Orchestrating a brighter world NEC

Realization of Open Optical Transport

NEC Corporation

Table of Contents

Introduction 3
What is Openness? 3
What is Disaggregation? 4
Openness of Optical Networks 5
Implementation Models for Openness 6
Implementing Openness with Alien Solutions 7
NEC's Solutions 8
Glossary of Terms and Abbreviations 10

Introduction

Openness is the catalyst for social change. In the white paper, "Toward Open Optical Networks," we showed how open optical networks would change society and networks. This white paper describes how we will implement openness.

What is Openness?

Openness refers to the release of specifications, designs, interfaces, etc., or the adoption of products based on published standard specifications. So what does openness bring?

Openness brings "interchangeability." Anyone can create products based on open specifications and interfaces, and anyone can freely incorporate products that meet those specifications and interfaces into systems.

At the opposite end of the spectrum of openness is the closed system. Closed systems consist of the vendor's proprietary specifications, and their functionality, pricing, and procurement are dependent on the vendor's plans. Although this type of system is easy to implement because a single vendor provides it, it can lead to vendor lock-in, in which the customer becomes dependent on a single vendor for operation, maintenance, additional functionality, lead time for goods, and support for the latest technology after the implementation. If the vendor withdraws from the market or components become difficult to obtain due to security, supply shortages, etc., the system becomes unusable.

On the other hand, a system built on open architecture is a flexible system created by selecting products and services from multiple product options according to budget and requirements. Openness allows users to select and integrate products at their will, making it easier to introduce the latest technology, upgrade operations, add functions, reduce unnecessary functions, reduce costs, and adopt highly procurable products, depending on their requirements. It allows users to implement tailor-made systems. In addition, product interchangeability will allow for greater competition, resulting in lower prices, higher performance for each product, and more user choices. Open systems can also be considered sustainable.

In addition, the ability to freely combine and integrate products will lead to the evolution of platforms for creating new systems. In addition to replacing one product that makes up an existing system with another, it will be possible to combine component products to create new systems freely. We believe that the ability to freely combine open components or allow users to create their own will lead to innovations.

In addition, open interfaces between hardware and software can help separate the two. Users will be free to choose and implement their software and will be free to control hardware built to open specifications (also known as white boxes). For example, it will be possible to integrate operations with other systems or support different types of hardware using the same software. Separating hardware from software also frees systems from the physical specifications and limitations of the hardware. Furthermore, these systems can develop into virtualized systems that share hardware resources.

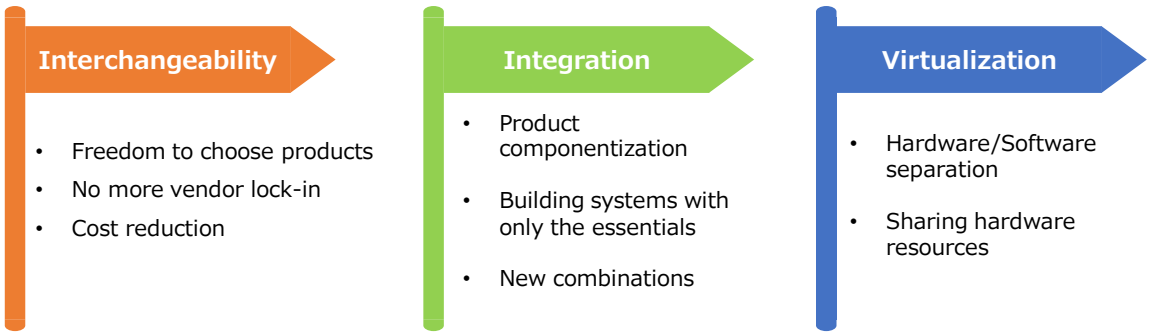


Figure 1　What openness brings

Openness has allowed users to freely choose operating systems, applications, and hardware in computing. In addition, competition has driven hardware and software to become more sophisticated and less expensive. Furthermore, new components such as blade servers and new software developed by OSS have emerged one after another, and new server systems have emerged by combining them. Furthermore, with the separation of hardware and software, the world of computing has evolved into systems where virtualization has progressed, and users can allocate resources on demand. All of this progress began with greater openness.

