Horizontal-Based Orchestration for Multi-Domain SFC in SDN/NFV-Enabled Satellite/Terrestrial Networks

Suheel S Nazeersab

November 9, 2018

Abstract

A horizontal based Multi Domain Service Function Chain(Md SFC) orchestration framework is proposed in this paper to construct network service function chains in such a multi domain environment.

1 Introduction

With the use of Software Defined Networking(SDN) and Network Function Virtualisation(NFV), it is feasible to integrate satellite and terrestrial networks. Building on the basis frame of NFV, we design a distributed orchestration framework for multi domain SFC in SDN/NFV-enabled satellite and terrestrial networks[1]. An integrated satellite and ground communication network brings many benefits, such as improved service coverage and footprint expansion, rapid dynamic and/or infrastructure-independent service deployment, increased network resilience, broader range of service provisioning with lower costs and improved Quality of Service/Experience(QoS/QoE) [1].

2 Horizontal-based multi-domain SFC Orchestration:

We can utilise the resources in a better way with multi domain orchestration. By flow steering, the MdO in the hybrid access scenario can integrate and share terrestrial network resources and satellite network for access service[1]. In the proposed framework, MdOs can communicate with each other in this environment by exchanging the messages. This ensures no domain is on top of every other domain. Though we chose a super orchestrator to coordinate with other domains, super orchestrator also need to communicate and involve in message exchanging. Service function chaining is a network capability that provides support for application-driven-networking through the ordered interconnection of service functions. The lifecycle management of service function chains is enabled by two recently emerged technologies, software defined networking and network function virtualization, that promise a number of efficiency, effectiveness, and flexibility gains.[2]

A Domain NFV Orchestrator(DoNFVO), present in each network will have the knowledge of resources and topology information in the domain. Coordination between MdOs and DoNFVOs will be carried out through vertical interfaces. To orchestrate the multi-domain network in a global view, a master orchestrator should be selected from MdOs to coordinate with other MdOs by horizontal interfaces[1]. Master orchestrator is usually selected of a user domain, which forwards the Md-SFC request to other MdOs through horizontal interfaces and informs DoNFVOs controlled by it through vertical interfaces. Master MdO collects the orchestration results from other MdOs(slave MdOs) and DoNFVO controlled by itself and makes a Md-SFC installation decision.

3 Md-SFC Mapping Algorithm

A flow usually passes through all SFs and virtual links in a service function chain[1]. We use greedy algorithm for SF mapping and K-Shortest Paths(KSP) algorithm for virtual link mapping[3].

- **Resource Constraints:**

  Resources constraint can be denoted by (1), (2) and (3), where CPU(sf_i) and Mem(sf_i) represent CPU and memory resource needed by service function sf_i and B(l(sf_i,sf_j)) represents bandwidth demand of virtual link l(sf_i,sf_j). Similarly, CPU(n_s) and Mem(n_s) represent remaining CPU and memory resources of node n_s, B(l(n_s, n_t)) represents remaining bandwidth resources of physical link l(n_s, n_t) between node n_s and n_t.[1]

$$\text{CPU}(n_s) \geq \text{CPU}(sf_i) \quad (1)$$

$$\text{Mem}(n_s) \geq \text{Mem}(sf_i) \quad (2)$$

$$\text{B}(\text{l}(n_s,n_t)) \geq \text{B}(\text{l}(sf_i,sf_j)) \quad (3)$$

  In the multi-domain situation, we aim to select proper domains and inter-domain paths from candidates to minimize end-to-end delay. The object is presented by (4), where delay(sub_u) represents delay of selected Sub-SFC subu and delay(D_l) represents delay of inter-domain path between selected Sub-SFCs.[1]

$$\text{Min } [\sum \text{delay}(sub_u) + \sum \text{delay}(D_l)] \quad (4)$$

- **Performance measures:**

  Bandwidth performance of a chain is decided by the bottleneck virtual link[1]. Sub-SFCs and inter-domain paths determines the end to end delay of a Md-SFC[1].

3.1 Intra-Domain Sub-SFC mapping

Intra-domain Sub-SFC mapping has two phases: SF mapping which selects physical node with maximum available resources from all nodes which have required SF type using greedy algorithm. Link mapping which searches shortest paths between physical nodes until bandwidth demand is satisfied or k paths have been searched[1].

3.2 Cooperative Md-SFC mapping

Besides the load of master orchestrator grows with the number of inter-domain path, that some of the operators may not be willing to provide topology information is the other reason why we need a cooperative way for Md-SFC mapping[1]. End SFs of the Sub-SFC and paths between all edge nodes will be calculated by DoNFVOs. Master orchestrator selects the best edge nodes for each domain based on the performance of the whole inter-domain path between Sub-SFCs provided by the DoNFVOs[1]. Master orchestrator will have to compare performance and choose the best inter-domain path as the path search tasks are finished by DoNFVOs, which in turn reduces the load on it[1]. After selecting the inter-domain path between Sub-SFCs, a shortest end to end inter-domain path can be calculated based on delay of Sub-SFCs and their inter-domain paths[1].

3.3 Inter-domain Md-SFC mapping

In Cooperative method, after intra-domain Sub-SFC mapping, the path between end SFs of a Sub-SFC and edge nodes should also be searched by DoNFVOs using KSP algorithm[1]. DoNFVOs also report delay of all candidate paths to edge nodes and inter-domain links along with the delay of complete Sub-SFC. In the process of cooperative inter-domain Md-SFC mapping algorithm, Firstly, the master orchestrator compares candidate inter-domain paths and chooses better ones for Sub-SFCs to build a weighted multi-domain directed graph based on domains' mapping results[1]. Then, based on this weighted graph, the end-to-end inter-domain path with minimum delay is selected by Dijkstra algorithm[1].

4 Conclusion

A horizontal-based multi domain orchestration framework for Md-SFC in SDN/NFV-enabled satellite and terrestrial networks is proposed in the paper[1]. DoNFVOs control and compute intra-domain Sub-SFCs in their respective domains and send the results to their MdOs. Master MdO will select the Sub-SFCs from candidate domains. It is evident from evaluations carried out in Reference [1] that cooperative inter-domain path calculation method has less mapping delay in comparison with naive uncooperative way. In cooperative way, operators do not need to provide topology information as it distributes computing load to DoNFVOs and it also ensures the shortest available inter-domain path to be selected[1].

References

[1] Guanglei Li, Huachun Zhou, Bohao Feng, Guanwen Li, and Qi Xu. Horizontal-based orchestration for multi-domain sfc in sdn/nfv-enabled satellite/terrestrial networks. *China Communications*, 15(5):77–91, 2018.

[2] Ahmed M Medhat, Tarik Taleb, Asma Elmangoush, Giuseppe A Carella, Stefan Covaci, and Thomas Magedanz. Service function chaining in next generation networks: State of the art and research challenges. *IEEE Communications Magazine*, 55(2):216–223, 2017.

[3] Minlan Yu, Yung Yi, Jennifer Rexford, and Mung Chiang. Rethinking virtual network embedding: substrate support for path splitting and migration. *ACM SIGCOMM Computer Communication Review*, 38(2):17–29, 2008.