

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

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Keywords

Monitoring; 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 resources 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. we must predict the performance of end-to-end Key performance Indicators based on a collection of features. While propositions have been done in Virtualized Networks [5], we expect to push here the problem further to address the inter-domain scenario.
2. we will select which metrics (aka features) to collect and to report from the different domains to make accurate predictions, even with complex interactions (each domain is itself divided in slices, etc.)

3. 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 embedded programming;
- Distributed algorithms;
- Wireless networks (protocols and radio propagation), energy efficiency;
- 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-2023@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

References

- [1] Keshav Sood, Kallol Krishna Karmakar, Vijay Varadharajen, Neeraj Kumar, Yong Xiang, and Shui Yu. Plug-in over plug-in evaluation in heterogeneous 5g enabled networks and beyond. *IEEE Network*, 35(2):34–39, 2021.
- [2] Mohamed Boucadair, Christian Jacquenet, and Emmanuel Bertin. *An Approach to Automated Multi-domain Service Production for Future 6G Networks*, pages 167–186. 2022.
- [3] Volkan Yazıcı, Ulas C. Kozat, and M. Oguz Sunay. A new control plane for 5g network architecture with a case study on unified handoff, mobility, and routing management. *IEEE Communications Magazine*, 52(11):76–85, 2014.
- [4] David M. Gutierrez-Estevez, Marco Gramaglia, Antonio De Domenico, Ghina Dandachi, Sina Khatibi, Dimitris Tsolkas, Irina Balan, Andres Garcia-Saavedra, Uri Elzur, and Yue Wang. Artificial intelligence for elastic management and orchestration of 5g networks. *IEEE Wireless Communications*, 26(5):134–141, 2019.
- [5] Gyeongsik Yang, Yeonho Yoo, Minkoo Kang, Heesang Jin, and Chuck Yoo. Bandwidth Isolation Guarantee for SDN Virtual Networks. In *IEEE INFOCOM 2021 - IEEE Conference on Computer Communications*, pages 1–10, Vancouver, BC, Canada, May 2021. IEEE.