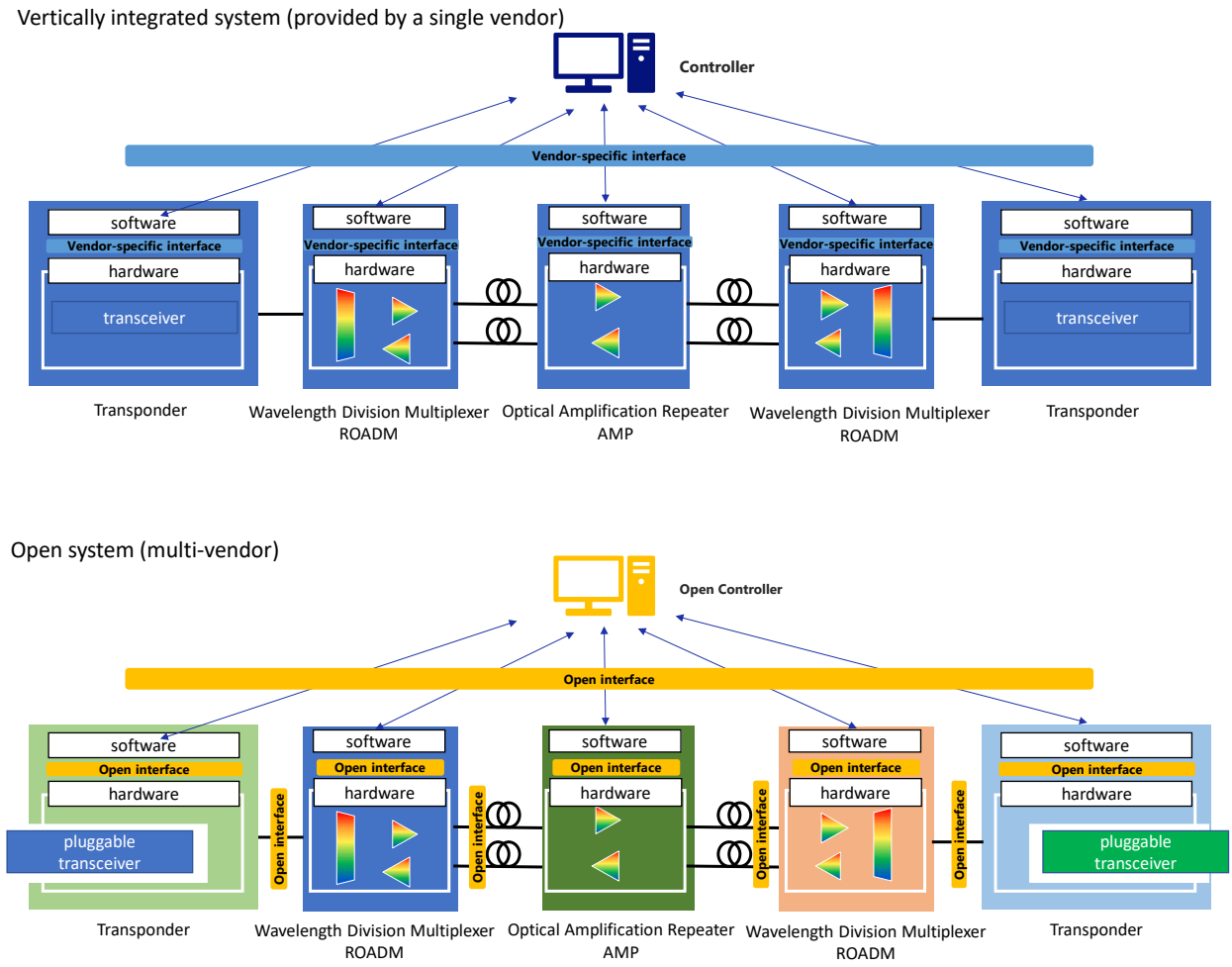
We believe the same thing will happen in the field of networks. We believe that optical networks, consisting of vertically integrated dedicated systems, will evolve into new systems that avoid vendor lock-in, have higher functionality, integrate with AI, and are virtualized through openness.

What is Disaggregation?

Disaggregation is the underlying basis for openness. Disaggregation divides a previously integrated system and defines specifications and interfaces according to function. When considering which areas to disaggregate, one should consider perspectives such as software vs. hardware, the speed of technological progress, and ease of commoditization. Various organizations, such as TIP and OpenROADM, are holding discussions about which areas are best suited for disaggregation. NEC actively participates in these activities, working with operators and vendors to promote standardization and implementation in systems.

Openness of Optical Networks

Openness in optical networks starts with separating (disaggregating) the functions previously provided by a single vendor and building systems with standardized and open interfaces, as shown in the figure below.



