QoS Constrained Path Optimization Algorithm in NFV/SDN Environment

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Abstract— **Network Functions Virtualisation (NFV) and Software-Defined Networking (SDN) have emerged as promising technologies in the telecommunication business. An important problem of NFV architecture is how to allocate virtualised resources to network services. Efficient resource allocation should consider not only the status of the Virtualized Network Function (VNF) but also the network condition. We propose a Quality of Service (QoS) constrained path optimization algorithm to set up the optimized VNF Forwarding Graphs (VNFFG) considering an available bandwidth. When the link bandwidth is not sufficient, competitor selection and priority switching of the super problem could find the optimized VNFFGs to accept more service requests by utilizing replaceable VNFs.**

Keywords-network functions virtualisation; software-defined networking; QoS; link capacity allocation.

I. INTRODUCTION

Network Functions Virtualisation (NFV) and Software-Defined Networking (SDN) are significant industry trends these days. The network abstraction and programmability of SDN complements the NFV architecture. ETSI NFV Industry Specification Group (ISG) proposes a NFV/SDN architecture and discusses the technical challenges [1][2]. Especially, a resource allocation to multiple network services and performance maintenance regardless of Virtual Network Function (VNF) status variation and network condition are the key challenges of NFV realization. To solve these problems, the only way is a proper link capacity allocation and VNF selection.

Some systems on the Internet provide QoS with certain packet processing in routers. There are two system models, which are, the integrated service model and the differentiated service model. For QoS service in NFV/SDN architecture, the integrated service model (e.g., RSVP-TE in MPLS) is more appropriate to provide a certain level of QoS requirement. There are many QoS parameters such as delay, bandwidth, jitter, loss probability and cost, but the crucial one is bandwidth [3][4][5]. If bandwidth for a packet flow is not enough, congestion will occur in bottleneck links, which causes severe packet drops and increases end-to-end delay. Thus, NFV/SDN architecture should manage link capacity allocation of the entire service and VNFFG simultaneously.

The paper is structured as follows: Section II outlines our proposed QoS constrained path optimization algorithm and architecture. Section III describes the competitor selection

and priority switching with a simple scenario. Finally, we conclude the paper with potential future work in Section IV.

II. QOS CONSTRAINED PATH OPTIMIZATION

In the NFV/SDN environment, some VNFs can be deployed in multiple data centers, or some busy VNFs can be established in the same data center for a load sharing purpose. Those VNFs which are performing identical functions are called a VNF set and are located in multiple service provider's data centers. For instance, Figure 1 describes a NFV/SDN network of a mobile cellular network provider.
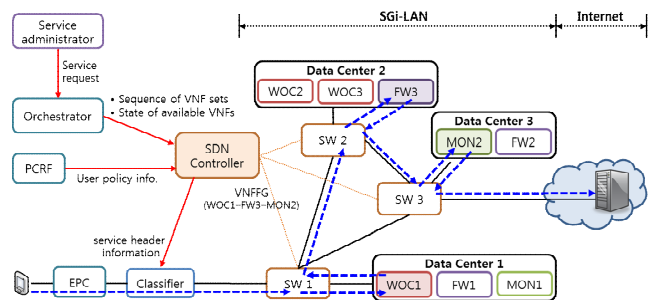

Figure 1. NFV/SDN based telecommunication network.

The telecommunication network is composed of Evolved Packet Core (EPC) and data centers, which are operated by the mobile cellular network provider. The operator manages the network between data centers with SDN. First, the service provider notifies the service request that characterizes their new value-added network service to the orchestrator. The orchestrator not only manages virtualized resources (e.g., CPU, memory, storage, switch of data centers), VNFs and lifecycle of network services, but also creates a sequence of VNF sets (e.g., WAN Optimization Controller (WOC) – Firewall (FW) – Monitoring (MON)) based on descriptors [2]. The sequence of VNF sets and its VNFs status are delivered to the VNFFG optimization algorithm on SDN controller. The SDN controller should maintain link capacity information of other network services as well as available network bandwidth information. In SGi-LAN, the telecommunication service provider operates three geographically split data centers for reasons related to operational cost or security issues. Maybe an external cloud service provider contracts with the telecommunication service provider. The VNFFG optimization algorithm creates and sets up the optimized VNFFG (e.g., WOC1 – FW3 –

MON2) considering VNF status, network topology and network condition. Finally, the packet flows from the user device and is forwarded to the EPC and classifier. The classifier marks network service header to packets based on pre-defined service header information that notifies what VNFFGs would be proper to this flow. Then, the SDN switch forwards the flow with pre-defined forwarding tables.

