Network Research Group

PhD thesis
2024–2027

Inter-domain Monitoring and Predictions for Service Orchestration in 5G

Location	Network research group – ICube (UMR CNRS 7357), University of Strasbourg (France)
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Keywords

Monitoring; SLA; Supervision; Aggregation; Prediction; Reinforcement learning

Context

5G networks expect to be particularly complex [1]: they mix different radio technologies, they provide slices mapped on the same physical topology, MVNO rely on other physical operators, etc. Moreover, we need to interconnect multiple domains [2], while each stakeholder must have the opportunity to keep most of its intellectual property (topology, protocols, intra-domain allocation, etc) secret. A hierarchical organization of the controller helps to make the infrastructure more efficient [3] but seems unrealistic in inter-domain topologies. More recently, Artificial Intelligence has been proved to be particularly relevant to make the network intelligent in intra-domain [4]. The challenge consists in providing a unified access to such multi-technology, multi-operator network infrastructure.

Scientific Objectives

In this PhD thesis, we focus on the inter-domain service assignment problem in 5G networks. The objective is to allocate enough ressources for services (fault-tolerance, response time, load, etc.) in a multi-domain infrastructure.

We consider the following architecture:

1. each domain reports a set of metrics collected in real-time. These time-series are stored in a distributed filesystem;
2. when the inter-domain decision engine receives a novel request, it has to decide which domains may respect the Service Level Agreements (SLAs). More precisely, based on the metrics collected, the decision engine predicts the performance of the request on each of the possible domains.
3. finally, the decision engine must select the most efficient set of domains (energy, cost, load-balancing)

The multidomain architecture make such approach challenging. We need to address the following challenges:

1. from a holistic examination of SLAs defined for 5G networks, we must identify the critical performance indicators essential for meeting service levels, and an in-depth analysis of the challenges posed by multi-actor environments.
2. subsequently, we must define comprehensive metrics and methodologies capable of quantitatively measuring 5G network performance. This involves identifying and formulating metrics that accurately reflect the diverse aspects of network operations and align with the dynamic nature of 5G services.

3. we must predict the performance of end-to-end Key performance Indicators based on a collection of features (aka metrics) from the different domains, even with complex interactions. While propositions have been done in Virtualized Networks [5], we expect to push here the problem further to address the inter-domain scenario.
4. we cannot have perfectly accurate measurement, and our algorithms have to accommodate uncertainty. Thus, we expect to leverage on Reinforcement Learning to explore the different set of solutions, and adapt the internal models accordingly. The models must keep on reflecting the actual performance measured in real-time.

Skills

The expected skills are:

- Excellent programming skills in C and Python;
- Distributed algorithms;
- Wireless networks (protocols and radio propagation), energy efficiency;
- Knowledge of Reinforcement Learning algorithms (e.g., Q-learning, Deep Q Networks, or policiy gradient methods);
- Applicants should possess good verbal and written English skills. French is **not** a requirement;
- Holding an MSc in Computer Science (CS) or Electrical and Computer Engineering (ECE) is mandatory.

Application

Please send an email to reseaux-pos-2024@icube.unistra.fr including:

- a detailed CV;
- your possible list of publications if applicable;
- the grades for the last three years, with your position after the final exams;
- a cover letter

Deadline : March 30, 2024

References

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