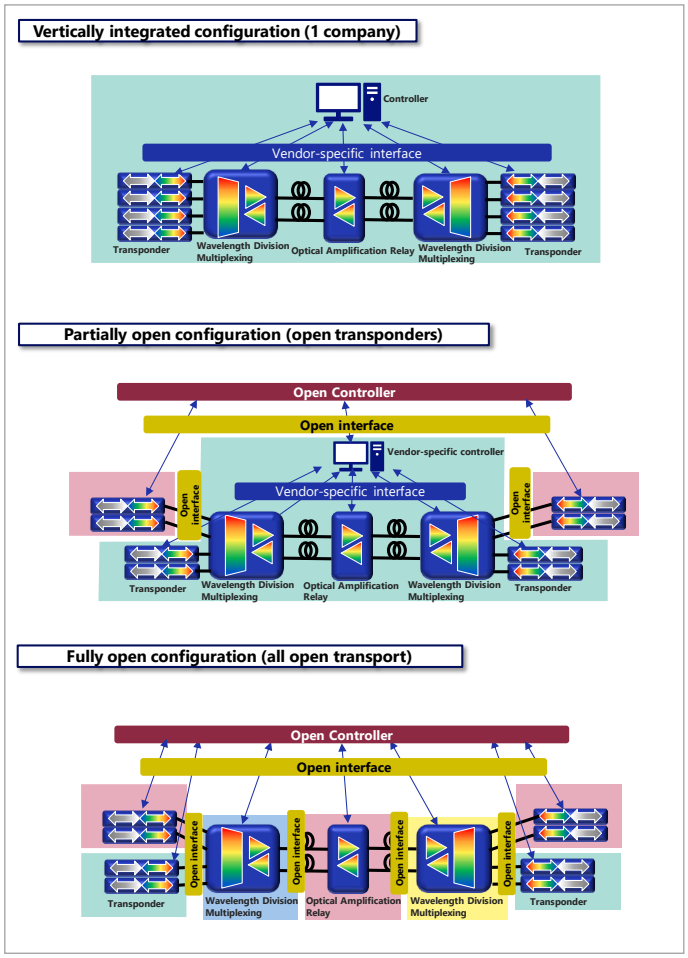
What openness achieves depends on which areas we open, enabling the following developments:

- ✓ Open main signals between devices allow interconnection between different devices/vendors.
- ✓ Open interfaces between controllers and devices allow a single controller to control different devices. In addition, since the network can be monitored and controlled from higher-level applications using open interfaces, it will be possible to manage and automate the network according to its status and to operate the network in an advanced manner (i.e., in conjunction with AI).
- ✓ By separating the optical transceiver component and making its control interface more open, the transceiver can be interchangeable. Users can interchange transceivers from various vendors and generations on a single platform. Recent advances in device technology have accelerated this openness, as coherent optical modules are now available as pluggable devices.
- ✓ Open interfaces between software and hardware can also help separate software and

hardware, freeing software from hardware's physical specifications and limitations. Users will be free to develop their own applications.

Implementation Models for Openness

The openness of optical networks requires the right tools, a transformation of the business processes that use those tools, and integration that combines the tools. Therefore, we believe it would be a steep challenge to shift, in a single step, from the existing vertically integrated model to a fully open, multi-vendor, fully open configuration by disaggregating all significant functions. We believe it is better to demonstrate the effectiveness of openness and take steps toward partially open configurations: gradually implementing open systems, starting with areas that would benefit the most. In partially open configurations, system components are functionally divided and opened, starting with transponder and optical transceiver functions, which have a particularly short cycle of technological innovation of one to two years. In recent years, advances in device technology have led to the emergence of coherent pluggable optical transceiver modules, expanding user options. First, opening up this area will provide optical networks that incorporate the latest technologies, reduce costs, and enhance operational sophistication.



