

NFP Brokering for VNF Chaining Models

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Abstract— NFP brokering framework is suggested to secure interoperability between heterogeneous chaining methods known so far and to address branching issues to reflect behaviour of VNFs to NFP forwarding rules at run time. Also, Functional architecture and interface between functional blocks of the framework are proposed based on NFP management information provided by the NFP control and orchestration.

Keywords— NFV, Network Forwarding Path, Service Functions Chaining, Orchestrator, NFP broker

I. INTRODUCTION

NFV is a promising technology to lower the network operator's capital expenditure and operational expenditure by replacing proprietary hardware-based network equipment with software-based VNFs (Virtualized Network Functions). In particular, NFV provides an efficient way to deploy service functions chaining that consists of a set of VNFs interconnected by virtual links [1]. Network Forwarding Path (NFP) is defined as the ordered list of connection points forming a chain of VNF, along with policies associated to the list [2].

The representative chaining methodologies for NFP are known as chaining header type and legacy header type such as MAC and VLANs. The chaining header type has packet overhead intrinsically in the forwarding packets and needs additional logic to analyse and process the chaining header in the packet forwarder or VNF itself. Even though it gives coherency of forwarding path with no incidental classification of packets coming from the same port because input packets have their own chaining header which specifies where to forward the packet itself [3]. On the contrary making use of legacy packet header requires more complicated procedures to distinguish packet flows coming from the same port and determine the next hop to forward the packet although it requires no overhead and logic to generate the chaining header [4]. However, it still remains as a conspicuous issue that those mechanisms are not interoperable.

Besides an issue of interoperability, there are some branching issues to address on how to reflect behaviour of VNFs to NFP forwarding rules at run time. For the first case of same-port-multiple-path, packets from same port might have different NFPs and we have to differentiate forwarding packets to the next VNFs with flow based forwarding mechanism such as SDN. To this end, we need the generalized NFP identification scheme applied for all chaining mechanisms. Same-path-multiple-branch is the second exceptional case of service chaining practices. It requires to

treat packets of incoming one packet flow separately by the results of the VNF application processing. The same as the first case is true with this case is that input port number and legacy packet header are insufficient to determine the forwarding path. Some correlation mechanism between result of VNFs and forwarding paths seem to be required for both cases.

To relieve the issues described, we propose the NFP brokering mechanism for the consistent operation over heterogeneous service functions chaining methodologies while reflecting VNF branching information to the NFP forwarding rules at the same time.

For the rest of the paper, section II introduces the NFP brokering framework and architecture, section III presents the suggested NFP brokering deployment model followed by conclusion.

II. NFP BROKERING FRAMEWORK

A Network Service is defined as a service steering users' packet to the destination after traversing through one or more VNFs [2]. The technology dropping users' packets into one VNF and relaying to other designated VNFs is called VNF Chaining dubbed Service Chaining technology.

Assuming that a Network Service is composed of 3 VNFs formulating NFPs by the combination of constituent VNFs. For example, NFP-1 is an instance of Network Service traversing VNF-1 and VNF-3 sequentially while NFP-2 is a case of stitching VNF-1 and VNF-2 respectively. Therefore Network Functions Path Forwarder (NFPF) has a crucial role of the packet forwarding function in between multiple VNFs for bridging them as illustrated in Figure 1.

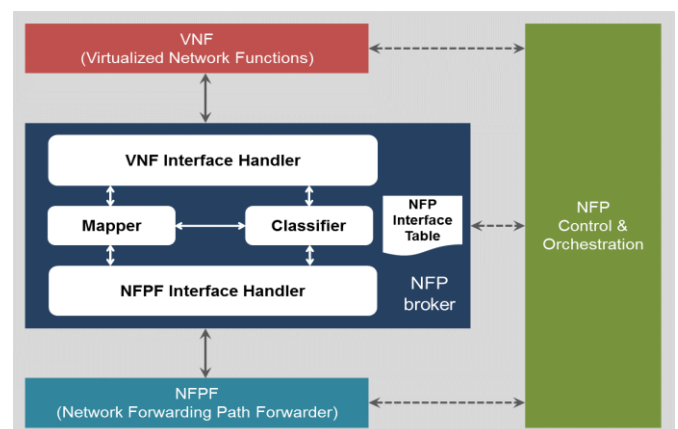


Figure 1. Functional architecture of NFP broker

NFP broker performs relaying downstream data packets from Virtual Network Functions to the NFPF after the modification of packet header and vice versa for upstream data packets. The information relevant to the VNF chaining which are required to update the header could be acquired from the NFP control and orchestration layers.

A. VNF interface handler

The VNF interface handler enables the NFP broker to operate agnostic to types of chaining methods by delivering data packets received from the NFPF to the VNFs with the NFP identifier which is extracted from the classification and mapping of the incoming packets. Unlike specific service chaining identifier of the chaining header type, the NFP identifier is the generic type of identifier supporting for both chaining header type and legacy header type such as MAC or VLAN based chaining mechanisms. It would be inserted in the header of the packets forwarding to the VNFs and used to identify the network forwarding path in the corresponding network service domain.

