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Resource Management in Service Chaining
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Abstract

This document specifies problem definition and use cases of NFV resource management in service chaining for path optimization, traffic optimization, failover, load balancing, etc. It further describes design considerations and relevant framework for the resource management capability that dynamically creates and updates network forwarding paths (NFPs) considering resource constraints of NFV infrastructure.

Status of This Memo

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1. Introduction

Network Functions Virtualisation (NFV) [ETSI-NFV-WHITE] offers a new way to design, deploy and manage network services. The network service can be composed of one or more network functions and NFV relocates the network functions from dedicated hardware appliances to generic servers, so they can run in software. Using these virtualized network functions (VNFs), one or more VNF forwarding graph (VNF-FG) can be associated to the network service, each of which describes a network connectivity topology, by referencing VNFs and Virtual Links that connect them. One or more network forwarding paths (NFPs) can be built on top of such a topology, each defining an ordered sequence of VNFs and Virtual Links to be traversed by traffic flows matching certain criteria.

The performance or state of the NFP depends on the ones of underlying NFVI resources including VNF instances (VNF-Is) and VLs. For example, if one of the VNF instances in a NFP gets failed, the whole network service using the NFP also gets failed. Thus, the VNF instances per NFP need to be carefully selected at VNF-FG instantiation or dynamically replaced by other VNF instances at run-time for better performance and resilience of the NFP.

The resource placement problem in service chains matters not only to the quality of NFPs but also to the optimized use of NFVI resources. For example, if some of the VNF instances and VLs are selected to constitute a NFP but the others are not, the processing and bandwidth burden will converge on those VNF instances and VLs, which results in scalability problem.

This document addresses resource management problem in service chaining to optimize the NFP quality and resource usage. It provides the relevant use cases of the resource management such as traffic optimization, failover, load balancing and further describes design considerations and relevant framework for the resource management capability that dynamically creates and updates NFPs considering resource state of VNF instances.

This document mainly focuses on the resource capability in the ETSI NFV framework [ETSI-NFV-ARCH] but also studies its applicability to the control plane of SFC architecture [I-D.ietf-sfc-architecture].

2. Terminology

This document uses the following terms and most of them were reproduced from [ETSI-NFV-TERM].

- Network Functions (NF): A functional building block within a network infrastructure, which has well-defined external interfaces and a well-defined functional behavior.

- Network service: A composition of network functions and defined by its functional and behavioural specification.

- NFV Framework: The totality of all entities, reference points, information models and other constructs defined by the specifications published by the ETSI ISG NFV.

- Virtualised Network Function (VNF): An implementation of an NF that can be deployed on a Network Function Virtualisation Infrastructure (NFVI).

- NFV Infrastructure (NFVI): The NFV-Infrastructure is the totality of all hardware and software components which build up the environment in which VNFs are deployed.

- NF Forwarding Graph: A graph of logical links connecting NF nodes for the purpose of describing traffic flow between these network functions.

- o VNF Forwarding Graph (VNF-FG): A NF forwarding graph where at least one node is a VNF.

- o Virtual Link: A set of connection points along with the connectivity relationship between them and any associated target performance metrics (e.g. bandwidth, latency, QoS). The Virtual Link can interconnect two or more entities (VNF components, VNFs, or PNFs).

- o Scaling: Ability to dynamically extend/reduce resources granted to the Virtual Network Function (VNF) as needed.

3. Resource management in service chain

The goal of the resource management is to optimize the quality of network services and resource usage of NFVI. To meet this goal, NFPs of the network services need to consider the state of NFV resources (such as VNF instances or virtual links) at construction. The NFPs also need to dynamically adapt to the changes of the resource state at run-time, such as availability, load, and topological locations of VNF instances; latency and bandwidth of virtual links. The adaptation of NFPs can be executed by monitoring the resource state of VNF instances and VLs and replacing the original VNF instances of the NFP with new VNF instances that constitute a NFP with better performance. This functionality can be a part of Orchestrator functional building block in the NFV framework [ETSI-NFV-MANO] but it needs further study.

3.1. Use cases

In this section, several (but not exhausted) use cases for resource management in service chaining are provided: fail-over, path optimization, traffic optimization, load balancing, and energy efficiency.

Fail-over

When one of VNF instances in a NFP gets failed to run due to failure of its VM or underlying network, the whole chain of network service also gets failed. For service continuity, the failure of VNF instance needs to be detected and the failed one needs to be replaced with the other one which is available to use. Figure 1 presents an example of the fail-over use case. A network service is defined as a chain of VNF-A and VNF-B; and the service chain is instantiated with VNF-A1 and VNF-B1 which are instances of VNF-A and VNF-B respectively. In the meantime, failure of VNF-B1 is detected so that VNF-B2 replaces the failed one for fail-over of the NFP.

```
                   +--------+                        +--------+
                   | VNF-B2 |                       #| VNF-B2 |###
      +--------+   +--------+           +--------+ # +--------+
   ###| VNF-A1 |       _|_           ###| VNF-A1 |#      _|_
      +--------+      (___)             +--------+      (___)
     ___/    #       /     \      \    ___/            /     \
    (___)+---#------+       +   ===}  (___)+----------+       +
             #       \ ___ /      /                    \ ___ /
             #        (___)                             (___)
             #          |                                 |
             #     +--------+                        +--------+
             ######| VNF-B1 |###        (failure)--> | VNF-B1 |
                   +--------+                        +--------+

   ### NFP
```

