Standardization by IETF and Discussion in Open Communities on Network Virtualization and Unified Method of Configuration

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Abstract

Network virtualization technologies have progressed with the emergence of software-defined networking, and the standardization of technologies for virtualized networks on autonomous Internet protocol networks is continuing. In addition, progress is being made in the standardization of standard protocols and data models for network devices that enable virtualized networks to be built using overlay networks. This article introduces the progress being made in standardization of network virtualization technologies by the IETF (Internet Engineering Task Force) and presents related discussions underway in open communities.

Keywords: network virtualizations, IETF, open community, SDN

1. Standardization of network virtualization technologies

The implementation of multiple virtual networks on a single network infrastructure using overlay network technologies is becoming more common thanks to software-defined networking (SDN) and network functions virtualization (NFV). This article introduces Virtual eXtensible Local Area Network (VXLAN), Ethernet virtual private network (EVPN), and Segment Routing, which are network virtualization technologies, as well as Network Configuration Protocol (NETCONF) and RESTCONF, which are network management protocols, and the OpenConfig model, a vendor-neutral data model for network management. NTT's activities related to overlay networks are also explained.

1.1 VXLAN

VXLAN is a typical overlay networking technology. It was published as RFC* 7348 by the Internet Engineering Task Force (IETF). VNI (Virtual Network Identifier), a 24-bit field in a VXLAN header, can distinguish around 16 million virtualized networks. VXLAN has already been implemented in various network products. Moreover, Generic Network Virtualization Encapsulation (Geneve) [1] is being discussed for standardization as a new standard overlay protocol in the NVO3 (Network Virtualization Overlay) Working Group (WG) of IETF. A Geneve header can contain not only a 24-bit field but also optional fields (**Fig. 1**).

Internet protocol (IP) multicast is used for transporting BUM (broadcast, unknown unicast, and multicast) frames on VXLAN. However, this method requires an IP multicast network infrastructure such as Address Resolution Protocol (ARP) generated on unicast communication in order to handle broadcast frames. Hence, IP multicast protocols such as PIM (Protocol Independent Multicast) are needed on transport devices.

* RFC: Request for Comments. Documents published by IETF, which include protocols, procedures, programs, and concepts.

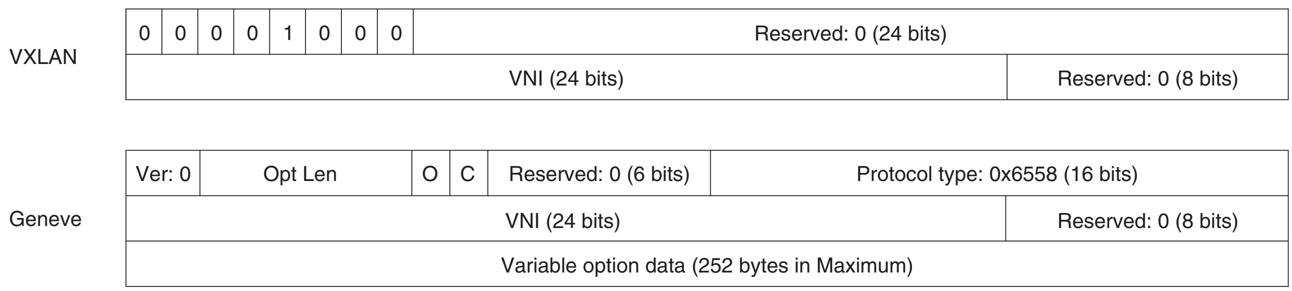
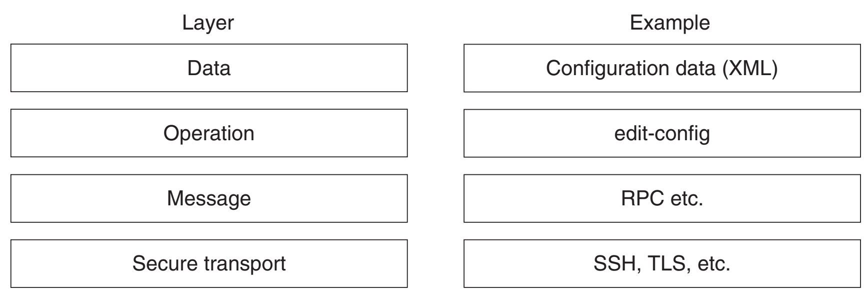


Fig. 1. Comparison of VXLAN header and Geneve header.



