how to utilize standardizations with existing systems.

This PoC will combine ZSM assets with other standardizations, technologies, products and operator's existing environment to validate the feasibility of autonomous network slice management. The network slice instance is based on the 3GPP NRM defined in TS28.541. 3GPP and TMF operation which are referred in ZSM are also taken into account. About each management domain, ONF TAPI specifications are referred by TN, 3GPP is for CN and TMF open API is for DN.

This PoC is based on the ZSM framework as Figure 1 and covers E2E management domain and management domains. The latest version of GSMA GST (Generic Network Slice Template) v5.0 will be adopted to create the service order.
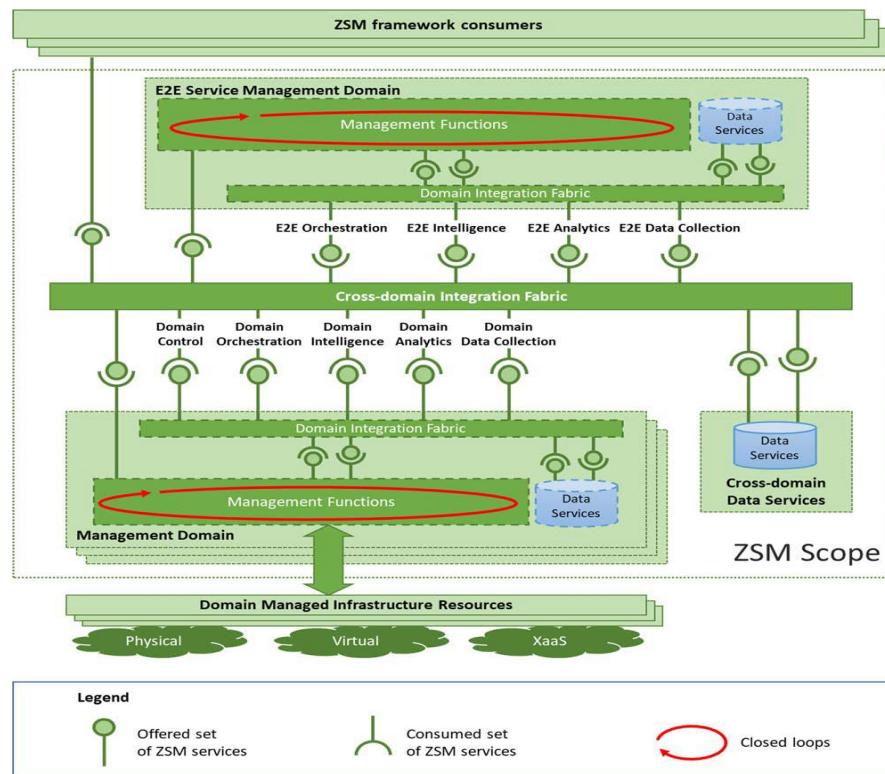

Figure 1 ZSM framework

The PoC will demonstrate management services (defined in ZSM 002), network sling management (defined in ZSM 003) and cross-domain orchestration (ZSM 008). Table 1 summaries the content of the PoC.

Table 1 Content of the PoC

Demo No.	Use-case Scenario	ZSM Management Service/ Sequence	Details
1	Network Slice Management	- Managed services catalogue management service (Creation) - Network Slice Instance Creation - E2E services inventory management - Domain inventory management	- Catalogue creation to create E2E services - Network slice instance creation according to service order - Inventory management with E2E services/slices information
2	Network Slice Management	- Network Slice Instance Deletion	- Network slice instance deletion according to service order
3	Service Operation	- Network Slice Modification	- Network slice modification(e.g. due to FM/PM notification or service order) or network slice instance scaling/healing

*: The use-case scenarios may be included in other scenarios.

3.1.2   Scope and Content of the PoC

The scope of the PoC is as the red part in Figure 2. The PoC covers the E2E management domain and TN, CN, DN* management domain to demonstrate the end-to-end orchestration with multi management domians.

RAN is not in the scope, however, a gNB simulator is used to provide call signal.

