Inria Associate Teams programme

Intermediate report (Year 1)

Associate Team acronym: EfDyNet (Efficient Dynamic Resource Allocation in Networks)
Period of activity: 2019.
Principal investigator (Inria): Frédéric Giroire (COATI, Inria Sophia Antipolis)
Principal investigator (Partner Institution): Brigitte Jaumard (Concordia University, Montréal, Canada).

1. Future of the Associate Team

Would you like to pursue this Associate Team for one more year? ☒ Yes ☐ No

2. Website of the Associate Team

https://team.inria.fr/coati/projects/efdynet/

3. List of participants

EPI Coati: David Coudert, (DR Inria), Giuseppe Di Lena (PhD Student, 2018-2021), Adrien Gausseran (PhD Student, 2018-2021), Frédéric Giroire (CR CNRS), Joanna Moulierac (MC Univ. Côte d'Azur)
Concordia University: Brigitte Jaumard (professor, chair), Huy Duong (PhD student since June 2018), Quang Anh Nguyen (PhD student since Sep. 2018), Shima Ghanei Zare (PhD student since Sep. 2018), Jean Toniolli (Master student 2018-2020)

During the first year, we organized the following visits:
- To Montréal: D. Coudert (July 12-27), A. Gausseran (3 months, Sep. 4- Dec. 4), F. Giroire and J. Moulierac (Oct. 8-18).
- To Nice: B. Jaumard (Jun 20-24 and Dec. 7-21).

4. Achievements and Planned activities

Context: Networks are evolving rapidly in two directions. On the one hand, new network technologies are developed for different layers, and in particular flexible optical technologies (enabling to allocate a fraction of the optical spectrum rather than a fixed wavelength), Software Defined Networks (SDN), and Network Function Virtualization (NFV). On the other hand, the traffic patterns evolve and become less predictable due to the increase of cloud and mobile traffic. In this context, there are new possibilities and needs for dynamic resource allocations. During the first year, we obtained the following achievements:

- **Reconfiguration.** We studied how to use SDN and NFV to allow the flexible deployment of new services in order to meet changing application requirements. We proposed efficient methods to reconfigure networks to close to optimal operational states during time, at the optical layer [1], at the user layer [2], and for Service Function Chains (SFC) [3,11,12].

- **Protection against failures**. The emergence of the NFV and SDN paradigms also led to rethink the way networks can be protected against failures. In [7,10], we developed two scalable mathematical models for a path-based protection scheme with a global rerouting strategy for the classic network dimensioning problem with protection against Shared Risk Link Group (SLRG) failures.

- Software tool. We tested our solutions by emulation using Mininet, the most popular tool when it comes to evaluate SDN propositions. However, for some of our resource intensive experiments, the host running Mininet was overladed. To tackle this issue, we developed a new generic tool Distrinet, a way to distribute Mininet over multiple hosts [8]. The distribution is automatically deployed in a Linux cluster, Grid5000, or in Amazon EC2. The tool was made available for the community [13] and will be demonstrated in CoNEXT 2019.

- Scheduling. We also consider the placement of cloud resources inside a data center [3,6]. Traditionally, this is done by a task orchestrator without taking into account network constraints. According to recent studies, network transfers represent up to 50% of the completion time of classical jobs. In [3], we propose a new scheduling framework taking into account the competition between communications for the network resources.

- Seminars.

- F. Giroire, presentation of the thematic of EfDyNet, during a team seminar at Concordia.
- D. Coudert, on the "Flinders Hamiltonian Cycle Problem Challenge", seminar of the Department of Computer Science & Software Engineering, Concordia Univ., Jul 25, 2019.

Work program for next year:

In the second year of the project, a first axis is to deepen our understanding of the multi-level network reconfiguration. A second axis is to consider the specific challenges brought by the 5G technology, and in particular, network slices.

5G is envisioned to allow a multi-service network supporting a wide range of communication scenarios with a diverse set of performance and service requirements. The concept of network slicing has been proposed to address these diversified service requirements. A network slice is an end-to-end logical network provisioned with a set of isolated virtual resources on a shared physical infrastructure. Network slicing will thus be a fundamental feature of 5G networks.

We started working on the efficient methods for the provisioning of static slices [4]. Our plan for next year is to tackle the problem of reconfiguring slices in very dynamic environments with a high churn of slice demands.

Last, more generally, we plan to study efficient ways to carry out service placements at the edge of the network to solve the challenges introduced by the 5G, Mobile Edge Computing or Fog Computing paradigms, i.e., how to efficiently handle the needs in computing, routing, and storing of very dynamic applications.

5. Budget requested for the coming year

Planned visits in the coming year:

Requested Budget: 13 000 euros.

