CIFRE PhD Proposal
Fault-management in software-defined networks

**Location:** Alcatel-Lucent Bell Labs (Villarceaux), XXX team, and INRIA (Rennes), SUMO team

**Topic:** Telecommunication networks long relied on dedicated equipment, software and management protocols. They are now at the edge of a new era, under the pressure of several factors: the convergence of IT (information technologies) and networking, the need to cut costs on operators’ side by sharing standardized hardware, the need to quickly and simply deploy tailored services for users, the increase in bandwidth demand, the need to cope with a variety of new and heterogeneous network usages, the necessity to reconcile network design and management with the applications developed on top of it. In practice, networks are progressively adopting virtualization techniques that were developed for cloud computing.

These software-defined networks (SDN) replace traditional dedicated hardware (for access control, load balancing, routing, firewall, data-base, etc.) by a combination of interacting virtualized network functions, i.e. software components, that can themselves run on virtual machines. SDNs bring the promise of networks that could be easily and quickly adapted to a wide variety of (new) services and demands, or even be self-adaptive, at the expense of an extra level of complexity. They therefore require to rethink the management paradigms in order to keep networks under control, while releasing human operators from routine and cumbersome operations.

The objective of this thesis is to contribute to the design of management functions for SDNs. The focus will be on trouble-shooting, that is the detection of malfunctions, the identification of their root-cause(s), the evaluation of their impact, and the recommendation of possible repair actions. A long term objective is to close the loop and contribute to self-healing methodologies. The candidate will explore model-based approaches to diagnosis, where the model encodes in particular how various network functions depend on one another, and how malfunctions propagate. The exact nature of these models will have to be adapted to the considered use-case, but several model families are envisioned, ranging from Bayesian Networks to networks of automata or Petri nets.

The thesis will focus on specific features of SDNs. First, SDNs are highly dynamic. This induces that their model must be adapted to track topological changes, or even be built in real time, following the needs of the supervision algorithms (self-modeling). Secondly, one must capture the random phenomena that occur in the dynamics of networks, in the occurrence of failures, in the load/usage of the network. Thirdly, the dynamics of SDNs are highly parallel: several changes can occur at the same time, and the time ordering of events is not a direct reflection of causality relations. Therefore network management must focus on the capture of causality relations between events. A fourth feature is that not all events are directly observed: routine management generally focuses on high-level indicators and on alarms that are raised by the network. One must then design diagnosis algorithms that adapt to this partially observed setting, and that refine their model of the network and dynamically query event logs to precisely locate the origins of malfunctions. Other research directions are envisioned, such as the distributed management of SDNs, to account for cross-layer or cross-domain trouble-shooting methods, or the design of richer logging mechanisms that allow for accurate forensics on failure events.

The expected contribution of the PhD candidate will be both theoretical, methodological, and practical, in the sense that a demonstrator of the proposed techniques is expected. An important part of the work will consist in extracting the most relevant use-cases of SDN malfunctions, and to prove that the proposed modeling formalisms and diagnosis algorithms are adequate.

The PhD candidate will be located both at Alcatel-Lucent Bell Labs France in Villarceaux, and at INRIA Rennes in the Sumo team.

**Ideal profile:** master or engineering degree in network management or computer science, with a taste for formal methods

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