Source: RFC 6241

TLS: Transport Layer Security

Fig. 2. NETCONF Protocol Layers.

This issue can be resolved by using the Open vSwitch Database (OVSDB) management protocol, which is published as RFC 7047 and developed by VMWare for their SDN solutions. An SDN controller can communicate multiple pairs of IP addresses and MAC (media access control) addresses to software switches (Open vSwitch) and hardware switches that implement OVSDB database schemes by using the OVSDB management protocol instead of using ARP.

1.2 EVPN

In IP networks, autonomous IP routing technologies provide fault tolerance. EVPN is an extension of BGP (Border Gateway Protocol), which brings information corresponding to ARP. EVPN has been published as RFC 7432 for the Multi-Protocol Label Switching (MPLS) data plane and RFC 8365 for VXLAN.

A draft [2] related to EVPN has been proposed that not only enables the sending of information corresponding to ARP but also enables layer 3 virtualizations on VXLAN protocols originally designed for layer 2 virtualization. This proposed technology makes it possible to provide a unified method for layer 2 and layer 3 overlay networks on an IP underlay network. However, concentrative configuration technologies are needed in order to deploy virtualized network technologies in large-scale environments.

1.3 NETCONF

NETCONF 1.1 is a standard protocol for configuring network devices. It was standardized in 2011 as RFC 6241. NETCONF makes it possible to achieve SDN. Basic operations such as get-config, edit-config, copy-config, and delete-config are defined. Their NETCONF operations are commanded using RPCs (remote procedure calls) over transport protocols such as SSH (Secure Shell). Message data in operations are encoded in Extensible Markup Language (XML) (**Fig. 2**). YANG (Yet Another Next Generation) is standardized as a data modeling language that can be mapped to XML. YANG was published as RFC 6020.

1.4 RESTCONF

Many recent web applications have been implemented

Table 1. Comparison between RESTCONF and NETCONF operations.

RESTCONF	NETCONF
OPTIONS	None
HEAD	get-config, get
GET	get-config, get
POST	edit-config (create)
POST	Invoke an RPC operaion
PUT	copy-config
PUT	edit-config (create/replace)
PATCH	edit-config
DELETE	edit-config (delete)

Source: RFC 8040

using Representational State Transfer (REST), which is based on HTTP (Hypertext Transfer Protocol). The same trend is seen in networking. RESTCONF is a protocol that applies REST to NETCONF and has been standardized as RFC 8040 (**Table 1**). RESTCONF can use XML as well as JSON (JavaScript Object Notification), which is generally used for REST to encode message data. The emergence of RESTCONF is therefore very promising, although it does not support full NETCONF functions such as a two-phase transaction.

2. Trends in standardization of data models

The standardization documents concerning NETCONF and RESTCONF described above define only protocols for communication. They do not define the content of messages. YANG, as mentioned above, is the language used for the data model (data structure) in messages. Standardization of YANG-based data models is continuing to progress. These data models can be classified into data models for service descriptions and data models for network devices (**Fig. 3**).

The data models for service description are used for layer 2 and 3 virtual private networks (VPNs) as examples. Layer 3 VPN service data models are already standardized as RFC 8299. Network device data models are used for configuring network interfaces and routing protocols. These data models for configuring network devices have been standardized by IETF and also defined by OpenConfig [3], an organization of service providers such as Google, Microsoft, Facebook, AT&T, BT, and Comcast. Some OpenConfig data models are already implemented in the devices of well-known router vendors. Hence, OpenConfig has the potential to become a common implementation led by service providers for network environments employing the products of multiple vendors. Furthermore, OpenConfig defines not only data models for IP transport devices but also data models for optical devices.

