An Update on Open Source Communities Engaged in SDN/NFV, with a Focus on the Open Networking Foundation

Dai Kashiwa and Wenyu Shen

Abstract

The Open Networking Foundation (ONF) was founded in 2011, and since then, numerous open source communities focusing on software-defined networking (SDN) and network functions virtualization (NFV) have been launched and are becoming more active. This article first gives an overview of the open source communities concerned with SDN/NFV technologies and then describes the latest activities of the ONF and the initiatives undertaken by the NTT Group. The activities of the MEF (Metro Ethernet Forum) are also explained as an example of work pursued by the NTT Group.

Keywords: open source community, SDN/NFV, Open Networking Foundation

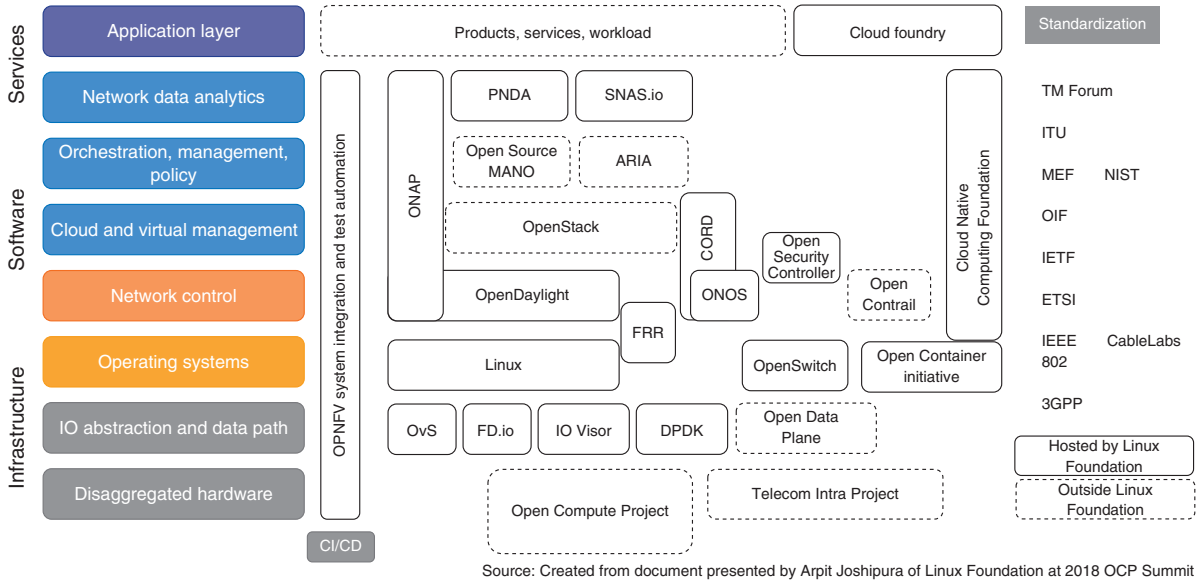
1. Introduction

The application of software-defined networking (SDN) and network functions virtualization (NFV) technologies is expanding, and in line with this trend, a variety of open source development projects and standardization projects have been launched. The results from these projects are being introduced in the construction of service systems by communication carriers, cloud providers, and enterprise users. These movements started with the development of SDN controllers such as the OpenDaylight and ONOS (Open Network Operating System) projects, after which they expanded to include the development of high-speed data planes, as represented by Open vSwitch and DPDK (Data Plane Development Kit), and the development of NFV infrastructures such as OPNFV (Open Platform for NFV).

These open source development activities have been linked with the standardization efforts of organizations such as ETSI (European Telecommunications Standards Institute) and the TMF Forum, creating a cycle of activities whereby standardization has influenced implementation, and the work of implementation has been fed back into the standardization process. Today, there is intense interest in orchestration platforms, as represented by ONAP (Open Network Automation Platform), and container management systems, as represented by Kubernetes.

The mappings of major networking-related projects, as compiled by the Linux Foundation (LF) [1], are shown in **Fig. 1**. There are projects in each of the three layers: the infrastructure layer consisting of devices, data transfer, and operating systems; the software layer consisting of network control, cloud platforms, and orchestration frameworks; and the service layer consisting of data analytics and applications. As the use of 5G (fifth-generation mobile communications), Internet of Things, and artificial intelligence technologies becomes more and more widespread, attention has been drawn to edge computing. As a result, many edge-related projects have been launched under the LF.

