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# Dual Management of Open XR pluggable modules in P2MP Applications Hosted in Various Routers with Transmission over Multiple Line Systems Proof of Concept Demonstration

**Open XR Optics Forum Document** 

OXR.POC.02.1 Dual Management of Open XR pluggable modules in P2MP Applications Hosted in Various Routers with Transmission over Multiple Line Systems September 2023

# ABSTRACT:

Here we report on the proof of concept of the Open XR Dual Management approach in P2MP applications where pluggables are hosted in various routers and signals transmitted over multiple line systems. The proof of concept demonstrates:

- 1. Compatibility of XR signals with a variety of line systems in
  - a. Point-to-point configuration and
  - b. Point-to-multipoint configuration
- 2. Compatibility of XR pluggable transceivers with a variety of host systems (Juniper, DriveNets & Ufispace, SONiC & Edgecore, Infinera TM301, and Infinera NDU)
- 3. Advanced management functionality of smart pluggable transceivers, demonstrating the capability of modern routers to seamlessly support remote management of pluggable transceivers through the Open XR Management Architecture.

This shows the viability of XR to transform the network, while being able to seamlessly integrate with legacy network infrastructure.

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The Open XR Optics Forum is the multi-source agreement (MSA) working group for XR optics, the industry's first point-to-multipoint coherent pluggable transceiver technology. The Open XR Optics Forum's mission is to foster collaboration that will advance development of XR optics-enabled products and services, accelerate adoption of intelligent coherent transceivers ,coherent point-to-multipoint network architectures, and drive standardization of networking interfaces to ensure ease of multi-vendor interoperability and an open, multi-source solution ecosystem.

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8

#### **Revision history:**

Version	Author	Date	Description
V2.0	Kamiel Braet Steven Hand David Hillerkuss	September 27, 2023	Date of initial publication
V2.1	Phill Amaya	November 21, 2023	Update Open XR Forum name to Open XR Optics Forum

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# Contents

1	Exec	utive Summary6
	1.1	Proof of Concept
2	Dem	onstration Objectives
	2.1	Interoperability with Deployed Line Systems in the Liberty Global Optical Network
	2.2	Interoperability with a variety of Routers and diverse Hosts supporting 400G pluggables7
	2.3	Demonstration of Advanced Open XR Management Functionality with the Open XR Controller8
3	Inter	operability with a variety of 400G Routers and diverse Hosts8
	3.1	Introduction
4	Inter	operability with Deployed Line Systems in the Liberty Global Optical Network
	4.1	Introduction
	4.2	Open XR 400G P2P signal and Infinera XTM 100GHz Flex Grid WSS9
	4.2.	1 Test results
	4.3	Open XR 400G P2P signal and Ciena OME 6500 112.5GHz Flex Grid WSS13
	4.3.	1 Test results
	4.4	Open XR 2x100G P2P signal and Infinera XTM 50GHz, Fixed Grid WSS, and DCU18
	4.4.	1 Test results
	4.5	Open XR 2x100G P2MP signal and Infinera XTM 100GHz Flex Grid WSS19
	4.5.	1 Test results
	4.6	Single fiber p2mp with XGS-PON coexistence with UfiSpace DriveNets 400G router20
	4.6.	1 Test results
5	Adva	nced Management of Smart Pluggable Transceivers in a Variety of Hosts
	5.1	Introduction
	5.2	CMIS managed Open XR Modules in UfiSpace and DriveNets 400G router
	5.3	Static IP Dual mgmt. with Open XR Modules in UfiSpace/DriveNets 400G router27
	5.4	Static IP Dual mgmt. with Open XR Modules in Juniper 400G router
	5.5	Dynamic IP Dual mgmt. with Open XR Modules in Juniper 400G router
	5.6	Line Side Dynamic IP Dual mgmt. with Open XR Modules in 400G router41
	5.7	P2MP with Open XR Modules in NDU and UfiSpace DriveNets router45
6	Sum	mary and Conclusion



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#### **1** Executive Summary

#### 1.1 Proof of Concept

Open XR promises to simplify the network architecture with long-reach coherent optics supporting pointto-point and point-to-multipoint connectivity, provide advanced transponder like functionality in a pluggable form factor, while being able to be deployed in existing optical fiber infrastructure and network equipment. This comes with a wide variety of challenges, from co-existence in deployed line systems and PON networks to being deployed in a variety of different types of hosts, all while providing full operational management functionality for advanced pluggable transceivers without full featured support by the diverse host system infrastructure.

In this Open XR Proof of Concept, we demonstrate the capabilities of Open XR transceivers to excel in such diverse environments by showing:

- The Coexistence of Open XR signals in a variety of line systems and networks, tested line systems from Ciena and Infinera, and Point to Multipoint deployment of XR in a legacy PON environment.
- Compatibility of Open XR transceivers with a variety of hosts, tested routers: Juniper / Evo, Ufispace / DriveNets, Infinera, and Edgecore / SONiC.
- Advanced management capabilities of Open XR transceivers and the Open XR controller, offering unambiguous control of the Optical Line Side independently from the (disaggregated) hosts [1], here tested in operating anJuniper / Evo and UfiSpace / DriveNets.

Open XR forum members Liberty Global, Infinera, Juniper, UfiSpace, and DriveNets supported this demonstration of a network with diverse hosts. Demonstrating interoperability of Open XR signals and multiple Optical Line Systems currently in use in Liberty Global networks, as well as Interoperability of Open XR modules with a diverse set of 400G routers (Juniper, Ufispace, ...). Both, 400G point-to-point and 400G to 4 x 100G point-to-multipoint are shown.

In addition, coexistence of the Open XR signals and the Liberty Global XGS-PON signals on the same PON single fiber infrastructure is demonstrated.

#### 2 Demonstration Objectives

2.1 Interoperability with Deployed Line Systems in the Liberty Global Optical Network First, the interoperability of the Open XR signal and deployed Liberty Global Optical Line Systems was demonstrated.

Liberty Global has deployed the Infinera XTM line system widely in the metro layer of the network in various countries.

The Ciena OME 6500 line-system supports the Liberty Global international network as well as the national network of the various countries Liberty Global operates in.

Interoperability between these line systems and the Open XR signal is crucial for brownfield deployments. This is key for the rapid adoption of Open XR in existing network infrastructures.



#### To demonstrate compatibility, the following scenarios are investigated for each line system:

- 1. 100GHz and 112.5GHz AWG Line System passband compatibility of a 16-subcarrier wide signal and 50GHz AWG Line System passband compatibility of an 8-subcarrier wide signal.
- 2. Ability of the Line System to read optical signal power level and regulate it to required power level at the line side.
- 3. Ability of the Rx side of the Open XR module to recover the signal after being transported across the line system.
- 4. Support for Open XR P2MP connectivity after the signal is transported over a Line System and an optical splitter.
- In a final test, interoperability of Open XR signals with current Liberty Global XGS-PON systems is tested, demonstrating the deployment of an Open XR signal in a single fiber point-tomultipoint Liberty Global PON testbed to show coexistence with XGS-PON signals in the same fiber tree.

For this evaluation, the pluggable transceivers were hosted in 400G EdgeCore Whitebox switch running SONiC or Infinera TM301 system equipped with CFP2 Open XR modules.

2.2 Interoperability with a variety of Routers and diverse Hosts supporting 400G pluggables The interoperability of the Open XR transceivers with 400G routers at Liberty Global is demonstrated. This is done by varying the host systems throughout the trials.

Host systems tested in the Liberty Global labs were Juniper PTX10K 400G routers and DriveNets UfiSpace 400G routers, 400GE EdgeCore Whitebox switches, Infinera TM301, and an Infinera Network Demarcation Unit (NDU) connected to a Nokia SR-7s. The Infinera NDU facilitates connectivity between XR pluggables and QSFP28 pluggables.

Verified Host Devices
Juniper PTX10K 400G routers
DriveNets UfiSpace 400G router
400GE EdgeCore Whitebox switch with Sonic
Infinera TM301
Infinera NDU connected to Nokia SR-7s through QSFP28

Table 1: Tested Host Devices

Compatibility of these routing platforms with Infinera Open XR compliant pluggable transceivers was tested:

- 1. Successfully power up the module,
- 2. start up the module through MDIO or CMIS management interface,
- 3. establish data connectivity though the module, verified by traffic test set,
- 4. and enable IP connectivity between the pluggable transceiver and an external Open XR Controller.





2.3 Demonstration of Advanced Open XR Management Functionality with the Open XR Controller Open XR modules provide advanced functionalities beyond the capabilities of currently deployed host systems. The Open XR management architecture [1] mitigates this mismatch by providing host independent management capabilities of advanced functionalities through the Open XR controller. These features include inventory and monitoring but also configuring advanced functionalities for point-to-point high performance transmission, point to multipoint (establishing point to multipoint module connectivity, assigning subcarriers, ...).

## 3 Interoperability with a variety of 400G Routers and diverse Hosts

#### 3.1 Introduction

A variety of host systems were tested in both P2P and P2MP configurations throughout the following two chapters.

Host	Section and application
Juniper PTX10K v23.1-EVO	5.4 - 5.5 p2p Dual Mgmt
DriveNets v17.3 & UfiSpace S9702-23D	4.6 p2mp single fiber, 5.2 p2p, 5.3 p2p Dual Mgmt, 5.6 p2p Dual Mgmt remote, 5.7 p2mp Hub
SONiC 2011-11 & EdgeCore	4.2 p2p, 4.3 p2
Infinera XR-NDU	4.5 p2mp Leaf, 5.7 p2mp Leaf
Infinera TM301	4.4 p2p, 4.5 p2mp Hub

Table on which host is tested in which section.

#### 4 Interoperability with Deployed Line Systems in the Liberty Global Optical Network

#### 4.1 Introduction

Compatibility with multiple line systems was investigated and successfully demonstrated. The line systems and utilized host devices are listed in the Table below. The line systems were representative of line systems deployed in the Liberty Global networks.

Table 2: Tested combinations of line systems and host devices for line system interoperability tests.

	Line System	Scenario	Host Device
4.2	Infinera XTM 100GHz Flex Grid WSS	1×400G point-to-point	400GE EdgeCore Whitebox switch running SONiC
4.3	Ciena OME 6500 112.5GHz Flex Grid WSS	1×400G point-to-point	400GE EdgeCore Whitebox switch running SONiC
4.4	Infinera XTM 50GHz, Fixed Grid WSS, and DCU	2×100G P2P point-to-point	Infinera TM301 system



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4.5	Infinera XTM 100GHz Flex Grid WSS with P2MP breakout after transmission	2×100G point-to-multipoint	Infinera TM301 and Infinera NDU
4.6	PON single fiber overlay scenario	2x100G point-to-multipoint	UfiSpace DriveNets and Infinera NDU

4.2 Open XR 400G P2P signal and Infinera XTM 100GHz Flex Grid WSS The Infinera XTM line system is widely used inside the metro layer of Liberty Global network. This line system is currently mostly in combination with transponders and muxponders, extending the usage of this infrastructure with Open XR technology would make it much more valuable for Liberty Global.

To demonstrate the interoperability an XTM line system setup with two optical nodes interconnected with 40 km of SMF-28E+ fiber was used. The XTM line system software version used was v35.0.

The line system was equipped with 100GHz AWG filters, 1x9 Route & Select WSS modules, and twin EFDA amplifiers. To control the optical signal power an OCM was deployed at the amplifier to measure the per channel signal power and control the VOA attenuation level inside the WSS module.

Connecting to the line system was a 400GE EdgeCore Whitebox switch running SONiC version SONiC.ec202111.0-dirty-20220928.150408. This device acted as the host for two XR modules running software version v0.2.2. One XR module was acting as the XR Hub module and the other as XR Leaf module.

The connection across the line system was established on 100GHz port 940 with optical signal center frequency 194.00GHz.



Figure 1 - Logical diagram of testbed 1 – Infinera XTM 100GHz



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Figure 2 - Rack layout and cabling of testbed 1

#### 4.2.1 Test results

Using testbed 1 a 400G P2P connection was successfully established between the two XR modules and across the Infinera XTM line system.

The OSA readings from the transmitted XR signals and the received XR signals indicated that the full 16 XR subcarriers fit through the AWG filter. The attenuation curve of the AWG was showing on the AWG, but the signal could be recovered on the outer subcarriers.



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Figure 3 - P2P Hub Tx (Green) and P2P Leaf Rx (Red) Optical Spectrum Analyzer readings



Figure 4 - P2P Leaf Tx (Green) P2P Hub Rx (Red) Optical Spectrum Analyzer readings

Liberty Global has deployed most of its XTM line systems as 40 channel systems. To achieve the best performance, the line side optical signal power per channel is set to 3.5 dB. During the test it was possible to achieve this power level of 3.5dB as shown in the XTM element manager screenshot. Also the XR signal was established successfully across the line system with Regulation switched on.



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Channel plan	Frequency slot	Carrier	
Search	Ţ	Verbose	ON Max/page: 100
Name		fs:2:67	
fs:1:5		- carrierRegulation:2:67	
fs:1:6		Attribute	Value
fs:1:7		Name	carrierRegulation:2:67
fs:1:8		Center frequency	194.000000 THz
fs:1:9		Carrier width	100.000 GHz
fs:1:10		Administrative status	up 🗸
fs:1:11		Operational status	up
fs:1:12		Status	idle
fs:1:13		Power level threshold	-2.5 dBm
fs:1:14		Optical power	3.3 dBm
fs:1:15		Wanted optical power	3.5 dBm
fs:1:16		Attenuation	5.7 dB
fs:1:17		Minimum supported attenuation	0.0 dB
fs:1:18		Maximum supported attenuation	15.0 dB
fs:1:19		Attenuation control offset	1.0 dB
fe:1:20		Force regulation	forceRegulation
fo-1-21		Startup	startup
15.1.21		Output power control failure	ok
15:1:22		Attenuation control degraded	ok
ts:1:23		Carrier not found	ok
fs:1:24		Measurement time	Tue Nov 1 15:06:50 CET 202
fs:1:25		Current power out of range	ok
fs:1:26		Attenuation out of range	ok

Figure 5 - Infinera XTM 3.5dBm line side & regulation





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Figure 6 - Infinera XTM line system of testbed 1

4.3 Open XR 400G P2P signal and Ciena OME 6500 112.5GHz Flex Grid WSS

The Ciena OME 6500 line system is widely used inside the core and international layer of the Liberty Global network. This line system is currently mostly in combination with transponders and muxponders, extending the usage of this infrastructure with Open XR technology would make it much more valuable for Liberty Global.

