



Inria Associate Teams programme

Intermediate report (Year 1, restart)

Associate Team acronym: TC(Pro)³

Title: Termination and Complexity Properties of Probabilistic Programs.

Period of activity: 2020-2024

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

2 Website of the Associate Team

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

3 List of participants

Vladimir Zamdzhiev, ISFP Inria, has moved to Inria Saclay and is still a member of the associate team. 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**, Quacs, ISFP Inria, members.loria.fr/VZamdzhiev/.

4 Achievements and Planned activities

Achievements (2022): Three online work sessions have been organized during the year 2022 (the precise schedule is provided on the website). They have been complemented by two talks by Vladimir Zamdzhiev (QPL 2022 and LICS 2022) and one talk of Georg Moser at Innsbruck University. The first offline meeting of the team has been held in Innsbruck from the 2nd to the 4th of November 2022 (8 members were attending).

Related to the main topic of the associated team, Dal Lago and Avanzini have organised the conference Logic of Probabilistic Programming in 2022¹ (from the 31st of January to the 4th of February). Avanzini has held a course on probabilistic rewriting at the 13th International School of Rewriting² (Tbilisi, Georgia, from the 19th of September to the 24th). Results. Three publications have been obtained by members of the associate team in 2022, a fourth one is under review:

- [Ava+22a], accepted at LICS 2022, extends the expectation transformers for reasoning about the expected cost or value of imperative probabilistic programs to a quantum imperative language with measurement. A short version of this result has also been presented at QPL 2022 [Ava+22b].
- [PH23], accepted at POPL 2023, introduces a new noninterference policy to capture the class of functions computable in polynomial time on an object-oriented programming language. This policy makes a clear separation between the standard noninterference techniques for the control flow and the layering properties required to ensure that each “security” level preserves polynomial time soundness, and is thus more expressive than existing tractable characterizations of polynomial time based on safe recursion. Despite the fact that this noninterference policy is Π_1^0 -complete, we show that it can be instantiated to some decidable and conservative instance using shape analysis techniques.
- Avanzini and Moser have submitted the paper “*Automated Expected Value Analysis of Recursive Programs*” to PLDI 2023. This work describes a recent extension of the tool `eco-imp` for reasoning about costs of probabilistic programs — developed within the associate team and presented at OOPSLA 2020 — to (i) permit reasoning about arbitrary expectations and (ii) deal with a more realistic imperative language with recursive procedures and local variables.

[Ava+22a] Martin Avanzini, Georg Moser, Romain Péchoux, Simon Perdrix, and Vladimir Zamdzhiev. “Quantum Expectation Transformers for Cost Analysis”. In: *LICS 2022*. 2022, 10:1–10:13.

[Ava+22b] Martin Avanzini, Georg Moser, Romain Péchoux, Simon Perdrix, and Vladimir Zamdzhiev. “Quantum Expectation Transformers for Cost Analysis”. In: *QPL 2022. Non-proceedings accepted paper*. 2022.

[PH23] Romain Péchoux and Emmanuel Hainry. “A general noninterference policy for polynomial time”. In: *Accepted to POPL 2023*. 2023.

Planned activities and visits (2023):

Activities. The team is currently working in two main directions:

¹<https://conferences.cirm-math.fr/2686.html>.

²<https://viam.science.tsu.ge/clas2022/isr/>.

- Complexity analysis and almost sure termination of probabilistic program: Avanzini, Hainry, P  choux, and Zamdzhiev 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.
- Avanzini, Moser, P  choux, Perdrix, and Zamdzhiev have introduced the extension of the average case resource analysis of probabilistic programs, namely expectation transformers, to a quantum programming language. This extension has been published at Logic In Computer Science (LICS) 2022 [Ava+22a]. However knowing whether this approach can be effectively automated is still an open issue on which the team members are actively working.

Concerning scientific events, Dal Lago will be in the organising committee of the FoPSS winter school <https://site.unibo.it/fopss2023/en> 4th edition of the School on Foundations of Programming and Software Systems (FoPSS 2023) that will be held in February 13-17, 2023, Bertinoro, Italy.

Visits. The team 8th meeting should take place in Inria Nancy Grand-Est. The following visits of the participants are planned in 2023:

- Avanzini (focus, Sophia) will visit Innsbruck for two weeks, during summer and Nancy for one weeks, during autumn (8th meeting).
- Dal Lago (focus, Bologna) and his PhD's student (Andrea Colledan) will visit Mocqua for one week during autumn (8th meeting).
- Moser and De Las Cuevas (Innsbruck) will visit Mocqua for one week during autumn (8th meeting).
- P  choux (mocqua, Nancy Grand Est) will visit Vladimir Zamdzhiev for two weeks. Two PhD students of Romain P  choux (Mario Silva, co-advised by Emmanuel Hainry, and Kinnari Dave, co-advised by Vladimir Zamdzhiev), will visit Bologna during 2 weeks in winter-spring.
- Zamdzhiev (quacs, Paris Saclay) will visit Mocqua for one week during autumn (8th meeting).

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

The covid-19 pandemic has mainly affected the associated team in 2020 and 2021. There was no impact on the year 2022.

6 Summary of the expenses

For 2022, the associate team had the following expenses on the Inria side:

- visits of Martin Avanzini, Andrea Colledan (Ugo Dal Lago's PhD student), Romain P  choux, Simon Perdrix, and Vladimir Zamdzhiev to the 7th meeting in Innsbruck (1st-5th of November 2022), 4400  .
- 7th meeting Diner (8 people involved), 675  .

- 2 visits of Romain P echoux to Inria Paris Saclay, to work with Vladimir Zamdzhiev, 322 .
- operating costs 673 .

The total amount of money spent is 6600 . The total budget of the team was 7000  on the Inria side. Hence 94,3% of the total budget has been spent. No action were not fulfilled due to lack of budget. However we regret that the team budget cannot be used to participate to conferences where, usually, several team members go and collaborate together. This is one weakness we have noticed in this funding action.

7 Budget requested for the coming year 2023

The budget for 2023 will finance journeys of participants. More specifically:

- There will be one trip of two weeks from Sophia to Innsbruck and one trip of one week from Sophia to Nancy, with an expected cost of 3080 .
- There will be two trips of one week from Innsbruck to Nancy, with an expected cost of 2760 .
- There will be two trips of one weeks from Bologna to Nancy, with an expected cost of 2200 .
- There will be two trips of two weeks from Nancy to Bologna, with an expected cost of 2500 .
- There will be two weeks of trip from Nancy to Paris, with an expected cost of 1200 .

Hence the total budget for 2022 will be of 11740 , of which 8980  will be provided by this associate team. The co-funding on the Austrian side will concern a total amount of 2 760 .