Title: Network-aware software deployment and configuration for the IoT

Location: Shared between Inria and Bell Labs

Supervisors: Olivier Barais, Ludovic Noirie, Johann Bourcier

PhD Topic:

The Internet has led to the creation of a digital society, where (almost) everything is connected and is accessible from anywhere. Most things we rely on in our everyday life will contain sensors and electronic-based information and have enough computing power to run embedded software applications which connect to the Internet and clouds to get access to virtually unlimited resources. The running environment of IoT services composed of a wide set of heterogeneous platforms, promises to be a fertile environment to engineer advanced services with high added value. Therefore, it is quite impossible to anticipate all the services that would be deployed on such a dynamic infrastructure. All the running systems (things, network devices, software function, network configuration) become dynamic and reconfigurable.

Among the difficulties when the applications and the running infrastructure are highly dynamics, the network configuration and its consistency with the software services requirements is one of the main challenge. Indeed, despite their widespread adoption, traditional IP networks are complex and very hard to manage. For example, the access to a smart thing installed at home generally requires to configure the local network. Therefore, designing new services by integrating a set of things from several buildings, cars, and smartphone becomes incredibly complex. The network is also complex to configure in order to automatically respond to natural changes in the environment such as: faults, changing loads, and the availability of specific devices. To make things even worse, current networks are also vertically integrated: the control and data planes are bundled together.

Software-defined networking (SDN) and Network Function Virtualization (NFV) are paradigms that promise to change this state of affairs. SDN breaks vertical integration, separates the network's control logic from the underlying network devices (routers, switches), promotes (logical) centralization of network control, and introduces the ability to program the network. The separation of concerns, introduced between the definition of network policies, their implementation in switching hardware, and the forwarding of traffic, is key to the desired flexibility: by breaking the network control problem into tractable pieces, SDN makes it easier to create and introduce new abstractions in networking, simplifying network management and facilitating network evolution. NFV virtualizes network functions that can then be implemented in the cloud, replacing some network functions that are classically implemented in the network elements. The combination of SDN and NFV paradigms allows to design, control and manage the network in a more flexible way than without them. If we assume a clear API to program and configure the network, the next research questions are the following:

1. How to program the network configuration of a SDN/NFV-based network (what is the right abstraction)?
2. How to ensure the consistency between the software layer and the network layer?
3. How to automatically (re)configure the network based on the IoT software requirements?
4. How to automatically ensure properties such as reachability, privacy, security, performance on a transient network configuration?

To face these challenges, the PhD aims at providing a common programming language and its runtime infrastructure for managing distributed assembly of NFV and SDN within an IoT use-case.

The main objectives of the PhD will be the following:

- Establish a clear state of the art on languages for NFV/SDN interfaces, NFV configuration and SDN services configuration and a taxonomy of inconsistency for SDN services configuration towards application services assembly description.
- Based on this taxonomy and on the existing approaches, the PhD candidate would define the set of properties that can be checked to guarantee reachability, privacy and performance.
- Following the related work, the existing standards and the set of properties to check, the next step is to propose a common configuration language to define SDN/NFV interface, the compatibility function, their assembly and deployment. During this step, we will also propose a programming model and environment for SDN/NFV. Based on this framework, a set of experiments will be performed to implement the scenario defined in axis 1 by using the proposed approach.
- Integrate a chaos engineering principles to the proposed approach to improve the robustness of the software-defined network services using this approach.
- Explore the concept of equivalence for SDN/NFV services and propose an approach to constantly evolve the attack surface of the network services.

Working Environment

The candidate will work at INRIA in the DIVERSE team (workplace: Université Rennes 1, Campus de Beaulieu, 35000 Rennes, France), the contract is for 36 months, and the monthly net salary is around 1600 euros. The candidate will also work part time at the Nokia Bell Labs in Nozay, close to Paris.

DIVERSE's research is in the area of software engineering, focusing on the management of diversity in the construction of software intensive systems. The team is actively involved in European, French and industrial projects and is composed of 8 faculty members, 18 PhD students, 2 postdocs and 4 engineers.

Nokia is a global leader in the technologies that connect people and things. With state-of-the-art software, hardware and services for any type of network, Nokia is uniquely positioned to help communication service providers, governments, and large enterprises deliver on the

promise of 5G, the Cloud and the Internet of Things. Serving customers in over 100 countries, our research scientists and engineers continue to invent and accelerate new technologies that will increasingly transform the way people and things communicate and connect.

How to apply

Please send your application (PDF) as soon as possible. Screening of applications starts immediately and continues until the position is filled. Send cover letter, CV, PDFs of Master thesis (or draft) to Olivier.barais@irisa.fr and Johann.Bourcier@irisa.fr.

References

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