Challenges in Optimizing Placement and Chaining of Heterogeneous Microservices

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Mots-clés : *Network Function Virtualization, Optimization, Orchestration, Low-latency*

1 Introduction

The virtualization of network architectures brings lots of benefits and tends to be an ever-increasing concern in telecommunication. It allows a wider flexibility for the deployment of network functions (NF), enabling emerging services such as those requiring low-latency. In this area, concepts of microservices and the network programmability act as promising solutions but induce issues concerning orchestration rules, network function placement or service chaining. After reviewing optimization related problems, we highlight some research tracks to explore. This research will be carried out as part of an ANR-project MOSAICO.

2 State-of-the-art

Deployment and placement of NF given related service requirements, is an issue largely studied in the context of Network Function Virtualization (VNF), with specific studies on placement and chaining, leading to *NP*-Hard optimization problems. They are usually subject to various possible constraints related to quality of service. In the following, we restrict them to those addressing latency issues. In most papers, the problem is first modeled as an ILP or a MILP and solved approximately.

VNF Placement - VNF-P

In NFV, a relevant problem consists in determining the best placement of VNF over the physical network (VNF-P) so that the demands of services and the quality are reached. For example Cohen *et al.* in [2] develop heuristic algorithms to optimize the operational cost of the network and the use of resources, but not considering latency issues. Moens and De Turck [9] consider a hybrid environment with the objective of minimizing the number of servers used. In few articles, authors solve the problem with metaheuristic algorithms like Windhya *et al.* [10].

VNF Chaining - VNF-C

The issue of VNF chaining (VNF-C) deals with managing both the chaining and the corresponding flows in order to reach destinations. Sahhaf *et al.* [11] and Lee *et al.* [4] formulate it as an ILP with the objective of minimizing total cost and end-to-end latency. Sahhaf *et al.* also proposed a heuristic-based algorithm. Others turn it into another type of problem. For instance, Li *et al.* [5] summarize the VNF-C problem as a grey theory problem. Besides those static problems, dynamic approaches present interesting insight for real cases. Liu *et al.* [6] addressed this by responding dynamically to new demands for services and readjusting ongoing demands.

VNF Placement and Chaining - VNF-PC

The VNF-PC problem deals with both objectives (placement and chaining). Without priority constraints, Addis *et al.* [1] study the case with only one type of fonction and solve it using a

solver (CPLEX). For its part, Gouareb *et al.* [3] consider that all VNFs associated with each SFC are located at the same and minimize the cost of delay on arcs. Luizelli *et al.* [7] handle the chaining using an ILP. Then, in [8] they solve it with a metaheuristic-based algorithm. Tomassilli [12] propose two approximation algorithms for a tree network topology.

3 Challenges

Given the papers surveyed above, it appears that the evolution of network virtualization and programmability induces challenges which directly impact orchestration solutions. First, the network programmability brings yet a novel type of NF deployment solution, thus inducing the need for orchestration algorithms able to deal with heterogeneous environments. Then, the development of microservices (the split of monolithic services into smaller components according to a given criterion : flows, network stack layer, sub-function, etc.) induces challenges such as the need to orchestrate both the service and micro-service levels and the scalability support of the related algorithms due to the potential exponential growth of microservices.

Références

[1] B. Addis, G. Carello, and M. Gao. On a virtual network functions placement and routing problem : Some properties and a comparison of two formulations. *Networks*, 75, 11 2019.

[2] R. Cohen, L. Lewin-Eytan, J. S. Naor, and D. Raz. Near optimal placement of virtual network functions. In *IEEE Conference on Computer Communications (INFOCOM)*, pages 1346–1354, 2015.

[3] R. Gouareb, V. Friderikos, and A. H. Aghvami. Delay sensitive virtual network function placement and routing. In *International Conference on Telecommunications)*, pages 394–398, 2018.

[4] G. Lee, M. Kim, S. Choo, S. Pack, and Y. Kim. Optimal flow distribution in service function chaining. In *The 10th International Conference on Future Internet*, CFI '15, page 17–20, New York, NY, USA, 2015. Association for Computing Machinery.

[5] T. Li, Z. Huachun, and H. Luo. A new method for providing network services : Service function chain. *Optical Switching and Networking*, 26, 09 2015.

[6] J. Liu, W. Lu, F. Zhou, P. Lu, and Z. Zhu. On dynamic service function chain deployment and readjustment. *IEEE Transactions on Network and Service Management*, 14(3) :543–553, 2017.

[7] M. C. Luizelli, L. R. Bays, L. S. Buriol, M. P. Barcellos, and L. P. Gaspary. Piecing together the nfv provisioning puzzle : Efficient placement and chaining of virtual network functions. In *IFIP/IEEE International Symposium on Integrated Network Management*, pages 98–106, 2015.

[8] Marcelo Caggiani Luizelli, Weverton Luis da Costa Cordeiro, Luciana S. Buriol, and Luciano Paschoal Gaspary. A fix-and-optimize approach for efficient and large scale virtual network function placement and chaining. *Computer Communications*, 102 :67 – 77, 2017.

[9] H. Moens and F. D. Turck. Vnf-p : A model for efficient placement of virtualized network functions. In *10th International Conference on Network and Service Management (CNSM) and Workshop*, pages 418–423, 2014.

[10] W. Rankothge, F. Le, A. Russo, and J. Lobo. Optimizing resource allocation for virtualized network functions in a cloud center using genetic algorithms. *IEEE Transactions on Network and Service Management*, 14(2) :343–356, 2017.

[11] S. Sahhaf, W. Tavernier, M. Rost, S. Schmid, D. Colle, M. Pickavet, and P. Demeester. Network service chaining with optimized network function embedding supporting service decompositions. *Computer Networks*, 93, 10 2015.

[12] A. Tomassilli. *Towards next generation networks with SDN and NFV.* PhD thesis, 2019.