In January 2019, a new organization called LF Edge was established to promote collaboration between different projects. It consolidated those



Source: Created from document presented by Arpit Joshipura of Linux Foundation at 2018 OCP Summit

ARIA: Agile Reference Implementation of Automation
CI/CD: continuous integration/continuous delivery
CORD: Central Office Re-architected as a Datacenter
FD.io: Fast Data - input/output
FRR: FRRouting (Free Range Routing)
IEEE: The Institute of Electrical and Electronics Engineers
IETF: The Internet Engineering Task Force
IO: input/output
ITU: The International Telecommunication Union
MANO: management and orchestration
MEF: Metro Ethernet Forum
NIST: National Institute of Standards and Technology
OIF: Optical Internetworking Forum
OvS: Open vSwitch
PNDA: Platform for Network Data Analytics
SNAS: Streaming Network Analytics System
3GPP: 3rd Generation Partnership Project

Fig. 1. Open source networking landscape.

projects that developed software programs to be used in edge computing. Five projects are in progress under the umbrella of LF Edge: Akraino Edge Stack, EdgeX Foundry, Home Edge Project, Open Glossary of Edge Computing Project, and EVE (Edge Virtualization Engine) [2].

2. Open Networking Foundation (ONF)

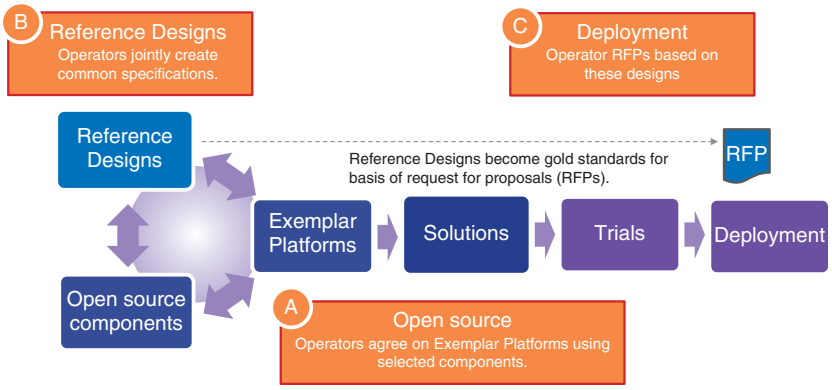
In October 2016, the ONF, which mainly worked on standardization, was merged with ON. Lab (Open Networking Lab), which was involved in open source development. Since then, the new ONF has been working on open source development and also specifying the design information obtained in the development process by publishing standards documents [3]. In March 2018, it announced the ONF Strategic Plan. This plan declares that operators (AT&T, Deutsch Telekom, NTT Group, etc.), participating as partners, will define common requirements, and that the ONF will work with ONF members, including vendors and system integrators, to create Reference Designs (RDs) and Exemplar Platforms (EPs), which are both needed for implementing these requirements (**Fig. 2**).

An RD defines software components needed for implementing specific use cases and also specifies the functional requirements for these components and inter-component interfaces. RD documents are released to ONF members. An EP is an aggregation of open source software programs that implement the RD and is core software used for the development of commercial products. The ONF aims to provide operators with systems that are based on open technologies (open source software, white boxes, and network disaggregation) by creating a cycle of design, development, deployment, and maintenance founded on the RDs and EPs [4].

As of June 2019, the ONF handles five use cases: SDN Enabled Broadband Access (SEBA), Trellis, Open and Disaggregated Transport Network (ODTN), next-generation SDN (NG-SDN), and Converged Multi-Access and Core (COMAC).

(1) SEBA

This use case virtualizes the functions of the optical line termination, broadband network gateway, and other components and implements access network



Source: Created from the website of the ONF [4]

Fig. 2. ONF's strategic plan.

technologies such as passive optical networks and G. Fast by combining open source programs. It also achieves a high-speed and seamless connection with the backhaul. This work is led by AT&T and Deutsche Telekom. The ONF devotes the greatest proportion of its resources to this use case.

(2) Trellis

The objective of this use case is to develop a leaf-spine fabric for NFV using open technologies. It implements routing (Border Gateway Protocol and Segment Routing), Q-in-Q control, and a dual-homing function.

(3) ODTN

This use case is aimed at disaggregating transmission network devices and achieving interactions between components and controllers through an open application programming interface (API). This is described in more detail in the following section.

(4) NG-SDN

This use case is designed to make the data plane programmable by using P4-language-based white box switches, network operating systems, and controllers.

(5) COMAC

This use case is intended to terminate and manage mobile and wireline access networks seamlessly and to provide network slices. It provides the data plane with programmability based on the P4 language. It also aims at providing customer management, a mobility management entity, home subscriber server, and other functions as a common platform.

