Standardization Progress in Software Defined Networking/OpenFlow

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Abstract

The concept of Software Defined Networking (SDN) has attracted attention recently from network carriers and service providers because of its potential to provide flexible/dynamic control and programmability in network topology and packet forwarding/processing functions. In this article, we briefly describe SDN and OpenFlow and discuss their standardization trends.

1. Overview of Software Defined Networking/OpenFlow network

The use of server virtualization technologies and cloud computing is increasing substantially, and it is therefore more important than ever to ensure that network infrastructures provide high flexiblity, adaptability, and scalability from the management and provisioning point of view. Software Defined Networking (SDN) is an architecture that has been developed to achieve this [1]. In SDN, the control plane and data plane are decoupled from the existing network node that they are tightly coupled to. SDN provides a centralized operation that includes network topology management, status tracking, and other advanced controls.

An overview of a basic SDN architecture is shown in **Fig. 1**. Resources of network elements in the infrastructure layer are logically abstracted to improve functionality and performance and then provided to the components in the upper layer. The control layer analyzes the network-related control including packet routing and forwarding and assigns the control of data planes in the infrastructure layer in accordance with a request from the upper software layer, for example, the network management system (NMS).

OpenFlow is an important technology used to realize SDN. It is a layer-2 control protocol between the control plane and the data plane. An overview of OpenFlow is shown in **Fig. 2**. The items that differ between the conventional network nodes and OpenFlow nodes are also indicated in Fig. 2.

An OpenFlow controller uses a rule set of the flow header pattern for the traffic packet data plane to control packet forwarding in the data plane of an OpenFlow switch. The OpenFlow controller centrally manages how packet forwarding in the data plane of the OpenFlow switch will be handled by issuing packet forwarding/processing rules for the data plane. This architecture provides users with high programmability and configuration capabilities; therefore, fine-grained per-flow traffic control can be achieved in the OpenFlow network, where it is difficult to achieve with existing network equipment.

In this article, we describe the organization that facilitates the standardization of SDN/OpenFlow. In addition, we explain the standardization of OpenFlow, one of the most important protocols in SDN, and the future direction of these standardizations.

2. SDN/OpenFlow standardization organization: OpenFlow Networking Foundation

The OpenFlow Switching Consortium was established in 2008. The purpose of the consortium is to popularize OpenFlow networking and maintain the OpenFlow Switch Specification. Discussions on OpenFlow standardization were carried out by this consortium. OpenFlow version 1.0 and version 1.1 were respectively published in January 2010 and February 2011.

The Open Networking Foundation (ONF) [2] was established in March 2011 in order to broaden the concept of OpenFlow and to promote the

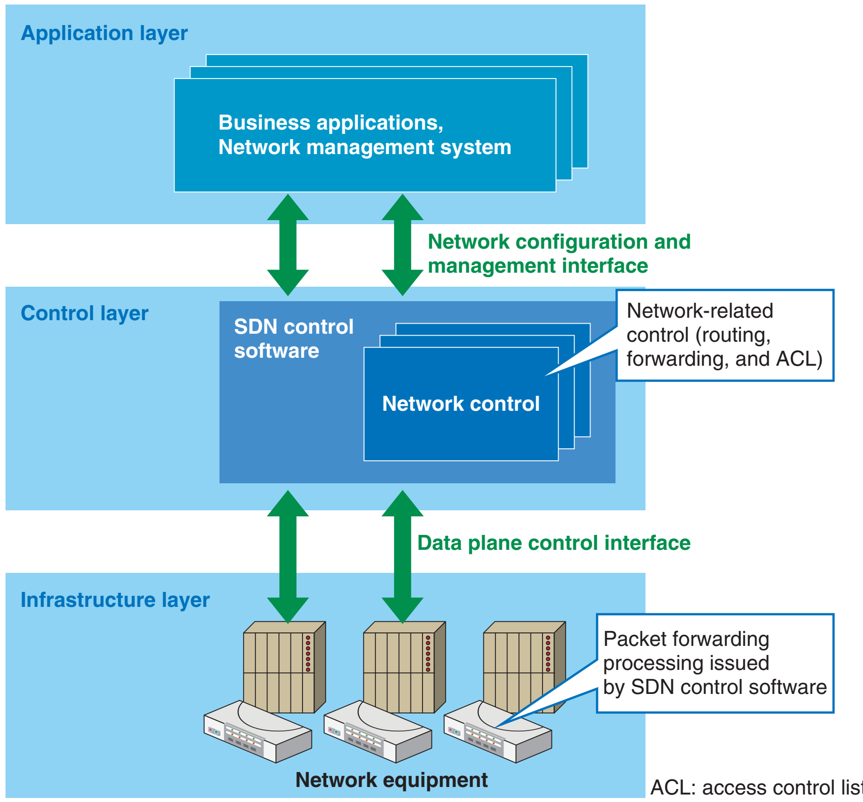

Fig. 1. Overview of SDN architecture.

