TELECOM INFRA PROJECT

OOPT-CANDI Whitepaper

Remote Migration Proof of Concept 2021

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1 CANDI's roadmap

1.1 The final goal of CANDI

The goals of CANDI are to flexibly allocate features on IP & optical network, achieve efficient internet protocol (IP) & optical networks, and provide inputs for the open optical packet transport (OOPT) sub-working group.

To achieve these goals, CANDI is taking the following actions.

1. CANDI clarifies issues to be solved for the future vision of packet optical transport networks
2. CANDI will take step-by-step approaches for achieving each use-case (Figure 1)
3. The main objectives of the proof of concept (PoC) are as follows:
   - To establish and test the basic architecture and workflow as a first step
   - To include both packet networks and optical networks, but not fully integrated networks

This whitepaper summarizes the PoC realized by the CANDI work group and the lessons learned after the trial. CANDI will continue to contribute to conducting enhanced PoCs twice a year to test and evaluate agreed upon use-cases and find the issues for developing the technology required to validate the feasibility of an operator's use-cases.

1.2. Summary of operator's use-cases

During its first phase, CANDI collected the use-cases shown in Figure 1 from operators. Initially, 10 use-cases were proposed from 5 carriers. Five of the use-cases (1, 3, 7, 9, and 10) were merged to "Provisioning of services in open optical and packet networks" because these use-cases are all related to the provisioning of network termination in both optical and packet networks. The current set of use-cases is detailed on the right part in Figure 1.

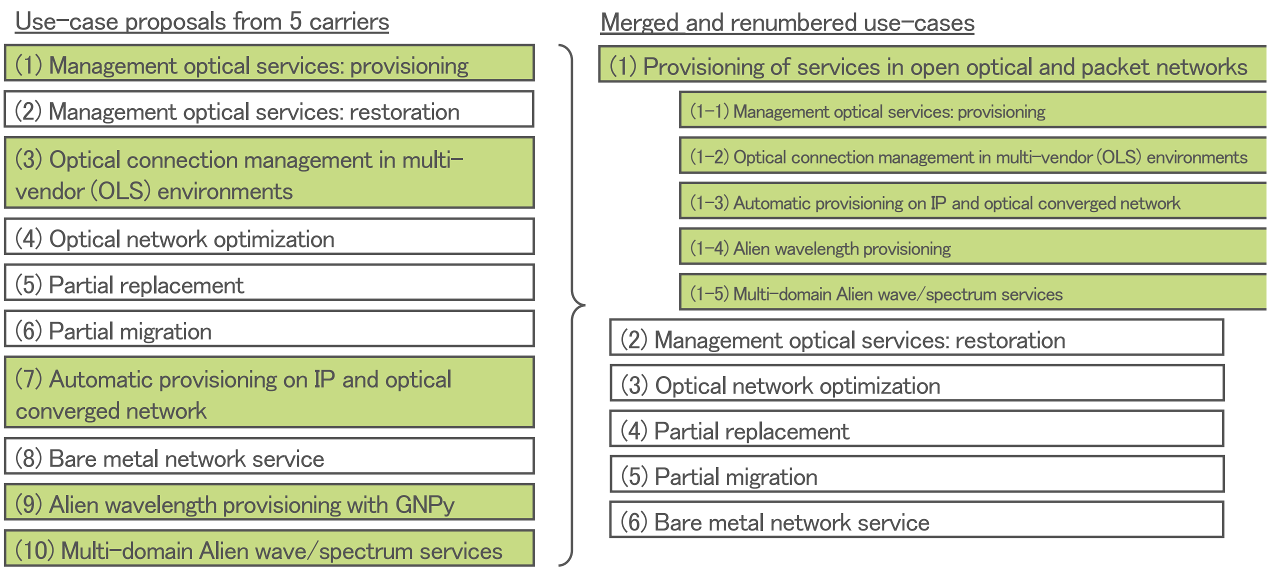

Figure 1. Use-case proposals

2 Experimental demonstration

2.1 Scope of demonstration scenario

CANDI PoC validates the end-to-end OOPT ecosystem. There are not just individual interfaces or products such as routers/transponders. CANDI provides a system view (devices, controllers, orchestrators, etc.). CANDI 2021 PoC divides the area and implements on the basis of four progressive and complementary scenarios. CANDI simplifies the overall process towards the final scenario.