The NFP identifier in the VNF is the key to resolve the same-port-multiple-path problem since it is used to distinguish data packets coming from the same port. There is no need to reclassify the data packets coming back from VNFs because they keep as same NFP identifier value as it was sent to the VNFs. The NFP identifier shall be preserved to the end of the Network Service to relay the data packet by the sequence of the designated VNFs.

Coming up with solution of the same-path-multiple-branch problem of conventional practices, additional branch identifier is required to be specified in the data packets coming back from the VNFs along with the NFP identifier preserved. The Flow identifier merged with NFP identifier and Branch identifier helps NFP broker discern the separated NFP branches to proceed the packet.

B. NFPF interface handler

NFPF interface handler performs transferring downstream data packets from VNFs to NFPF and vice versa. NFPF interface handler has the adaptation function for data packets aligned with NFPF which is supposed to receive the data packet from the current VNF. The adaptation function carry out adjustment of packet header in concordance with the chaining type of NFPF. VNF chaining header information is determined as chaining type of NFPF where the corresponding VNF connects to.

When the NFPF interface handler receives the request of sending packet out of Mapper in NFP Broker, it composes NFP header according to the header information provided by the Mapper. NFP header interprets one of the types of packet header including chaining header, MAC address and VLAN identifiers. At the same time transport header will be attached using transport information and output port number given to the NFPF interface handler.

For the upstream data packets from the NFPF, NFPF interface handler strips off the transport header after examining and transfer the data packet to the Classifier if it is applicable

C. Classifier and Mapper

The Classifier in NFP broker has a role of analysis and classification of the data packets for upward and downward data packet streams in between NFPF and VNFs.

The following steps denote operational procedure of Classifier for upstream data packets from the NFPF interface handler along with the additional information related with input port and packet received.

- ① Check the validation of packet and relevant information to discover the chaining method.
- ② Extract the NFP identifier if the packet header received turns out to be a chaining header type
- ③ If not the case of 2, determine the NFP identifier out of input port and legacy data packet header
- ④ For the step 4, NFP identifier table composed of combination of input port and packet header might be used or query procedure to the Network orchestration and management plane if applicable
- ⑤ Send the NFP identifier and data packet to the Mapper

After receiving the notification of receiving upstream data packets from the Classifier, Mapper takes the steps below.

- ① Confirms the packet validity from the NFP identification and data packet header information
- ② Extracts corresponding VNF interface information
- ③ Construct VNF interface details with the NFP identifier transferred from the Classifier
- ④ Send the data packet and VNF interface information to the VNF interface handler

Downstream data packets from the VNF interface handler at the Classifier and Mapper will be processed

- ① Extracts the NFP identifier out of Flow identifier information received
- ② Extracts the Branch identifier out of Flow identifier information received
- ③ Zero value of Branch identifier means that no branch for the case exists
- ④ NFP identifier would be generated based on the non-zero Branch identifier
- ⑤ For the step 4, NFP identifier table composed of combination of Branch identifier and packet header might be used or query procedure to the Network orchestration and management plane if applicable
- ⑥ Send the NFP identifier and data packet to the Mapper

On receiving the data packets form Classifier, Mapper takes following steps of procedure.

- ① Acquire the information of next stop VNF to be chained with the NFP identifier transferred from the Classifier
- ② The information includes chaining method and their corresponding parameters such as chaining header service identifier, MAC address of next VNF or VLAN identifier of the logical link to the next VNF
- ③ Build NFP header making use of information of the step 2

- ④ Collect the information to transfer the data packet to the next NFPP such as address of NFPP, tunneling information and output port to NFPP
- ⑤ Send the data packet and all of relevant information to the NFPP interface handler

D. NFP control and orchestration

In terms of NFV management and orchestration [5], a VNFFG (VNF Forwarding Graph) can reference other information elements in the Network Service such as PNFs, VLs and VNFs. A VNFFG also contains a Network Forwarding Path (NFP) element. NFP control and orchestrator may support NFP brokering by offering the information about Network Forwarding Path proactively or on the fly. The supporting capabilities of the NFP orchestration include;

- Processing VNF branch information
- Mapping NFP identifier information with the combination of input port and packet header
- Mapping information to couple Branch identifier and NFP identifier in case of Branch type of VNF
- Management of NFP interface table

To this end, branch typed VNF shall expose the information relevant to branching of the VNF to the VNF Descriptor (VNFD). VNFD is a deployment template which describes a VNF in terms of its deployment and operational behaviour requirements. It is primarily used by the VNFM (VNF Manager) in the process of VNF instantiation and lifecycle management of a VNF instance. The information provided in the VNFD is also used by the NFVO (NFV Orchestrator) to manage and orchestrate Network Services and virtualised resources on the NFVI (NFV Infrastructure). The VNFD also contains connectivity, interface and KPIs requirements that can be used by NFV-MANO functional blocks to establish appropriate Virtual Links within the NFVI between its VNFC (VNF Component) instances, or between a VNF instance and the endpoint interface to the other Network Functions.