To demonstrate the interoperability a two node Ciena OME 6500 line system setup with two optical nodes interconnected with 10dB attenuators was used. The Ciena OME 6500 line system software version used was v12.72.

Open XR Optics Forum | 13

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The line system was equipped with 112.5GHz AWG filters, 1x9 Broadcast & Select WSS modules, and two stages of twin EFDA amplifiers. To control the optical signal power an OCM was deployed at the amplifier to measure the per channel signal power and control the VOA attenuation level inside the WSS module.

Connecting to the line system was a 400GE EdgeCore Whitebox switch running SONiC version SONiC.ec202111.0-dirty-20220928.150408. This device acted as the host for two XR modules running software version v0.2.2. One XR module was acting as the XR Hub module and the other as XR Leaf module.

The connection across the line system was established on 112.5GHz with optical signal center frequency 195.0188GHz.



Figure 7 - Logical diagram of testbed 2 – Ciena OME6500 112.5GHz



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Figure 8 - Rack layout and cabling of testbed 2

#### 4.3.1 Test results

Using testbed 2 a 400G P2P connection was successfully established between the two XR modules and across the Ciena OME 6500 line system.

The OSA readings from the transmitted XR signals and the received XR signals indicated that the full 16 XR subcarriers fit easily through the 112.5GHz AWG filter. The attenuation curve of the AWG was showing on the AWG, but the signal could be recovered on the outer subcarriers.





Figure 9 - XR Downlink (Green) and Uplink (Black) Optical Spectrum Analyzer readings



Figure 10 - Ciena OME 6500 line system of testbed 2



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ciena. 🕅 🕅 Network	Planning	🗘 System		~	C 30 M 16 m	9 W
ZRP-3   NL-SRK03A-DH4-LAB-2 Photonic   OTSi   Unprotected	■—■ NL-SRK03A-E Discovered   Up	0H4-LAB-1 🗾				
Topology Attributes Optical pov	er Performance	Alarms (2)	Depends on (2)	Supports (0)	Related services (0)	Se
		NL-SRK03A-D	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	A-DH4-LAB-2		
	•••••• • •••••	› ···· ›	· ···· · ··	···· > ····	> ····· > ·····	•
	CMD42 LIM 2-83 2-12	WSSOPM 2-3	LIM L 2-2 2	.IM WSSOPM 2-2 2-3	LIM CMD42 2-12 2-83	2
	NL-SRK0	3A-DH4-LAB-2		NL-SRK0	A-DH4-LAB-1	

Figure 11 - Ciena MCP Topology view of testbed 2

ZRP-3   NL Photonic	-SRK03A-DH4-LAB-2 DTSi   Unprotected   Disc	NL-SRK03A-E	0H4-LAB-1		~ <mark>C</mark>	30 <mark>M</mark> 16 <mark>M</mark> 9 W	1
opology Attrib	utes Optical power	Performance	Alarms (2)	Depends on (2)	Supports (0)	Related services (0)	
✓ Primary attri	butes						
Label	ZRP-3			Domains		P-SNC	
Description	-			Resilience		Unprotected	
Management name	-			Channel		10	
Native name	-			Mesh restor	able	_	
Туре	Photonic			Minimum gu	ardband	0.000	
Rate	OTSi			Maximum g	uardband	0.000	
Center frequency	195.018750 THz			Frequency re	esolution	0.100 GHz	
				Signal band	width 10dB	65.000	
				Signal band	width 3dB	55.600	
				Spectral wid	th	62.50 GHz	
✓ States							
Deployment	Discovered			Operational	last	2022-08-17 03:39:37+01	.00
Operational	Up			updated		2022 02 08 11 20 20 10	.00
Admin	Enabled			Admin last u	ipdated	2022-02-06 11:39:29+01	.00
✓ Endpoints							
Endpoint				Endpo	pint		
NE	NL-SRK03A-DH4-L	AB-2		NE		NL-SRK03A-DH4-LA	AB-1
Port	2-83-19,2-83-20 (s	h-sl-pt)		Port		2-83-19,2-83-20 (sh	-sl-p
CDFI	— (Adj-Tx), — (Adj-	Rx)		CDFI		— (Adj-Tx), — (Adj-R	bx)

Figure 12 - Ciena MCP Photonic Service view of testbed 2

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4.4 Open XR 2x100G P2P signal and Infinera XTM 50GHz, Fixed Grid WSS, and DCU The Infinera XTM line system is widely used inside the metro layer of Liberty Global network. This line system is currently mostly in combination with transponders and muxponders, extending the usage of this infrastructure with Open XR technology would make it much more valuable for Liberty Global.

In its most common setup, the XTM is equipped with a 50GHz fixed grid system, which includes a 1x2 WSS and Dispersion Compensation Units. These systems are 10G signal optimized but lack support for 400G coherent signals. The passband should allow for up to 8 Open XR subcarriers which allows for the delivery of 200G worth of capacity on a single 50GHz channel.

To demonstrate the interoperability an XTM line 50GHz system setup with two optical nodes interconnected with 40 km of SMF-28E+ fiber was used. The XTM line system software version used was v35.0.

The line system was equipped with 50GHz AWG filters, 1x2 Route & Select WSS modules, and twin EFDA amplifiers. To control the optical signal power an OCM was deployed at the amplifier to measure the per channel signal power and control the VOA attenuation level inside the WSS module.

Together with the Open XR signal a 100G QPSK optical signal and a 10G optical signal were transported by the XTM line system.

Connecting to the line system was an Infinera TM301 system equipped with CFP2 Open XR modules. One XR module was acting as the XR Hub module and the other as XR Leaf module.

The connection across the line system was established on 50GHz with optical signal center frequency 194.00GHz. The Open XR modules were configured to send 8 subcarriers with 16QAM modulation by switching off 4 of the outer subcarriers on both sides.



Figure 13 - Logical diagram of testbed 3 – Infinera 50GHz

#### 4.4.1 Test results

Using testbed 3 eight 25G subcarriers were successfully transported across the 50GHz XTM line system with one subcarrier margin on both sides.



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XR - Downlink & Uplink

Figure 14 - XR Downlink (Green) and Uplink (Black) Optical Spectrum Analyzer readings

4.5 Open XR 2x100G P2MP signal and Infinera XTM 100GHz Flex Grid WSS

The Infinera XTM line system used in testbed 1 was extended with a 4x4 Coupler for Open XR 2x100G P2MP signal interoperability testing as part of testbed 4.

Connecting to the line system were an Infinera TM301 with CFP2 Hub and CFP2 Leaf module, as well as a NDU with CFP2 Leaf module.

The connection across the line system was established on 100GHz port 940 with optical signal center frequency 194.00GHz.



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Figure 15 - Logical diagram of testbed 4 – Infinera 100GHz with 4x4 Coupler

#### 4.5.1 Test results

The 2x100G P2MP signal was successfully transported across the 100GHz XTM line system and the 4x4 Coupler. The optical signal was also received, demodulated, and decoded successfully at the Hub and the two Leaf sides.

The XTM had to be configured for a 0.5dBm line side power to successfully regulate the XR signal.

C	ptical manageme	ent Carrier R	egulation	Mean channel power control			
С	hannel plan	requency slot	Carrier				
Se	arch	Ţ					Verbe
	Name			fs:2:67			
	fs:1:5			- carrierRegulation:2:67			
	fs:1:6			Attribute	Value		
	fs:1:7			Name	carrierR	egulation:2:67	
	fs:1:8			Center frequency	194.000	000 THz	
	fs:1:9			Carrier width	100.000	GHz	
	fs:1:10			Administrative status	up	~	
	fs:1:11			Operational status	up		
	fs:1:12			Status	idle		
	fs:1:13			Power level threshold	-5.5 dBr	n	
	fs:1:14			Optical power	0.5 dBm		
	fs:1:15			Wanted optical power	0.5	dBm	
	fs:1:16			Attenuation	1.7 dB		
	fs:1:17			Minimum supported attenuation	0.0 dB		
	fs:1:18			Maximum supported attenuation	15.0 dB		
	fs:1:19			Attenuation control offset	1.0	dB	
	fs:1:20			Force regulation	forcel	Regulation	
	fo:1:21			Startup	startu	P	
	fo: 1:21			Output power control failure	ok		
	15.1.22			Attenuation control degraded	ok		
	15.1:23			Carrier not found	ok		
	ts:1:24			Measurement time	Thu Nov	3 17:13:19 CET 2022	
	fs:1:25			Current power out of range	ok		
	fs:1:26			Attenuation out of range	ok		

Figure 16 - Infinera XTM 0.5dBm line side & regulation

4.6 Single fiber p2mp with XGS-PON coexistence with UfiSpace DriveNets 400G router The Nokia XGS-PON test network in Liberty Global's lab facility was extended with a circulator and multiple splitters. This allows for testing the coexistence of the XGS-PON optical signal and the Open XR signal on the same single fiber tree.

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The Open XR hub side was set up in a p2mp fashion connecting to two leafs with 100G full duplex speed for each. In parallel to this a single XGS-PON ONU device was connecting with a 10G speed to an OLT using the same fiber.



Figure 17 - Logical diagram of the Open XR and XGS-PON coexistence testbed

#### 4.6.1 Test results

The 2x100G P2MP signal was successfully transported across the single fiber tree including the circulators and splitters. At the same time the XGS-PON signal was also transmitted successfully and the working of the IP packet forwarding function was successfully verified.



Figure 18 - High Resolution OSA graph of the Single Fiber XR signal from hub and leaf interleaved



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Figure 19 - Wideband OSA graph showing both XGS-PON and Open XR signal.

#### 5 Advanced Management of Smart Pluggable Transceivers in a Variety of Hosts

5.1 Introduction

The Advanced management capabilities of the smart pluggable transceivers were tested in a variety of scenarios and hosts, carefully selected to represent the most promising use cases of the Open XR technology as identified by Liberty Global. Connectivity was verified using a Viavi traffic tester and additional telemetry was obtained through a high-resolution optical spectrum analyzer and the Open XR Controller.

In these investigations, connectivity for the remote management of smart pluggable transceivers was facilitated by virtual routing and forwarding (VRF), which is a standard feature available in modern routers.

In the following sections, we show different management concepts up to the zero-touch provisioning in section 5.7.

The selected use cases were:

- 1. Initial verification of connectivity between pluggable, host, and Open XR controller
- 2. 400G Transmission through a line system with local management by host system
- 400G Transmission through a line system with remote management by the Open XR controller and static configuration of the IP connectivity in a UfiSpace/DriveNets 400G router as the host system
- 4. 400G Transmission through a line system with remote management by the Open XR controller and static configuration of the IP connectivity in a Juniper PTX10K 400G router as the host system
- 5. 400G Transmission through a line system with remote management by the Open XR controller and zero touch provisioning of the IP connectivity in a Juniper PTX10K 400G router as the host system
- 6. 400G Transmission through a line system with remote management by the Open XR controller and zero touch provisioning of the IP connectivity through a supervisory channel on the line side of a module in a UfiSpace/DriveNets 400G router as the host system



7. Point to Multipoint commissioning through VRF in a UfiSpace/DriveNets host to multiple Infinera XR NDUs, one connected to a Nokia SR-7s.

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5.2 CMIS managed Open XR Modules in UfiSpace and DriveNets 400G router

Liberty Global is using UfiSpace hardware with DriveNets software as a 400G routing platform for its Core Network. This testbed is used to confirm interoperability between this router platform and the Open XR Modules running in point-to-point mode.

In this test bed the Open XR modules are configured with a center frequency and Tx power using the DriveNets CLI. The Open XR Controller was placed in monitoring mode, which is identified by the "Discovered" text in the Constellations and Services pages.



Figure 20 - CMIS Management test bed logical diagram

DriveNets DNOS 17.3 configuration:

```
ge400-0/0/1
admin-state enabled
transceiver
optical-transport
center-frequency 194800 ghz
target-output-power -2000
ge400-0/0/6
admin-state enabled
transceiver
```

Open XR Optics Forum | 23



www.openxropticsforum.org

8

optical-transport center-frequency 194800 ghz target-output-power -2000

The 400GE connection availability was successfully verified using a VIAVI tester.