*In this PoC, DN management domian not only provides management function to the DN, but also to the multi-domain (TN and CN) as described in 3.2. Hence, "DN management domain" is named as "interwork management domain" here.
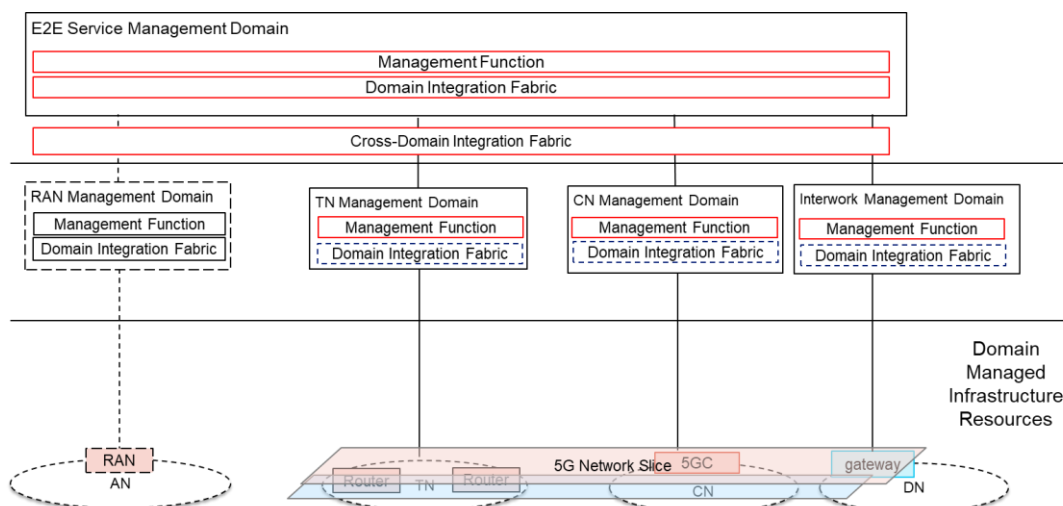

Figure 2 Scope of the PoC

3.2　PoC Architecture

Figure 3 depicts the PoC architecture. It is bases on the ZSM framework and adopts some commercial products.
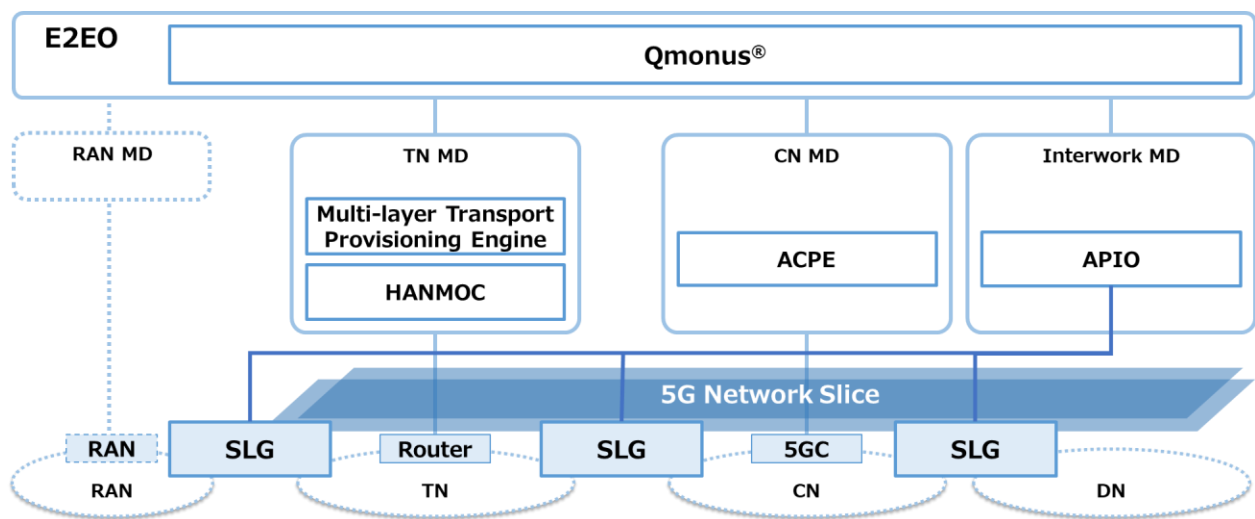

Figure 3 PoC Architecture

Qmonus[1], which is a PaaS for advanced cloud-native application development, delivery and management, is adopted to the implementation of E2EO management domain.

Multi-layer Transport Provisioning Engine provides transport slice resource optimization engine configuring both of optical and packet transport networks dynamically.

HANMOC[2] realizes the simulation of the latency and manages the network domain with network routing technology.
ACPE is a server resource design optimization engine for 5G cloud-native network capabilities.
One-stop construction agent technology (APIO) realizes one-stop provisioning of multi-domain services through coordinating APIs.
SLG provides a virtual gateway function that provides 5G network slice connectivity by connecting paths between domains and network quality control.

3.3　Network Topology

The network topology (Data-plane) of this PoC is shown as figure 4.