Figure 1: A fail-over use case

Path optimization

Traffic for a network service traverses all of the VNF instances and the connecting VLs given by a NFP to reach a target end point. Thus, quality of the network service depends on the resource constraints (e.g., processing power, bandwidth, topological locations, latency) of VNF instances and VLs. In order to optimize the path of the network service, the resource constraints of VNF instances and VLs need to be considered at constructing NFPs. Since the resource state may vary in time during the service, NFPs also need to adapt to the changes of resource constraints of the VNF instances and VLs by monitoring and replacing them at run-time.

Traffic optimization

A network operator may provide multiple network services with different VNF-FGs and different flows of traffic traverse between source and destination end-points along the VNF-FGs. For efficiency of network management resource usage, the NFPs need to be built as to localize the traffic flows or as to avoid bottleneck links shared by multiple traffic flows. In this case, multiple NFV instances of different NFPs need to be considered together at constructing a new NFP or adapting one.

Load balancing

A single VNF instances may be shared by multiple traffic flows of the same of different network services. In order to avoid bottleneck points due to overloaded NFV instances, NFPs need to be constructed or maintained to distribute workloads of the shared VNF instances.

Energy efficiency

Energy efficiency in the network is getting important to reduce impact on the environment so that energy consumption of VNF instances using VNFI resources (e.g., compute, storage, I/O) needs to be considered at NFP construction or adaptation. For example, a NFP can be constructed as to make traffic flows aggregated into a limited number of VNF instances as much as its performance is preserved in a certain level.

3.2. Design considerations

To support the aforementioned use cases, it is required to support resource management capability which provides service chain (or NFP) construction and adaptation by considering resource state or constraints of VNF instances and virtual links among them. The resource management operations for service chain construction and adaptation can be divided into several sub-actions:

- o Select a VNF instance
- o Evaluate a VNF instance and a virtual link
- o Replace a VNF instance to update a NFP
- o Monitor state or resource constraints of a VNF instance and a virtual link
- o Migrate a VNF instance to another ones in different locations

Note: While scaling-in/out or -up/down of VNF instances is one of the essential actions for NFV resource management, it is a different approach with a finer granularity than service chain adaptation. The scaling approach may be integrated together with the service chain adaptation but it is still under study.

As listed above, VNF instances are selected or replaced according to monitoring or evaluation results of performance metrics of the VNF instances and virtual links. Studies about evaluation methodologies and performance metrics for VNF instances and NFVI resources can be found at [ETSI-NFV-PER001] [I-D.liu-bmwg-virtual-network-benchmark] [I-D.morton-bmwg-virtual-net]. The performance metrics of VNF instances and virtual links specific to service chain construction and adaptation can be defined as follows:

- o availability (or failure) of a VNF instance and a virtual link
- o a topological location of a VNF instance
- o a utilization rate of a VNF instance
- o a throughput of a VNF instance
- o energy consumption of VNF instance
- o bandwidth of a virtual link
- o latency of a virtual link

3.3. Framework

The resource management functionality for dynamic service chain adaptation takes role of NFV orchestration with support of VNF manager and Virtualised Infrastructure Manager (VIM) in the NFV framework [ETSI-NFV-ARCH]. Detailed functional building block and interfaces are still under study.

4. Applicability to SFC

4.1. Related works in IETF SFC WG

IETF SFC WG provides a new service deployment model that delivers the traffic along the predefined logical paths of service functions (SFs), called service function chains (SFCs) with no regard of network topologies or transport mechanisms. Basic concept of the service function chaining is similar to VNF-FG where a network service is composed of SFs and deployed by making traffic flows traversed instances of the SFs in a pre-defined order.

There are several works in progress in IETF SFC WG for resource management of service chaining. [I-D.ietf-sfc-architecture] defines SFC control plane that selects specific SFs for a requested SFC, either statically or dynamically but details are currently outside the scope of the document. There are other works [I-D.ww-sfc-control-plane] [I-D.lee-sfc-dynamic-instantiation] [I-D.krishnan-sfc-oam-req-framework] [I-D.aldrin-sfc-oam-framework] which define the control plane functionality for service function chain construction and adaptation but details are still under study. While [I-D.dunbar-sfc-fun-instances-restoration] and [I-D.meng-sfc-chain-redundancy] provide detailed mechanisms of service chain adaptation, they focus only on resilience or fail-over of service function chains.