Implementing Openness with Alien Solutions

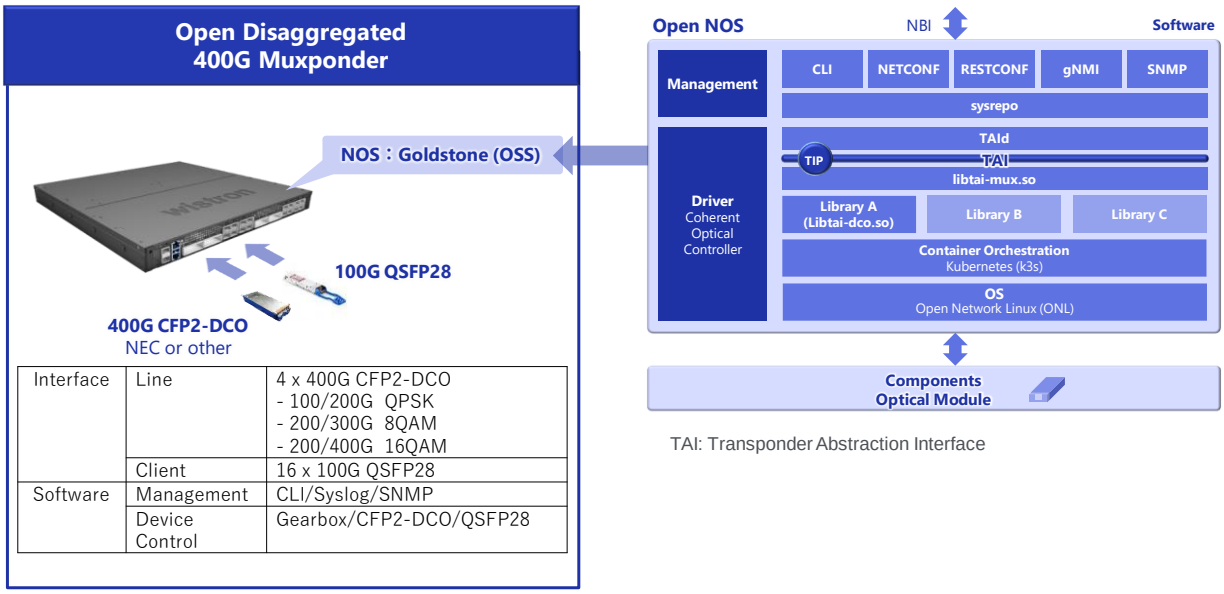
A partially open configuration is a configuration in which transponders and optical transceivers, which experience rapid technological innovation, are functionally divided and opened and connected to existing WDM systems. Using different vendors for the transponder component has been discussed and introduced since the 2000s as the Alien Solution. However, until now, the focus has been on the main signal interconnections, with solutions simply connecting new transponders and existing WDM systems at the main signal level. The Alien solution was not integrated and implemented as a system. On the other hand, Alien solutions with open products will be able to integrate Alien transponders and existing WDM as a system because of the standardization and hardware/software separation of not only the main signals but also the monitoring and control interfaces, management models, and optical components. NEC strives to promote openness in optical networks with Alien solutions for open transponders.

	Conventionally (~2018) Proprietary Alien Connection	Recently/Future (2019~) Open Alien Connection	User Benefits
Traits	Connects optical signals between line systems and transponders across different vendors	Additional standardization in areas such as monitoring and control interfaces, hardware-software separation, optical components, etc., in addition to optical signals	Understanding of applicability and feasibility through standardized model definitions and precedents Reducing the burden of verification through validation by the standardization community Greater choice of hardware and software components and greater cost optimization
Line Interface	• Checking connectivity by cross-checking vendor-specific interfaces • Only the wavelength grid is standardized in ITU-T	• Standardized with OpenROADM and OIF • Demonstrated interconnection of LineSystem and transponders	
Monitoring/ Control Interface	• Line Systems and transponders each have their own interface • Separate Line Systems and transponders for controllers	• Standardization by OpenROADM, ONF, TIP • Increased use of open-source versions of both transponders and controllers, and increased affinity between NEs and controllers	
Architecture	Transponder development integrates optical components, hardware, and software. Options for optical components depend on each vendor. Software embedded in hardware.	• Easy addition of third-party vendors for optical components that increase the range of combinations through increased separation of hardware and software and applications of standardized models. Continuity of software allows for easy integration with the Controller when adding functions.	
Marketability	Market environment is immature (standardization, ecosystem, operational models, etc.)	Market environment is aligning with standardization, ecosystems, operational models, and pluggable optical components	

NEC's Solutions

Open transponders

We have added a 400G Whitebox Muxponder to our lineup for TIP OOPT's "Phoenix" project to support partially open configurations of optical networks. Whitebox Muxponder separates software and hardware and uses the open-source Goldstone as the network OS. Each control function is a container based on Kubernetes. The modular structure facilitates updates for each function and new functions. As an optical transceiver, it supports Gen3 DSP (200Gbps/lambda) and Gen4 DSP (400Gbps/lambda), and its configuration allows for efficient upgrades by simply replacing modules. This allows for a partially open configuration.



Interface	Line	4 x 400G CFP2-DCO - 100/200G QPSK - 200/300G 8QAM - 200/400G 16QAM
	Client	16 x 100G QSFP28
Software	Management	CLI/Syslog/SNMP
	Device Control	Gearbox/CFP2-DCO/QSFP28

TAI: Transponder Abstraction Interface

Optical devices

Optical transceivers, which are responsible for the optical interface, also play an essential role in opening optical networks. Optical transceivers are vital because it is necessary to ensure interconnectivity at the optical interface and employ optical transceivers with common specifications to various optical communication devices (multi-sourcing: MSA). Therefore, various standardization activities are closely related to the development of optical transceivers. The following table summarizes each technology and the standardization organizations involved. The standardization activities include discussions on optical transceiver internal components, optical transceiver engineering and control specifications, and interconnectable optical interface specifications. By participating in these standardization activities, NEC strives to promote openness.