Figure 21 - CMIS Management test bed Viavi test results

The High resolution OSA readings from the Hub and Leaf side with all 16 digital subcarriers:

Figure 22 - CMIS Management test bed Hub Tx OSA 90/10

Open XR Optics Forum | 24



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Figure 23 - CMIS Management test bed Leaf Tx OSA 99/1

# Several different Open XR Controller screenshots:

🗼 ІРМ	Modules	
Dashboard	C REFERSE B FORCE NO.	
	Status Module name	
¥	MA222234003	
Constellations	© MA222242A00A	
Transport Capacities	MA2223112A010	
CI2 Services	O selected, total records: 4 7 columns selected	
A. Woones		
🗼 ІРМ	Constellations	xr-user-1 v
Dashboard		TV
💮 Hosts	Note: Module name A LLDP System Name Host Ports MAC address Constellation frequency (THz) Modulation Topology IEEE 1588 TC	Lifecycle State
	Discoursed         M2223112A010         3C:02:68:00:16:80         194.800000         160AM         V         III	Configured
	Diselected, total records: 1 10 columns selected V	> >> 20 🗸
🗼 ІРМ	Services	↓ <b>#</b> ~ <b>▲</b> XR-USER-1 ~
Dashboard		
Hosts		
MDU	Endpoint Z Endpoint Z Indpoint Z	s) Lifecycle State Mar
		Conformed 11



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/ Modules / MA22231	12A010 / Settings / General				
🗢 Se	ettings	C Line Port (Optical)	Star Client Port (Ether	net)   2	K co
General	Labels				
Device name	MA2223112A010			G	
bettee flame				13/64	
Access identifier	XR				
Status	() Online				
WARM START	S COLD START O FACTOR	YRESET			
Configuratio	n		^ Nardware Des	cription	
Configuration stat	e Ready		Serial number	MA222312A010	
Configured Role	Auto		MAC address	3C:02:68:00:16:80	
Current Role	Hub		Software version	v1.1.0.6	
Host ID			Hardware version	ocf.2.2.5	
Host port ID			Form factor	QSFP-DD	
IEEE 1588 TC			Connector type	LC connector	
Role Status	Ready		Model number		
Serdes lane rate	50 Gbps		CLEI Code		
Service mode	Auto		Module Id	84e982f8-f031-4755-5d47-cc2448	871d1b8
Traffic mode	11 mode		Vendor	INFINERA	

# DriveNets DNOS 17.3 CLI show command output:

OpenXR1# show interfaces counters ge400-0/0/1				Interface ge400-0/0/6:			
Interface ge400-0/0/1: Operational state: up Ethernet counters: RX octets: RX unicast frames: RX multicast frames: RX multicast frames: TX octets: TX frames: TX broadcast frames: TX broadcast frames: TX multicast frames:	6212702501261 ( 809522 91363272132 ( 1488 91363272127 ( 1488 0 ( 5 ( 6212702437283 ( 809526 91363270799 ( 1488 91363270779 ( 1488 0 ( 20 (	256985 bps / 86 309136 fps / 1 0 fps / 0 fps / 0 fps / 59710 bps / 86 308912 fps / 1 0 fps / 0 fps / 0 fps /	0952.26 Mbps) 148.81 Mfps) 0 Mfps) 0 Mfps) 925.06 Mbps) 148.81 Mfps) 0 Mfps) 0 Mfps) 0 Mfps)	Operational state: up Ethernet counters: RX octets: RX frames: RX broadcast frames: RX multicast frames: TX octets: TX frames: TX broadcast frames: TX broadcast frames: TX multicast frames: Ethernet control counters: RX pause frames: RX pause frames:	6232996758315 ( 91661721369 ( 6232997965295 ( 91661736825 ( 91661736825 ( 0 ( 0 ( 0 ( 0 ( 0 )	80939516954 bps / 148786250 fps / 0 fps / 0 fps / 8094072373 bps / 148787856 fps / 148787856 fps / 0 fps / 0 fps /	80939.52 Mbps) 148.79 Mfps) 0 Mfps) 0 Mfps) 80940.47 Mbps) 148.79 Mfps) 148.79 Mfps) 0 Mfps) 0 Mfps)
Ethernet control counters: RX pause frames: TX pause frames: RX PPC frames: TX PFC frames:	0 0 0			TX pause frames: RX PPC frames: TX PFC frames: Ethernet drop counters: & errors:	0 0 0		
Ethernet drop counters: RX too short: RX too short: RX too long: RX FCS errors: RX internal MAC errors: RX jipeline MAC drops: TX errors:	0 0 0 0 0 0 0			RX too short: RX too long: RX FCS errors: RX internal MAC errors: RX jipeline MAC drops: TX errors: FEC counters:			
FEC counters: FEC corrected errors: FEC uncorrected errors: FEC symbol errors: FEC bit errors:	169862 0 169888 161308			FEC CONTRECTOR OFFICES FEC SUNCONTRECTORS: FEC Symbol enrors: FEC bit enrors: Forwarding drops summary of logical and sub-IF	29 0 29 28		
Forwarding drops summary of logical and sub-I RX VLAN mismatch: Destination MAC mismatch: Invalid IP header: Total RX dropped packets: Total TX dropped packets:	F: 0 5 0 5 0			NA VLAW MILIMICAC MISmatch: Destination MAC mismatch: Invalid IP header: Total RX dropped packets: Total TX dropped packets: OpenXR1#	0 1 0 1 0		
OpenXR1# show interfaces counters ge400-0/0/6							

Open XR Optics Forum | 26



#### More DriveNets DNOS 17.3 CLI show command output:

OpenXR1# show interfaces transceiver ge400-0/6	0/6	OpenXR1# show interfaces transceiver ge400-0/0/1				
Interface ge400-0/0/6		Interface ge400-0/0/1				
Identifier	: QSFP_DD	Identifier	: QSFP_DD			
Connector	: 0x7 (LC type fiber connector)	Connector	: 0x7 (LC type fiber connector)			
Length (OM3 50um)	: 05Km	Length (OM3 50um)	: 0m			
Length (OM2 50um)	: Om	Length (OM2 50um)	: Om			
Length (OM1 62.5um)	: Om	Length (OM1 62.5um)	: Om			
Length (Copper or Active cable)	: Om	Length (Copper or Active cable)	: Om			
Iransmitter technology	: 0x10 C-band tunable laser	Iransmitter technology Ontical transport info	: 0x10 C-band tunable laser			
Tx Power	: -2.0 dBm	Tx Power	: -2.0 dBm			
Laser wavelength	: 1547 nm	Laser wavelength	: 1547 nm			
Laser wavelength tolerance	: 0 nm	Laser wavelength tolerance	: 0 nm			
Vendor name	: INFINERA	Vendor name	: INFINERA			
Vendor PN	. 00.00.00	Vendor PN	. 00.00.00			
Vendor rev		Vendor rev				
Vendor SN	: MA222242A00A	Vendor SN	: MA222312A010			
Firmware version	: 1.1	Firmware version	: 1.1			
Module temperature	: QSFP-DD OF QSFP-DD CMIS KEV 5.1 : 62 A degrees C / 144 3 degrees F	Module temperature	: USFP-DD OF USFP-DD CMIS REV 5.1 : 48 8 degrees C / 119 8 degrees F			
Module voltage	: 3.2 V	Module voltage	: 3.2 V			
Alarm/warning flags implemented	: Yes	Alarm/warning flags implemented	: Yes			
Laser tx bias current (Channel 0)	: 100.0 mA	Laser tx bias current (Channel 0)	: 100.0 mA			
Transmit avg optical power (Channel 0)	: -3.1 dBm / 0.5 mW	Transmit avg optical power (Channel 0)	: -2.0 dBm / 0.6 mW			
Laser hiss current high plarm (Chan 0)	: -2.5 GBM / 0.6 MW	Laser bias current bigb alarm (Chan 0)	: -3.1 GBM / 0.5 MW			
Laser bias current low alarm (Chan 0)	: off	Laser bias current low alarm (Chan 0)	: off			
Laser bias current high warning (Chan 0)	: off	Laser bias current high warning (Chan 0)	: off			
Laser bias current low warning (Chan 0)	: off	Laser bias current low warning (Chan 0)	: off			
Module temperature high alarm	: off	Module temperature high alarm	: off			
Module temperature low alarm	: OTT : off	Module temperature low alarm Module temperature high warning	: OTT : off			
Module temperature low warning	: off	Module temperature low warning	: off			
Module voltage high alarm	: off	Module voltage high alarm	: off			
Module voltage low alarm	: off	Module voltage low alarm	: off			
Module voltage nigh warning	: 011	Module voltage high warning	: 011			
Laser tx nower high alarm (Channel 0)	: Off	Laser tx nower high alarm (Channel 0)	: OTT : off			
Laser tx power low alarm (Channel 0)	: off	Laser tx power low alarm (Channel 0)	: off			
Laser tx power high warning (Channel 0)	: off	Laser tx power high warning (Channel 0)	: off			
Laser tx power low warning (Channel 0)	: off	Laser tx power low warning (Channel 0)	: off			
Laser rx power high alarm (Channel 0)	: off	Laser rx power high alarm (Channel 0)	: off			
Laser rx nower high warning (Channel 0)	: off	Laser rx nower high warning (Channel 0)	off			
Laser rx power low warning (Channel 0)	: off	Laser rx power low warning (Channel 0)	: off			
Laser bias current high alarm threshold	: 105.0 mA	Laser bias current high alarm threshold	: 105.0 mA			
Laser bias current low alarm threshold	: 95.0 mA	Laser bias current low alarm threshold	: 95.0 mA			
Laser bias current high warning threshold	: 102.5 mA	Laser bias current nigh warning threshold	: 102.5 mA			
Laser output power high alarm threshold	: 4.0 dBm / 2.5 mW	Laser output power high alarm threshold	: 4.0 dBm / 2.5 mW			
Laser output power low alarm threshold	: -19.0 dBm / 0.0 mW	Laser output power low alarm threshold	: -19.0 dBm / 0.0 mW			
Laser output power high warning threshold	: 3.0 dBm / 2.0 mW	Laser output power high warning threshold	: 3.0 dBm / 2.0 mW			
Laser output power low warning threshold	: -18.0 dBm / 0.0 mW	Laser output power low warning threshold	: -18.0 dBm / 0.0 mW			
Module temperature low alarm threshold	· -5 0 degrees C / 23 0 degrees F	Module temperature low alarm threshold	· -5.0 degrees C / 23.0 degrees F			
Module temperature high warning threshold	: 70.0 degrees C / 158.0 degrees F	Module temperature high warning threshold	: 70.0 degrees C / 158.0 degrees F			
Module temperature low warning threshold	: 0.0 degrees C / 32.0 degrees F	Module temperature low warning threshold	: 0.0 degrees C / 32.0 degrees F			
Module voltage high alarm threshold	: 3.6 V	Module voltage high alarm threshold	: 3.6 V			
Module voltage low alarm threshold	: 3.0 V • 3.5 V	Module voltage low alarm threshold	: 3.0 V • 3.5 V			
Module voltage low warning threshold	: 3.1 V	Module voltage low warning threshold	: 3.1 V			
Laser rx power high alarm threshold	: 4.0 dBm / 2.5 mW	Laser rx power high alarm threshold	: 4.0 dBm / 2.5 mW			
Laser rx power low alarm threshold	: -18.0 dBm / 0.0 mW	Laser rx power low alarm threshold	: -18.0 dBm / 0.0 mW			
Laser rx power high warning threshold	: 2.0 dBm / 1.6 mW	Laser rx power high warning threshold	: 2.0 dBm / 1.6 mW			
Chromatic dispersion (min / avg / max)	: -16.0 0BM / 0.0 MW · 108 / _250689 / 188017 ns/nm	Chromatic dispersion (min / avg / max)	: -15.0 GBM / 0.0 MW · 155 / _250689 / 213692 ns/nm			
Pre-fec-ber (curr / min / avg / max)	: 8.430e-04 / 1.451e-03 / 3.240e-04 / 2.360e-02	Pre-fec-ber (curr / min / avg / max)	: 9.800e-05 / 8.230e-04 / 7.800e-05 / 2.600e-02			
Post-fec-ber (FERC) (curr / min / avg / max)	: 0.000e+00 / 3.800e+06 / 0.000e+00 / 2.380e+08	Post-fec-ber (FERC) (curr / min / avg / max)	: 0.000e+00 / 1.540e+07 / 0.000e+00 / 1.669e+08			
Osnr (min / avg / max)	: 210.000 / 260.000 / 276.000 dB	Osnr (min / avg / max)	: 207.000 / 288.000 / 305.000 dB			
Active application	· 78400 OFEC 1600M	Active application	· 78480 OFEC 1604M			
Supported applications:	. 214400-01-CC-10QAN	Supported applications:	. 2K400-0FEC-100AM			
1. 100GBASE-ZRplus		1. 100GBASE-ZRplus				
2. ZR200-OFEC-QPSK		2. ZR200-OFEC-QPSK				
3. ZR300-OFEC-8QAM		3. ZR300-OFEC-8QAM				
4. 21400-07EC-IOUAN		4. 21400-UFEC-IOVAM				
Configuration:		Configuration:				
Application	: N/A	Application	: N/A			
Frequency	: 194.8 THz	Frequency	: 194.8 THz			
Target output power	: N/A : -2.0 dBm	Target output power	: -2.0 dBm			
- Or		Sector Press				

#### 5.3 Static IP Dual mgmt. with Open XR Modules in UfiSpace/DriveNets 400G router

This test bed has the same physical setup as the previous one. But in this test bed the Open XR modules are fully under the control of the Open XR Controller. The connectivity between the Open XR modules and the Open XR Controller is established through an MPLS L3VPN to a remote PE router. This

Ø,



demonstrates the flexibility in the deployment of a centralized Open XR Controller that manages all Open XR Modules deployed in different routers throughout the network.



Figure 24 - Static IP Dual Mgmt test bed logical diagram

DriveNets DNOS 17.3 configuration:

```
interfaces
  ge400-0/0/1
    admin-state enabled
 !
!
interfaces
  ge400-0/0/6
    admin-state enabled
    ipv6-admin-state enabled
```

The 400GE connection availability was successfully verified using a VIAVI tester.



