Yang Data Model for SFC Control Plane

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***Abstract*— Service Function Chaining (SFC) consists of SFC data plane and control plane from the aspect of architecture. The standard document of I-D.ietf-sfc-control-plane-00 describes requirements for delivering information between SFC control elements and SFC functional elements. This paper defines requirements of management of SFC control plane and defines Yang data model of management operations performed in a SFC control plane based on the standardization documents of the SFC architecture and SFC control plane components and requirements.**

Keywords—Yang Data Modeling; Service Function Chaining (SFC), Control Plane

I. INTRODUCTION

The NFV [1] virtualizes network service functions, which consist of hardware, with software to provide a characteristic of being able to relocate them flexibly. The network service implementation technology [2] using the virtual network functions forwarding graph (hereafter, VNFFG), which selectively connects and executes the network functions needed according to traffic, has drawn high attention from the network and service providers. The VNFFG could combine multiple virtualized network component services in the fixed order to configure a network service. While the existing network services are implemented by arranging one or more component devices physically on a network path, this technology could define a path consisting of the virtualized component services with software to configure the network services in time and control them actively. In addition to the NFV, the service function chaining (SFC or service chaining for short) technology is introduced around the NFV technology experts in order to implement these advantages also in the existing network structure.

The SFC means a technology of sequencing the middle boxes such as firewalls, deep packet inspection (DPI) and network address translation (NAT), in other words, service functions (SFs) by a single logical connection. The service chaining technology is discussed primarily in the SFC working group (WG) [3] of IETF which is an international standardization meeting, and the standardization on problem definition, functional structure, use case, and control requirements are in progress. According to the functional structure, the SFC is composed of data and control planes, and the requirements for them are defined. At present, the management model for the data plane is proposed by the Yang modeling language [4], and the standardization on the requirements for the SFC control plane is also in progress [5]. To understand and manage the SFC's operation, the information modeling of SFC should be firstly carried out, and the information modeling of data plane is currently defined by Yang, but the information modeling is insufficient for the control plane in which the SFC operates actually. This paper presents the management information model by Yang for the control and management functions to be carried out by SFC based on the standardization document of requirements of SFC control plane. The Yang modeling language [6] is standardized for the NetConf's transfer contents, but currently not dependent on the NetConf protocol and applied to various modeling areas. At present, many standardization groups tend to use Yang as a modeling language to manage SDN and NFV. By modeling the information of SFC control plane through the Yang having this standardization tendency, it would like to match the standardization tendency and help understand the SFC's operation. In addition, it could also be included in a part of the SFC module of an open source community such as ODL to implement by extending functions through the Yang tool.

II. REALTED WORK

This section describes the service function chaining (SFC), which is a related standard technology to sequence multiple network services by a single connection, and the Yang which is a data modeling language.

A. Service Function Chaining

The NFV is a technology that separates various functions in the network devices used by telecommunication service providers and virtualizes them to control and manage with software. In particular, the service chaining technology [3], which sequences these virtual network functions to connect and execute, receives attention as the next study issue of NFV in terms of enabling to automate and customize major network services. SFC is the abstraction of the service functions needed for specific services and the application order between them. The SFC WG in IETF, which is the largest standardization organization to establish Internet-related standards, held the first official working group meeting in March, 2014. SFC WG's specific charters were defined by five ones such as problem definition, architecture, generic SFC encapsulation, control layer mechanism and management. In accordance with these 5 charters, standardization is currently in progress on the basis of many Internet drafts.

As shown in the conceptual diagram of Fig 1, if user traffic enters the network, a specific service function chain is selected through traffic classification by a predetermined policy. Then, user traffic is transferred and executed sequentially to the service functions of the order predefined in the relevant service function chain, and sent to its destination.

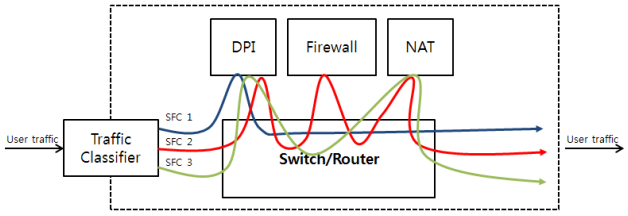

Fig. 1. Conceptual Diagram of SFC Technology

B. Yang Data Model Applied to the SDN/NFV Management

Yang is a data modeling language for the NetConf network configuration protocol [6]. In other words, Yang is used to model the operation and content layer of NetConf. The Yang data modeling language was developed by NETMOD (NetConf data modeling language) WG of IETF, and defined as RFC 6020 in October, 2010. Yang could be used also in the modeling of network state monitoring data as well as configuration data. In addition, Yang defines types of the event notification occurred in network elements and enables a data modeler to define signatures of remote procedure call (RPC) to be applied to the network elements through the NetConf protocol. Yang is a typical modular language defining a data structure, which has a tree structure. It has a scalable embedded data type, and is possible to define complex reusable data structures by grouping. Also, it matches with XML one-to-one, the Yang data model is encoded in XML format, that is, the Yang data model is mapped with XML one-to-one. In this way, the Yang modeling language is standardized for the transfer content of NetConf, but not dependent on the NetConf protocol and applied to various modeling areas.

