PhD Position at laboratory L2TI (UR3043, www-l2ti.univ-paris13.fr), University Paris 13 (Sorbonne Paris Nord)

Title: **Optimal Virtual Network functions Placement and chaining under SDN/NFV paradigm**

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Detailed proposal:

To respond quickly and effectively to the growing needs of emerging and various networking-based services, the networks must be flexible, responsive, with adequately dimensioned resources (CPU, storage and bandwidth), with a high degree of resilience. The precedent generation of networks, which is mostly composed of proprietary hardware that is often strongly coupled with a particular technology (IPv4 for example), is unable to achieve this mutation with a reasonable CAPEX (capital expenditure) and OPEX (operational expenses). The SDN/NFV [1] (*Software Defined Network*/*Network Function Virtualization*) paradigm was born from this observation, in order to offer a new way of building networks.

By separating the *Control Plane* and the *Data Plane*, SDN allows the *virtualization* of the *network functions* (storage, computation, filtering, NAT, *etc.*) which can be implemented as software decoupled from the equipment. In this way, the *Virtual Network Functions (VNFs)* can be installed anywhere all over the physical as well as virtual networking infrastructure. The SDN/NFV architecture [2] is divided into three layers : (1) the NFV infrastructure (NFVI) which corresponds to the data plane for data routing (switches, links, etc.) and provides the necessary resources (memory, CPU, etc.) for the execution of network services; (2) the VNF layer which hosts and supplies the VNFs and (3) the orchestrator whose role is to establish the service by reserving the resources and determining the placement and chaining of different VNFs, while ensuring the management and the control of the service during its lifetime.

Take the example of a mobile user receiving a *video-streaming* service. This service claims various elementary functions: authentication, billing, transcoding (which may change during transmission depending on the locality and the terminal), *etc.* These functions are hard to be setup on proprietary hardware (manual reconfiguration, additional equipment, etc.). With NFV, this service can be provided through a control center by establishing a path crossing the equipment where the basic functions VNF-authentication, VNF-invoicing, VNF-transcoding are either already existing or to be hosted. Obviously, this path, which determines the chaining of VNFs, must respect the functional logic and have sufficient resources (CPU capacity, memory, bandwidth, etc.). This example shows the benefits of SDN/NFV which allows the composition of network services by chaining VNFs, with a great flexibility in the *placement of VNFs,* so that *the whole service can be provided with an optimization of* the networking resources. Traffic will be *steered* according to the specific service chaining (SFC, *Service Function Chaining*). Notice that a service may generate multiple paths forming a *VNF forwarding graph*.

In this thesis, we propose to study the joint problem of *Placement and Chaining of VNFs* (*PC-VNF*) which is an NP-difficult problem. The approach of this thesis consists of first identifying specific cases where the PC-VNF problem can be solvable by fast algorithm; then proposing heuristics for more generic situations based on dynamic programming or the use of meta-heuristics, *etc*. We will place ourselves successively in a centralized (mono-operator) then distributed (multi-operators) contexts. In a centralized context, all the information necessary for the calculations is known. It is therefore possible to explore various approaches to reduce the computation time (study of sparse *VNF forwarding* graphs, or transformation of the *VNF forwarding* graph in virtual networks instances). In a distributed context, the network operators should collaborate to reach a global and effective solution. To do this, there is a need to select the partial information to share before proposing efficient algorithms for PC-VNF problem.

In addition to the optimization and/or verification of the most common quality criteria, we wish to study and propose, in this thesis, new algorithms solving PC-VNF by maximizing the resilience. The method we used for minimizing the probability of failure or using protection [3] in a similar context (Virtual Network Embedding) can then be adopted.

Finally, the placement and chaining of VNF for multicasting is another direction which could be explored.

Bibliography

[1] Bo Yi, Xingwei Wang, Keqin Li, Sajal k. Das and Min Huang. *A Comprehensive survey of Network Function Virtualization. Computer Networks* , vol. 133, pp 212-262, 2018.

[2] ETSI, *Network function virtualization* . White paper1, SDN and openflow world congress, 2012, Darmstadt, Germany. http://portal.etsi.org/NFV/NFV_White_Paper.pdf.

[3] Shuopeng Li, Mohand Yazid Saidi and Ken Chen. Survivable services oriented protection level-aware virtual network embedding. Computer Communications, vol. 152, pp 34-45, 2020.

Required skills

- Combinatorial optimization. - Good English skills (read, write) - Basic knowledge in Computer Networks.