Experimental Report of Elastic Lambda Aggregation Network (EλAN) Control Method for SDN-based Carrier Class Network

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Abstract—The unified control of core / metro / access networks using Software-Defined Networking (SDN) is effective for providing services flexibly. In this paper, experimental results of the unified control by hierarchized Controller utilizing OpenFlow protocol and abstracted network are presented.

Keywords—Optical Access Network, Aggregation Network, Software-Defined Networking (SDN), Unified Control

I. INTRODUCTION

Elastic network technologies will provide flexible network capacity to the service requirement. In order to accelerate the paradigm shift, introducing network virtualization technologies with elastic network technologies into an access network is needed. From this background, the next-generation network integrated aggregation / access network [1], Elastic Lambda Aggregation Network (EλAN) [2, 3] has been proposed. EλAN virtualizes access and aggregation network devices having adaptivity to the service requirement. EλAN integrates several individual service access networks, e.g. private line, Internet, and mobile, and aggregation networks into one optical switching network.

Software defined networking (SDN) becomes attractive to reduce the operational cost of service delivery and to provide services flexibly [4]. SDN, i.e. OpenFlow protocol, will also provide a unified control of end-to-end access/metro (aggregation)/core networks. Therefore, it is preferable to apply the SDN control method to EλAN. Because EλAN is composed of multi-layer networks and multi-technologies are used in the transport plane. As a result, many logical devices for realizing a virtualized network, many optical switches and layer-2 switches for realizing a physical network should be controlled by the SDN control method.

This paper proposes a unified EλAN control method and reports experimental results. By abstraction of the EλAN topology, we have solved the problem of the unified control of EλAN. We have verified the feasibility of the unified control by experiment.

II. ELASTIC LAMBDA AGGREGATION NETWORK (EλAN)

A. Architecture of EλAN

The EλAN is a network that integrates access network and aggregation network by applying optical aggregation technologies [2, 3]. EλAN is composed of programmable-optical line terminals (P-OLTs), programmable-optical network units (P-ONUs), an active optical distribution network (ODN), and virtual layer-2 network (VL2NW) as shown in Fig.1. EλAN's OLT and ONU have programmability. Programmability makes EλAN possible to change the provided services and logical connection between OLT and ONUs.

![EλAN Architecture and unified control model](image)

Fig. 1. EλAN Architecture and unified control model.

P-OLT generates multiple logical-OLTs (L-OLTs). P-ONU also generates multiple logical-ONUs (L-ONUs). There are multiple types of L-ONU and L-OLT for multi-services for example, inter-datacenter network, private line, and residential Internet access. P-OLT covers multiple areas, and P-OLTs coordinately operate. ODN is an all-optical network composed of optical devices such as optical switches and splitters. ODN provides optical aggregation function and flexible optical paths. VL2NW supplies electrical aggregation function and flexible Layer-2 paths among L-OLTs and core networks. A network management system (NMS) will manage and control P/L-OLTs, P/L-ONUs, ODN, and VL2NW. NMS includes SDN control function to EλAN equipment.

B. Control Architecture

Fig.1 also shows the unified control model with EλAN. This model is composed of a unified controller, core (/metro)
network, core (/metro) NMS, E\(\lambda\)AN and E\(\lambda\)AN NMS. The unified controller plays a role of an orchestrator of core / metro / access networks. The unified controller sends control message to each network utilizing the OpenFlow protocol. Each NMS has an SDN controller. Therefore, controllers are hierarchized on the assumption that differences in network administrator. In E\(\lambda\)AN, the unified controller sends messages to E\(\lambda\)AN NMS and E\(\lambda\)AN NMS sends control massages to each devices of E\(\lambda\)AN utilizing OpenFlow protocol. If a device does not support the OpenFlow protocol natively, a protocol converter is used. The protocol converter converts the OpenFlow protocol into a device dependent control protocol. If the unified controller is responsible for the all of operation to E\(\lambda\)AN, the unified controller has to know how to calculate to decide route in E\(\lambda\)AN, information and status of all devices, and so on, and has to send messages contended setting information of device-specific to each devices. This will cause a scalability problem of the unified controller.

C. Abstracted E\(\lambda\)AN Topology

In order to solve the problem, we propose an abstracted E\(\lambda\)AN topology. By the abstraction, the unified controller can control E\(\lambda\)AN without knowing the detailed inside structure of E\(\lambda\)AN. The unified controller sends a message contended only actions (e.g. connect, disconnect, modify), source/destination interfaces (e.g. Network to Network Interface (NNI) number and User to Network Interface (UNI) number), a service type, and a specific request of the service to E\(\lambda\)AN NMS. E\(\lambda\)AN NMS converts the information into the messages for each device by computing the best route in E\(\lambda\)AN.

III. EXPERIMENTS AND RESULTS

A. Experimental Network

Fig. 2 shows a structure of the experiment network. Two E\(\lambda\)ANs are constructed and attached to the 100 Gbps class WDM core and metro networks. In a data-plane, E\(\lambda\)AN A and E\(\lambda\)AN B are connected across the core / metro network. Users are connected to ONUs in each E\(\lambda\)AN. In a control-plane, the unified controller and NMSs of each network are connected. As a unified control protocol, the OpenFlow1.0 protocol is used between the unified controller and the E\(\lambda\)AN NMS, and between the E\(\lambda\)AN NMS and each device. For devices that do not support the OpenFlow protocol, we developed protocol converters which are remodeled Open vSwitch [5]. The protocol converter receives the OpenFlow message from the NMS and sends a control command based on the received the message in the protocol that supports each device. In this experiment, we used Traffic Generator (TG) instead of Data Center, Video Server (VS) and Video Client (VC) as a service type.

B. Experiment Results

By message from the unified controller, TG1 in E\(\lambda\)AN A and TG2 in E\(\lambda\)AN B were connected. (red line in Fig. 2). VS and VC2 in E\(\lambda\)AN B were also connected (blue line in Fig. 2) while connecting the red line.

According to the traffic state, E\(\lambda\)AN is needed to change the connection between ONU and OLT, and reconfigure the ODN. Setting time in E\(\lambda\)AN is one of the indicators that can determine how E\(\lambda\)AN can configure frequently. Therefore, we measured setting time period using the wireshark [6]. Start time was when E\(\lambda\)AN NMS received the message from the unified controller. Finish time was when E\(\lambda\)AN A and E\(\lambda\)AN B were connected / disconnected. In measurement, E\(\lambda\)AN A had been setup in advance for measuring time setting an E\(\lambda\)AN. As a result, it took average connection set up time of 29.87 (sec) and average disconnection time of 0.027 (sec) under 5 times test.

We examined which device is the slowest setting device. As a result, we found that it took the longest time setting connection to VL2NW. And we measured time period after VL2NW had been set in advance. As a result, connection time changed to less than 1 (sec). Other layer-2 switches had been controlled in 1 (sec) and this program due to device-dependent. Therefore, if we use appropriate switch, we expect that the unified controller will control E\(\lambda\)AN within 1 (sec).

IV. CONCLUSION

In order to realize that E\(\lambda\)AN responds to a variety of service requests, to cope with the unified control is needed. For unified control of E\(\lambda\)AN, we have proposed controlling the abstracted E\(\lambda\)AN topology. We have verified the feasibility of the unified control of E\(\lambda\)AN using OpenFlow-enabled SDN controllers, and measured the time to control.

REFERENCES