Standardizations of SDN and Its Practical Implementation

Software-Defined Networking (SDN) is a new approach to computer networking. The goal is to decouple the network control and forwarding functions in order to allow directly programming the network. Thus the underlying infrastructure is abstracted for applications and network services. This paper introduces the ongoing activities of ONF, NFV, ITU-T, IETF, OpenDaylight, OpenStack, and other organizations in the SDN space. It offers an overview of the future direction of proposed standards as well as NEC's involvement in these processes.

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1. Introduction

OpenFlow is the technology that brought SDN (Software-Defined Networking) from academia to the telecommunications market. OpenFlow decouples the network control from the actual data forwarding and thereby brings programmability to computer networks. Starting in data center environments, the scope of SDN extended to enterprise and carrier networks. Its conceptual range has thereby advanced to include various communication resource and to likewise embrace computing and storage. Following this trend, standardization activities to shape and define SDN are intensifying.

Deliberations began initially by focusing on the improvement and extension of the OpenFlow protocol at the Open Networking Foundation (ONF). Since then, topics are shifting to include a wider range, such as controller applications and northbound interfaces, practical usages in the optical and wireless fields, and also Network Function Virtualisation (NFV) which focuses on implementing network functions in one or multiple virtual machines (VMs). OpenDaylight and OpenStack are projects that promote Open Source Software (OSS) activities in order to verify and disseminate relevant applications by implementing them. These projects are also aiming to create an ecosystem for SDN while complementing traditional standardization activities.

In this paper, we offer an overview of these themes and report on NEC's own program and on the proposed orientation of our standardization activities.

2. Activities of ONF

The ONF aims at the dissemination and practical implementation of SDN through open standard development such as OpenFlow. As of the February 17th 2014 it has more than 130 member organizations, ten active Working Groups (WGs), and six Discussion Groups (DGs).

2.1 Working Groups (WGs)

The Architecture and Framework WG is defining ONF's view of the SDN architecture along with its components and interfaces. The Extensibility WG maintains and extends a crucial part of the above architecture: The OpenFlow protocol. At present, protocol 1.3.3[1)] belonging to the long-term stable version of the 1.3 series has been released, and new versions and maintenance releases are expected to follow. The Config-

uration & Management WG has defined the OF-Config protocol to configure OpenFlow switches, and currently version 1.2 is available[2]. While OpenFlow and OF-Config define the interface between SDN controllers and network elements, the recently (Oct. 2013) created Northbound Interface WG is exploring the interfaces needed between SDN Controllers and SDN applications.

To broaden the range of SDN enabled network elements two WGs have been created: First, the Optical Transport WG aims at understanding what is needed to extend OpenFlow for controlling optical transport networks. On this topic it is collaborating with the OIF (Optical Internetworking Forum). Second, the Wireless & Mobile WG is studying the application of OpenFlow and SDN to radio access networks (RAN) and the mobile core networks.

The Forwarding Abstractions WG is developing models to further abstract and allow to negotiate about the forwarding capabilities. Particular goals include solving the implementation dependency of multiple flow tables, and allowing to define profiles of network elements capabilities.

According to the technical deliberations cited above, the Testing & Interoperability WG holds the interconnect event "PlugFest" each spring and fall in order to ensure interoperability between vendors. The WG has the equally important task of defining test specifications that allow for conformance certification of OpenFlow products. The Migration WG studies successful OpenFlow deployments and develops guidelines for transitioning from legacy to SDN networks as well as tools to help in such transitions. Finally, the Market Education WG educates the market with solutions briefs and by organizing seminars and showcase events.

2.2 Discussion Groups (DGs)

Discussion Groups allow for open discussions on topics and are often used in preparation of the chartering of a WG on their topic. The Forum DG is an open-topic list used for general questions and non-technical subjects such as meeting plans. The Layer 4-7 DG has been created to discuss the OpenFlow applications for network functions looking into higher layers, such as firewalls, load-balancers and HTTP proxies. The Security DG is intended to promote discussion of security considerations relating to OpenFlow and OF-Config protocols and SDN infrastructure more generally. The Skills Certification DG discusses the certification of SDN-related skills, and the Carrier Grade SDN DG deals with use cases and requirements that are specific to carrier networks as well as considerations regarding actual applications. In addition, there is also a Japanese DG that discusses topics in Japanese language. We invite Japanese readers from ONF member companies to use this DG as an entry and information point to ONF.

2.3 NEC's Involvement in ONF

NEC has been participating in the ONF since its establishment. NEC holds a work group chair position and has been and is actively contributing to several WGs and DGs. Through these contributions, we have been promoting the dissemination of OpenFlow and SDN according to the intended aims of ONF.

3. SDN-Related Activities at ETSI

The Industry Specification Groups (ISGs) of the ETSI (European Telecommunications Standards Institute) include a group called the Network Functions Virtualisation (NFV) Group.