3. NTT Group's initiatives for collaboration with open communities

NTT Group companies have been collaborating with various open source communities for many years. Some of these collaborations are described in more detail in this section.

3.1 Collaboration with ONF

NTT Communications has participated in the ONF since the inception of the latter in 2011. It has been actively involved in ONF activities and holds the status of a partner (the highest level of participation, serving as a board member and thus being involved in the ONF's decision-making). The entire NTT Group has been a partner since 2017, thereby further increasing its involvement. NTT Communications has launched and led the ODTN project as part of its effort to implement a transport network using open technologies.

With the aim of making the data plane programmable, NTT EAST and NTT Network Service Systems Laboratories are participating in the NG-SDN project and driving its technical studies, with a focus on P4. NTT WEST also takes part in the NG-SDN project. NTT Access Network Service Systems Laboratories is involved in the SEBA project and contributes to the formulation of the RD and implementation of parts of the EP.

3.2 ODTN

Transport networks comprise optical transmission systems such as transponders and ROADM (reconfigurable optical add/drop multiplexers). Most of

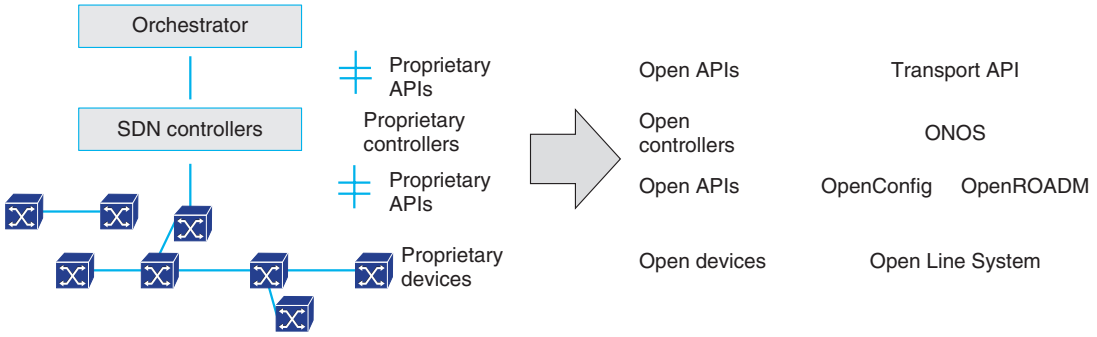


Fig. 3. Configuration of ODTN.

these network devices and control software programs, for example, element management systems and network management systems, are implemented by vendors in a proprietary manner with vertical integration, which hinders interoperability or open architecture. The results are strong vendor lock-in and long update cycles, making it difficult to introduce leading-edge technologies and products at short intervals.

The idea of disaggregating functions has emerged as a way to solve these problems. Several initiatives are in progress. The Open Line System (OLS) [5] separates transponders from transport systems—which have conventionally integrated the functions of transponders, multiplexers, demultiplexers, and amplifiers—so that multi-vendor transponders can coexist in a single transport system. The OpenConfig [6] working group defines the data model and API for open optical transport, making it possible to control and manage compliant devices in an integrated manner, and to monitor and collect data from these devices using telemetry.

The ODTN is a technical development project aimed at innovating transport networks end-to-end by collaborating in the above-mentioned activities, using an aggregation of open technologies and open source software, including controllers [7]. The correspondence between component devices and open technologies used is shown in **Fig. 3**. The ODTN project plans to integrate the devices, API definitions, and controllers shown in Fig. 3, conduct a technical verification to demonstrate technical feasibility, and provide the related initiatives with detailed design values and feedback on the problems and requirements identified through technical evaluation. To date, it has completed Phase 1, in which an initial technical verification is carried out for the use case of a point-to-point connection using transponders and OLS. It is now endeavoring to enhance quality and expand use cases.

3.3 Collaboration with the Metro Ethernet Forum (MEF)

The MEF is a not-for-profit organization established in 2001 that currently has a membership of 220 companies. It formulated the device specifications needed for providing Carrier Ethernet services. It has now added elements of SDN and NFV to the specifications and announced life service orchestration (LSO), a concept model for building a network that features high agility. The MEF defines the functional requirements for LSO and APIs that support them in order to provide for end-to-end orchestration between the networks of different operators. Together with the NTT laboratories, NTT Communications has begun activities to use these APIs to achieve interconnections and collaboration between mobile and fixed network slices as well as activities to use these APIs for interconnection between software-defined wide area networks (SD-WANs).