The network is consisted of metro network as known as backhaul (between gNB and UPF) and data network as known as core network (between UPF and application).
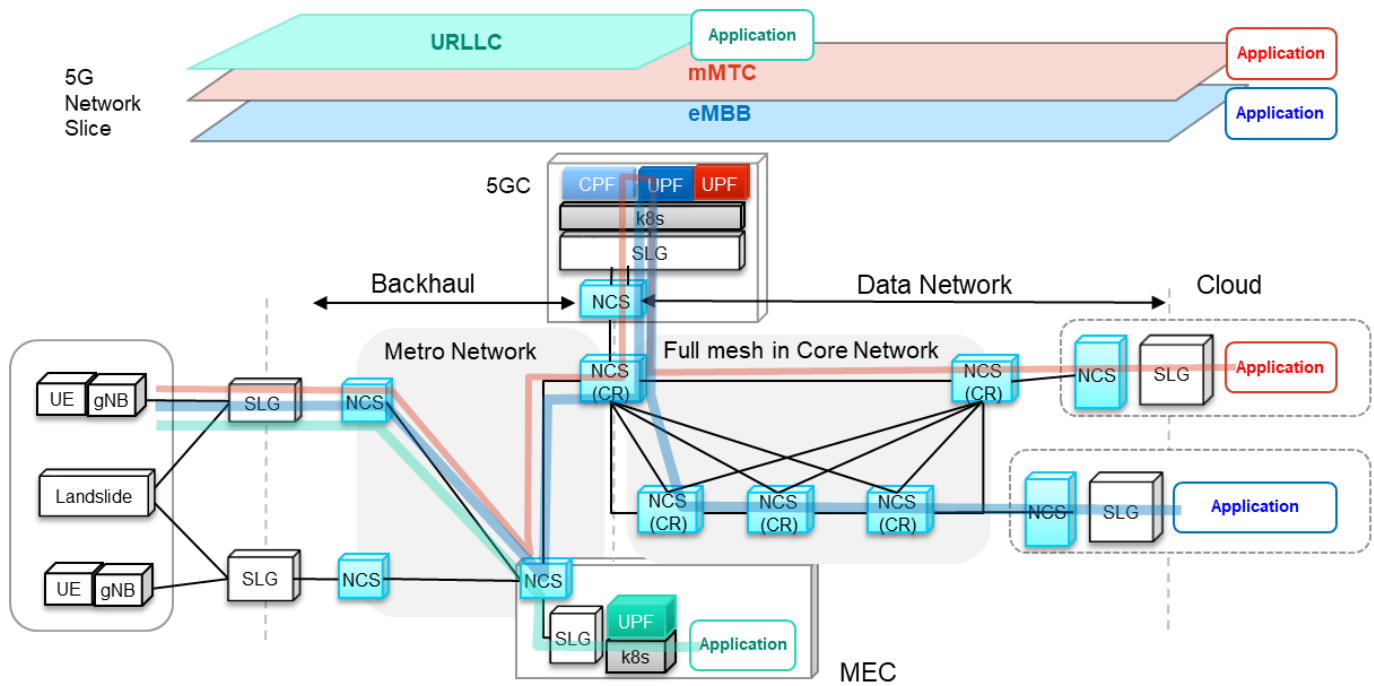
Figure 4   Network Topology

3.4   Scenarios

This section details the scenarios of demos.

In general, the standardizations as below are adopted in this PoC.

- GSMA GST v5.0 (Generic Network Slice Template) is adopted to create the service order.

- Network slice instance is based on the 3GPP NRM defined in TS 28.541 (5G; Management and orchestration; 5G Network Resource Model (NRM); Stage 2 and stage 3) v17.4.0.

- About each management domain, ONF TAPI TR-547 (Reference Implementation Agreement) v2.1.3 is referred by TN, 3GPP TS 28.531 (5G; Management and orchestration; Provisioning) Rel.16 is for CN. TMF open API TMF 622 (Product Ordering API REST Specification) v4.0.1 is for DN.

