M2 Internship

Title: "Concurrent Autonomic Control for the Computing Continuum"

Keywords: Autonomic Computing; MAPE–K; Concurrent Control; Cloud-Edge-IoT Continuum; Service Placement; Orchestration; Distributed Systems.
Duration: 5–6 months.
Start Date: Ideally in February 2026.
Supervisors: Farah AIT-SALAHT (ESILV/DVRC) and Christian PEREZ (Inria/AVALON).
Internship Location: Research Center of the Léonard de Vinci Pôle Universitaire, 92916 Paris La Défense, France.

PEPR Cloud/TARANIS
This internship is part of the PEPR Cloud program, within the TARANIS project and Work Package 3 on Service and Resource Orchestration. The AVALON research team is seeking an internship candidate to work on the design and evaluation of adaptive and autonomic orchestration algorithms for service and resource management in the Cloud-Edge-IoT continuum.

Context

The *Computing continuum* poses complex management challenges [1]. Its distributed, heterogeneous, and dynamic nature demands control systems that can adapt in real time to changing conditions, new demands, and potential failures. To achieve this agility, self-adaptive (autonomic) systems are widely employed, typically organized around the MAPE–K loop: *Monitor, Analyze, Plan, Execute* over a shared *Knowledge* base [2]. However, many implementations adhere to a rigid, sequential pipeline in which each phase waits for the previous one to complete, incurring latency and degrading responsiveness to rapid changes.

A promising alternative is *intra-loop parallelism*: overlapping the planning and execution phases, potentially running multiple plan–execute cycles concurrently, while preserving safety and stability. In addition, decentralized control patterns can reduce bottlenecks at scale and are relevant comparators for this work [3]. As a representative use case within the Computing continuum, the *service placement* problem will be considered as a primary case study for the proposed concurrent model [4], alongside related work on optimizing autonomic managers in service-based applications [5, 6].

This internship has a theoretical part - formalization of a *concurrent* autonomic control model, and a practical part - rigorously quantifying their impact relative to classic sequential models and decentralized control architectures.

Potential PhD Thesis: Successful completion of this internship may lead to a PhD opportunity.

Objective

The main objective is to design, implement, and comparatively evaluate autonomic control patterns (sequential, concurrent/overlapped, decentralized) within the Edge–Cloud continuum, using both simulation and a real prototype, and to consolidate theoretical results on intra-loop parallelism with empirical evidence. More precisely, the internship is about:

1. Structuring the research problem by analyzing the assumptions and limitations of existing autonomic control models [1, 2, 3].
2. Formalizing a concurrent autonomic control model, identifying hypotheses, constraints, and expected benefits, with service placement as the main application problem.
3. Designing a rigorous evaluation methodology to compare sequential, overlapping, and decentralized controllers on service placement use cases.
4. Developing a lightweight simulation environment and a proof-of-concept prototype, used primarily as tools for scientific investigation on service placement in the Edge–Cloud continuum.
5. Evaluating and comparing the proposed approaches (trade-offs, bottlenecks, limits).
6. Producing a research-oriented synthesis that highlights findings, limitations, and future directions.

Expected skills and profile

We are looking for a final-year engineering or master's student with the following characteristics:

- Solid programming abilities (Python), sufficient to build prototypes supporting scientific exploration.
- Good understanding of distributed systems, cloud/edge computing, and containerized architectures (*e.g.*, Docker, Kubernetes).
- Strong interest in research questions related to autonomic systems, performance modeling, or adaptive algorithms.
- Experience with experimental design, benchmarking, or evaluation methodologies is a plus.
- Curiosity, rigor, autonomy, and good communication skills. Interest in pursuing a PhD is appreciated.

Supervision and location

The internship will be jointly supervised by

- the De Vinci Research Center (DVRC) (with Farah AIT-SALAHT and Daniel Wladdimiro).
- the AVALON team (Inria – CNRS – ENS de Lyon – Université Claude Bernard Lyon 1) at the LIP laboratory (ENS Lyon) (with Christian Perez and Laurent Lefèvre)

Location: The internship will take place at the Léonard de Vinci Pôle Universitaire, Paris La Défense.
Note: Short research visits to the AVALON team at ENS Lyon will be required during the internship.

Contact Information and Application Process

Supervisors:

- Farah AIT-SALAHT (farah.ait_salaht@devinci.fr)- Associate Professor at ESILV-DVRC.
- Christian PEREZ (christian.perez@inria.fr) - Inria Senior Researcher at AVALON, LIP, ENS Lyon.

Application: Please send the following documents as a single PDF file to both supervisors:

- Motivation letter (at most one page);
- Detailed Curriculum Vitae (maximum 2–4 pages);
- Academic transcripts (Bachelor and Master levels);
- Contact information of two academic references.

Application Deadline: The position remains open until we find a suitable applicant.

Last but not least

Only applications including all required documents will receive full consideration. Only shortlisted applicants will be contacted for an interview.

References

[1] F. Golpayegani, N. Chen, N. Afraz, E. Gyamfi, and et al., "Adaptation in edge computing: a review on design principles and research challenges," *ACM Transactions on Autonomous and Adaptive Systems*, vol. 19, no. 3, pp. 1–43, 2024.

[2] J. O. Kephart and D. M. Chess, "The vision of autonomic computing," *Computer*, vol. 36, no. 1, pp. 41–50, Jan 2003.

[3] D. Weyns, B. Schmerl, and et al., *On Patterns for Decentralized Control in Self-Adaptive Systems.* Springer Berlin Heidelberg, 2013, pp. 76–107.

[4] F. Aït-Salaht, F. Desprez, and A. Lebre, "An overview of service placement problem in fog and edge computing," *ACM Computing Surveys (CSUR)*, vol. 53, no. 3, pp. 1–35, 2020.

[5] V. Cardellini, T. Galinac Grbac, M. Nardelli, and et al., "Qos-based elasticity for service chains in distributed edge cloud environments," in *ACROSS.* Springer Int. Publ. (Cham), 2018, pp. 182–211.

[6] L. Hadded, F. B. Charrada, and S. Tata, "An efficient optimization algorithm of autonomic managers in service-based applications," in *On the Move to Meaningful Internet Systems: OTM 2015 Conferences.* Springer, 2015, pp. 19–37.