More than 40 companies are currently producing individual solutions in the rapidly growing SD-WAN market. Although the number of operators that handle multiple solutions are on the rise, they face serious problems related to delivery and operations. For example, since the type of customer premises equipment (CPE) varies from solution to solution, these operators need to have a sales and delivery organization specific to each solution. Also, each time a new solution is introduced, they need to make a large investment to develop new peripheral systems such as operation support systems and business support systems.

The MEF is standardizing an SD-WAN data model

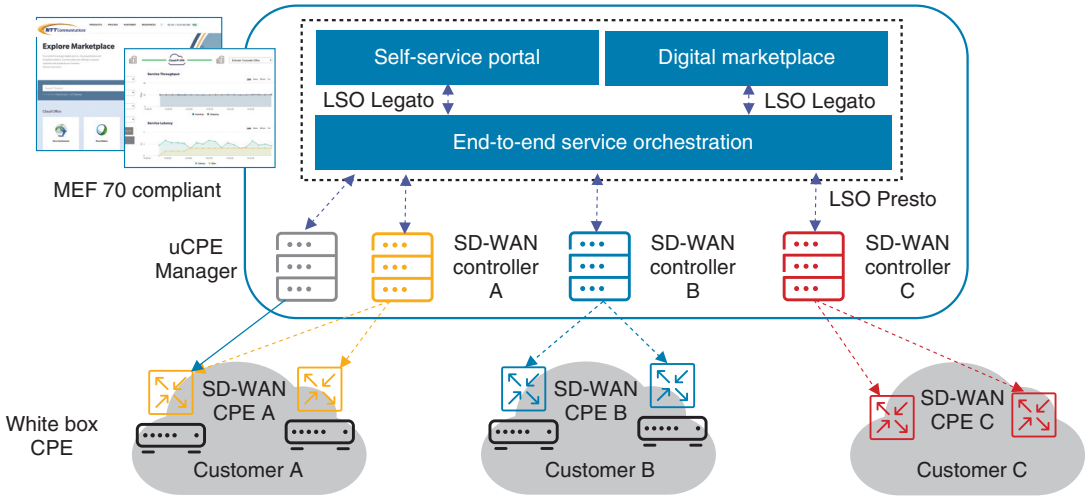


Fig. 4. Proof-of-concept configuration of multi-vendor SD-WAN service based on white boxes.

and various interfaces, thereby offering the possibility to rectify the above problems. NTT Communications started a project called a *multi-vendor SD-WAN service based on white boxes*. The aim of the project is to evaluate and verify a universal CPE platform that enables multiple SD-WAN solutions to be implemented on white boxes; MEF SD-WAN Presto, an interface that enables multiple SD-WANs to be controlled in an integrated manner using the same portal; and SD-WAN services that conform to MEF 70 standards (**Fig. 4**). A proof of concept will be demonstrated at an MEF 19 event to be held in November 2019 [8].

4. Future outlook

This article described open source community activities in the area of SDN/NFV technologies, the latest developments in the ONF, and initiatives taken by the NTT Group. Community activities will reinforce the trend toward developing software components through open innovation, which in turn will invigorate community activities. There have been many cases recently where the subject areas of different communities overlap. It is expected that communities will increase their efforts to collaborate or merge with other communities to allocate responsibilities appropriately.

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Dai Kashiwa
Vice President of SDN/NFV Technology Development, NTT Communications Corporation.

He received a Ph.D. in engineering in 2003. After joining NTT in 1997, he was involved in researching network management systems, network security, and active networks. He has been with NTT Communications since 2004, where he has been developing business network services including video broadcasting, dynamic VPN (virtual private network) and SDN services. He currently leads a number of incubation and software development projects using SDN/NFV technologies.

He has been a board member of ONF since 2015 and is leading the ODTN project, an operator-led initiative to build datacenter interconnects using disaggregated optical equipment, open and common standards, and open source software. He was successively appointed to the ONOS/CORD board and the OpenDaylight user advisory board.

Wenyu Shen
Manager of SDN/NFV Technology Development, NTT Communications Corporation.

He has over 10 years of experience in the telecommunications industry and currently serves as a technology development manager at NTT Communications. In this role, he drives NTT Communications' SDN/NFV strategy and leads a team developing a next generation SD-WAN and NFV service platform. He is also actively involved with open source communities and standardization bodies including ONF and MEF. As a representative of the NTT Group, he is currently a member of the technical leadership team at ONF.

Prior to joining NTT Communications, he was with NTT Network Innovation Laboratories, where he oversaw many core research projects including a European FP7 project, covering generalized multiprotocol label switching, operation support systems/business support systems, and network virtualization. He holds more than 10 patents and is the author of numerous papers and presentations on network architecture and design.