3.4.1   Demo 1: Network Slice Management (Network Slice Creation)

This procedure creates a network slice instance by requesting the orchestration of the domain service instances that make up the network slice from TN, CN, DN management domains.
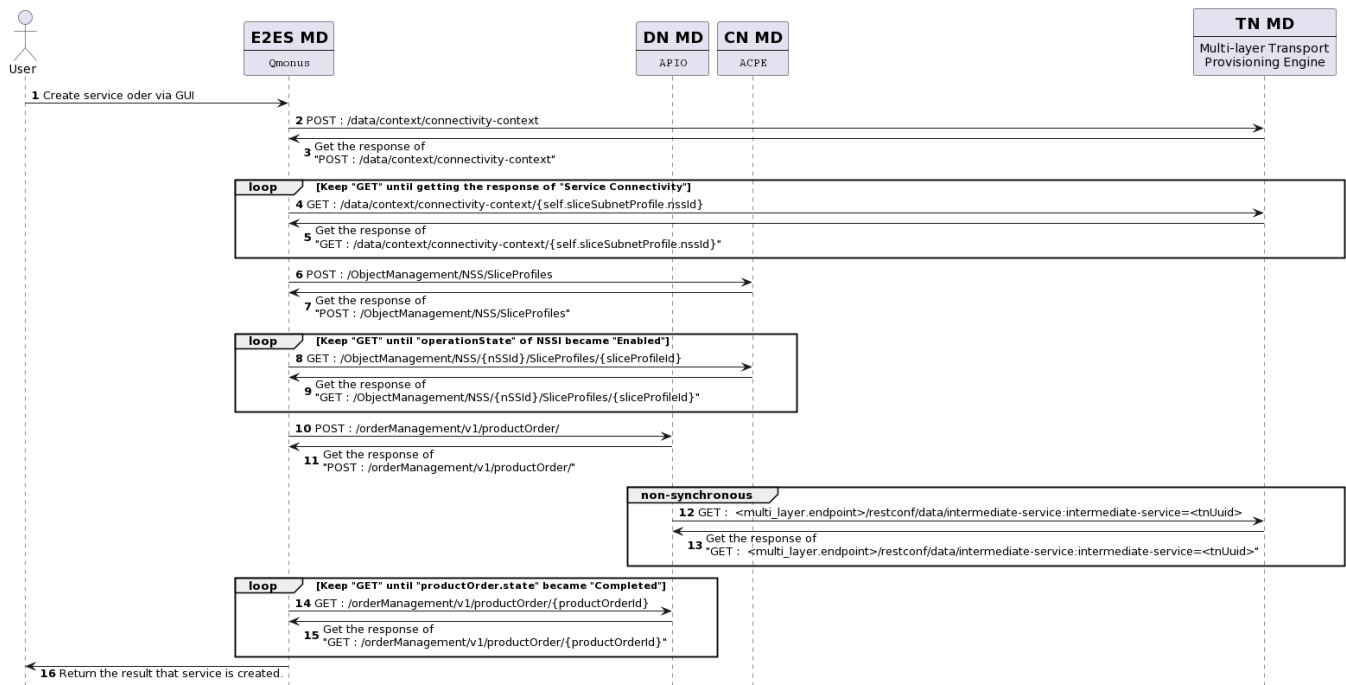
Figure 5   Network Slice Creation

PRECONDITIONS:

- The network slice catalogue has been onboarded.

The procedure, as illustrated in figure 5, consists of the following steps:

1. The ZSM framework consumer requests service management domain for the service order of network slice creation.

2. The E2E service management domain requests transport management domain for allocating the network slice subnet instance serve as "AllocateNssi" operation with data API defined in ONF TAPI TR-547.

3. The E2E service management domain gets the "uuid" of "connectivity service" from transport management domain as the response of service order of network slice creation.

4. The E2E service management domain requests transport management domain for service connectivity.

5. The E2E service management domain gets the result of "Connectivity Service" from transport management domain.

6. The E2E service management domain requests core management domain for allocating the network slice subnet instance with "AllocateNssi" operation defined in TS 28.531.

7. The E2E service management domain gets the "nssId" from core management domain as the response of the network slice subnet instance allocation.

8. The E2E service management domain requests core management domain for enabling the network slice subnet instance.

9. The E2E service management domain gets the "Enabled" from core management domain as the response of "operationState".

10. The E2E service management domain requests data management domain for allocating the network slice subnet instance serve as "AllocateNssi" operation with TMF "productOrder" API defined in TMF 622.

11. The E2E service management domain gets the "productOrderId" from data management domain as the response of the network slice subnet instance allocation.

12. The data management domain request transport management domain for connecting.

13. The data management domain gets the response of transport management domain connecting.

14. The E2E service management domain requests data management domain for completing the network slice creation with TMF "productOrder" API defined in TMF 622.

15. The E2E service management domain gets the "Completed" from data management domain as the response of "productOrder.state".

16. The ZSM framework consumer gets the result from E2E service management domain as the response of service creation.

POSTCONDITIONS:

- The network slice has been created.

ERROR CONDITIONS:

- Failing individual steps of this procedure will terminate the procedure with an error.

3.4.2 Demo 2: Network Slice Management (Network Slice Deletion)

This procedure deletes a network slice instance by requesting the orchestration of the domain service instances that make up the network slice from TN, CN, DN management domains.
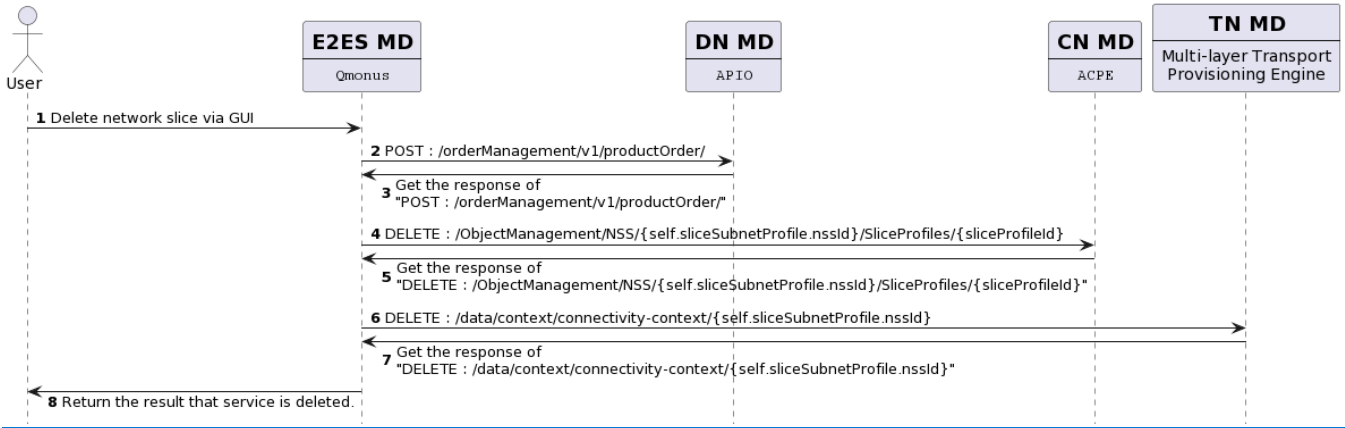