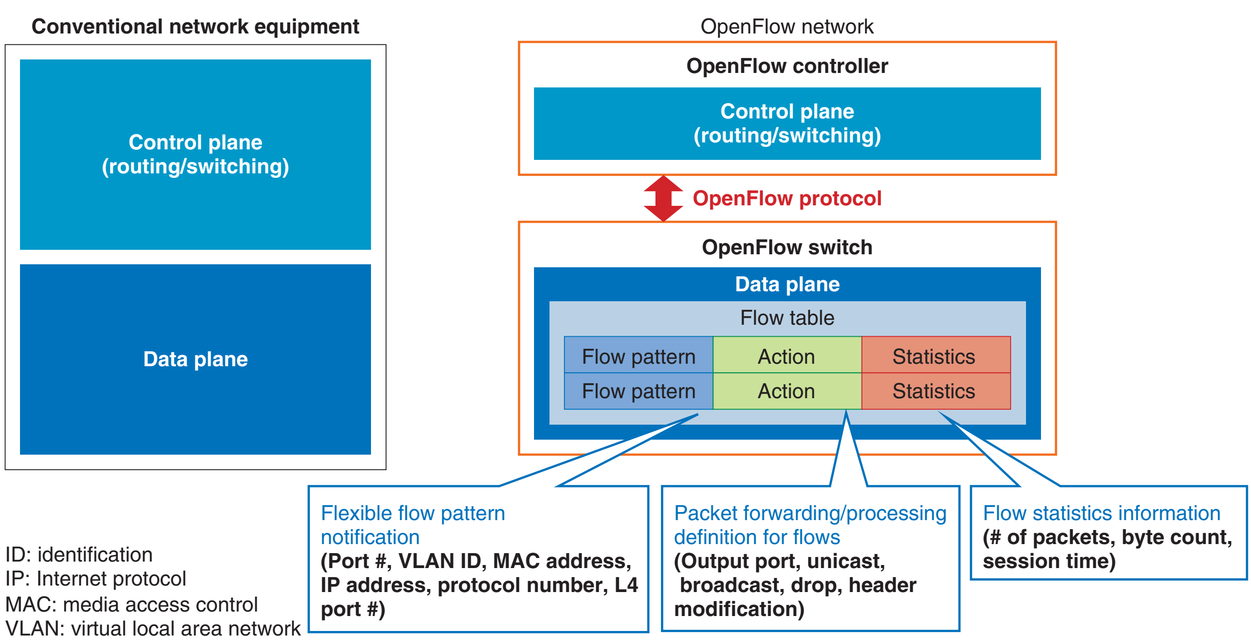

Fig. 2. Overview of OpenFlow.

