Open PhD Position :
Fault-management in cloud networks

General context : Telecommunication networks long relied on dedicated equipment, software and management protocols. Today, at the edge of a new era, networks are progressively adopting virtualization techniques that were developed for cloud computing. The emerging software-driven networking approaches aim at putting as much of the networking tasks as possible into software and run them on commodity servers to make the network more agile and responsive. Namely, NFV (Network Functions Virtualisation) transforms network services such as load balancing, firewall, or traffic analysis into software applications running on virtual machines (VM), while SDN (Software-defined Networking) decouples the network control plane from the underlying hardware-based data forwarding plane. These software-driven approaches are deployed over cloud infrastructures which provide methods to enhance resource availability and usage by means of orchestration and management mechanisms. The presence of this additional infrastructure layer together with other above mentioned factors requires to rethink the supervision and management paradigms in order to keep these cloud networks under control, while releasing human operators from routine and cumbersome operations.

Objectives : The objective of this thesis is to contribute to the design of such multi-layer management mechanisms. 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 or arbitrary telco applications 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.

Challenges : The contribution of the PhD candidate will be both theoretical, methodological, and practical, in the sense that experimentation and testing of the proposed techniques are expected. An important part of the work will consist in extracting the most relevant failure use-cases in cloud networks, to prove that the proposed modeling formalism and diagnosis algorithms are adequate. The thesis will focus on specific features of the emerging cloud networks.

- *Dynamicity*: due to the elasticity of cloud networks, the models must be adapted to track topological changes, or even be built in real time, following the needs of the diagnosis algorithm (self-modeling).
- *Uncertainty*: one must capture random phenomena that occur in the dynamics of networks, in the occurrence of failures, in the load/usage of the network.
- *Concurrency*: several changes can occur at the same time, and the time ordering of events is not a direct reflection of causality; one must focus on capturing the causality relations between events.
- *Partial observability*: not all events are directly observed, the diagnosis algorithms must be able to infer the missing events when localizing the malfunctions.
- *Scalability*: cloud network are large-scale distributed systems, the adequate supervision mechanisms should rely on sclalable distributed algorithms which foster local data processing and summarization.

Location and organization : The PhD position is established in the scope of a Common Lab Nokia Bell Labs - INRIA. The PhD candidate will be located at Nokia Bell Labs in Paris region (Nozay) with frequent visits to INRIA lab in Rennes, and will benefit from the advantages of both academic and industrial research environments.

Candidate profile : master or engineering degree in computer science with strong knowledge in at least one of the following areas: networking technologies, cloud computing, and formal methods.

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