The QoS constrained path optimization algorithm of the SDN controller is composed of a super problem and sub problems, as depicted in Figure 2.
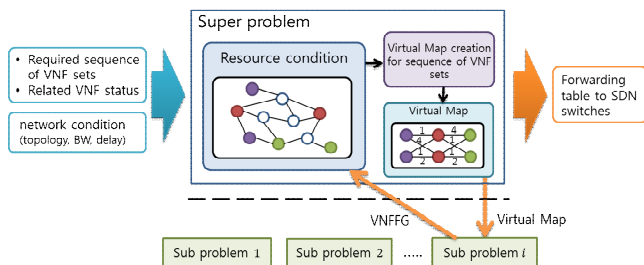

Figure 2.   QoS constrained path optimization algorithm.

The super problem provides the virtual map to sub problems. The virtual map is an abstraction of the network that describes related VNFs and available bandwidth between the VNFs. The sub problems are created when a new service request arrives. Each sub problem chooses the virtual path that has the largest available bandwidth and the appropriate VNFs. The VNFFG, the result of the sub problem, is delivered taking into account the super problem's resource condition, and then the super problem deducts the resources that the VNFFG uses. When all of the sub problems are satisfied, the super problem forwards the optimized forwarding tables to the SDN switches.
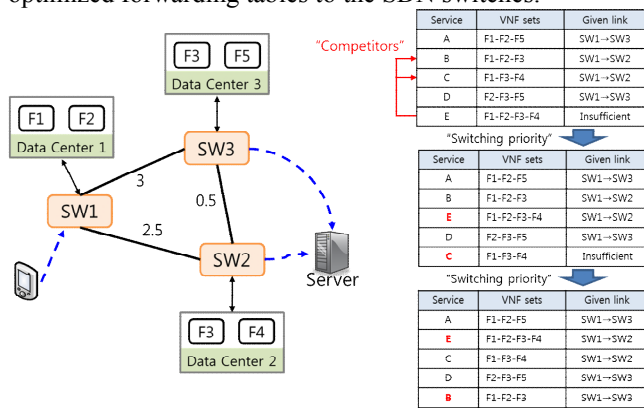

Figure 3.   Competitor selection and priority switching.

III.   COMPETITOR SELECTION AND PRIORITY SWITCHING

The super problem is a heuristic optimization algorithm based on competitor selection and switching priority. When the resource condition is not enough, the super problem is not able to create the virtual map for a new service request. However, in NFV/SDN environment, there is a chance that the prior sub problems could modify their VNFs and virtual

path. For instance, the left side of the Figure 3 shows two different paths for using VNF 3.

The number on the links means the number of acceptable VNFFGs. The first chart of Figure 3 shows five service requests that are requested to SDN controller and their sequence of VNF sets. However, Service E is not accepted because of insufficient link resource. If prior services change their VNFFG, service E could be accepted.

To maximize network service acceptance, competitor selection of the super problem finds the prior sub problems that use bottleneck link of the unaccepted sub problem. Then, priority switching of the super problem switches the priorities of unaccepted sub problem and the sub problem, which has the lowest priority among the competitors. The second chart shows the priorities of service C and service E are changed but the service C is not accepted. Finally, priority switching of service E and the other competitor, which is service B, makes all services to be accepted. This heuristic optimization maximizes the number of service requests by utilizing replaceable VNFs.

IV.   CONCLUSION AND FUTURE WORK

In the NFV/SDN environment, a link capacity allocation is an important problem to provide a stable QoS of network services. We propose a QoS constrained path optimization algorithm considering VNF status, network topology and network condition. The super problem of VNFFG optimization algorithm manages resources and creates the virtual map about the related VNFs and virtual path between them. The sub problem chooses sufficient VNFs and links at the given virtual map. Furthermore, we propose a heuristic super problem algorithm, which uses competitor selection and priority switching to maximize the network service acceptance. For the next step of research, we will include real-world performance comparison with other researches and analytic tools of a sequence of VNF sets and network conditions to prove the resource efficiency of the proposed algorithm.

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