4.2. Integration in SFC control-plane architecture

In SFC WG, [I-D.ww-sfc-control-plane] defines a generic architecture of SFC control plane with well-defined functional building blocks and interfaces as follows:

```
                     +-------------------------------------------------+
                     |                     SFC  Control Plane          |
                     | +---------------+  +---------------+            |
             +-------| |Chain Management  |Service Overlay|            |
             |       | |Policy Control |  |Topo Management|            |
             |       | +---------------+  +---------------+            |
             |       | +---------------+ +---------------+             |
             +---------|Chain Selection| | Chain Mapping | +----------+|
             |       | | Policy Control| | and Forwarding| |External SF|
             |         +---------------+ |    Control    | |Management||
             |       |                   +---------------+ +----------+|
             C1      +------^-----------^-------------^----------------+
      +---------------------|F----------|-------------|-------------+
      |      |            +----+        |             |             |
      |      |            | SF |        |C2           |C2           |
      |                   +----+        |             |             |
      | +----V--- --+       |           |             |             |
      | |   SFC     |     +----+      +-|--+        +----+          |
      | |Classifier |---->|SFF |----->|SFF |------->|SFF |          |
      | |   Node    |<----|    |<-----|    |<-------|    |          |
      | +-----------+     +----+      +----+        +----+          |
      |                     |           |              |            |
      |                     |C2      -------           |            |
      |                     |       |       |     +-----------+ F   |
      |                     V     +----+ +----+   | SFC Proxy |-->  |
      |                           | SF | |SF  |   +-----------+     |
      |                           +----+ +----+                     |
      |                             |F     |F                       |
      |  SFC Data Plane Components  V      V                        |
      |                                                             |
      +-------------------------------------------------------------+
```

Figure 2: SFC control plane architecture

The service chain adaptation addressed in this document may be integrated into the Chain Mapping and Forwarding Control functional block and may use the C2 and F interfaces for monitoring or collecting the resource constraints of VNF instances and VLs.

Note that SFC does not assume that Service Functions are virtualized. Thus, the parameters of resource constraints may differ, and it needs further study for integration.

5. Security Considerations

TBD.

6. IANA Considerations

TBD.

7. References

7.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

7.2. Informative References

[ETSI-NFV-ARCH]
ETSI, "ETSI NFV Architectural Framework v1.1.1", October 2013.

[ETSI-NFV-MANO]
ETSI, "Network Function Virtualization (NFV) Management and Orchestration V0.6.3", October 2014.

[ETSI-NFV-PER001]
ETSI, "Network Function Virtualization: Performance and Portability Best Practices v1.1.1", June 2014.

[ETSI-NFV-TERM]
ETSI, "NFV Terminology for Main Concepts in NFV", October 2013.

[ETSI-NFV-WHITE]
ETSI, "NFV Whitepaper 2", October 2013.

[I-D.aldrin-sfc-oam-framework]
Aldrin, S., Krishnan, R., Akiya, N., Pignataro, C., and A. Ghanwani, "Service Function Chaining Operation, Administration and Maintenance Framework", draft-aldrin-sfc-oam-framework-01 (work in progress), October 2014.

[I-D.dunbar-sfc-fun-instances-restoration]
Dunbar, L. and A. Malis, "Framework for Service Function Instances Restoration", draft-dunbar-sfc-fun-instances-restoration-00 (work in progress), April 2014.

[I-D.ietf-sfc-architecture]
Halpern, J. and C. Pignataro, "Service Function Chaining (SFC) Architecture", draft-ietf-sfc-architecture-08 (work in progress), May 2015.

[I-D.krishnan-sfc-oam-req-framework]
Krishnan, R., Ghanwani, A., Gutierrez, P., Lopez, D., Halpern, J., Kini, S., and A. Reid, "SFC OAM Requirements and Framework", draft-krishnan-sfc-oam-req-framework-00 (work in progress), July 2014.

[I-D.lee-sfc-dynamic-instantiation]
Lee, S., Pack, S., Shin, M., and E. Paik, "SFC dynamic instantiation", draft-lee-sfc-dynamic-instantiation-01 (work in progress), October 2014.

[I-D.liu-bmwg-virtual-network-benchmark]
Liu, V., Liu, D., Mandeville, B., Hickman, B., and G. Zhang, "Benchmarking Methodology for Virtualization Network Performance", draft-liu-bmwg-virtual-network-benchmark-00 (work in progress), July 2014.

[I-D.meng-sfc-chain-redundancy]
Wu, C., Meng, W., and C. Wang, "Redundancy Mechanism for Service Function Chains", draft-meng-sfc-chain-redundancy-01 (work in progress), December 2014.

[I-D.morton-bmwg-virtual-net]
Morton, A., "Considerations for Benchmarking Virtual Network Functions and Their Infrastructure", draft-morton-bmwg-virtual-net-03 (work in progress), February 2015.

[I-D.ww-sfc-control-plane]
Li, H., Wu, Q., Boucadair, M., Jacquenet, C., Haeffner, W., Lee, S., and R. Parker, "Service Function Chaining (SFC) Control Plane Achitecture", draft-ww-sfc-control-plane-04 (work in progress), March 2015.

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