6



Figure 25 - Static IP Dual Mgmt test bed Viavi test results



Figure 26 - Static IP Dual Mgmt test bed Hub Tx OSA 90/10



Figure 27 - Static IP Dual Mgmt test bed Leaf Tx OSA 99/1



8

Open XR Controller screenshots showing the Open XR modules:

🌞 Set	tings		C Line Port (Optical)	r i	Client Port (Ether	net)
General	Labe	ls				
Device name	MA2223112A010	D				G
Access identifier	XR ① Online					12/62
K WARM START	B COLD START	O FACTORY RESET				
Configuration				^	N Hardware Des	cription
Configuration state Configured Role Current Role Host ID Host port ID IEEE 1588 TC Role Status Serdes Iane rate Service mode Traffic mode / Modules / MA222311	Ready Hub Unknown Scanning 50 Gbps Auto L1 mode 24019 / Line Per	t.(Onticel) / Carrier			Serial number MAC address Software version Hardware version Form factor Connector type Model number CLEI Code Module Id Vendor	MA222312A010 3C:02-68:00:16:80 v1.10.6 ocf.2.2.5 QSFP-DD LC connector 84e982f8:1031-4755:5d INFINERA
🔷 Sel	tings		C Line Port (Optical)	1.	🖡 Client Port (Ether	met)
Carrier Access identifier Actual constellation f Actual Tx Target Pow Baud rate Client port mode Operating FEC iterati	Digital	Sub-Carriers (R4.1-C1 94.800000 THz 0.00 dBm 40 GBd sthemet Standard	Digital Sub-Carriers Groups			
Operating frequency Operating modulation	1 1	194.800000 THz 16QAM				

Figure 28 - Hub Open XR Controller



8

Settings		C Line Port (Optical)	ata Client Port (El	hernet)
🔯 General 📎	Labels			
Device name MA2222	42A00A			•
Access identifier XR				12/
No cold s	ATART O FACTORY R	SET		
Configuration			^ 📎 Hardware	Description
Configuration state Ree Configured Role Les Current Role Unit Host ID Host port ID IEEE 1588 TC	dy f nown Signs o node ime <u>Port (Optical)</u> / Cerner		Serial number MAC address Software versio Hardware versio Form factor Connector type Model number CLEI Code Module Id Vendor	MA222242A00A 00.08:F8.68.CE:C n v1.1.0.6 ocf.2.2.5 QSFP-DD LC connector 88b38231-bfe0-4: INFINERA
🍄 Settings		C Line Port (Optical)	📲 Client Port (Et	hernet)
Carrier III I	Digital Sub-Carriers	Digital Sub-Carriers Groups		
Access identifier Actual constellation frequency Actual Tx Target Power Baud rate	XR-L1-C1 / 194.800000 THz 0.00 dBm 60 GBd			
Silent port mode Operating FEC iterations	Ethernet Standard			
Operating modulation	16QAM 63 GHz			

Figure 29 - Leaf Open XR Controller

# DriveNets DNOS 17.3 CLI show command output:

OpenXR1# show interfaces counters ge400-0/0/6	)					
T 1 C 100 0/0/c				Forwarding drops summary of logical and sub-li	-:	
Interface ge400-0/0/6:				RX VLAN mismatch:	0	
operational state: up				Destination MAC mismatch:	0	
				invalid iP neader:	0	
Ethernet counters:				Total RX dropped packets:	0	
RX octets:	1650652255472	( 80944365020 bps / 80944.37 l	Mbps)	Total TX dropped packets:	0	
RX frames:	24274255534	( 148794694 fps / 148.79 M	Mfps)			
RX unicast frames:	24274255525	( 148794694 fps / 148.79 M	Mfps)	OpenXR1# show interfaces counters ge400-0/0/1		
RX broadcast frames:	0	( 0 fps / 0 M	Mfps)			
RX multicast frames:	9	( 0 fps / 0 M	Mfps)	Interface ge400-0/0/1:		
TX octets:	1008013765002	( 80944380557 bps / 80944.38	3 Mbps)	Operational state: up		
TX frames:	14823727726	( 148794856 fps / 148.79 M	Mfps)			
TX unicast frames:	14823727726	( 148794856 fps / 148.79 M	Mfps)	Ethernet counters:		
TX broadcast frames:	0	( 0 fps / 0 M	Mfps)	RX octets:	1129501749403 (	80948323874 bps / 80948.32 Mbps)
TX multicast frames:	0	( 0 fps / 0 M	Mfps)	RX frames:	16610284256 (	148802329 fps / 148.8 Mfps)
				RX unicast frames:	16610284256 (	148802329 fps / 148.8 Mfps)
Ethernet control counters:				RX broadcast frames:	0 (	0 fps / 0 Mfps)
RX pause frames:	0			RX multicast frames:	0 (	0 fps / 0 Mfps)
TX pause frames:	0			TX octets:	1772110212735 (	80948712302 bps / 80948.71 Mbps)
RX PFC frames:	0			TX frames:	26060435945 (	148802736 fps / 148.8 Mfps)
TX PFC frames:	0			TX unicast frames:	26060435935 (	148802736 fps / 148.8 Mfps)
				TX broadcast frames:	0 (	0 fps / 0 Mfps)
Ethernet drop counters:				TX multicast frames:	10 (	0 fps / 0 Mfps)
RX errors:	0					
RX too short:	0			Ethernet control counters:		
RX too long:	0			RX pause frames:	0	
RX FCS errors:	0			TX pause frames:	0	
RX internal MAC errors:	0			RX PFC frames:	0	
RX pipeline MAC drops:	0			TX PFC frames:	0	
TX errors:	0					
				Ethernet drop counters:		
FEC counters:				RX errors:	0	
FEC corrected errors:	6			RX too short:	0	
FEC uncorrected errors:	0			RX too long:	0	
FEC symbol errors:	6			RX FCS errors:	0	
FEC bit errors:	6			RX internal MAC errors:	0	
	1.04					

Open XR Forum | 31





RX pipeline MAC drops:	0	RX VLAN mismatch:	0
TX errors:	0	Destination MAC mismatch:	0
		Invalid IP header:	0
FEC counters:		Total RX dropped packets:	0
FEC corrected errors:	127840	Total TX dropped packets:	0
FEC uncorrected errors:	0		
FEC symbol errors:	127867	OpenXR1#	
FEC bit errors:	121006		

Forwarding drops summary of logical and sub-IF:

#### More DriveNets DNOS 17.3 CLI show command output:

OpenXR1# show interfaces transceiver ge400-0/	0/1	2. ZR200-OFEC-QPSK	
Interface ge400-0/0/1		4. 7R400-0FEC-160AM	
Identifier	: OSEP DD	11 20100 0120 20001	
Connector	: 0x7 (LC type fiber connector)	Configuration:	
Length (SMF,km)	: 63km	Application	: N/A
Length (OM3 50um)	: Om	Frequency	: N/A
Length (OM2 50um)	: Om	Grid spacing	: N/A
Length (OM1 62.5um)	: Om	Target output power	: N/A
Length (Copper or Active cable)	: Om	• • •	
Transmitter technology	: 0x10 C-band tunable laser		
Optical transport info	: Grid 6.25GHz, Frequency 194.8 THz	OpenXR1# show interfaces transceiver ge400-0/	0/6
Tx Power	: 0.0 dBm		
Laser wavelength	: 1547 nm	Interface ge400-0/0/6	
Laser wavelength tolerance	: 0 nm	Identifier	: QSFP_DD
Vendor name	: INFINERA	Connector	: 0x7 (LC type fiber connector)
Vendor 001	: 00:0B:F8	Length (SMF, km)	: 63km
Vendor PN		Length (UM3 500m)	: Om
Vendon SN	• MA222212A010	Length (OM1 62 Fum)	: 0m
Einmuono vonsion	· 1 1	Longth (Connon on Active cohle)	. 0m
Revision compliance	· OSEP_DD on OSEP_DD CMTS Rev 5 1	Transmitten technology	: 0x10 C-band tunable laser
Module temperature	· 47 9 degrees ( / 118 2 degrees E	Ontical transport info	· Grid 6 25GHz Enguency 104 8 THz
Module voltage	· 3 2 V	Ty Power	· 0 0 dBm
Alarm/warning flags implemented	· Yes	laser wavelength	: 1547 nm
Laser tx bias current (Channel 0)	: 100.0 mA	Laser wavelength tolerance	: 0 nm
Transmit avg optical power (Channel 0)	: 0.0 dBm / 1.0 mW	Vendor name	: INFINERA
Rcvr signal avg optical power (Channel 0)	: -3.0 dBm / 0.5 mW	Vendor OUI	: 00:0B:F8
Laser bias current high alarm (Chan 0)	: off	Vendor PN	:
Laser bias current low alarm (Chan 0)	: off	Vendor rev	:
Laser bias current high warning (Chan 0)	: off	Vendor SN	: MA222242A00A
Laser bias current low warning (Chan 0)	: off	Firmware version	: 1.1
Module temperature high alarm	: off	Revision compliance	: QSFP-DD or QSFP-DD CMIS Rev 5.1
Module temperature low alarm	: off	Module temperature	: 62.4 degrees C / 144.3 degrees F
Module temperature high warning	: off	Module voltage	: 3.2 V
Module temperature low warning	: off	Alarm/warning flags implemented	: Yes
Module voltage high alarm	: off	Laser tx bias current (Channel 0)	: 100.0 mA
Module voltage low alarm	: off	Transmit avg optical power (Channel 0)	: -3.0 dBm / 0.5 mW
Module voltage high warning	: 0++	Rcvr signal avg optical power (Channel 0)	: -0.6 dBm / 0.9 mW
Module voltage low warning	: 011	Laser bias current nigh alarm (Chan 0)	
Laser tx power high alarm (Channel 0)	: 0TT	Laser bias current low didrim (Chan 0)	: UTT
Laser tx power low alarm (Channel 0)	: OTT	Laser bias current high warning (Chan 0)	: OTT
Laser tx power low warning (Channel 0)	· off	Module temperature high alarm	: off
Laser rx power high alarm (Channel 0)	· off	Module temperature low alarm	: off
Laser rx power low alarm (Channel 0)	: off	Module temperature high warning	: off
Laser rx power high warning (Channel 0)	off	Module temperature low warning	: off
Laser rx power low warning (Channel 0)	: off	Module voltage high alarm	: off
Laser bias current high alarm threshold	: 105.0 mA	Module voltage low alarm	: off
Laser bias current low alarm threshold	: 95.0 mA	Module voltage high warning	: off
Laser bias current high warning threshold	: 102.5 mA	Module voltage low warning	: off
Laser bias current low warning threshold	: 97.5 mA	Laser tx power high alarm (Channel 0)	: off
Laser output power high alarm threshold	: 4.0 dBm / 2.5 mW	Laser tx power low alarm (Channel 0)	: off
Laser output power low alarm threshold	: -19.0 dBm / 0.0 mW	Laser tx power high warning (Channel 0)	: off
Laser output power high warning threshold	: 3.0 dBm / 2.0 mW	Laser tx power low warning (Channel 0)	: off
Laser output power low warning threshold	: -18.0 dBm / 0.0 mW	Laser rx power high alarm (Channel 0)	: off
Module temperature high alarm threshold	: 75.0 degrees C / 167.0 degrees F	Laser rx power low alarm (Channel 0)	: 011
Module temperature low alarm threshold	: -5.0 degrees C / 23.0 degrees F	Laser rx power nign warning (Channel 0)	: 011
Module temperature high warning threshold	: 70.0 degrees C / 158.0 degrees F	Laser rx power low warning (Channel 0)	
Module temperature low warning threshold	: 0.0 degrees C / 32.0 degrees F	Laser bias current nigh alarm threshold	: 105.0 mA
Module voltage nign alarm threshold	: 3.6 V	Laser bias current low alarm threshold	: 95.0 MA
Module voltage jow alarm threshold	· 3.5 V	Laser bias current low warning threshold	· 102.5 ΠΑ • 97.5 mΛ
Module voltage low warning threshold	· 3 1 V	laser output nower high alarm threshold	· 4 0 dBm / 2 5 mld
Laser rx nower high alarm threshold	4.0 dBm / 2.5 mW	Laser output power low alarm threshold	: -19.0 dBm / 0.0 mW
Laser rx power low alarm threshold	: -18.0 dBm / 0.0 mW	Laser output power high warning threshold	: 3.0 dBm / 2.0 mW
Laser rx power high warning threshold	: 2.0 dBm / 1.6 mW	Laser output power low warning threshold	: -18.0 dBm / 0.0 mW
Laser rx power low warning threshold	: -16.0 dBm / 0.0 mW	Module temperature high alarm threshold	: 75.0 degrees C / 167.0 degrees F
Chromatic dispersion (min / avg / max)	: -2147483648 / -2147483648 /	Module temperature low alarm threshold	: -5.0 degrees C / 23.0 degrees F
2147483647 ps/nm	. ,	Module temperature high warning threshold	: 70.0 degrees C / 158.0 degrees F
Pre-fec-ber (curr / min / avg / max)	: 9.300e-05 / 2.930e-04 / 6.500e-05	Module temperature low warning threshold	: 0.0 degrees C / 32.0 degrees F
/ 2.300e-02		Module voltage high alarm threshold	: 3.6 V
Post-fec-ber (FERC) (curr / min / avg / max)	: 0.000e+00 / 3.320e+06 / 0.000e+00	Module voltage low alarm threshold	: 3.0 V
/ 1.901e+08		Module voltage high warning threshold	: 3.5 V
Osnr (min / avg / max)	: 210.000 / 300.000 / 309.000 dB	Module voltage low warning threshold	: 3.1 V
	70400 0550 46044	Laser rx power high alarm threshold	: 4.0 dBm / 2.5 mW
Active application	: 2K400-UFEC-16QAM	Laser rx power low alarm threshold	: -18.0 GRM / 0.0 MW
1 100GBASE_7Pplus		Laser rx power nigh warning threshold	- 16 0 dBm / 0 0 ml
1. 1000DMDE-TUDIN2		raser is howen tow warning curesuota	10.0 ubii / 0.0 iiiw

Open XR Forum | 32

OPENXR			١	www.openxrforum.org
Chromatic dispersion (min / avg / max) 2147483647 ps/nm Pre-fec-ber (curr / min / avg / max) / 2.300e-02 Post-fec-ber (FERC) (curr / min / avg / max) / 2.200e+08 Osnr (min / avg / max) Active application Supported applications:	: -2147483648 / -2147483648 / : 9.180e-04 / 1.089e-03 / 2.680e-04 : 0.000e+00 / 4.250e+06 / 0.000e+00 : 210.000 / 260.000 / 279.000 dB : ZR400-OFEC-16QAM	<ol> <li>100GBASE-ZRplus</li> <li>ZR200-OFEC-QPSK</li> <li>ZR300-OFEC-8QAM</li> <li>ZR400-OFEC-16QAM</li> <li>Configuration: Application: Application Frequency Grid spacing Target output power</li> </ol>	-	: N/A : N/A : N/A : N/A

5.4 Static IP Dual mgmt. with Open XR Modules in Juniper 400G router

To make it possible to take advantage of all the innovative XR Module features in existing 400G routers, the Open XR Module Dual Management feature is required. This capability avoids two integration points which are hard to do. First of all, the CMIS implementation of the router must be complete and supporting the CMIS implementation and the CMIS vendor extensions available on the Open XR Module. Secondly the router mgmt. interface must support all the functionality needed to manage the Open XR Modules, which is currently not available for the enhanced p2mp features of Open XR.

For the Open XR Module to expose its IP management interface to the Open XR Controller, several different approaches exist. The approach taken for this test bed is using functionality that exists in most Service Provider 400G routers sold today. In this case the physical 400GE port is configured with one additional IP interface that is associated with a particular VLAN tag. This enables the Open XR Module to redirect Ethernet Frames with the VLAN tag to its own management plane, as illustrated in the Figure below.



Figure 30 - Open XR Module MGMT VLAN redirect to Module control plane

This additional IP interface can then be considered an Open XR Module management interface, which can be connected into a separate MPLS VPN isolating it from other traffic. Based on this principle the test bed as shown below is implemented. The Open XR Module that is used for this test is a module with Serial Number MA222312A00B and IP address 10.101.70.2.