3.1 Activities of ETSI ISG NFV

This group collects the requirements and proposes an architecture for building new network environments by virtualizing network functions esp. for the telecommunication carrier networks. This pre-standards group was founded in January 2013 by telecom carriers and grew to more than 180 organizations by now. The ISGs lifetime is limited to 2 years and the expected outputs are recommendations and a gap analysis to existing technology based on the proposed architecture.

3.2 Outline of NFV

NFV is highly complementary to SDN, especially in the fields of performance improvement, simplification of compatibility with the existing systems and the implementation of effective operation management. These topics are mutually beneficial but are not dependent on each other. The NFV ISG explores how to realize the following points:

- Software-based prompt service innovation
- Operational efficiency improvement by common automation/operation
- Power consumption reduction by switching off the power of unused equipment
- Opening and standardization of virtual network functions and the interfaces between their management functions
- Improved flexibility in allocating network functions to hardware
- Improvement in capital efficiency by allocating hardware that is available on the market

The NFV started studies and documentations by defining four priority work items including the use case, end-to-end architecture, requirements and terminology. First, use cases of interest for NFV were determined and the requirements and architectures were discussed in order to implement those use cases. Subsequently, a terminology and an experimental

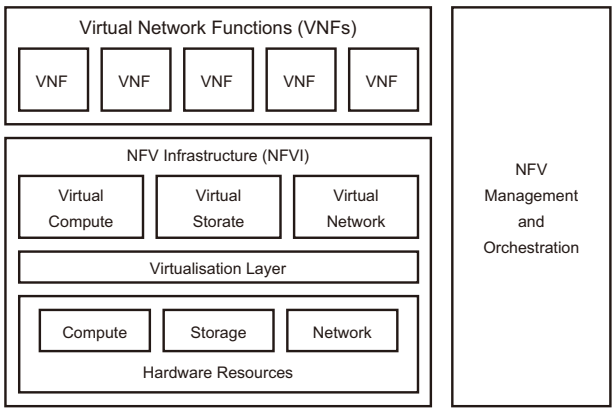

Fig. 1 General framework of NFV.

framework for verifying the overall concept were compiled. Ultimately, five documents were published in October 2013, which are the NFV use case[3], the architecture framework[4], terminology[5], virtualisation requirements[6] and proof of concept - framework[7] .

The following use case scenarios are compiled as a basis of discussion[3].

(1) Network Functions Virtualization Infrastructure as a Service (NFV IaaS)
(2) Virtual Network Function as a Service (VNFaaS)
(3) Virtual Network Platform as a Service (VPNaaS)
(4) VNF Forwarding Graphs
(5) Virtualization of Mobile Core Network and IMS
(6) Virtualization of Mobile base stations
(7) Virtualization of the Home Environment
(8) Virtualization of CDNs - vCDNs (Virtualization of Contents Delivery Networks)
(9) Fixed Access Network Functions Virtualization

Fig. 1 the outline of the NFV framework for implementing the use case. The general framework is composed of the virtualized network functions implemented using the software called the VNF, the NFVI that is the execution infrastructure, and the NFV Management and Orchestration that performs integrated management of the NFV. The NFVI is composed of the hardware resources including server computers, storages and networks, the Virtualisation Layer that virtualizes them, and the virtual resources including virtual servers, virtual storages and virtual networks which are provided for the VNF. Within this framework, an open interface is specified between the functions so that the NFV can be formed by multi-vendors[4].

The work of the NFV ranges from decisions on requirements of the framework, performance, flexibility, service continuity and security, as far as the establishment of the overall framework. Thereafter, the NFV performs standardizations and establishes protocols in collaboration with the other standardization organizations.

3.3 NEC's Involvement in ETSI NFV

Since the groups creation, NEC heavily supports these activities by proposing use case scenarios that can promote the virtualization of network functions and contributes to the discussions and output documents. NEC holds a WG vice-chair and two rapporteur positions in the ISG.

4. Activities of the Internet Research Task Force (IETF)

To deal with SDN, the Internet Research Task Force (IRTF) founded the SDN RG in order to exchange opinions on SDN in general, but with particular focus on its academic aspects. Subsequently, once SDN started to mature several work items have been proposed in the Internet Engineering Task Force (IETF) addressing specific problems in the SDN space. These range from OpenFlow competitor protocols (e.g. I2RS) to detailed cloud management issues (e.g. ALTO, CDNI, NVO3).

The Interface to the Routing System (I2RS) WG aims to provide interfaces for applications to access the routing system. It is envisaged that applications of the I2RS interfaces will be management applications, network controllers and user applications that make specific demands on the network. In order to achieve this, I2RS WG is currently discussing issue definitions and then working toward developing high-level architectures. It can be seen as a competitor to ONF's OpenFlow, but I2RS is restricted to network control of L3 and above.

The Source Packet Routing in Networking (SPRING) WG is discussing the routing control that supports both the centralized and distributed path computation. Another IETF WG that was just founded is the Service Function Chaining (SFC) WG, which will explore how to enable network function chaining, one of the main requirements for NFV. More SDN related activities are expected to start in the near future. NEC is currently holding one of the area director positions, and is monitoring ongoing discussions. In addition, NEC started to contribute to SFC.