Figure 6   Network Slice Deletion

PRECONDITIONS:

- The network slice instance has been activated.

The procedure, as illustrated in figure 6, consists of the following steps:

1. The ZSM framework consumer requests service management domain for the service order of network slice deletion.

2. The E2E service management domain requests data management domain for deallocating the network slice subnet instance serve as "DeallocateNssi" operation with TMF "productOrder" API defined in TMF 622.

3. The E2E service management domain gets the response from data management domain.

4. The E2E service management domain requests core management domain for deallocating the network slice subnet instance with "DeallocateNssi" operation defined in TS 28.531.

5. The E2E service management domain gets the response from core management domain.

6. The E2E service management domain requests transport management domain for deallocating the network slice subnet instance serve as "DeallocateNssi" operation.

7. The E2E service management domain gets the response from transport management domain.

8. The ZSM framework consumer gets the result from E2E service management domain as the response of network slice deletion.

POSTCONDITIONS:

- The network slice has been deleted.

ERROR CONDITIONS:

- Failing individual steps of this procedure will terminate the procedure with an error.

3.4.3 Demo 3: Service Operation

Editor's Notes: This part will be reported at the end of the PoC.

3.5 Demo screen

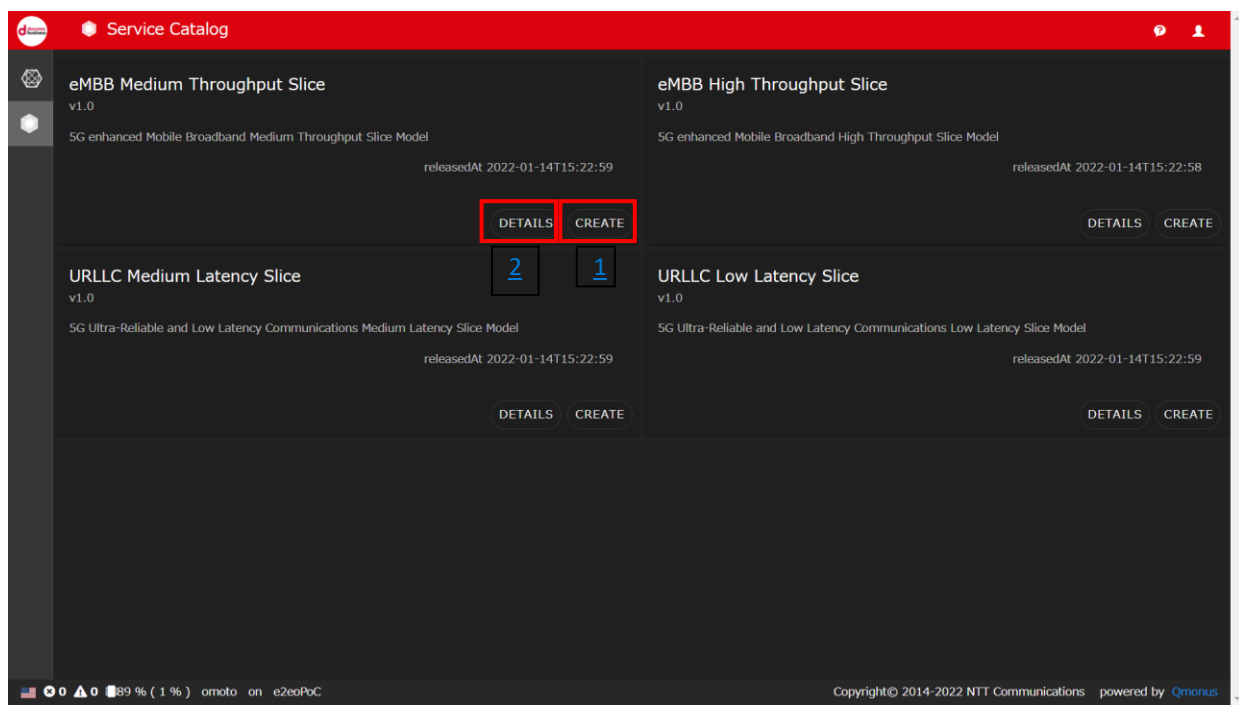This session provides the demo screen for each part with description.

