PhD Thesis on Causality-Based Virtualized Network Configuration

Keywords: network, virtualisation, NFV, SDN, provisioning, causalities

Context:

With the ever increasing complexity of networks composed of numerous middleboxes, configuration of networks is a major challenge to address. Still mainly human-based, configuration often leads to error and wasting resources due to over-provisioning.

To cope with these problems, there have been initiatives to help in automating configuration but they are very focused for example to detect inconsistencies over distributed systems or to optimize a very specific application type, for instance the order of firewall rules [1], or the scheduling of flow [2] over an existing topology. Going further by making the network configuration more dynamic with fully automated processes is thus challenging because this would require first to know precisely at each time what is requested in terms of configured resources.

Thanks to SDN (Software-Define Networking) and NFV (Network Function Virtualisation), network services can be easily split into small building blocks which can be then assembled into a service chain on demand. One major research area in network provisioning using SDN/NFV is the automated construction of the service chain [3] which implies to know the dependencies among network services (or network functions).

However, it is impossible nowadays to predict what will be the necessary function at a particular time and how such a function (By function, we refer to a network service instantiated with a particular configuration) should be scaled regarding allocated resources. With virtualisation, another question is where to place this function.

Objectives:

The first objective of the thesis is to model causal dependencies (causalities). Causalities are arefinement of service dependencies which are used to specify necessary services to run another one. **Causalities is going further by defining the causes of the apparition of an event in a complex system**. Causalities are thus fine-grained. **They represent how a system behaves and are so more representative of what resources are needed** since events are related to a system state, especially because we promote to monitor them at different levels: network, system and application.

The second objective aims at optimizing the network and network services configuration in advance (provisioning) relying on the causalities for defining configuration decisions and on virtual network technologies to implement them. As previously highlighted, the causal model introduces a fine-grained understanding of the network behavior regarding network, application and system events, which will thus also results in fine-grained provisioning decisions.

Automation of configuration will come from the automatic inference of the network service chain. **Occurring events, considered as premises, can be mapped to an instantiated causal model to predict the events** in a close future, i.e. from few seconds to few hours, which is now relevant in the context of SDN and NFV. This encompasses both flows and network functions.

References:

[1] E. Al-Shaer, “Dynamic firewall configuration optimization,” in Automated Firewall Analytics. Springer International Publishing, 2014, pp. 95–127.

[2] M. Al-Fares, S. Radhakrishnan, B. Raghavan, N. Huang, and A. Vahdat, “Hedera: Dynamic flow scheduling for data center networks.” in NSDI, vol. 10, 2010, pp. 19–19.

[3] T. Wolf, “In-network services for customization in next-generation networks,” Network, IEEE, vol. 24, no. 4, pp. 6–12, 2010.

Working Environment:

The PhD candidate will integrate the Madynes research group (http://madynes.loria.fr/). Madynes is a leading research team on network management. The team is a joint project-team between Inria, CNRS and Université de Lorraine. The goal of the research team is to design, validate and deploy novel management and control paradigms and software architectures able to cope with (1) the growing dynamics of both telecommunication infrastructures and services and, (2) the scalability issues induced by the ubiquitous Internet. The group therefore works on autonomous management with a strong focus on three functions: security, configuration and monitoring.

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