Figure 31 - Static IP Dual Management test bed logical diagram

Below is displayed the Juniper Junos configuration of the physical interface with the payload and the mgmt. logical interfaces. The logical interface with VLAN tag 600 is used for carrying traffic between the routers, while the interface with VLAN tag 4090 is used for the Open XR management traffic. Please note that the payload traffic can also be carried untagged to increase the available bandwidth for IP packets on the 400G link.

```
set interfaces et-0/0/23 description "OpenXR Testing - connection to XR 1"
set interfaces et-0/0/23 flexible-vlan-tagging
set interfaces et-0/0/23 speed 400g
set interfaces et-0/0/23 mtu 9192
set interfaces et-0/0/23 encapsulation flexible-ethernet-services
set interfaces et-0/0/23 unit 600 vlan-id 600
set interfaces et-0/0/23 unit 600 family inet address 44.44.44.1/30
set interfaces et-0/0/23 unit 4090 vlan-id 4090
set interfaces et-0/0/23 unit 4090 family inet mtu 1500
set interfaces et-0/0/23 unit 4090 family inet address 10.101.82.1/24
set interfaces et-0/0/23 unit 4090 family inet6
set routing-instances OpenXR-Testing-MGMT interface et-0/0/23.4090
```

The CLI output below shows on top the state of IP interfaces on the Open XR Module during the test. Below this CLI output from the Juniper router it is showing how the router has detected the Open XR module and registered it as OpenZR+ transceiver type.



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root@xr:~# ip addr show dev br0					
47: br0: <broadcast,multicast,up,lower_< td=""><td>UP&gt; mtu 1500 qdisc noqueue state UP (</td><td>group default qlen</td><td>1000</td><td></td><td></td></broadcast,multicast,up,lower_<>	UP> mtu 1500 qdisc noqueue state UP (	group default qlen	1000		
link/ether 3c:02:68:00:17:0d brd ff	:ff:ff:ff:ff				
inet 10.101.70.2/24 scope global br	0				
<pre>valid_lft forever preferred_lft</pre>	forever				
inet 169.254.82.72/16 brd 169.254.2	55.255 scope global noprefixroute br	0			
<pre>valid_lft forever preferred_lft</pre>	forever				
inet6 fe80::c8b7:65ff:fe4e:71fb/64	scope link				
<pre>valid_lft forever preferred_lft</pre>	forever				
lab@prod-lab03d-rc1-re0> show chassis p	ic fpc-slot 0 pic-slot 0  match "INF	INERA  Wave-"			
Fiber	Xcvr vendor Wave-		Xcvr	JNPR	MSA
15 400g-zr-m SM INFINER	. 1528.77	nm - 1567.13 nm	0.1	XXXX	CMIS 5.1
lab@prod-lab03d-rc1-re0> show chassis h	ardware   match "Xcvr 15  Item"				
Item Version Part number	Serial number Description				
Xcvr 15 XXXX NON-JNPR	MA222312A00B QSFP56-DD-400G-ZR-	M			

The CLI output below shows the output of a Python script that is used to configure the Open XR Module via its CMIS interface. As shown by the output, the module is statically configured with IP addresses and DCHP is disabled.

To understand how the Open XR Modules connect to the Open XR Controller a Wireshark traffic capture was made using the Tcpdump application feature that allows writing to a .pcap file. This capture was made in the IP subnet the Open XR Controller connected to.

The packet capture shows that the Open XR Module (10.101.70.2) initially establishes a connection to the Device Provisioning Service server (DPS) (10.101.71.2). This allows the Open XR Module to obtain the contact information of the Open XR Controller and collect the needed certificate to securely connect to it.

The packet capture shows the initial TCP session establishment, which is followed by a TLS session setup. This is a relatively short-lived connection.



N	o. Time	Source	Destination	Protocol	Lengt Info
	1 0.000000	10.101.70.2	10.101.71.2	TCP	74 38630 → 25684 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=578391257 TSecr=0 WS=4
	2 0.000212	10.101.70.2	10.101.71.2	TCP	74 38644 → 25684 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=578391264 TSecr=0 WS=4
	3 0.000503	10.101.71.2	10.101.70.2	TCP	74 25684 → 38630 [SYN, ACK] Seq=0 Ack=1 Win=65160 Len=0 MSS=1460 SACK_PERM TSval=1350680526 TSecr=578391257 WS=128
	4 0.000537	10.101.71.2	10.101.70.2	TCP	74 25684 → 38644 [SYN, ACK] Seq=0 Ack=1 Win=65160 Len=0 MSS=1460 SACK_PERM TSval=1350680526 TSecr=578391264 WS=128
	5 0.001157	10.101.70.2	10.101.71.2	TCP	60 38630 → 25684 [RST] Seq=1 Win=0 Len=0
	6 0.005981	10.101.70.2	10.101.71.2	TCP	66 38644 → 25684 [ACK] Seq=1 Ack=1 Win=64240 Len=0 TSval=578392283 TSecr=1350680526
	7 0.030104	10.101.70.2	10.101.71.2	TLSv1.2	170 Client Hello
	8 0.030291	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=1 Ack=105 Win=65152 Len=0 TSval=1350680555 TSecr=578392312
	9 0.030936	10.101.71.2	10.101.70.2	TLSv1.2	1162 Server Hello, Certificate, Server Key Exchange, Certificate Request, Server Hello Done
	10 0.031328	10.101.70.2	10.101.71.2	TCP	66 38644 → 25684 [ACK] Seq=105 Ack=1097 Win=64088 Len=0 TSval=578392313 TSecr=1350680556
	11 0.047150	10.101.70.2	10.101.71.2	TLSv1.2	609 Certificate
	12 0.087736	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=1097 Ack=648 Win=64640 Len=0 TSval=1350680613 TSecr=578392329
	13 0.231561	10.101.70.2	10.101.71.2	TLSv1.2	141 Client Key Exchange
	14 0.231716	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=1097 Ack=723 Win=64640 Len=0 TSval=1350680757 TSecr=578392514
	15 0.281521	10.101.70.2	10.101.71.2	TLSv1.2	150 Certificate Verify
	16 0.281672	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=1097 Ack=807 Win=64640 Len=0 TSval=1350680807 TSecr=578392563
	17 0.281953	10.101.70.2	10.101.71.2	TLSv1.2	72 Change Cipher Spec
	18 0.282035	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=1097 Ack=813 Win=64640 Len=0 TSval=1350680807 TSecr=578392564
	19 0.282517	10.101.70.2	10.101.71.2	TLSv1.2	111 Encrypted Handshake Message
<	00.0.000000	40 404 74 0	40 404 70 0	700	
5	Frame 46: 74 by	tes on wire (5	92 bits), 74 by	tes captur	ed (592 bits)
	Ethernet II, Sro	: JuniperN Øe	:fd:7d (78:fe:3	d:0e:fd:70	l), Dst: GoodWayI 24:87:bf (00:50:b6:24:87 0010 00 3c df 3f 40 00 3e 06 2b 6a 0a 65 46 02 0a 64 < ?@>> +j eF
	Internet Protoco	ol Version 4,	Src: 10.101.70.	2, Dst: 10	.100.215.71 0020 d7 47 c0 8a 16 34 a3 f2 c4 c2 00 00 00 a0 02 G 4
1	/ Transmission Con	ntrol Protocol	, Src Port: 492	90, Dst Po	ort: 5684, Seq: 0, Len: 0 0030 fa f0 91 be 00 00 02 04 05 b4 04 02 08 0a c2 c0
1	Source Port:	49290			
	Destination F	ort: 5684			
	[Stream index	: 2]			
	[Conversation	completeness	: Incomplete, D	ATA (15)]	
	[TCP Segment	Len: 0]			
	Sequence Numb	er: 0 (rela	ative sequence	number)	

Figure 32 - Wireshark capture of TCP traffic between Open XR Module and Devices Provisioning Service

Once the Open XR Module has collected all needed data from the Device Provisioning Service, then the TLS session is terminated, and the Module will initiate a new TLS session to the Open XR Controller server IP address being 10.100.215.71. This stage in the Open XR Module management communication is shown in the Wireshark screenshot included below.

ľ	Io. Time	Source	Destination	Protocol	Lengt Info
	39 0.536614	10.101.71.2	10.101.70.2	TLSv1.2	593 Application Data
	40 0.544973	10.101.70.2	10.101.71.2	TLSv1.2	97 Encrypted Alert
	41 0.545035	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=3932 Ack=1754 Win=64128 Len=0 TSval=1350681070 TSecr=578392827
	42 0.545086	10.101.71.2	10.101.70.2	TLSv1.2	97 Encrypted Alert
	43 0.545126	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [FIN, ACK] Seq=3963 Ack=1754 Win=64128 Len=0 TSval=1350681070 TSecr=578392827
	44 0.547671	10.101.70.2	10.101.71.2	TCP	66 38644 → 25684 [FIN, ACK] Seq=1754 Ack=3964 Win=64088 Len=0 TSval=578392830 TSecr=1350681070
	45 0.547750	10.101.71.2	10.101.70.2	TCP	66 25684 → 38644 [ACK] Seq=3964 Ack=1755 Win=64128 Len=0 TSval=1350681073 TSecr=578392830
	46 2.562026	10.101.70.2	10.100.215.71	TCP	74 49290 → 5684 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=3267397390 TSecr=0 WS=4
	47 2.562179	10.100.215.71	10.101.70.2	TCP	74 5684 → 49290 [SYN, ACK] Seq=0 Ack=1 Win=65160 Len=0 MSS=1460 SACK_PERM TSval=8564577 TSecr=3
	48 2.562795	10.101.70.2	10.100.215.71	TCP	66 49290 → 5684 [ACK] Seq=1 Ack=1 Win=64240 Len=0 TSval=3267397391 TSecr=8564577
	49 2.571296	10.101.70.2	10.100.215.71	TLSv1.2	170 Client Hello
	50 2.571472	10.100.215.71	10.101.70.2	TCP	66 5684 → 49290 [ACK] Seq=1 Ack=105 Win=65152 Len=0 TSval=8564587 TSecr=3267397399
	51 2.578508	10.100.215.71	10.101.70.2	TLSv1.2	1089 Server Hello, Certificate, Server Key Exchange, Server Hello Done
	52 2.578927	10.101.70.2	10.100.215.71	TCP	66 49290 → 5684 [ACK] Seq=105 Ack=1024 Win=64088 Len=0 TSval=3267397407 TSecr=8564594
	53 2.947145	10.101.70.2	10.100.215.71	TLSv1.2	141 Client Key Exchange
	54 2.987785	10.100.215.71	10.101.70.2	TCP	66 5684 → 49290 [ACK] Seq=1024 Ack=180 Win=65152 Len=0 TSval=8565003 TSecr=3267397775
	55 2.988456	10.101.70.2	10.100.215.71	TLSv1.2	117 Change Cipher Spec, Encrypted Handshake Message
	56 2.988575	10.100.215.71	10.101.70.2	TCP	66 5684 → 49290 [ACK] Seq=1024 Ack=231 Win=65152 Len=0 TSval=8565004 TSecr=3267397816
	57 2.988880	10.100.215.71	10.101.70.2	TLSv1.2	117 Change Cipher Spec, Encrypted Handshake Message
	50 0 000007	10 100 015 71	10 101 70 0		
	Company and the Real Products		2 hite) 74 hite		
	Frame 46: 74 Dyt	es on wire (59	2 DITS), 74 DYT	es captur	ed (592 Dits)
	Teternet II, Src	: JuniperN_0e:	Ta:/a (/8:Te:5a	:0e:10:70	0020 d7 47 c0 8a 16 34 a3 f2 c4 c2 00 00 00 00 00 a0
	Internet Protoco	trol Dectorel	FC: 10.101.70.2	, DST: 10	0030 fa f0 91 be 00 00 204 05 b4 04 02 08 0a c2
8	Founce Dents	40200	SPC POPT: 4929	o, DST PO	0040 87 0e 00 00 00 01 03 03 02
	Destination D	49290			
	Estroom index	. 21			
	istream thoex				

Figure 33- Wireshark capture of TCP traffic between Open XR Module and the Open XR Controller

After the TLS session with the Open XR Controller is setup and all data has been exchanged, then the Open XR Controller web portal shows the Open XR Module as online and managed by the controller.



Ø,

K IPM	Module Name Host Name MA222312A00B -	Status Online		🔹 🕐 🔡 ~ 🗶 XR-USI
Dashboard	💏 / Modules / MA222312A008 / Settings / General			
Hosts	Settings	C Line Port (Optical)	Ethernet)	₩ Local Connections
MDU				
	General Schere Labels			
Transport Capacities	Device name MA222312A00B		Ø	
Services	Access identifier XR Status (1) Online		16/6-	4
Modules	🗱 WARM START 🛛 🕅 COLD START 🗿 FAO	CTORY RESET		
Software Management	Configuration	^ 📎 Hardwa	re Description	^
User Management	Configuration state Ready	Serial number	r MA222312A00B	
Fault Management	Configured Role Auto	MAC address	3C:02:68:00:17:0C	
	Current Role Unknown	Software ver	sion v1.1.0.8-rc2-5-g1b7b4bfe2	
Configuration	Host ID	Hardware ve	sion ocf.2.2.6	
	Host port ID	Form factor	QSFP-DD	
	IEEE 1588 TC	Connector ty	pe LC connector	
	Serres lane rate 50 Choc		1	
	Service mode Auto	Module Id	541hf322-6a94-4dah-5c8f-7530ae8989ff	
	Traffic mode L1 mode	Vendor	INFINERA	
		DELETE		
	Sidebar expanded			Copyright © 2023 Infinera. All rights re

Figure 34 - Open XR Controller web portal with Open XR Module reported as Online

5.5 Dynamic IP Dual mgmt. with Open XR Modules in Juniper 400G router

This test extends the previous test bed with a DCHP server and client added to it. In this case the Open XR Module has a DHCP client activated, as opposed to manually configuring the IP address of the Module and the DPS server. This allows for using Open XR Modules in any router port without first manually configuring them. The Open XR Module that is used for this test is a module with Serial Number MA222312A00B and Dynamically assigned IP address 10.101.70.3.