A variety of management methods such as SNMP, CLI, JSON-RPC and NetConf/Yang were suggested as the southbound interface (SBI) of SDN/NFV. Of them, an advantage of the NetConf protocol is a standard protocol that could be used simultaneously in the traditional and SDN network environments. In addition, NetConf provides a powerful modeling language called Yang together, thus its effectiveness is increased. Arranging the cases of applying Yang for the configuration and integrated management of SDN/NFV is as follows.

The OpenDayLight (ODL) is an open source software platform for the Linux Foundation's SDN/NFV [8]. For the ODL, many IT companies such as Cisco, Dell, HP and Juniper Networks are participating in the project to accelerate the SDN/NFV development and improve the quality mainly within the community. The ODL uses a standardized model to have high portability between platforms. It uses the Yang to model the service abstraction layer (SAL), which could support various SBI protocols, APIs used in the model driven-service abstraction layer (MD-SAL), data structure used in the plug-in, and messages sent by the plug-ins. In addition, the ODL's MD-SAL based plug-in developer defines a model for data structure, message, etc. to be used in each plug-in by the Yang language to provide it. The API of MD-SAL data repository is created on the basis of this Yang model to enable data exchange between plug-ins.

The Open Networking Foundation (ONF) is an organization that standardizes technologies to implement SDN. The OpenFlow is a core protocol adopted by ONF, which implements SDN through communication between network devices and controllers. While the OpenFlow is a technology to implement SDN, the OF-Config [9] is a protocol for configuration management of OpenFlow switches, which could get the state of a logical switch, port, queue, etc. or set up it. The OF-Config is currently standardized up to version 1.2, and defined on the premise that the NetConf protocol and Yang data modeling language are used.

III. RFCs

The SFC is currently discussed mainly in the IETF SFC WG and the standardization on problem definition, functional structure, use case, control requirements, etc. is in progress. According to the SFC WG's charters, two RFCs, five Active Internet Drafts (I-D) and forty-three Related Internet-Drafts (I-D) are under discussion. This section describes the Yang Data Model for Service Function Chaining (draft-penno-sfc-yang-13) document, which defines the Yang data model used to manage and set the SFC, and the Service Function Chaining (SFC) Control Plane Components & Requirements (draft-ietf-sfc-control-plane-02) which describes components for the SFC control plane and its requirements.

A. YANG Data Model for SFC Data Plane

There is the Yang Data Model for Service Function Chaining (draft-penno-sfc-yang-15) document [4] which defines the Yang data model used to manage and set the SFC. The early version, which was updated on October 20, 2013, had defined a total of four items (VXLAN-GPE, Service Function Chain, Service Node and Service Function Path). The Remote Procedure Call (RPC) was not defined separately. The latest version was updated on June 19, 2016, and expired on December 19, 2016. It was composed of ten module, and ten RPCs were defined. The following Table 1 shows the names and description of the respective modules.

TABLE I. MODULES OF SFC DATA PLANE YANG MODEL

Module Name	Explanation
Service Function (SF)	This module describe a Service Function, which is an essential building block of other modules
Service Function Type (SFT)	This module holds one list for each service function type found in the system
Service Function Chain (SFC)	This model describes a service function chain which is basically an ordered list of services
Service Function Path (SFP)	A Service Function Path is an instantiation of a service function chain.
Service Function Forwarder (SFF)	This module describes the configuration a SFF needs to have in order to route packets to the service functions it serves

Service Locator (SL)	This module provides a single point of registration for all network locators types used in Services Function Chaining
Rendered Service Path (RSP)	This module holds the actual service-hops a packet will traverse when forwarded through a specific service path
Service Function Common (SFC-common)	This module holds common definitions for Service Chain modules
Service Statistics (SFC-ss)	This module holds common statistics definitions for Service Chain modules
Service Function Path Metadata(SFC-MD)	This module holds the service function path metadata that is attached to a packet as it traverses a specific service path.

B. Requirements of SFC Control Plane

In this section, SFC Draft standard document is analyzed to summarize and describe the requirements and control functions in the aspect of network and service control of newly presented SFC [5][7][10]. The requirements are classified into 8 requirements namely, topology, connectivity, quality of service (QoS), performance, traffic classification, recovery and load balancing, security and additional considerations. Details of each requirement are as follow.