Figure 7   Service Catalog on Qmonus

eMBB medium throughput slice, eMBB high throughput slice, URLLC medium latency slice, URLLC low latency slice are prepared in this PoC.

1.   "CREATE": create a network slice with the catalog.

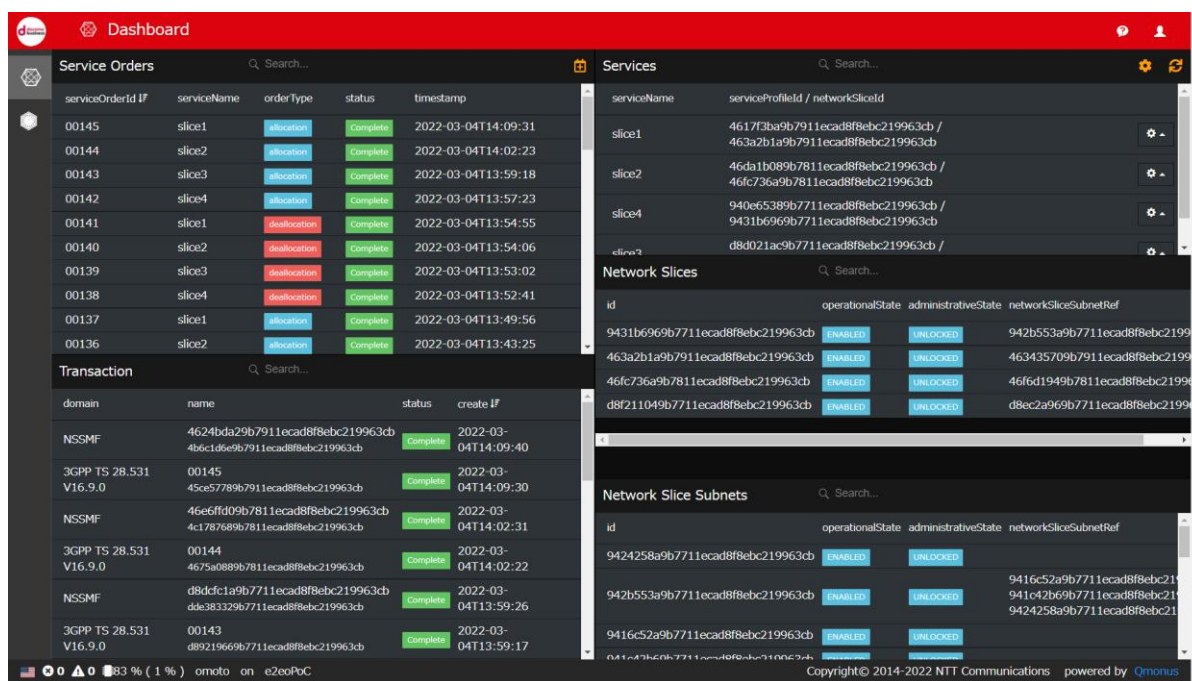2.   "DETAILS": confirm the parameters of the catalog.

Figure 8   Service and Slice Management on Qmonus

According to the service order, one network slice instance and four network slice subnet instance are created.

If it is created once, the status will change from red to green.

And if all network slice instance and network slice subnet instance are created, the transaction of the service order will change from red to green.

"id" means the number of Qmonus job id and NSSID is shown for each job.

Only the network slice whose status is shown as green can be deleted.