Figure 35 - Dynamic IP Dual Mgmt test bed logical diagram





To support the DHCP client on the Open XR Module the 400G router must be configured with DHCP message forwarding/relaying to a centralized DHCP server. This is configured as follows:

set routing-instances OpenXR-Testing-MGMT forwarding-options dhcp-relay group OpenXR\_Group interface et-0/0/23.4090 set routing-instances OpenXR-Testing-MGMT forwarding-options dhcp-relay servergroup OpenXR\_IPM\_servers 10.101.71.2 set routing-instances OpenXR-Testing-MGMT forwarding-options dhcp-relay group OpenXR Group active-server-group OpenXR IPM servers

The Open XR Module for this test bed also configured with an active DHCP client.

XR modu	le DHCP c	onfigured	l through CMIS	script							
# ./sfp	util_dn.p	y show mg	mt-p6								
Port	DHCP	ND	debugport	ip address	ip gateway	NTP server	ip call home	mvlan channel	oui etype	sgmii	mvlan id
6	enabled	enabled	open	0.0.0.0/0	0.0.0.0	0.0.0.0	0.0.0.0:0	manual	enabled	disabled	4090

After the Open XR Module has requested an IP address from the DHCP server, the IP addresses active on the Open XR Module looks as follows:



The Wireshark screenshot below shows the DHCP messages that are exchanged between the client and server. Also visible is the IP addressing information provided by the DHCP server including the URL of the DPS service as DHCP option 114 (CoAPs URL).



N	o.	Time		Source	Destination	Protocol	Lengt Info
		128 243	.415573	10.101.70.1	10.101.71.2	DHCP	A DHCP Discover - Transaction ID 0xc2b760a
		129 243	.416279	10.101.71.2	10.101.70.1	DHCP	405 DHCP Offer - Transaction ID 0xc2b760a
		130 243	.418382	10.101.70.1	10.101.71.2	DHCP	342 DHCP Request - Transaction ID 0xc2b760a
		131 243	.419380	10.101.71.2	10.101.70.1	DHCP	405 DHCP ACK - Transaction ID 0xc2b760a
		138 252	.661204	10.101.70.3	10.101.71.2	TCP	74 34858 → 35684 [SYN] Seg=0 Win=64240 Len=0 MSS=1460 SACK PERM TSval=1982775625 TSecr=0 WS=4
		139 252	.661684	10.101.71.2	10.101.70.3	TCP	74 35684 → 34858 [SYN, ACK] Seq=0 Ack=1 Win=65160 Len=0 MSS=1460 SACK PERM TSval=2004004199 TSecr=1982775625 WS=128
		140 252	.662394	10.101.70.3	10.101.71.2	TCP	66 34858 → 35684 [ACK] Seq=1 Ack=1 Win=64240 Len=0 TSval=1982775627 TSecr=2004004199
		141 252	.673553	10.101.70.3	10.101.71.2	TLSv1.2	170 Client Hello
		142 252	.673707	10.101.71.2	10.101.70.3	TCP	66 35684 → 34858 [ACK] Seq=1 Ack=105 Win=65152 Len=0 TSval=2004004211 TSecr=1982775638
		143 252	.674441	10.101.71.2	10.101.70.3	TLSv1.2	1159 Server Hello, Certificate, Server Key Exchange, Certificate Request, Server Hello Done
		144 252	.674837	10.101.70.3	10.101.71.2	TCP	66 34858 → 35684 [ACK] Seq=105 Ack=1094 Win=64088 Len=0 TSval=1982775639 TSecr=2004004212
		145 252	.683964	10.101.70.3	10.101.71.2	TLSv1.2	609 Certificate
		146 252	.726538	10.101.71.2	10.101.70.3	TCP	66 35684 → 34858 [ACK] Seq=1094 Ack=648 Win=64640 Len=0 TSval=2004004264 TSecr=1982775648
		147 252	.861968	10.101.70.3	10.101.71.2	TLSv1.2	141 Client Key Exchange
		148 252	.862110	10.101.71.2	10.101.70.3	TCP	66 35684 → 34858 [ACK] Seq=1094 Ack=723 Win=64640 Len=0 TSval=2004004399 TSecr=1982775826
		149 252	.910043	10.101.70.3	10.101.71.2	TLSv1.2	150 Certificate Verify
		150 252	.910196	10.101.71.2	10.101.70.3	TCP	66 35684 → 34858 [ACK] Seq=1094 Ack=807 Win=64640 Len=0 TSval=2004004447 TSecr=1982775874
		151 252	.910501	10.101.70.3	10.101.71.2	TLSv1.2	72 Change Cipher Spec
		152 252	.910583	10.101.71.2	10.101.70.3	TCP	66 35684 → 34858 [ACK] Seq=1094 Ack=813 Win=64640 Len=0 TSval=2004004448 TSecr=1982775875
4	0						>
		Boot fi	ile name	e not given			▲ 0040 00 00 0a 65 46 01 3c 02 68 00 17 0d 00 00 00 ····eF·<· h······
		Magic d	cookie:	DHCP			0050 00 00 00 00 00 00 00 00 00 00 00 00
	>	Option	: (53) D	HCP Message 1	Type (ACK)		0060 00 00 00 00 00 00 00 00 00 00 00 00
	>	Option:	: (1) Su	bnet Mask (25	5.255.255.0)		0070 00 00 00 00 00 00 00 00 00 00 00 00
	>	Option:	: (3) Ro	outer			
	>	Option:	: (6) Do	omain Name Ser	rver		
	>	Option:	: (15) D	Oomain Name			
	>	Option	: (42) N	Wetwork Time P	Protocol Servers	s	00⊂0 00 00 00 00 00 00 00 00 00 00 00 00
	>	Option:	: (51) I	P Address Lea	ase Time		
	>	Option:	: (54) D	HCP Server Id	dentifier (10.10	01.71.2)	
	>	Option	: (58) R	Renewal Time \	/alue		
	>	Option:	: (59) R	Rebinding Time	e Value		
	>	Option	: (61) C	lient identif	fier		
	~	Option:	: (114)	DHCP Captive-	Portal		0130 00 02 02 0f 0b 65 78 61 6d 70 6c 65 2e 6f 72 67 ····exa mple.org
		Leng	gth: 31				0140 2a 04 0a 65 47 02 33 04 00 00 02 58 36 04 0a 65 *··eG·3···X6··e
		Capt	tive Por	tal: coaps%2b	tcp://10.101.71	1.2:35684	0150 47 02 3a 04 00 00 01 2c 3b 04 00 00 02 12 3d 13 G:, ;=
	~	Option	: (255)	End			0160 ff 68 00 17 0d 00 01 00 01 2c 30 d7 80 26 90 fd h
		Opti	ion End:	255			0170 81 cb 46 72 1f 63 6f 61 70 73 25 32 62 74 63 70 ···Fr·coa ps%2btcp
							V 0100 36 27 27 31 30 26 31 30 31 26 37 31 26 32 33 33 ://10.10.1.71.2:3
4							
	03	DHCP	BOOTP op	tion type (dhcp.op	tion.type), 33 bytes		Packets: 349 · Displayed: 318 (91.1%) · Ignored: 4 (1.1%) Profile: Defa

Figure 36 - Wireshark capture of DHCP messages and TCP traffic between Open XR Module and Devices Provisioning Service

Once the DPS data exchange is completed the TLS session to 10.101.71.2 is terminated and the TLS session to the Open XR Controller at 10.100.215.7 is initiated.



No.	Time	Source	Destination	Protocol	Lengt Info	
1	74 253.137144	10.101.70.3	10.101.71.2	TCP	66 34858 → 35684 [FIN, ACK] Seq=1758 Ack=3925 Win=64088 Len=0 TSval=1982776102 TSecr=200400466	5
1	75 253.137328	10.101.71.2	10.101.70.3	TLSv1.2	97 Encrypted Alert	
1	76 253.137412	10.101.71.2	10.101.70.3	TCP	66 35684 + 34858 [FIN, ACK] Seq=3956 Ack=1759 Win=64128 Len=0 TSval=2004004675 TSecr=198277610	2
1	77 253.137769	10.101.70.3	10.101.71.2	TCP	60 34858 → 35684 [RST] Seq=1759 Win=0 Len=0	
1	78 253.137892	10.101.70.3	10.101.71.2	TCP	60 34858 → 35684 [RST] Seq=1759 Win=0 Len=0	
- 1	79 255.148241	10.101.70.3	10.100.215.71	TCP	74 53242 → 5684 [SYN] Seq=0 Win=64240 Len=0 MSS=1460 SACK_PERM TSval=510455930 TSecr=0 WS=4	
1	80 255.148432	10.100.215.71	10.101.70.3	TCP	74 5684 → 53242 [SYN, ACK] Seq=0 Ack=1 Win=65160 Len=0 MSS=1460 SACK_PERM TSval=13951476 TSecr	=510455930 WS=128
1	31 255.149238	10.101.70.3	10.100.215.71	TCP	66 53242 → 5684 [ACK] Seq=1 Ack=1 Win=64240 Len=0 TSval=510455932 TSecr=13951476	
1	32 255.157037	10.101.70.3	10.100.215.71	TLSv1.2	170 Client Hello	
1	33 255.157171	10.100.215.71	10.101.70.3	TCP	66 5684 → 53242 [ACK] Seq=1 Ack=105 Win=65152 Len=0 TSval=13951484 TSecr=510455939	
1	34 255.157858	10.100.215.71	10.101.70.3	TLSv1.2	1088 Server Hello, Certificate, Server Key Exchange, Server Hello Done	
1	35 255.158197	10.101.70.3	10.100.215.71	TCP	66 53242 → 5684 [ACK] Seq=105 Ack=1023 Win=64088 Len=0 TSval=510455941 TSecr=13951485	
1	36 255.534265	10.101.70.3	10.100.215.71	TLSv1.2	141 Client Key Exchange	
1	37 255.578557	10.100.215.71	10.101.70.3	TCP	66 5684 → 53242 [ACK] Seq=1023 Ack=180 Win=65152 Len=0 TSval=13951906 TSecr=510456317	
1	88 255.579239	10.101.70.3	10.100.215.71	TLSv1.2	117 Change Cipher Spec, Encrypted Handshake Message	
1	39 255.579370	10.100.215.71	10.101.70.3	TCP	66 5684 → 53242 [ACK] Seq=1023 Ack=231 Win=65152 Len=0 TSval=13951907 TSecr=510456361	
1	0 255.579673	10.100.215.71	10.101.70.3	TLSv1.2	117 Change Cipher Spec, Encrypted Handshake Message	
1	1 255.579790	10.100.215.71	10.101.70.3	TLSv1.2	105 Application Data	
1	2 255.579977	10.101.70.3	10.100.215.71	TCP	66 53242 → 5684 [ACK] Seq=231 Ack=1074 Win=64088 Len=0 TSval=510456363 TSecr=13951907	
1	3 255.580107	10.101.70.3	10.100.215.71	TCP	66 53242 → 5684 [ACK] Seq=231 Ack=1113 Win=64088 Len=0 TSval=510456363 TSecr=13951907	
1	94 255.587602	10.101.70.3	10.100.215.71	TLSv1.2	620 Application Data	
1	95 255.630279	10.100.215.71	10.101.70.3	TCP	66 5684 → 53242 [ACK] Seq=1113 Ack=785 Win=64640 Len=0 TSval=13951957 TSecr=510456370	
1	6 255.640613	10.100.215.71	10.101.70.3	TLSv1.2	572 Application Data	
1	7 255.640881	10.101.70.3	10.100.215.71	TCP	66 53242 → 5684 [ACK] Seq=785 Ack=1619 Win=64088 Len=0 TSval=510456423 TSecr=13951968	
1	8 257.655314	10.101.70.3	10.100.215.71	TLSv1.2	597 Application Data	
1	99 257 655455	10 100 215 71	10 101 70 3	TCP	66 5684 → 53242 [ACK] Sen=1619 Ark=1316 Win=64128 Len=0 TSval=13953983 TSecr=510458437	
<pre>&gt; Fram &gt; Ethe &gt; Inte &gt; Trar &gt; Trar &gt; T &gt; T</pre>	e 184: 1088 rnet II, Src rnet Protoco smission Con sport Layer LSV1.2 Record LSV1.2 Record LSV1.2 Record LSV1.2 Record	bytes on wire : GoodWayI_24: l Version 4, S trol Protocol, Security d Layer: Hands d Layer: Hands d Layer: Hands d Layer: Hands	(8704 bits), 10 87:bf (00:50:b6 rc: 10.100.215. Src Port: 5684 hake Protocol: hake Protocol: hake Protocol: hake Protocol:	88 bytes :24:87:bf 71, Dst: , Dst Por Server He Certifica Server Ke Server He	captured (8704 bits) ), Dst: JuniperN_0e:fd:7d (78:fe:3d:0e:fd:7d) 10.101.70.3 t: 53242, Seq: 1, Ack: 105, Len: 1022 110 te y Exchange 110 Done	0000         78         fe         3d         0e         1           0010         04         32         32         59         4           0020         46         03         16         34         0           0023         01         16         36         84         0         34         0           0030         01         63         86         03         6         34         0

Figure 37 - Wireshark capture of TCP traffic between Open XR Module and the Open XR Controller

Just as with the previous test bed, after the TLS session with the Open XR Controller is setup and all data has been exchanged, then the Open XR Controller web portal shows the Open XR Module as online and managed by the controller.

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Figure 38 - Open XR Controller web portal with Open XR Module reported as Online



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## 5.6 Line Side Dynamic IP Dual mgmt. with Open XR Modules in 400G router

When a Service Provider extends the network footprint to a new technical site, then the router deployed and connected to the network via a new DWDM link might not yet have management connectivity. For this reason, it is possible to enable a DHCP client on the line side of the Open XR Module. See the diagram for the connectivity path that is used in this case. This functionality is being tested in Test Bed 5.



Figure 39 - Open XR Module MGMT VLAN redirect to Module control plane on a remote 400G router

The logical diagram of the test bed is shown in the Figure below. The Open XR Modules used for this test is a module with Serial Number MA222312A00B as local and a module with Serial Number MA122244A003 on the remote end.