First, the topology requirement includes the capability to handle various topologies, monitoring method and access in addition to the IP address system. Second, the connectivity requirement includes a method to test connectivity to verify whether the service of given SF is being performed. The SFC OAM message requires a mechanism for transmission through the same path as the flow of given data packet. Third, the QoS requirement includes the capability for SFC to provide different Service Level Agreement (SLA). In addition, a mechanism is required to verify whether the process of a message arriving at SFC boundary node has been accurately completed. Fourth, the performance requirement includes a method to measure various parameters from given SFP and a method to evaluate the service status of SF. In addition, a method is required to provide the activity status of every SFC through records and statistics. Fifth, the traffic classification requirement includes a decision of classification rules based on deployment and policy. In addition, classification rules need to be prepared by the main agent that operates and manages SFC domain. Sixth, the recovery and load balance requirement includes load balancing and load-sharing to minimize the impact from load balancing needs to be allowed between multiple instances of same SF. Seventh, the security requirement includes a preventive measure against the leaking of inference information of SF. In the case where different service is provided other than the service provided by an SF instance, a method of detecting it and notifying related information is needed. The additional consideration requirement includes a method of managing the life cycle of SF.

IV. YANG DATA MODEL FOR SFC CONTROL PLANE

This section models SFC control plane which is called main-module based on the standardization documents of SFC control plane [11]. The main module consists of seven sub-modules (Path Management, Load Balancing, SFC Topology, Policy, Monitoring, Fault Handling, and Event). In addition, the RPC operations are defined. The following Table 2 shows the name and element of the respective modules.

TABLE II. MODULE OF SFC CONTROL PLANE YANG MODEL

Main-Module	**Element**
SFC Control Plane	• Path Management • Load Balancing • SFC Topology • Policy • Monitoring • Fault Handling • Event
Sub-Module	**Element**
Path Managment	• Path Maintenance − SFP name − Aliveness of SFP: True or False − RPC: check-path-aliveness (input: SFP name, output: aliveness) • Path Optimization − SFP name − Optimized SFP − SFP availability − Load status − RPC: find-optimized-SFP (input: SFP name, output: optimized SFP, SFP availability, Load status)
Load Balancing	• Load type: traffic/CPU/memory • Source SFP name • Target SFP name • RPC: perform-load-balance (input: Load type, source SFP name, output: target SFP name)
SFC Topology	• Name: SFC name or SFP name or SFI name • Lists of SF node • RPC: show-SFC-topology (input: SFC name, output: list of SF nodes)
Policy	• Classification Policy Table − Flow identifier − Matching condition − Priority − Mapping SFC name • Forwarding Policy Table − SFF name − Condition − SFC name − SFP name
Monitoring	• Performance Table − Name: SFC name or SFP name − Time − Aliveness − Resource utilization • Fault Table − Fault name − Fault occurrence time − Fault type − Fault occurrence location − Fault handling action
Fault Handling	• Fault name: Key • Fault type: Node/Link/Path failures • Fault handing action: Bypass/Use alternate node/Use alternate chain/Drop traffic • RPC: handle-fault (input: fault name, output: fault handle result)
Event	• Notification − Event-type − Severity − Event-explanation

The following Fig. 2 shows the source code of path optimization of path management that is one of the sub-modules of the SFC Control Plane. The path optimization

module consists of container that represents necessary information to optimization and RPC operation that finds an optimized path replacing the current heavy path.

```
submodule path-optimization {
    belongs-to sfc-control-planes {
        prefix sfc-po;
    }
    description "This module constructs and maintains a SFP
                 with a low stretch considering the topological
                 locations and properties (e.g., latency, bandwidth) of SF.
    revision 2015-10-15;
    container path-optimization {
        leaf sfp-name {
            type string;
            description "The name of service function path to be changed f
        }
        leaf optimized-sfp {
            type string;
            description "The name of optimized service function path.";
        }
        leaf sfp-availability {
            type string;
            description "The availability of the optimized service functic
        }
        leaf load-status {
            type int8;
            description "A percentage value of load status.";
        }
    }
    rpc find-optimized-sfp {
        description "Find an optimized service function path.";
        input {
            leaf sfp-name {
                type string;
                description "The name of service function path to be chang
            }
        }
        output {
            leaf optimized-sfp {
                type string;
                description "The name of optimized service function path.'
            }
            leaf sfp-availability {
                type string;
                description "The availability of the optimized service fur
            }
        }
```

Fig. 2. Source Code of Path Optimization

V. Conclusion

This paper examined the SFC, which is a related standard technology of sequencing multiple network services by a single connection, and the Yang which is a data modeling language. Currently, for the SFC, the management model for the data plane is defined by the Yang modeling language, but for the SFC control plane, only the requirement for management is suggested, and the discussion about data modeling is insufficient. This paper analyzed the requirements of the control and management functions to be carried out by the SFC based on the standardization document of SFC control plane, and modeled the management information of the control plane as a total of seven modules such as path management, load balancing, SFC topology, policy, monitoring, fault handling and event by Yang. In addition, it was defined the RPC management operation needed for the respective modules.

In the future study, it is planned to extend functions and implement methods for network management through the Yang tool included in a part of the SFC module of the open source community such as the ODL which is an open source software platform for the SDN/NFV of the Linux Foundation.

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