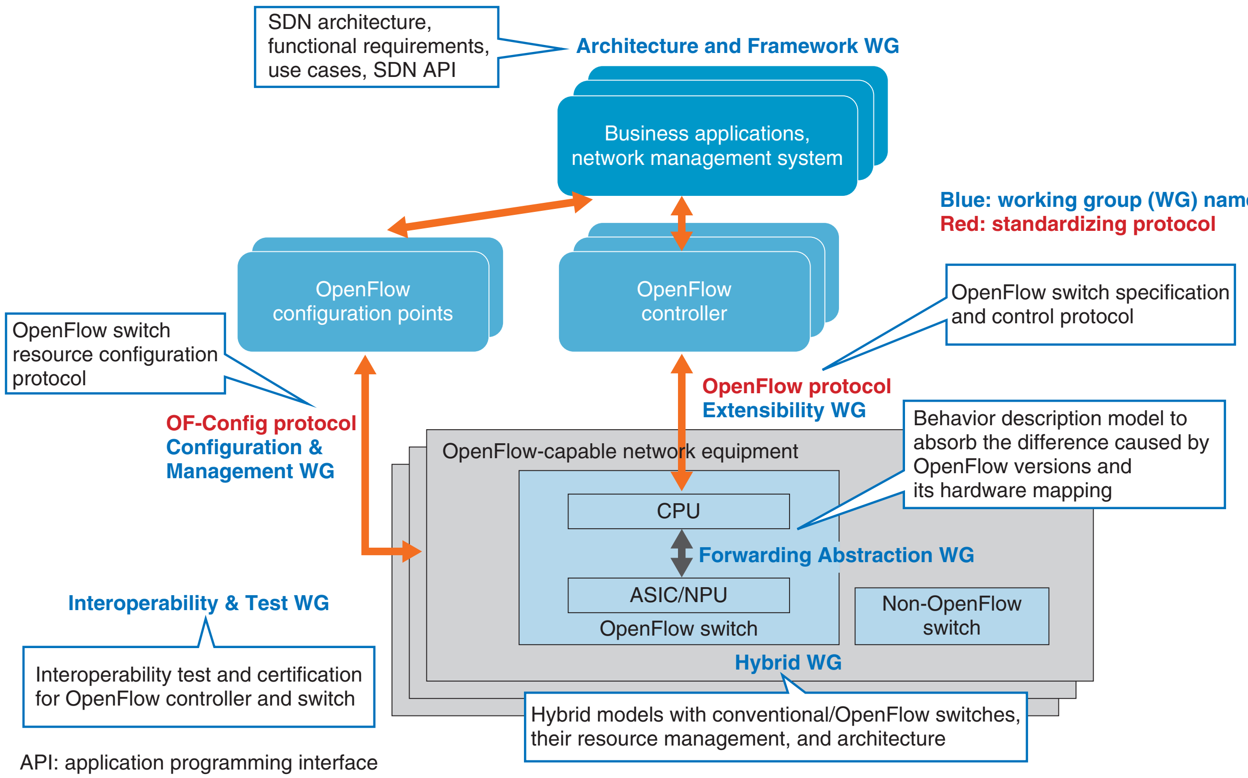

Fig. 3. ONF working groups and standardization areas.

commercialization of SDN. Activities related to the standardization process of SDN and OpenFlow specifications are now overseen by the ONF.

The ONF has formed working groups that conduct the technical standardization tasks of SDN/OpenFlow. These groups hold technical discussions, conduct compatibility test studies, and prepare charter drafts or standardization drafts for ONF board members. When a draft is approved by the ONF board members, an ONF standardized specification is issued. Discussion areas, names of working groups, and standardized protocols and technology points are shown in **Fig. 3**.

The ONF board members consist of directors of major global carrier operators including NTT, directors of major global service providers, and academic researchers. More than 70 companies, including carrier operators, software vendors, switch chip vendors, network equipment vendors, and system virtualization vendors, have joined ONF.

The OF-Config protocol has also been standardized. This protocol makes it possible to configure OpenFlow switch resources to connect to the OpenFlow controllers. Version 1.0 was published in January 2012, and version 1.1 was developed in accordance with OpenFlow 1.3.0.

3. Standardization progress of OpenFlow

The standardization of OpenFlow has been in progress since 2008. The latest OpenFlow version 1.3.0 was published in February 2012. Here, we describe the major updates and changes of each OpenFlow version.

- OpenFlow 1.0
  OpenFlow supports network protocols (e.g., Ethernet, VLAN (virtual local area network), IPv4 (Internet protocol version 4), TCP (transmission control protocol), UDP (user datagram protocol)) for campus networks and data center networks.
- OpenFlow 1.1
  Several functions in OpenFlow switches were extended to meet the requirements for wide area networks. OpenFlow supports network protocols such as MPLS (multiprotocol label switching) and the Q-in-Q extention of VLAN; these focus on inter-datacenter networks and carrier net-

works. A multiple flow table mechanism was introduced to enable packet pipeline processing in order to reduce the number of flow rules.

- OpenFlow 1.2
  Openflow added support for the IPv6 protocol in the data plane as well as for the network protocols that were supported in earlier versions of OpenFlow. An OpenFlow extensible match notification based on type-length-value (TLV) was introduced in order to achieve flexibility in protocol message parameters between the controller and switches for newly emerging protocols. A multi-controller mechanism was added to allow switches for controller failover.
- OpenFlow 1.3
  Openflow supports the operation of the control plane in IPv6 environments. Tunneling protocols, which are often used in intra-datacenter networks and virtual private networks, and provider backbone bridging (PBB) are also supported. An OpenFlow switch that adds logical port capability for link aggregation and flow control functionality for higher quality of service (QoS) to enable per-flow bandwidth control have been introduced. Furthermore, in order to support multiple OpenFlow controllers, per-flow-based traffic measurement and per-connection-based event filtering functionality have been implemented.

ONF introduced OpenFlow version 1.3.0 to provide stable specifications for network equipment vendors and software vendors in order to prevent divergence between the progress of OpenFlow specifications and the implementation of OpenFlow-enabled switches and controllers. Switch chip vendors and software vendors have proceeded with the development of OpenFlow products using OpenFlow version 1.3.0 as a target.

4. Future direction

ONF created a working group called “Architecture and Framework WG” in order to accelerate the discussions of the SDN framework and architecture. This working group is conducting discussions on the scope and standardization of SDN, SDN use cases, northbound/southbound application programming interfaces, and data models. It is also discussing SDN adaptation to transport networks, and the next generation of OpenFlow forwarding plane modeling.

References

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