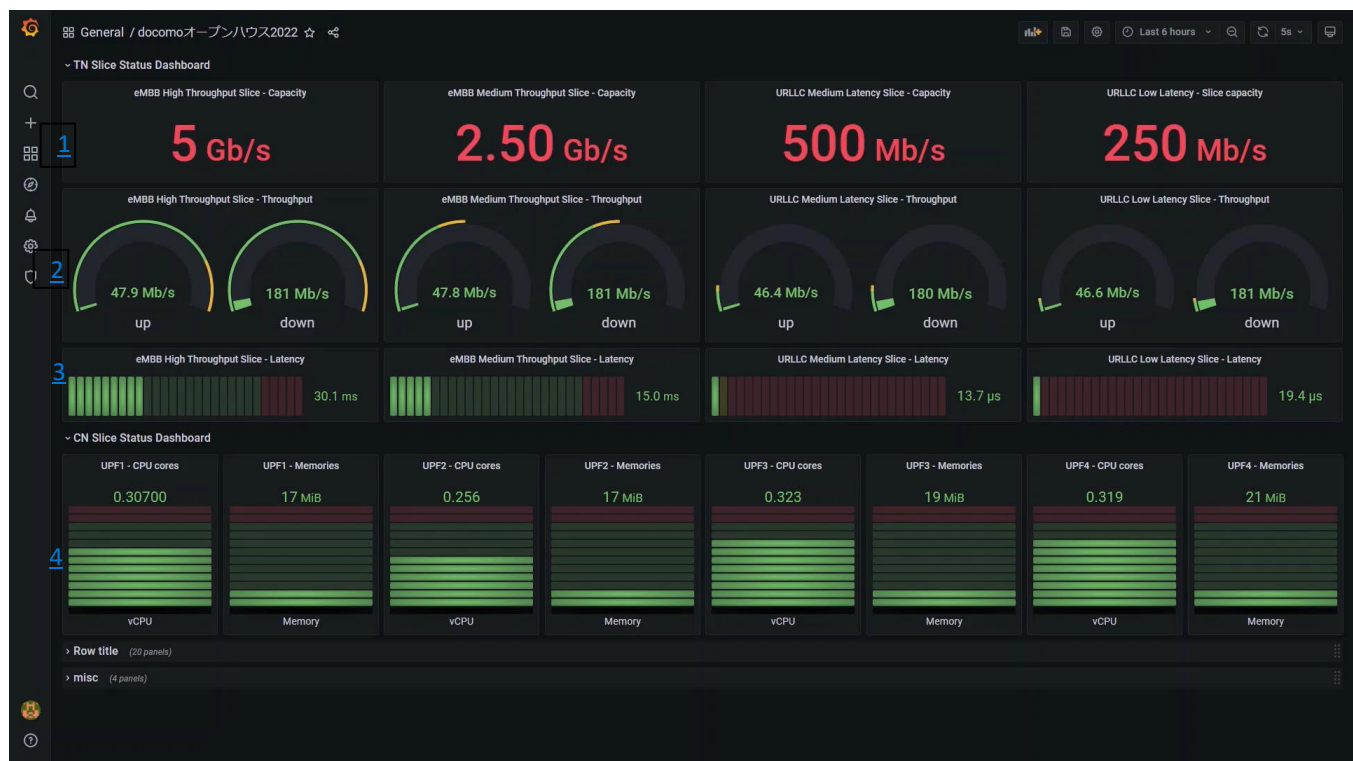**Figure 9   Slice Status Monitoring**

Slice status contains capacity, bandwidth and latency is under monitoring as Figure 9.

All the data are collected from the transport and core management domain.

The monitor item are listed as below.

1.   The maximum of the network slice bandwidth(transport management domain): when network slice is active

2.   The current throughput(transport management domain): when traffic flow occurs

3.   The round-trip latency of transport(transport management domain): when traffic flow occurs

4.   The number of vCPU cores and memory of UPF(Core management domain) : when network slice is active
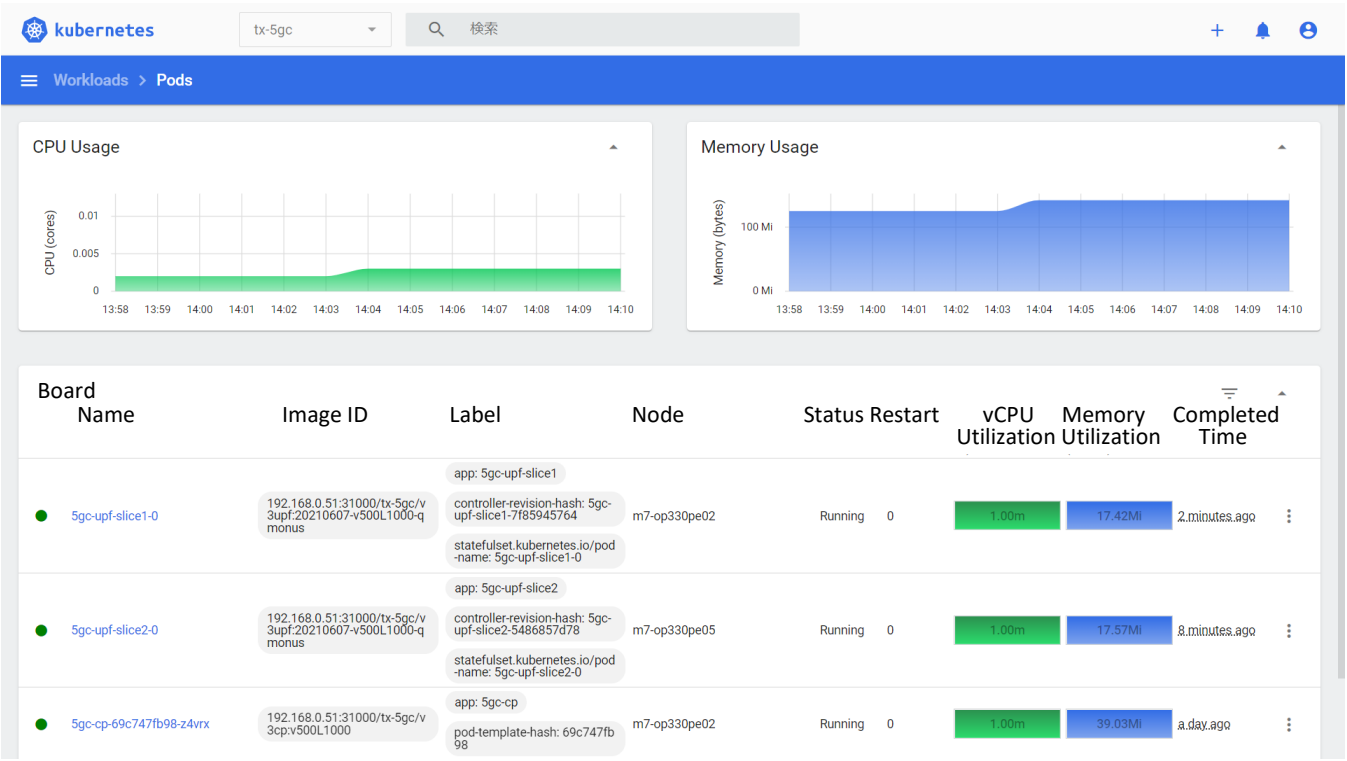