Inria to Concordia	People	Duration	Estimated cost (including travel)
Researchers	3	3 * 2 weeks	9k euros
Ph.D. student	1	3 months	6k euros
Estimated total cost			15k euros

Concordia to Inria	People	Duration	Estimated cost (including travel)
Researcher	1	2 weeks	3k euros
Ph.D. student	1	2 month	4k euros
Estimated total cost			7k euros

Additional Fundings:

- Brigitte Jaumard has secured several contracts with CIENA on topics related to the ones of the associate team. Four Ph.D. students and one master student are working in the next years 2 or 3 years on the optimization of next-generation networks.
- We have current discussion with MITACS and CIENA for potential collaboration and grants to hosts students in 2020.
- The 3 months visit of A. Gausseran was funded by the EUR-DS4H.
- The work of G. Di Lena is funded by and Orange Ph.D. grant (CIFRE).
- We are planning to apply to the next year editions of France-Quebec calls.

Publications of the project

International Journals

[1] **Brigitte Jaumard**, Hamed Pouya, **David Coudert,** Wavelength Defragmentation for Seamless Migration. *Journal of Lightwave Technology, Institute of Electrical and Electronics Engineers (IEEE)/Optical Society of America(OSA)*, 2019, 37 (17), pp.4382-4393.

[2] **B. Jaumard**, **H. Q. Duong**, R. Armolavicius, T. Morris, Todd and P. Djukic. Efficient real-time scalable make-before-break network re-routing. In *IEEE/OSA Journal of Optical Communications and Networking (JOCN),* 11(3) pp. 52—56, 2019.

International Conferences

[3] **F. Giroire**, N. Huin, A. Tomassilli, and S. Pérennes. When network matters: Data center scheduling with network tasks. In IEEE International Conference on Computer Communications (INFOCOM), Paris, France, 2019.

[4] **H. Q. Duong, B. Jaumard**, A Nested Decomposition Model for Reliable NFV 5G Network Slicing. In *International Network Optimization Conference (INOC),* Avignon, France, Jun. 2019.

[5] **A. Gausseran**, A. Tomassilli, **F. Giroire**, and **J. Moulierac**. No Interruption When Reconfiguring my SFCs. In *IEEE International Conference on Cloud Networking (CloudNet)*, Coimbra, Portugal, 2019.

[6] **J. Toniolli**, **B. Jaumard**. Resource Allocation for Multiple Workflows in Cloud-Fog Computing Systems. In Workshop of IEEE/ACM International Conference on Utility and Cloud Computing (UCC Workshop), Auckland, New Zealand, Dec. 2019.

[7] A. Tomassilli, **G. Di Lena**, **F. Giroire**, I. Tahiri, D. Saucez, S. Pérennes, T. Turletti, R. Sadykov, F. Vanderbeck, and C. Lac. Bandwidth-optimal failure recovery scheme for robust programmable networks. In *IEEE International Conference on Cloud Networking (CloudNet*), Coimbra, Portugal, 2019.

[8] **G. Di Lena**, A. Tomassilli, D. Saucez, **F. Giroire**, T. Turletti, and C. Lac. Mininet on steroids: exploiting the cloud for mininet performance. In *IEEE International Conference on Cloud Networking (CloudNet)*, Coimbra, Portugal, Nov. 2019.

Extended Abstracts and Demos

[9] **G. Di Lena**, A. Tomassilli, D. Saucez**, F. Giroire**, T. Turletti, and C. Lac. Demo proposal – distrinet: a mininet implementation for the cloud. In International Confer- ence on emerging Networking EXperiments and Technologies (CoNEXT), Orlando, US, December 2019. Extended Abstract.

[10] A. Tomassilli, **G. Di Lena**, **F. Giroire**, Issam Tahiri, D. Saucez, S. Pérennes, T. Turletti, R. Sadykov, F. Vanderbeck, and C. Lac. Poster: Design of survivable sdn/nfv-enabled networks with bandwidth-optimal failure recovery. In IFIP Networking, Varsovie, Poland, May 2019. Extented abstract.

[11] **A. Gausseran**, A. Tomassilli**, F. Giroire**, and **J. Moulierac**. Poster: Don't Interrupt Me When You Reconfigure my Service Function Chains. In IFIP Networking, Varsovie, Poland, May 2019. Extented abstract.

National Conference.

[12] **A. Gausseran**, A. Tomassilli, **F. Giroire**, and **J. Moulierac**. Reconfiguration de chaînes de fonctions de services sans interruption. In Rencontres Francophones sur la Conception de Protocoles, l'Évaluation de Performance et l'Expérimentation des Réseaux de Communication (Cores), Saint Laurent de la Cabrerisse, France, Jun 2019.

Code

[13] Distrinet, https://distrinet-emu.github.io