1. Optical scenario (PoC #1): provisioning including physical impairment information

2. Packet scenario (PoC #2): Data center interconnection with layer 3 virtual private network (L3VPN) service provisioning

3. Packet scenario (PoC #3): Service provisioning with service level agreement (SLA) using traffic engineering and precise delay measurements

4. Migration scenario (PoC #4): Remotely replace a box network operating system (NOS) (starting with white-boxes)

The PoC Network scenario consists of a mixture of contributor's and Telecom Infra Project's (TIP's) products (Physical Simulation Environment (PSE), Disaggregated Optical Systems (DOS), and potentially Disaggregated Cell Site Gateways (DCSG)). New TIP products will be incorporated when available. CANDI has elaborated workflows to implement the use-cases using the set of TIP technologies showcasing the programmability of the IP/optical network.

This document describes the migration scenario with experimental details, results, and discussion.

2.2 Schedule

Table 1. Schedule for PoC testing

Items	Due date
Start to Develop/prepare environment	December 1, 2020
Complete PoC environment	February 28, 2021
Start PoC	March 1, 2021
Complete all PoC testing	March 31, 2021

2.3 Location

We conducted the PoC testing at the TIP Community Laboratory owned by Facebook in London, United Kingdom. Facebook, 1 Rathbone Square, London, W1T 1 FB. United Kingdom.

3 Remote and automatic migration

3.1 Test scope

3.1.1 Overview of relating use-case

This test scenario is related to use-case (4) in merged and renumbered use-cases of Figure 1. These use-cases aim to replace existing network elements (NEs) with other NEs. Furthermore, by introducing the white-box switch, we not only enable the entire NE swap but also the NOS upgrade/replacement. We also consider an effective system that manages replacement/migration of network functions with minimal service interruptions.

3.1.2 Motivation

A carrier must sometimes carry out network maintenance, i.e., replace or migrate a NE. However, these maintenance activities are generally complex and take a long time, resulting in service disruption. Hence, these maintenance works are carried out when service usage is low (e.g., at night). Also, the migration requires on-site work, and maintenance staff must visit all sites where NEs are located during the migration.
On the other hand, by introducing the disaggregation model, we obtain benefits (e.g., easy scaling), but the number of elements will be larger, so required replacements might increase. Both use-case (4) and use-case (5) in merged and renumbered use-cases of Figure 1 enable NEs to be efficiently replaced and migrated with minimal disruption to service provision.

3.1.3 Issues to be solved

Issues to be solved are the interoperability between any NOS and any network hardware and effective replacement/migration management systems. Below are the major issues with use-case (4) and use-case (5) in merged and renumbered use-cases of Figure 1.

(1) Interoperability between NOS and network device
(2) Short duration for replacement/migration even for a large carrier network
(3) Replacement procedure with minimal or no service interruptions
(4) Remote and automatic operation

In CANDI's first demonstration carried out at Madrid Labs in 2019 [1], we replaced an NOS by conducting manually executed operations and on-site work. In addition, NOS upgrade on white-box has been studied, and time taken has been measured in detail [2]. The earlier work focused on automatic upgrades, but our study focuses on remote and automatic migration as well.
This PoC focused on (2) short duration for replacement/migration even for a large carrier network, (3) procedure of replacement, and (4) remote and automatic operation. In the

experiments described in this report, we were able to demonstrate an approach that successfully addresses the issues listed above.

3.2 Contributors

NTT: Provide test scenario / Define issues / Complete test / Provide NOS for whitebox switch
Telefónica /Orange: Comment to PoC
UBiqube: Provide MSActivator an Integrated Automation Platform and applied MSActivator for Packet controller
Delta: Provide whitebox switch/ Technical support on whitebox switch
DCSG: Comment to PoC / Share Node Life Cycle Proposal and Technical requirement specifications for ZTP
Facebook: Provide Test environment / On-site support on Community lab

3.3 Test specifications and results

3.3.1 Workflow of remote NOS replacement

Figure 2 shows the schematic workflow for a remote NOS replacement. This workflow starts from the replacement call to the packet controller. Thereafter the packet controller manages the NOS replacement procedure without any intervention from the operator.
Firstly, the packet controller changes the interface configuration on the target switch to avoid traffic drop. Secondly, the NOS information stored in packet controller is updated to the target NOS. Later, the packet controller initiates the NOS uninstall procedure and transfers NOS images to the target white-box switch. After NOS transport, NOS installation starts automatically. Finally, after NOS replacement, the packet controller configures the network settings into the target NOS to restore the traffic to the target NOS. This is the basic automatic NOS replacement procedure defined by the authors.

