Inria Associate Teams programme

Intermediate report (Year 2)

Associate Team acronym: TC(Pro)^3

Title: Termination and Complexity Properties of Probabilistic Programs.

Period of activity: 2020-2022

Principal investigator (Inria): Romain Péchoux, Inria project team Mocqua, Inria Nancy Grand Est

Principal investigator (Main team): Georg Moser, University of Innsbruck, Austria

Other participants: Martin, Avanzini, Inria project team Focus, Inria Sophia

1 Future of the Associate Team

Would you like to pursue this Associate Team for one more year? ■ Yes □ No
A restart in year 1 in 2022 for 3 years has been requested.

2 Website of the Associate Team

https://members.loria.fr/RPechoux/ea-tcpro%c2%b3/

3 List of participants

Vladimir Zamdzhiev, who has been hired on an Inria ISFP position, starting the 1st of October 2020, is joining the Associate team. He will bring his expertise on the semantics of quantum programming languages to the project. The permanent members of the project are listed below.

- **Martin Avanzini**, Focus, CR Inria, two weeks visit to Innsbruck, www-sop.inria.fr/members/Martin.Avanzini/.
- **Ugo Dal Lago**, Focus, PR, www.cs.unibo.it/~dallago/.
- **Gemma De las Cuevas**, Innsbruck, MCF,www.gemmadelascuevas.com/.
- **Emmanuel Hainry**, Mocqua, MCF,members.loria.fr/EHainry/.
- **Emmanuel Jeandel**, Mocqua, PR, members.loria.fr/EJeandel/.
- **Georg Moser** (PI), Innsbruck, PR, cl-informatik.uibk.ac.at/users/georg/.
- **Romain Péchoux** (PI), Mocqua, MCF HDR, members.loria.fr/RPechoux/.

- **Simon Perdrix**, Mocqua, CR HDR CNRS, members.loria.fr/SPerdrix/.
- **Florian Zuleger**, Innsbruck, MCF, informatics.tuwien.ac.at/florian-zuleger.
- **Vladimir Zamdzhiev**, Mocqua, CR Inria, members.loria.fr/VZamdzhiev/.

4 Achievements and Planned activities

Achievements (2021): Five online meetings or work sessions have been organized during the year 2021 (the precise schedule is provided on the website). They have been complemented by the two visits of Martin Avanzini to Innsbruck (July 2021) and Nancy (October 2021).

The team is currently working in two main directions:

- Complexity analysis and almost sure termination of probabilistic program: Avanzini, Hainry, and Péchoux have started new work in which they intend to provide characterizations of probabilistic complexity classes such as PP and to adapt termination techniques of classical programs (e.g. the size change principle) to the (almost-sure) termination of probabilistic programs. This work is under development and will be pursued in 2022.
- Average case complexity analysis of Quantum programs: Avanzini, Moser, Péchoux, Perdrix, and Zamdzhiev have worked on the extension of the average case resource analysis of probabilistic programs [2] (2020 achievement) to a quantum programming language. A paper is being written and should be submitted to the Logic In Computer Science (LICS) 2022 conference in January 2022.

Related to the main topic of the associated team, Dal Lago and Avanzini are organising the conference Logic of Probabilistic Programming in 2022 (from the 31st of January to the 4th of February) https://conferences.cirm-math.fr/2686.html.

Further, a publication of interest has been obtained by members of the associate team in 2021: [1] extends the ert-calculus for reasoning about the cost of imperative probabilistic programs to the context of higher-order, probabilistic functional programs.

[1] Martin Avanzini, Gilles Barthe, and Ugo Dal Lago. "On continuation-passing transformations and expected cost analysis". In: *Proc. ACM Program. Lang.* 5.ICFP (2021), pp. 1–30. DOI: 10.1145/3473592. URL: https://doi.org/10.1145/3473592.

[2] Martin Avanzini, Georg Moser, and Michael Schaper. "A Modular Cost Analysis for Probabilistic Programs". In: *OOPSLA 2020*. 2020.

Planned activities and visits (2022): Subject to the evolution of the COVID-19 pandemic, the participants will visit their partner during one or two weeks in 2022:

- Avanzini (Focus) will visit Innsbruck for two weeks, during summer and Nancy for two weeks, during autumn.
- Péchoux (Mocqua) will visit Innsbruck for two weeks, during summer.
- Perdrix (Mocqua) will visit Innsbruck for two week, during summer.
- Moser (Innsbruck) will visit Mocqua for one week, during autumn.
- Zamdzhiev (permanent, Mocqua) will visit Innsbruck for two week, during summer.

5 Impact of covid-19 on the Associate Team's activity

The covid-19 pandemic mainly affected the associated team in 2020, the year of its creation, when most planned activities were cancelled. As a result, the implementation of work and exchanges were mostly postponed to 2021.

In 2021, most of the face-to-face exchanges planned in the calendar were cancelled. Only the two planned visits of Martin Avanzini to Innsbruck and to Nancy were maintained in the final schedule. Consequently, the associated team mostly worked using online tools and we expect to be able to delay the 2021 exchanges to 2022.

6 Budget requested for the coming year

The budget for 2022 will finance journeys of participants. More specifically:

- There will be one trip of two weeks from Sophia to Nancy, with an expected cost of 2000€.
- There will be one trip of one week from Innsbruck to Nancy, with an expected cost of 1380€.
- There will also be four trips, each of two weeks, of French members (Mocqua and Focus) to Austrian sites. Each trip Nancy-Innsbruck has an expected cost of 2 860€ and each trip Sophia-Innsbruck has an expected cost of 3320€ for two weeks, summing to 11 900€.

Hence the total budget for 2021 will be of 15 280€, of which 9 000€ will be provided by this associate team, and 2 950€ consists in co-funding from the ANR Project SoftQPro, ("Solutions logicielles pour l'optimisation des programmes et ressources quantiques"), 2018-2022, leaded by Simon Perdrix, and to which Mocqua participates (secured). Co-funding on the Austrian side will be applied by the University of Innsbruck for a total amount of 3 330€ (secured).