5. Activities of ITU-T

The International Telecommunication Union Telecommunication Standardization Sector (ITU-T) is capable of undertaking comprehensive discussions on the public networks, particularly with regard to their international connections, of covering billing issues and of aspects related to restrictions. This is a unique feature of the ITU-T.

At WTSA-2012, the general assembly of the ITU-T that was held in November 2012, a resolution was approved to accelerate studies into SDN[11]. This has led to a detailed examination for required systems. NEC proposed the foundation of a Joint Coordination Activity (JCA) with the aim of coordinating activities both inside and outside the ITU-T. Our proposal

was approved and JCA-SDN was established. It is currently creating a map of SDN-associated standardization activities conducted both inside and outside the ITU-T.

Each study group (SG) is also holding SDN-related discussions in the specific field for which it is in charge. SG13, which is the leading SG on SDN, is attempting to present an overall image of SDN for public networks by compiling a document defining the SDN framework by early 2014 that can be a basis for the entire discussion at the ITU-T. The SG is also discussing applications for Next Generation Networks (NGN). SG15 has begun a study on the architectures of optical transport networks while SG11 has started studies on the signaling framework as well as on issues of the actual signaling.

6. Open-Source Software Communities

Various OSS communities are conducting activities in the SDN field. They implement and verify the requirements and architectures established by traditional standardization organizations in order to foster the deployment and development.

6.1 OpenDaylight

The OpenDaylight project was started in April 2013 based on the participation of multiple enterprises to construct a practical environment for comprehensive and open SDN. OpenDaylight is a Linux Foundation project. It aims to build a comprehensive SDN environment consisting of the controller platform, the management GUI (Graphical User Interface)/CLI (Command Line Interface), a northbound API for virtual tenant network (VTN) management, and various applications including the DDoS protection. The controller platform cited above includes an OpenFlow Southbound Interface that controls physical and virtual components and also basic network functions such as protocols, topology manager and status manager (see **Fig. 2**). OpenFlow 1.0 and 1.3, Netconf and SNMP are expected to be mounted for the southbound interfaces and protocols. The OpenDaylight project consists of 14 internal projects, and its first release called "Hydrogen[12]" was published in Feb 2014, which included 12 projects.

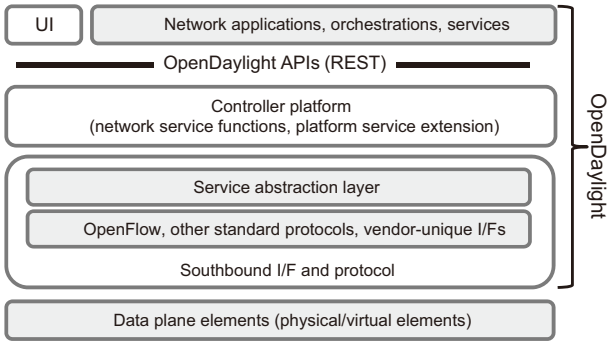

Fig. 2 OpenDaylight Architecture

6.2 OpenStack

SDN supports construction and simplifies management of cloud computing environments. OpenStack is a project for building an open source cloud infrastructure and is widely employed by data centers. Via the Neutron network management plugin, OpenStack can interface with open-source SDN controllers, to give the whole data center an open environment.

6.3 NECs involvement in SDN Open-Source Efforts

NEC's main contribution to the OpenDaylight project is the Virtual Tenant Network (VTN) that can accommodate multiple tenants. It also allows for developing SDN applications jointly for OpenDaylight and NEC's commercial ProgrammableFlow products. In OpenStack NEC is actively contributing to the development of the SDN control module "Neutron."

7. Conclusion

In the above, we presented an overview of the activities of the main standards setting organizations associated with SDN and also gave details of NECs involvement in this field. Various activities have also been started by other organizations such as the Broadband Forum (BBF) and the TeleManagement Forum (TMF) and it is anticipated that the number of organizations engaged in standardizations will tend to increase following advancements in the fusion of communications and IT that will be brought about by SDN. Under this trend, NEC aims to contribute to standardizations with the intention of implementing more open environments.

* OpenFlow is a trademark or registered trademark of Open Networking Foundation.
* Linux is a registered trademark of Linus Torvalds in the U.S. and other countries.

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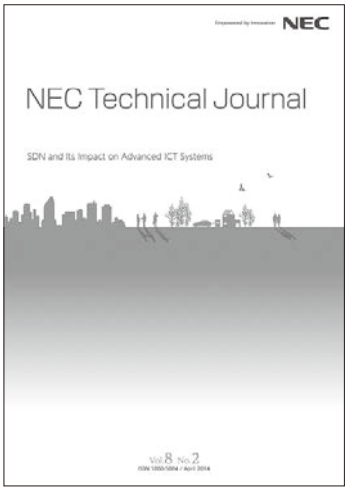

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