3. Trends in new network virtualization technologies

To date, virtualized networks have been achieved by using MPLS or IP tunneling such as VXLAN. The concept of Segment Routing [4] discussed in the SPRING (Source Packet Routing in Networking) WG in IETF may change the situation. The data plane technology expected to be used for Segment Routing is MPLS (SR-MPLS) or IPv6 (SRv6). Segment Routing is a source routing technology. It can control the forwarding path from the source node by using an embedded node list in a packet header. Therefore, Segment Routing is one of the technologies expected to be implemented to achieve service function chaining. It also enables fast rerouting achieved by TI-LFA (Topology Independent Loop Free Alternative) when routes change in failure cases. Moreover, SRv6 will be able to provide layer 2 and 3 VPNs [5], which have thus far only been achieved on MPLS, on IPv6 data planes by giving new functions to part of the IPv6 address. Hence, SRv6 is expected to be a unified data plane.

4. NTT activities

NTT Network Service Systems Laboratories is developing Multi-Service Fabric (MSF) [6] and publishing it as open source software [7]. MSF is an SDN system that configures and manages multiple vendors' merchant-silicon-based network devices including white-box switches via NETCONF and other protocols. It is used for deploying layer 2 overlay networks based on VXLAN with EVPN and layer 3 overlay networks based on MPLS to a wide area. MSF was used in a collaborative proof of concept (PoC) [8, 9] with an APAC (Asia Pacific) carrier. In addition, it was introduced into a PoC environment by Dimension Data Asia Pacific [10], which is an NTT Group company. MSF uses IP routing technologies including EVPN to achieve fault tolerance and to prevent high loads from concentrating at a particular node. NTT has joined open communities that carriers and OTT (over the top) players lead collaboratively such as ONF (Open Networking Foundation) and TIP

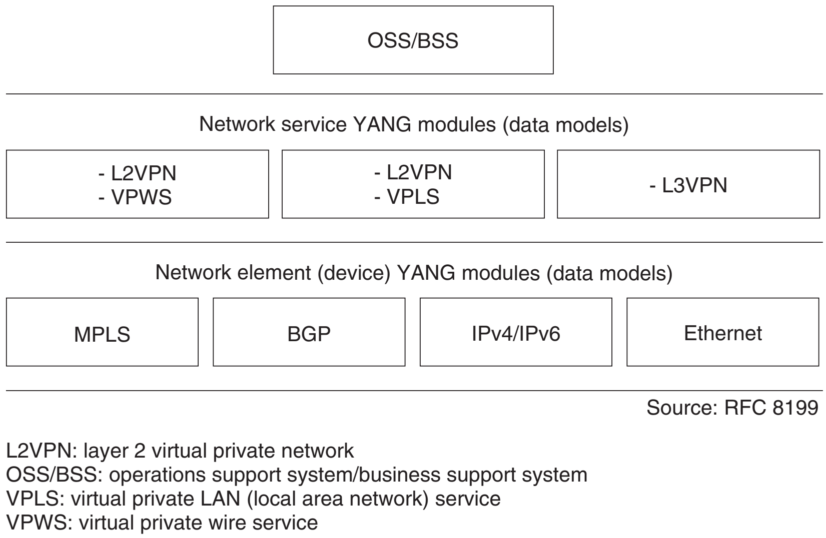


Fig. 3. Classification of data models.

(Telecom Infra Project) to discuss fault tolerant networks achieved by autonomous mechanisms.

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Trademark notes

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He received a B.A. in environmental information and an M.A. in media and governance (I.T.) from Keio University, Kanagawa, in 2003 and 2005. He joined NTT Network Service Systems Laboratories in 2005. He researched traffic analysis technologies using flow information such as NetFlow/IPFIX (IP Flow Information Export) and proposed drafts about IPFIX in IETF as part of standardization efforts. He has been one of the original architects of NTT's SDN technology for Multi-Service Fabric (MSF) since July 2014. He also initiated a project to construct an original networking OS called Beluganos using open source software and OpenFlow on merchant-silicon-based switches. He is a member of the Institute of Electronics, Information and Communication Engineers (IEICE).

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