PhD Position - Reconfiguration of large scale distributed systems and software in a Fog computing context

About Inria

Inria, the French national institute for research in computer science and control, is dedicated to fundamental and applied research in information and communication science and technology (ICST). Inria has a workforce of 3,800 people working throughout its eight research centers established in seven regions of France.
The PhD student will be integrated into the Ascola Research Team localized in Nantes, and the Avalon Research Team localized in Lyon. The co-advisor will be Hélène Coullon (Nantes) and the advisor will be Christian Perez (Lyon).

Mission and activities

This Ph.D. position targets dynamic reconfiguration of distributed systems and distributed software at large scale in a Fog computing context. The candidate will study the specific use case of a distributed OpenStack system as targeted by the Discovery project.

Distributed systems and distributed applications are an important and old topic of computer science where developers can build block-based codes that can be distributed among geo-distributed communicating resources. Nowadays this topic is very active because of the emergence of the Fog computing paradigm (which is an extension of the cloud to the core and the edge of the network), and the democratization of connected intelligent objects (IoT and smart-*) [1].

The topic tackled by the Ph.D. candidate will be the reconfiguration of distributed systems and distributed software in the specific context of Fog computing. Thus, the work will focus on how to express the way a large-scale distributed system (or software) is able to evolve regarding some external events and choices.
For example, a distributed system has to be able to dynamically change its structure because of external energy constraints or because of the evolution of the underlying infrastructure. Thus, a challenge is being able to express how this system should possibly evolve in the future, while not knowing in advance what could happen. A difficulty is how to easily and securely express and enforce such global reconfiguration without a centralized point of management.
The real case study of OpenStack will be handled during the Ph.D. work. OpenStack is the de-facto open-source solution to address the Infrastructure as a Service (IaaS) level of the Cloud paradigm. OpenStack is a large distributed system, which, applied to the specific Fog computing paradigm, is subject to large-scale reconfigurations. These reconfigurations could be due, for example, to the highly moving state of the infrastructure, to some energy saving strategies, or to scaling problems etc.
One can note, however, that this work could be enlarged to many other use cases such as applications of IoT and smart-*.

The domain of component programming models will be a starting base for the Ph.D. candidate, even if she/he will be free to also investigate into hybrid programming models if needed.
Component programming models have shown many times their powerful software engineering features [2] regarding distributed software development. In such models, components and connectors are independent pieces of code defining functionalities and their interactions with the outer world. Component assemblies represent the specific way to instantiate components and connectors for a specific software. As a result, reconfiguration in

such a model is the possibility to move from one component assembly (a graph) to another one [3,4].
In previous work, a “general purpose” solution has already been proposed to be able to specialize a component assembly [5], i.e. choosing one assembly or another at compile time. However, this solution does not address code specialization on the fly for a running software.
Finally, the DirectMOD component model [6] proposes a set of assembly transformations and their associated operational semantics to be able to reconfigure at runtime a high performance computing application (HPC). However, specificities of distributed systems has not been studied and handled in this work.

This work will be part of the Discovery Inria Project Lab (http://beyondtheclouds.github.io/), which opens to many research collaborations and huge impact on the community.

References

[1] Bonomi, Flavio and Milito, Rodolfo and Zhu, Jiang and Addepalli, Sateesh. Fog Computing and Its Role in the Internet of Things. In Proceedings of the First Edition of the MCC Workshop on Mobile Cloud Computing, 2012.

[2] Szyperski, Clemens. Component Software: Beyond Object-Oriented Programming. 2002.

[3] Coullon, Hélène and Bigot, Julien and Pérez, Christian. The Multi-Stencil Language: orchestrating stencils with a mesh-agnostic DSL. Inria Research Report, 2016.

[4] Richard, Jérôme and Pérez, Christian and Lanore, Vincent. Towards Application Variability Handling with Component Models: 3D-FFT Use Case Study. In UnConventional High Performance Computing, 2015.

[5] Lanore, Vincent and Pérez, Christian. A Calculus Enabling Reuse and Composition of Component Assembly Specialization Processes. Inria Research Report, 2015.

[6] Lanore, Vincent and Pérez, Christian. A Reconfigurable Component Model for HPC. In Proceedings of the 18th International ACM SIGSOFT Symposium on Component-Based Software Engineering, 2015.

Skills and profiles

Knowledge and/or experience on programming languages and software engineering
Knowledge and/or experience on distributed systems
Experimentation skills
Autonomy / Curiosity
English mandatory

Additional information

The candidates are invited to contact Helene Coullon and Christian Perez (firstname.name@inria.fr).

Duration: 36 months
Location: Nantes, France
Monthly salary after taxes: around 1958 euros (medical insurance included).