Figure 10   CN Container Monitoring on Kubernetes

Container of core management network is under monitoring on Kubernetes as Figure 10.

The utilization of vCPU and memory of each cluster are shown by minute.

The summary of U-plane and C-plane are available.

Figure 11   Traffic Flow Simulator Landslide

Landslide is used as traffic flow simulator in this PoC.

When network slice is active once, selected test session can be executed. Otherwise, an error occurs.
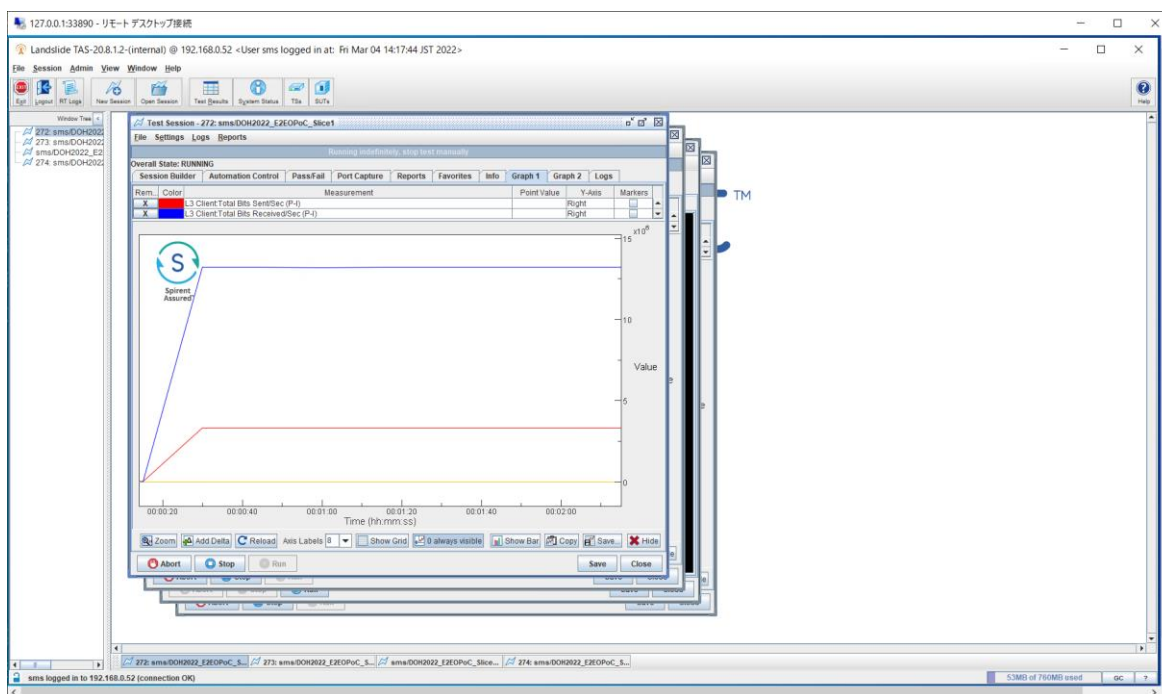

Figure 12   Traffic Flow Test on Landslide

When traffic flow test session is executed, gNB and device instance will be launched.

After 5GC registration and set-up of session, traffic flow will be shown.

Since serval device instance is launched, throughput will increase for a while and then remain flat.

3.63   Additional information

[1]   The information about Qmonus is available at the following link (Japanese only):

https://axis-edge.github.io/qmonus-developer-portal/#/

[2]   The information about HANMOC is available at the following link.

https://www.rd.ntt/e/research/NIC0008.html

The information about this PoC is available at the following link.

https://openhouse.docomo.ne.jp/en/main/exhibition/080