Figure 40 – Line Side Dynamic IP Dual Mgmt test bed logical diagram

In this test bed the 400G router that is used is the DriveNets/UfiSpace router running DNOS v18.0. This is configured as follows:

```
interfaces
  ge400-0/0/1
    admin-state enabled
```

www.openxrforum.org



```
transceiver
   optical-transport
     center-frequency 194200 ghz
     target-output-power -3
   1
  !
!
ge400-0/0/1.4090
 admin-state enabled
 ipv4-address 10.101.81.1/24
 vlan-id 4090 tpid 0x8100
 dhcp relay-agent
  admin-state enabled
   server 10.101.71.2
 !
!
ge400-0/0/6
 admin-state enabled
 transceiver
   optical-transport
     center-frequency 194200 ghz
     target-output-power -3
   1
  !
!
ge400-0/0/6.4090
 admin-state enabled
 ipv4-address 10.101.80.1/24
 vlan-id 4090 tpid 0x8100
```

The Wireshark screen capture below shows how the local Open XR Module obtains its DHCP lease (IP address 10.101.81.2 is provided) and then registers at the Open XR Controller.



**(** 

															_
No.	Time	Source	Destination	Protocol	Lengt Int	fo									=
	7 85.747099	10.101.81.1	10.101.71.2	DHCP	342 DH	HCP Discove	er - Tra	nsacti	on ID	0x6d4cf	fb39				
	8 85.747730	10.101.71.2	10.101.81.1	DHCP	405 DH	HCP Offer	- Tra	nsacti	lon ID	0x6d4ct	fb39				
	9 85.749774	10.101.81.1	10.101.71.2	DHCP	342 DH	ICP Request	t - Tra	insacti	lon ID	0x6d4cf	fb39				
	10 85.750473	10.101.71.2	10.101.81.1	DHCP	405 DH	ICP ACK	- Tra	insacti	ion ID	0x6d4cf	fb39				
	11 92.483031	10.101.81.1	10.101.71.2	DHCP	342 DH	HCP Discove	er - Tra	insacti	lon ID	0xb3cdb	o5a0				
	12 92.483802	10.101.71.2	10.101.81.1	DHCP	405 DH	HCP Offer	- Tra	insacti	lon ID	0xb3cdb	o5a0				
1	13 94.822186	10.101.81.2	10.100.215.71	TCP	74 55	5596 → 5684	4 [SYN]	Seq=0	Win=64	1240 Ler	n=0 MS	5=1460	SACK_PE	RM TSval=2	1
	14 94.822373	10.100.215.71	10.101.81.2	TCP	74 56	584 → 55596	6 [SYN,	ACK	Seq=0 A	Ack=1 Wi	in=651	60 Len	1=0 MSS=1	460 SACK_PI	8
	15 94.823084	10.101.81.2	10.100.215.71	TCP	66 55	596 → 5684	4 [ACK]	Seq=1	Ack=1	W1n=642	240 Le	n=0 15	va1=2589	484827 TSe	¢
1	16 94.834160	10.101.81.2	10.100.215./1	TLSV1.2	1/0 CI	Lient Hello	O FACUL						TC 1 05		
	17 94.834306	10.100.215.71	10.101.81.2	TLCP	1000 50	084 → 55596	6 [ACK]	Seq=1	ACK=10	05 Win=0	5152 Sucha	Len=0	ISVal=25	30543648 I	Ĩ
	10 94.0540/1	10.100.215.71	10.101.01.2	TCD TCD	1009 26	Enver Hello	A FACEL	See-10	s Ark-	1004 W	EXCIIA	nge, s	-O Trunl	-10 Done	
1	20 95 241977	10 101 81 2	10.100.215.71	TLSv1 2	141 C1	lient Kev F	+ [ACK] Evchange	Seq-10	J ACK-	-1024 WJ	11-040	DO LEI	1-0 13041	-230540405	
	21 95 285686	10.101.01.2	10.100.215.71	TCP	66 56	584 - 55596	6 [ACK]	Sec-10	AZA Ack	-180 Wi	in-651	52 Len	-0 TSval	-253054410	_
	22 95 286251	10 101 81 2	10.101.01.2	TI Sv1 2	117 Ch	ange Cinhe	er Snec	Encry	inted H	Handshak	re Mes	cade	1-0 15001	-255054410	1
1	23 95 286293	10, 100, 215, 71	10.101.81.2	TCP	66 56	584 → 5559P	6 [ACK]	Seg=10	124 Ack	(=231 Wi	in=651	52 Ler	=0 TSval	=253054410	d
1	24 95,286405	10, 100, 215, 71	10.101.81.2	TI Sv1.2	117 Ch	ange Cinhe	er Spec.	Encry	inted H	landshak	ce Mes	sage	-o ibidi	200001120	1
1	25 95.286460	10.100.215.71	10.101.81.2	TLSv1.2	105 An	onlication	Data	enery	pecui	iana shar	ie nes	Juge			
<	25 551200400	1011001110171	10110110111		200 14	pricecion	bucu							>	-
													2		_
>	Option: (51) I	P Address Lease Time				A 00 0	00 00 00	00 00	00 0	0 00 00	00 00	0000	0		
>	Option: (54) D	HCP Server Identifier (10	.101.71.2)			00 0	00 00 00	63 82	53 6	3 35 01	02 01	04 f	f	·c· Sc5····	
2	Option: (58) R	enewal lime Value				00 0	03 04 0a	65 51	01 0	6 08 c0	00 00	2 01 c	0	·e0 ·····	
>	Option: (59) R	ebinding Time Value				02 0	of Øb 65	78 61	6d 7	0 6c 65	2e 61	72 6	7	exa mple.c	org
~	Option: (61) C	lient identifier				0a 6	55 47 02	33 04	00 0	0 02 58	36 04	4 0a 6	5 *··e(	5·3· ···X6·	·e
~	Option: (114)	DHCP Captive-Portai				3a 0	00 00	01 2c	3b 0	4 00 00	02 12	2 3d 1	3 G .:··		= -
	Length: 31	tal, coans%2htcn://10.101	71 0.25694			00 1	L7 0d 00	01 00	01 2	c 30 d7	80 20	5 90 1	d ·h···	···· · ,0··8	
	Captive Por	tal: coaps%20tcp://10.101	./1.2:55064			46 7 2f 3	2 IT 05	31 30	31 2	0 20 02	2 02 74	+ 00 / ) 3a 3	3 ·//10	COA PS/6201	
	Option. (255)	LIIU								P 7/ 7/					
						✓ 38 3	34 ff	52 50	51 6	e 57 51	26 34		5684		2:3
	. 120 N					♥ 38 3	84 ff		51 2	.e 57 51	. 20 3.		5684		2:3
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<ul> <li>▲ IF</li> <li>▲ IF</li> <li>▲ IF</li> <li>▲ N</li> <li>▲ N<th>PM ashboard osts DU onstellations ransport Capacities ervices locidiles oftware Management ser Management ault Management onfiguration</th><th>Module Name Here MA222312A008 -</th><th>Settings / General Settings / General Labels Labels START P FACTORY R ady to ady to be</th><th>e C L</th><th>ine Port (</th><th>♥ 38 3</th><th>34 ff</th><th>^</th><th>Seri MAA Soft Harr Forn Cor Moto CLE</th><th>ent Port (I ent Po</th><th>e Descr r sion sion pe r</th><th>t) ption MA2223 3C:02-6i v1.1.0.8 ocf.2.2.0 QSFP-DI LC conn</th><th>312A00B 8:00:17:0C rc2-5-g1b7b4 6 D eector</th><th>the2</th><th>Cor</th></li></ul>	PM ashboard osts DU onstellations ransport Capacities ervices locidiles oftware Management ser Management ault Management onfiguration	Module Name Here MA222312A008 -	Settings / General Settings / General Labels Labels START P FACTORY R ady to ady to be	e C L	ine Port (	♥ 38 3	34 ff	^	Seri MAA Soft Harr Forn Cor Moto CLE	ent Port (I ent Po	e Descr r sion sion pe r	t) ption MA2223 3C:02-6i v1.1.0.8 ocf.2.2.0 QSFP-DI LC conn	312A00B 8:00:17:0C rc2-5-g1b7b4 6 D eector	the2	Cor
<ul> <li>▲ IF</li> <li>■ D</li> <li>● H</li> <li>■ N</li> <li>▲ N</li> <li>▲ N</li> <li>▲ N</li> <li>▲ S</li> <li>▲ S</li> <li>▲ N</li> <li>▲ N<th>PM ashboard oosts DU onstellations ransport Capacities ervices ervices oftware Management ser Management ser Management onfiguration</th><th>Module Name MA222312A008  MA222312A008  MA222312A008  MA222312A008  MA2223  Settings  Settings  Settings  Configuration  Confi</th><th>Settings / General Settings / General Labels Labels 312A00B estart START START FACTORY R eady to b b comparison</th><th>e C L</th><th>ine Port (</th><th>♥ 38 3</th><th>34 ff</th><th>^</th><th>Seri MAG Soft Cor Moc CLE Moc</th><th>ent Port (I ent Port (I c address tware vers dware vers dware vers dware vers del number El Code dule Id</th><th>e Descr r sion sion pe r</th><th>t) ption MA22223 3C:02:6/ v1.1.0.8 ocf.2.2.4 QSFP-DI LC conn e519876</th><th>312A00B 8:00:17:0C rc2-5-g1b7b4 0 ector</th><th>₩ bfe2 7871-f1e74afd8</th><th>2:3 Cor</th></li></ul>	PM ashboard oosts DU onstellations ransport Capacities ervices ervices oftware Management ser Management ser Management onfiguration	Module Name MA222312A008  MA222312A008  MA222312A008  MA222312A008  MA2223  Settings  Settings  Settings  Configuration  Confi	Settings / General Settings / General Labels Labels 312A00B estart START START FACTORY R eady to b b comparison	e C L	ine Port (	♥ 38 3	34 ff	^	Seri MAG Soft Cor Moc CLE Moc	ent Port (I ent Port (I c address tware vers dware vers dware vers dware vers del number El Code dule Id	e Descr r sion sion pe r	t) ption MA22223 3C:02:6/ v1.1.0.8 ocf.2.2.4 QSFP-DI LC conn e519876	312A00B 8:00:17:0C rc2-5-g1b7b4 0 ector	₩ bfe2 7871-f1e74afd8	2:3 Cor

After the local Open XR Module is registered the remote module also manages to obtain its DHCP lease (IP address 10.101.81.3 is provided) and then also registers at the Open XR Controller.