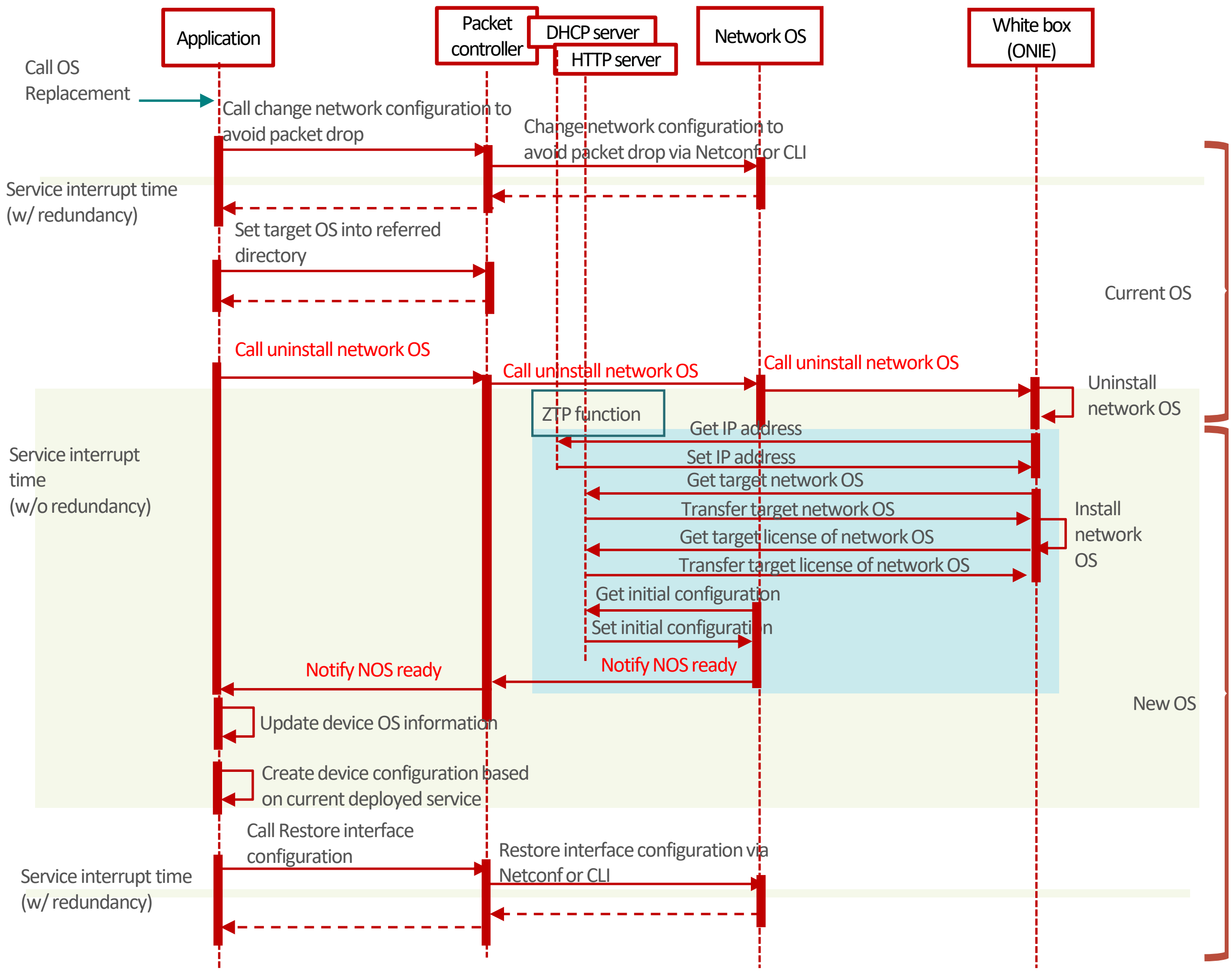

Figure 2. Workflow for automatic NOS replacement procedure

3.3.2 Network configuration

The experimental testbed implements a white-box based IP packet layer as shown in Figure 3. The IP segments are composed as two sites. The first site (site 1) is shown in the left of Figure 3 and is built up with four IP white-box switches from Delta hardware with software from open-source SONiC [3] and Beluganos [4]. Leaf2 is used as the border leaf in site 1. Leaf2 is connected to Leaf3. The second site (site 2) is constructed from one Delta IP switch with Cumulus software connected with site1. Both IP segment sites are managed by the packet controller. The packet controller used here is UBiqube MSActivator 2.3, which acts as a centralized management layer that manages all switches for maintenance across the two sites. In the test, L2VPN will be established between Leaf1 and Leaf3 by using Ethernet VPN virtual extensible local area network (EVPN-VXLAN) and VLAN. To verify the NOS replacement without service interruptions, a L2VPN service is established before the testing. In this test, we replace Beluganos on

Spine2 switch with SONiC with the workflow triggered by the MSActivator as an automated end-to-end process illustrated in the previous section.