- Branch type or not
- Number of branches
- Details of branch information including attributes of branch, effects, and related description of the branches

VNF provides only Flow identifier, a combination of NFP identifier received and Branch identifier, to the NFP broker with the data packet to be transferred. The system dependent information required to deal with service functions chaining of the network service will be prepared in the NFP broker in cooperation with NFP orchestrator and manager to keep VNF agnostic to system and service chaining mechanisms as the form of NFP interface table.

III. NFP BROKERING DEPLOYMENT MODEL

Basically the NFP broker positions in between VNF and NFPP. However the deployment model of NFP brokering gives variant options for implementation as shown in Figure 2.

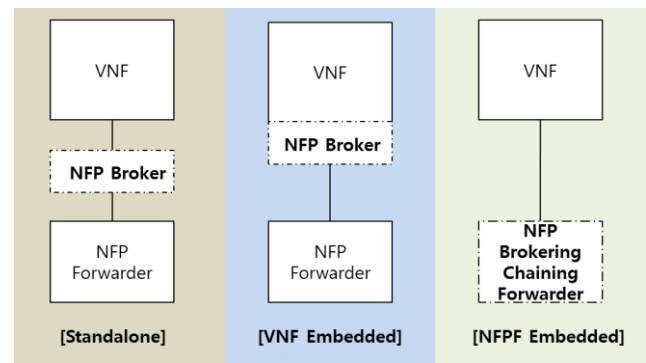
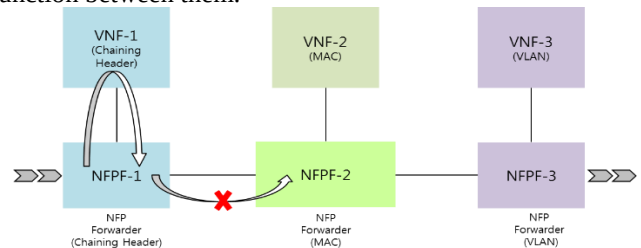


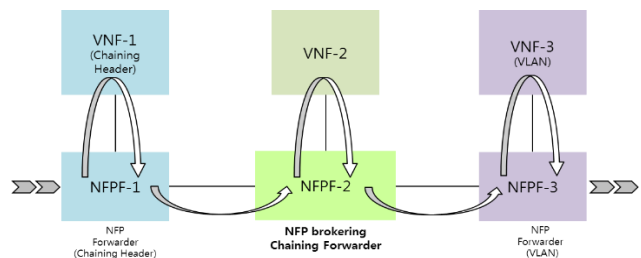
Figure 2. NFP Brokering Deployment Models

Firstly, it works as an independent entity for brokering with two separate interfaces with NFPP and VNFs. For the second option, NFP brokering functions might be embedded in VNF itself. The last optional model is the case with merging NFP broker and NFPP considering interoperability between multiple types of NFPP. This NFP Brokering Chaining Forwarder works for any chaining type of data packet and keeps away the dependence of VNF on network infrastructure.

It is complicate to set up the NFP for VNF chaining over the infrastructure composed of heterogeneous NFPPs because their chaining headers and operations are not interoperable as shown in Figure 3(a). NFPP-2 could not process the packet from NFPP-1 which has chaining process based on chaining header because NFPP-2 has no knowledge on chaining header. The other direction is not compatible because MAC-based packet chaining mechanism doesn't work in the NFPP working based on chaining header mechanism either. Figure 3(b) shows an example with NFP Brokering Chaining Forwarder that data packets with chaining header from NFPP-1 can proceed to VNF-2 and NFPP-3 for heading to VNF-3. Consequently, chaining header type and legacy VLAN type NFPP could interwork together with the NFP brokering function between them.



(a) Incompatible case between NFPPs



(b) Compatible case with NFP brokering

Figure 3. Example of NFP Brokering

IV. CONCLUSION

The chaining methods known so far are not compatible to operate interchangeably for now. To cope with this issue we suggest a new NFP brokering mechanism using NFP header which is the generic type of header for all possible types of packet headers for NFP process such as L2 MAC address, VLANs, and special purpose Chaining Headers while Transport header is for overlaid packet header for transferring data packets to the next hop in the transport network domain. Also, to solve the same-path-multiple-branch problem of conventional practices, Flow identifier merged with NFP identifier and Branch identifier is proposed as the new interface with VNF.

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REFERENCES

- [1] Zilong Ye et al, "Joint topology design and mapping of service function chains for efficient, scalable, and reliable network functions virtualization", IEEE Network, vol. 30, pp 81-87, 2016
- [2] "ETSI GS NFV 003: Network Functions Virtualisation (NFV); Terminology for Main Concepts in NFV", ETSI ISG NFV, Dec. 2014
- [3] Paul Quinn and Jim Guichard, "Service Function Chaining: Creating a Service Plane via Network Service Headers", IEEE Computer, vol. 47, pp. 38-44, 2014
- [4] "Service Function Chaining-Helium, Lithium and the way forward...", OPEN DAYLIGHT Forum India, 2015
- [5] "ETSI GS NFV 001: Network Functions Virtualisation (NFV); Management and Orchestration", ETSI ISG NFV, Dec. 2014



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