**(** 

CLEI Code Module Id

Vendor

f11527be-9755-404d-6b91-f81e61b33aec

INFINERA

	Tree	0	Destruction	Destand	Lawet To Co				
NO.	Time	Source	Destination	Protocol	Lengt Into		70 0 04 450		
	3/8 /4/.6/3/23	10.101.81.1	10.101./1.2	DHCP	342 DHCP Discover	- Transactio	on 10 0x94c1Tb0c		
	3/9 /4/.6/4481	10.101./1.2	10.101.81.1	DHCP	405 DHCP Offer	- Iransactic	on 10 0x94c1fb0c		
	380 747.680894	10.101.81.1	10.101.71.2	DHCP	342 DHCP Request	- Transactio	on 10 0x94c1fb0c		
	381 /4/.682619	10.101./1.2	10.101.81.1	DHCP	405 DHCP ACK	- Transactio	on 10 0x94c1Tb0c		
	382 748.709670	10.101.81.1	10.101.71.2	DHCP	342 DHCP Discover	- Transactio	on ID 0x366570aa		
	383 748.710377	10.101.71.2	10.101.81.1	DHCP	405 DHCP Offer	- Transactio	on ID 0x366570aa		
	384 752.096828	10.101.81.1	10.101.71.2	DHCP	342 DHCP Discover	- Transactio	on ID Øxe1dd3d5e		
	385 752.097692	10.101.71.2	10.101.81.1	DHCP	405 DHCP Offer	- Transactio	on ID 0xe1dd3d5e		
	386 753.853119	10.100.215.71	10.101.81.2	TLSv1.2	105 Application Da	ata			
	387 753.853778	10.101.81.2	10.100.215.71	TCP	66 45602 → 5684 [	[ACK] Seq=428	316 Ack=13444 Win	=64088 Len=0	) TSval=7083312
	388 753.858170	10.101.81.2	10.100.215.71	TLSv1.2	105 Application Da	ata			
	389 753.901676	10.100.215.71	10.101.81.2	TCP	66 5684 → 45602 [	[ACK] Seq=134	44 Ack=42855 Win	=64128 Len=0	) TSval=2531202
8	390 756.136284	10.101.81.3	10.100.215.71	TCP	74 33800 → 5684 [	[SYN] Seq=0 W	lin=64240 Len=0 M	SS=1460 SACK	(_PERM TSval=4)
1	391 756.136447	10.100.215.71	10.101.81.3	TCP	74 5684 → 33800 [	[SYN, ACK] Se	eq=0 Ack=1 Win=65	160 Len=0 MS	S=1460 SACK_PE
	392 756.138062	10.101.81.3	10.100.215.71	TCP	66 33800 → 5684 [	[ACK] Seq=1 A	Ack=1 Win=64240 L	en=0 TSval=4	139363217 TSec
1	393 756.158054	10.101.81.3	10.100.215.71	TLSv1.2	170 Client Hello				
	394 756.158188	10.100.215.71	10.101.81.3	TCP	66 5684 → 33800 [	[ACK] Seq=1 A	Ack=105 Win=65152	Len=0 TSval	=1610767614 TS
	395 756.158805	10.100.215.71	10.101.81.3	TLSv1.2	1089 Server Hello,	Certificate,	Server Key Exch	ange, Server	Hello Done
	396 756.164965	10.101.81.3	10.100.215.71	TCP	66 33800 → 5684 [	ACK] Seq=105	Ack=1024 Win=64	088 Len=0 TS	val=4139363244
<									>
	Client TD adda				A 90 00	00 00 00 00	00 00 00 00 00 00	0 00 00	
	Vour (client)	TD address, 10 101 91 2			00 00	00 00 00 00	00 00 00 00 00 00	00 00 00	
	Your (client)	1P address: 10.101.81.5			00 00	00 00 63 82	53 63 35 01 02 0	01 04 ff	·····c· Sc5·····
	Next server IP	address: 0.0.0.0			00 03	04 0a 65 51	01 06 08 c0 00 0	02 01 c0 ·	·····e0 ·····
	Relay agent IP	address: 10.101.81.1		22.0	02 0f	Øb 65 78 61	6d 70 6c 65 2e 6	of 72 67 ·	····exa mple.org
	Client MAC add	ress: Infinera_56:1c:28 (0	0:0b:†8:56:1c:2	8)	0a 65	47 02 33 04	00 00 02 58 36 0	04 0a 65 *	· • eG • 3 • • • • X6 • • e
	Client hardwar	e address padding: 0000000	000000000000000		3a 04	00 00 01 2c	3b 04 00 00 02 1	L2 3d 13 G	·:···, ;····=·
	Server host na	me not given			56 1c	28 00 01 00	01 2c 30 d7 80 9	92 ab c1 ·	·V·(····,0·····
	Boot file name	not given			Se 72	1f 63 6f 61	70 72 25 22 62 7	74 63 70 M	0. n. con nr%2htcn
					00 72	TI 02 01 01	10 13 23 32 02 1	4 05 70 1	9 Picoa ps/2000p
	Magic cookie:	DHCP			2f 31	30 2e 31 30	31 2e 37 31 2e 3	32 3a 33	//10.10 1.71.2:3
>	Magic cookie: Option: (53) D	DHCP HCP Message Type (Offer)			✓ 38 34	30 2e 31 30 ff	31 2e 37 31 2e 3	32 3a 33 :	//10.10 1.71.2:3 684 <mark>.</mark>
>	Magic cookie: Option: (53) D	DHCP HCP Message Type (Offer)		-	2f 31 ✓ 38 34	30 2e 31 30	31 2e 37 31 2e 3	32 3a 33 5	//10.10 1.71.2:3
>	Magic cookie: Option: (53) D M	DHCP HCP Message Type (Offer)	t Name Status	o	✓ 2f 31 38 34	30 2e 31 30	31 2e 37 31 2e 3	32 3a 33 5	//10.10 1.71.2:3 684
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, , , , ,	Magic cookie: Option: (53) D M	DHCP HCP Message Type (Offer) Module Name Hos MA122244A003 -	t Name Status Online	e	2f 31	11 03 01 01 30 2e 31 30 ff	31 2e 37 31 2e 3	32 3a 33 5	684
Lipe Lipe	Magic cookie: Option: (53) D YM Ishboard	DHCP HCP Message Type (Offer) Module Name Hos MA122244A003 -	t Name Estatus Online Settings / General	e	v <mark>38 34</mark>	30 2e 31 30	31 2e 37 31 2e 3	32 3a 33 5	//10.10 1.71.2:3
→ IF	Magic cookie: Option: (53) D YM Nshboard	DHCP HCP Message Type (Offer) Module Name Hoe MA122244A003 - / Modules / MA122244A003 / 1	t Name Status Online Settings / General	e	v <mark>38 34</mark>	ff	31 2e 37 31 2e 3	32 3a 33	/10.10 1.71.2:3
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→ IP ■ Da ● Ho ■ NI → Co → Tr Co Se	Magic cookie: Option: (53) D M Ishboard Du Sts DU Sts SDU Statellations ansport Capacities rvices	DHCP HCP Message Type (Offer) MA122244A003 - / Modules / MA122244A003 / 1 Settings General Device name Access identifier XR	t Name Online Settings / General	e C I	v <mark>2f 31</mark> 38 34	1 00 2e 31 30 ff	31 2e 37 31 2e 3	net)	(101 pszetcp) (101
→ IP ■ Da → Ho → Ho → Tr → Tr ~ Se	Magic cookie: Option: (53) D M Ishboard Dats Du ushboard Dats AU unstellations ansport Capacities rvices	DHCP HCP Message Type (Offer) MA122244A003 - 1 / Modules / MA122244A003 / 1 Settings Ceneral Device name Access identifier XR Status @ Onlin	( Name Continue Settings / General Labels 44A003	e © I	v 2f 31 38 34	1 00 2e 31 30 ff	31 2e 37 31 2e 3	net)	(10, 10 1.71.2:3 684 ↑ Ne
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<ul> <li>↓</li> <li></li></ul>	Magic cookie: Option: (53) D M ashboard osts DU onstellations ansport Capacities ansport Capacities avices pdules	DHCP HCP Message Type (Offer) Module Name Hos MA122244A003 - MA122244A003 - MA122244A003 - Settings General Device name MA1222 Access identifier XR Status ① Onlin W: WARM START I Cold:	t Name Continue Battings / General	e © 1	v 2f 31 38 34	30 2e 31 30 ff	31 2e 37 31 2e 3	net)	1710-109 pszetcp 684- € ₩ Ne
	Magic cookie: Option: (53) D M Ishboard osts DU onstellations ansport Capacities rvices odules	DHCP HCP Message Type (Offer) MA122244A003 - 1 / Modules / MA122244A003 / 1 Settings General Device name Access identifier XR Status We coup	e start of factory of	e ©   ESET	v <mark>2f 31</mark> 38 34	1 00 2e 31 30 ff	31 2e 37 31 2e 3	net)	(10.10 1.71.2:3) 684- € ↑ Ne
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>	Magic cookie: Option: (53) D M shboard osts ou vostellations ansport Capacities rvices odules oftware Management er Management	DHCP HCP Message Type (Offer) Madde Name Hos MA122244A003 -	t Name Continue Bettings / General Labels 44A003 e START O FACTORY R	e O I	v 2f 31 38 34	A 00 00 01 30 20 31 30 ff	Client Port (Ethern Hardware Desc Serial number	net)	1710-195-2000 684- Ne
	Magic cookie: Option: (53) D M Ishboard osts DU onstellations ansport Capacities rvices odules oftware Management ier Management	DHCP HCP Message Type (Offer) MA122244A003 - 1 / Modules / MA122244A003 / 1 Settings General Device name MA1222 Access identifier XR Status We coup Configuration Configuration state Rea Configured Role Aut	A Name Continue Settings / General Cabels A4A003 e START O FACTORY R ady o	e ©   ESET	v 2f 31 38 34 Line Port (Optical)	A 00 00 01 01 00 00 01 00 00 00 00 00 00	Client Port (Ethern     Hardware Desc Serial number MAC address	net)	
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<ul> <li>▲</li> <li>↓</li> <li>↓</li></ul>	Magic cookie: Option: (53) D M which board basts basts AU onstellations ansport Capacities rvices podules offware Management ser Management with Management onfiguration	DHCP HCP Message Type (Offer) MA122244A003 - MA122244A003 - MA122244A003 / Settings Ceneral Device name Access identifier XR Status Dollar K* WARM START M* Configuration Configuration state Rec Configuration State Rec Conf	t Name Continue Settings / General Labels 44A003 e START O FACTORY R ady o f	e © 1	Line Port (Optical)	A 00 00 01 01 00 01 01 00 01 01 01 01 01	Hardware Desc Serial number MAC address Software version Hardware version Form factor Connector type	net)	

400G router CLI ARP output showing the two DHCP assigned IP addresses for the local and the remote module associated with the same interface ge400-0/0/1.4090.

Serdes lane rate

Service mode

Traffic mode

50 Gbps

L1 mode

Auto

OPEN XR
FORUM

OpenXR1# show arp	,					
VRF: default						
IPv4 Address	MAC Address	Origin	State	Age	Interface	l
	+	+	+	+	+	1
10.101.69.1	fc:96:43:aa:70:42	dynamic	reachable	0 days, 0:57:30	ge400-0/0/9.4090	I.
10.101.69.2	e8:c5:7a:b7:25:48	local		I	ge400-0/0/9.4090	1
10.101.80.1	e8:c5:7a:b7:25:30	local		I	ge400-0/0/6.4090	1
10.101.81.1	e8:c5:7a:b7:25:08	local	1	ĺ	ge400-0/0/1.4090	1
10.101.81.2	3c:02:68:00:17:0d	dynamic	reachable	0 days, 0:04:29	ge400-0/0/1.4090	1
10.101.81.3	00:0b:f8:56:1c:28	dynamic	reachable	0 days, 0:02:52	ge400-0/0/1.4090	l

5.7 P2MP with Open XR Modules in NDU and UfiSpace DriveNets router

This test bed is built to test the ability of an Open XR Module inside a UfiSpace DriveNets router to act as a Hub module connecting to multiple NDU devices with Open XR Modules as leaf. The test setup is as follows:



Figure 41 - Test bed 6 logical diagram

The interface configuration of the Open XR Hub Module for the traffic forwarding:

```
interfaces
ge400-0/0/4
admin-state enabled
fec none
ipv4-address 44.44.44.21/30
speed 100
!
!
```

Open XR Forum | 45

```
OpenXR1# show config interfaces ge100-0/0/1/0
interfaces
  ge100-0/0/1/1
   admin-state enabled
   fec rs-fec-544-514
 !
!
OpenXR1# show config interfaces ge100-0/0/1/1.601
interfaces
  ge100-0/0/1/1.601
   admin-state enabled
   ipv4-address 44.44.44.29/30
   vlan-id 601 tpid 0x8100
!
```

The interface configuration of the Nokia 100G router with a 100G grey client optic connecting to the NDU:

```
A:admin@prod-lab03c-ral# info flat | match 1/1/c6
   port 1/1/c6 { }
   port 1/1/c6 { admin-state enable }
   port 1/1/c6 { description "** In use for Open XR testing - 100G LR4 **" }
   port 1/1/c6 { connector }
   port 1/1/c6 { connector breakout c1-100g }
   port 1/1/c6/1 { }
   port 1/1/c6/1 { admin-state enable }
   port 1/1/c6/1 { description "** In use for Open XR testing - 100G LR4
transceiver **" }
   port 1/1/c6/1 { ethernet }
   port 1/1/c6/1 { ethernet mode hybrid }
   port 1/1/c6/1 { ethernet mtu 9192 }
    router "Base" { interface "OpenXR c6 tag 1" port 1/1/c6/1:601 }
[pr:/configure]
A:admin@prod-lab03c-ra1# info flat | match "OpenXR c6 tag 1"
    router "Base" { interface "OpenXR c6 tag 1" }
   router "Base" { interface "OpenXR c6 tag 1" port 1/1/c6/1:601 }
    router "Base" { interface "OpenXR c6 tag 1" ipv4 }
   router "Base" { interface "OpenXR c6 tag 1" ipv4 primary }
   router "Base" { interface "OpenXR c6 tag 1" ipv4 primary address 44.44.44.30 }
   router "Base" { interface "OpenXR c6 tag 1" ipv4 primary prefix-length 30 }
```

```
[pr:/configure]
```

The High Resolution OSA devices reading from both the Hub (black) and the two Leaf modules (green):





The Hub and Leaf modules are fully registered and controlled by the Open XR Controller:

Topology:									
🗼 IPM	Constillation Name Const1							<u> </u>	3 ■ ~ <sup>▲</sup> XR-USER-1 ~
Bashboard	1 Constellations / Const1 / Topology								
😵 Hosts	🕷 Constellation 👍 H	ub Module	Leaf Module	s Discove	red	Control Links	٠	Topology	3 Neighborhood
THE NOU				Constellat	ion(s)				0 7
💥 Constellations									
Transport Capacities									
Services									
Nodules									
Software Management									•
ag. User Management								MA22	232A001
🔔 Fault Management									
Configuration			LS		Splitter/Combi	iner			•
Services:								M0422	233A003
🗼 IPM	Services							• <u> </u>	? ■ ~ ▲ xnusen1 ·
Dashboard	Comment De contart at								
Hosts	C HONESH CEL CHONE + E								1.
a NDU	Name A Service Mode LLDP System N	En ame Port Id Module name	dpoint A Access identifier	Rate (Gbos) Port speed (Gbos)	LLDP System Name	En Port id Module name	Access identifier	Rate (Gbos) Port speed (Gbos	Lifecycle State Managed
Constellations	<u>S1</u> XR41	MA222232A001	XR-T1	100 100		MA222312A010	XR-T1	100 100	Configured IPM
Toursel Consulting	52 XR-L1	MA222233A003	XR-T1	100 100		MA222312A010	XR-T3	100 100	Configured IPM
Constellation:	4								
🗼 ІРМ	Constellations							<u> </u>	⑦ ■ ~ ▲ xn-usen-1
Dashboard		DELETE							<b>T</b> -
😵 Hosts	Name Module nam	LLDP System Name	Host Ports	MAC address	Constellation freque	ncy (THz) Modulation	Topology	IEEE 1588 TC	Lifecycle State
mdu 📅	Const1 MA222312A	010		30:02:68:00:16:80	194.800000	16QAM	V P2MP	~ D	Configured
X Constellations	LLDP System Name Host Ports	Module name	MAC address	Configured Role	Current Role	Role Status	Fiber Mode	Lifecycle State	Connectivity Type
<ul> <li>Transport Capacities</li> </ul>		MA222232A001	00:08 F8:68.08:80	Leaf	Unknown	Scanning	Dual	Configured	Control Plane Neighbor
C Services		MA222233A003	00:08:F8:68.07:60	Leaf	Unknown	Scanning	Dual	Configured	Control Plane Neighbor
Nodules	0 selected, total records: 1     10 columns selected	~						1 of 1 << < 1	> >> 20 🗸





#### 6 Summary and Conclusion

In this Proof of concept, we have successfully demonstrated:

- 1. Coexistence of XR signals with a variety of brownfield DWDM and XGS-PON line systems in:
  - a. Point-to-point configuration and
  - b. Point-to-multipoint configuration
- 2. Compatibility of XR pluggable transceivers with a variety of host and NOS systems (Juniper, DriveNets & Ufispace, SONiC & Edgecore, Infinera TM301, and Infinera NDU).
- 3. Host independence of optical management when XR coherent optics are deployed in a packet host demonstrating the Open XR Management Architecture's dual management paradigm.
- 4. Advanced management functionality of smart pluggable transceivers, demonstrating the capability of modern routers to seamlessly support remote management of pluggable transceivers through the Open XR management architecture.

This demonstrates the viability of XR to transform the network architecture with long-reach coherent optics supporting both P2P and P2MP connectivity, while being able to seamlessly integrate with legacy network management and installed infrastructures.



8

# 7 References

[1] Open XR Forum, "Open XR Management Architecture Specification," March 2022. [Online]. Available: https://www.openxrforum.org/documents.