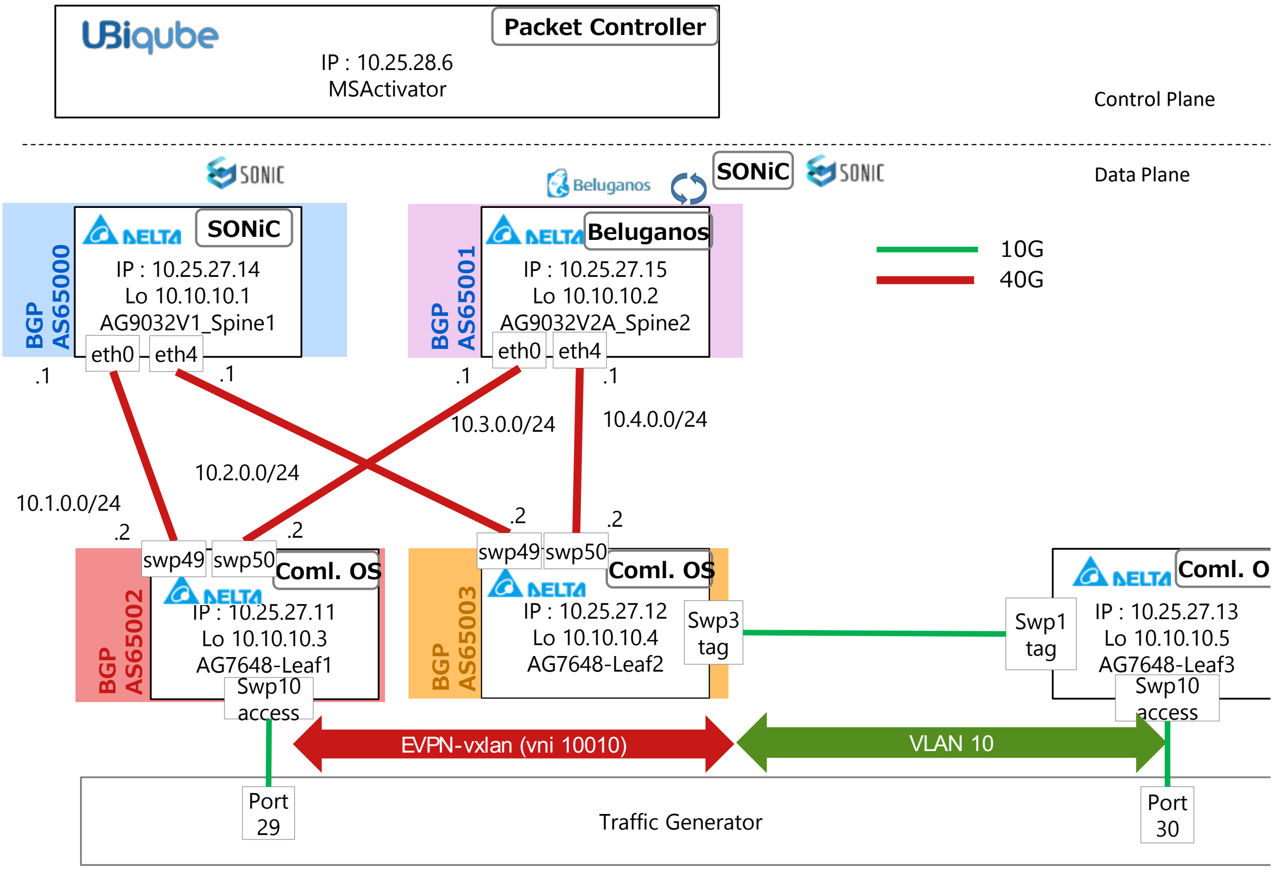

Figure 3. Experimental setup

Table 2. Management systems

Management systems			
Component	**Product**	**Quantity**	**Provider**
Packet controller	MSActivator 2.3/UBiqube	1	UBiqube