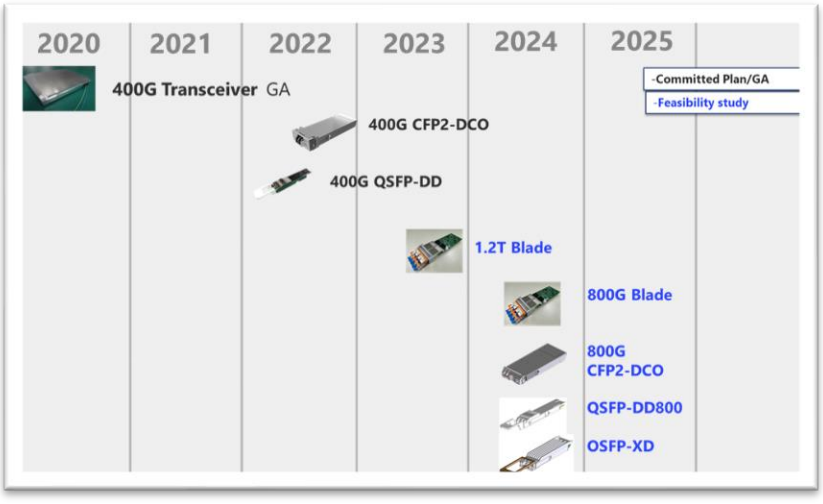
Technical domain	Standardization body	Standard name, etc.
Optical transmitter/receiver component specifications	OIF	IC-TROSA, CDM, ICR, ITLA
Optical transceiver equipment specifications	OIF, QSFP-MSA, CFP-MSA, OSFP-MSA	100G-LH-MSA, QSFP-DD, CFP2-DCO, OSFP-XD, etc.
Optical transceiver control specifications	OIF, QSFP-MSA, CFP-MSA, OpenROADM	MIS, CMIS, C-CMIS, YANG model, etc.
Optical interface specifications	OIF, OpenZR+-MSA, OpenROADM-MSA、IEEE	400ZR, OpenZR+(400G), OpenROADM(400G), IEEE 802.3cw, etc.

In the 400Gbps digital coherent optical interface currently emerging in the market, various standards exist depending on the equipment and distance to which it is applied. Buyers can select the optimal one according to the application. The table below shows some examples. NEC offers various optical transceiver solutions according to the desired balance between low power consumption to increase the port density of open communication devices and high performance for long-distance transmission.

Applied devices	DCI	Metro	ROADM	Ultra-long distance
Transmission distance	~100km	~600km	~600km＋ROADM	~3000km
Optical interface	400ZR	OpenZR+(400G)	OpenROADM(400G)	Dedicated optical interface
Shape	QSFP-DD	QSFP-DD	CFP2-DCO/QSFP-DD	Board-mounted type
Power consumption	<20W	20W	24W	~60W

Low power ← → **High**

In the future, optical interfaces will continue to expand their capacity to 800 Gbps and beyond. NEC plans to continue to provide optical transceivers in line with openness on a timely basis, as shown in the roadmap below.



Integration

Until now, in vertically integrated systems, communication equipment vendors have designed and evaluated each module, assembled it, and guaranteed its operation as a system. On the other hand, in creating a system by freely combining open components, there is a new need for the role of the integrator, who is responsible for selecting equipment and software based on the operator's requirements, verifying operation, building a system of operation, and managing bugs and vulnerabilities. NEC provides integration to build carrier-grade optical networks by combining open components based on its knowledge and experience in building products and highly reliable networks for telecommunication carriers over many years. We also partner with various open product companies to promote the creation of ecosystems.

Glossary of Terms and Abbreviations

CDM: Coherent Driver Modulator
DSP: Digital Signal Processor
ICR: Integrated Coherent Receiver
ITLA: Integrated Tunable Laser Assembly
OIF: Optical Internetworking Forum (standardization organization)
OOTP: Open Optical and Packet Transport (project within TIP)
OpenZR+ MSA: Standardization organization for optical communication
OpenROADM MSA: Standardization organization for optical communication
QSFP-MSA: Standardization organization for optical transceivers
OSFP-MSA: Standardization organization for optical transceivers
TIP: Telecom Infra Project (standardization organization)
ROADM: Reconfigurable Optical Add/Drop Multiplexing
WDM: Wavelength Division Multiplexing

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