"Infrastructure adaptation for applications in the edge-cloud spectrum"

Ph.D. thesis proposal in the group for the Security and Performance of Networked Systems, UCLouvain, in the context of a 4-year collaborative project between UCLouvain and UNamur.

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Context

Emerging collaborative applications such as smart cyber-physical environments, augmented reality, or virtual spaces typically rely on cloud infrastructures to host applications backends, store shared state, and implement the logic of interactions between users. Traditional cloud infrastructures formed of centralized data centers have enabled ease-of-programming, scalability, and cost-efficiency but are a poor fit for latency-sensitive applications due to the significant network latency between users and data centers.

An emerging model to solve this issue is the *edge-cloud* model, where large data centers are complemented by smaller ones distributed over the globe and operating close to the users. However, the complexity of edge-cloud infrastructures makes the task of writing efficient application backends a tedious task for programmers. The manual management of application state and data sharing, and the placement of application components over the edge-cloud spectrum requires to factor in a lot of complexity in the application development.
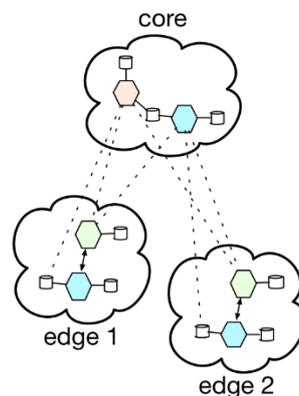
Goal

This Ph.D. thesis will be part of a collaborative project between UCLouvain and UNamur that has as goal to enable and support **the automatic adaptation of applications (so-called "edgified applications") in the edge-cloud spectrum**. More specifically, the researcher will work on methods and tools for the dynamic adaptation of core-edge infrastructures according to the needs of such edgified applications. This includes the dynamic allocation of infrastructure resources as well as the continuous monitoring of the infrastructure state and application performance to guide the adaptation process. Concrete goals will be:

- Extend Kubernetes-based open-source frameworks for edge computing by a management layer that supports the adaptation process.
- Develop resource management strategies that distribute the available resources between the different edgified applications hosted by the infrastructure.
- Create performance models for the infrastructure that allow, based on the collected monitoring data, to visualize and predict the impact of adaptation actions on the

performance of the applications. Ultimately, the researcher will contribute, in cooperation with other researchers working on the project, to the definition of joint models of the application, of its execution, and of its adaptation at runtime. These models and the collected data will allow the application developers to evolve the application towards more amenability to edge-cloud deployment and automated adaptation.

Profile and skills

This thesis is particularly suited for a candidate with interests in network and infrastructure management, cloud computing, and monitoring and modeling of computer system performance.

The research will focus on a *systems* approach, meaning that the conceptual contributions must be validated by the development and evaluation of proof-of-concept prototypes. Therefore, programming skills and the will to delve into the practical aspects of containerization/virtualization tools and system monitoring is required.

In addition to the technical skills, the candidate is expected to be able to work in collaboration with other junior and senior researchers active in fields such as software engineering, database engineering, cloud computing, and security.

English will be the primary working language (i.e., speaking French is not a requirement).

Environment

The Ph.D. position is funded for a total of 4 years (competitive salary + research expenses). The Ph.D. candidate will be hosted in the group for *Security and Performance of Networked Systems* at UCLouvain's ICTEAM (Institute for Information and Communication Technologies, Electronics and Applied Mathematics). They will interact with other members of the group as well as members of ICTEAM's Cloud and Large-Scale Computing group and of the Research Center on Information Systems Engineering (PReCISE) at the University of Namur.

ICTEAM is a top-level research institute with excellent facilities. The candidate will have access to several distributed clusters with high-end, recent servers and edge resources to test the contributions. UCLouvain is Belgium's largest French-speaking university and is ranked in the first 100 institutions for computer science and information systems by the QS World University Ranking. The position is in Louvain-la-Neuve, a modern city 30 km south of Brussels with excellent quality of life and connectivity to Belgium, Europe, and the world.

Application

Interested students should send an application file (PDF only, in English) with the following information to both of the promoter:

- An up-to-date CV;
- Link to a copy of the publication(s), if any, and to Masters' thesis;
- If applicable, a link to a GitHub (or similar) profile with examples of personal software contributions;
- Masters' degree transcripts;
- The name and emails of up to three reference persons able to provide an assessment of the application. Reference letters sent by the applicant her/himself will be ignored;

- A short cover email detailing your motivation for pursuing a Ph.D. and your interest in this specific topic.

Application deadline: ASAP -- applications will be screened as they arrive. Feel free to send a declaration of intent or request for clarification before sending a formal application.

Target starting date: September 1st, 2022 (flexible)

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