Table 3. Network elements

Network elements			
Component	**Product**	**Quantity**	**Provider**
Leaf switch (H/W)	AG7648/Delta Electronics	3	Delta Electronics
Leaf switch (S/W)	Commercial OS	3	NTT
Spine switch (H/W) for SONiC	AG9032V1/Delta Electronics	1	Delta Electronics
Spine switch (H/W) for	AG9032V2A/Delta Electronics	1	Delta Electronics

Beluganos and SONiC			
Spine switch (S/W)	SONiC/OCP	1	NTT
Spine switch (S/W)	Beluganos/NTT	1	NTT

Table 4. Test environment

Management systems			
Component	**Product**	**Quantity**	**Provider**
Traffic generator	Traffic generator	1	Facebook

3.3.3 Test items and results

Table 2. Test items and results for partial replacement scenario

Items	Description	Result
(1)	[Verify interoperability between white-box and NOS] - Install two NOSs, SONiC and Beluganos, into the same hardware (AG9032V2A from Delta) in manual operation.	☑
(2)	[Verify Spine switch's NOS replacement with remote and automatic procedure] - Change Spine switch's NOS from Beluganos to SONiC as a remote and automated process orchestrated by MSActivator.	☑
(3)	[Verify Leaf switch's NOS replacement with minimal service interruptions] – Suppress service interruption by rerouting data plane traffic to another Spine switch while target Spine switch's NOS is replaced. Service interruption time is only 0.001918739 seconds out of 1310.735 seconds in total operation time. – Service interruption time : 1.9 micro seconds – All operation time : 22 minutes – Install/Uninstall time : 21 minutes – ZTP time : 3.1 minutes	☑

☑: Approved, ☑: Partially Approved, ☐: NG

3.3.4 Analysis

All testing items were approved. The following conclusions are based on the authors' analysis.
(1) Installation of multiple OSS NOS has been tested successfully. However, few NOSs support all requirements, i.e., NOS uninstall commands, ZTP function, and the same type of VXLAN-EVPN. The choice of candidate NOS suitable for the same white-box switch is hence limited. Further standardization around the NOS features is recommended.

(2) We have replaced the Spine switch's NOS by conducting a remote and automatic procedure. However, ONL supports the uninstallation command of NOS, but most switches do not. Hence, we have limited candidates to execute remote NOS replacement. Also, few NOSs support OpenConfig/Netconf, and therefore northbound interface (NBI) of NOS replacement is not implemented.
(3) Defined workflow does not include abnormal system behavior.
(4) We have measured service interruption time at each process point. The result depends on the traffic amount because the service interruption time is calculated in detail by the ratio of packet loss to the traffic amount at the timing of packet loss occurrence. Carriers require service interruption time to be under 1 second, and we usually take two hours to migrate NOS. In this PoC, all processes took 22 minutes and, NOS uninstallation and installation took 21 minutes. However, the service interruption time was only 1.9 micro seconds because the configuration was changed to re-route traffic from the target Spine to another Spine before the NOS replacement. Most of the time is consumed by the NOS uninstallation, and NOS uninstallation time heavily depends on the switch's central processing unit (CPU) performance and disk size. Redundant configuration reduced service interruption time. Having said that, NOS uninstallation time needs to be reduced if we need to reduce all operation time. For example, to reduce the OS replacement time, A/B system updates and OS overrides are generally used, but seamless update systems, rollback systems, storage capacity, and partition management need to be discussed.

4 Future plans

The results and issues gained from this experiment will be fed back to the Mandatory Use Case Requirements for software defined networking (SDN) for Transport (MUST) subgroup, which specifies the TIP standards within the TIP OOPT, and to external communities such as ODL and the Open Compute Project (OCP). It is also desired to develop the replacement of network OS in an optical transmission white-box such as a transponder.

5 References

[1] CANDI First Experimental Demonstration,
https://cdn.brandfolder.io/D8DI15S7/as/q43vmp-30aaqg-3sbb3u/CANDI_-1st_experimental_demonstration-_Telecom_Infra_Project.pdf
[2] S. Barguil, R. Makarov, M. Mugan, J. P. Fernandez-Palacios and V. López, "Enabling Network Operating System Automated Upgrade in Packet/Optical Whiteboxes," 2020

International Conference on Optical Network Design and Modeling (ONDM), Barcelona, Spain, 2020, pp. 1-3.
[3] SONiC: https://azure.github.io/SONiC/
[4] Beluganos: https://github.com/beluganos/

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