



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: 2020-2024 (restarted in 2022)

Principal investigator (Inria): Romain Péchoux, Inria project team Mocqua, Inria NGE

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/REchoux/ea-tcpro%2%b3/>

3 List of participants

- Martin Avanzini, Focus, CR Inria, www-sop.inria.fr/members/Martin.Avanzini/.
- Kathleen Barse, Mocqua, M2 student from ENS Paris-Saclay, february-july 2023.
- Ugo Dal Lago, Focus, PR, www.cs.unibo.it/~dallago/.
- Kinnari Dave, Mocqua-Quacs, PhD student, defense planned in 2026.
- 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/REchoux/.
- Simon Perdrix, Mocqua, CR HDR CNRS, members.loria.fr/SPerdrix/.
- Mario Silva, Mocqua, PhD student, defense planned in december 2024.
- Vladimir Zamdzhiev, Quacs, ISFP Inria Paris Saclay, members.loria.fr/VZamdzhiev/.
- Florian Zuleger, Innsbruck, MCF, informatics.tuwien.ac.at/florian-zuleger

4 Achievements and Planned activities

Achievements (2023).

Events. The following events have been organized within the perimeter of the associate team:

- 5 work sessions to start writing an ANR proposal between Inria NGE, Saclay, Sophia, University of Innsbruck and University of Linz (PREQUEL: Providing Resource Estimation for Quantum Emerging Languages).
- 10 work sessions have been held on Quantum Expectation Transformers
- 7 members of the team have attended the workshop QPL 2023 (<https://qpl2023.github.io/>). Vladimir Zamdzhiev was co-chair.
- 2 visits between sites have been planed (Innsbruck and Nancy)
- the annual online meeting is to be held on the 4th of december 2023

Publications. Three related publications have been obtained by members of the associate team in 2023, a fourth one is under review:

- Emmanuel Hainry and Romain Péchoux, *a general noninterference policy for polynomial time*, *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.
- Martin Avanzini, Georg Moser, and Michael Schaper. *Automated Expected Value Analysis of Recursive Programs*, *PLDI 2023*, 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.
- Alejandro Díaz-Caro, Emmanuel Hainry, Romain Péchoux and Mário Silva. *Light types and polynomial time for quantum lambda-calculi*, *QPL 2023, poster*, describes a programming language with quantum control whose type system ensures unitarity (i.e., typable functions on qubits are unitary operators) and polynomial time normalization.
- Martin Avanzini, Georg Moser, Romain Péchoux and Simon Perdrix. *On the Hardness of Analyzing Quantum Programs Quantitatively*, *submitted*, studies that synthesis of quantum expectation transformers — developed within the associate team and presented at LICS 2022 — on the Clifford+T fragment of quantum mechanics.

Planned activities and visits (2024).

The team is pursuing its work towards two main directions:

- Complexity/termination analysis of probabilistic program: Avanzini, Hainry, Péchoux, 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 2024.

- Global properties of quantum programs: Avanzini, Moser, P  choux, Perdrix, and Zamdzhiev have introduced the notion of quantum expectation transformers in LICS 2022. However, the current technique does not manage to express globally quantum properties of programs. Hence knowing whether this approach can be extended to global properties is currently under investigation.

Concerning scientific events, Zamdzhiev will be in co-chair of QPL 2024 <https://qp12024.dc.uba.ar/> that will be held in July 14-19, 2024, Buenos Aires, Argentina.

The team 9th meeting should take place in Inria NGE and the following visits are planned:

- Avanzini (focus, Sophia) will visit Innsbruck for two weeks, during summer and Nancy for one weeks, during autumn (9th meeting).
- Moser and De Las Cuevas (Innsbruck) will visit Mocqua for one week during autumn (9th meeting).
- Dave, Hainry, P  choux, Perdrix, Silva, Zamdzhiev will attend QPL 2024.

5 Summary of the expenses, year 2023

For 2023, the associate team had the following expenses on the Inria side:

- visits of Martin Avanzini (August 2023) and Andrea Colledan (PhD student of Ugo Dal Lago, Nov. 2022) in Innsbruck, with a total amount $1136+341=1477\text{€}$.
- visit of Martin Avanzini (November 2023) to Nancy, for an expected amount of 985€ .
- the participation of Kahtleen Barsse (M2 student of Romain P  choux and Simon Perdrix), Emmanuel Hainry, Romain P  choux, Simon Perdrix, and Mario Silva to the QPL 2023 workshop (chaired by Vladimir Zamdzhiev), for a total amount of 4259€ .

The total amount of money spent by the Inria side is 6721€ . The total budget of the team was 7000€ on the Inria side. Hence $96,1\%$ of the total budget has been spent. No actions were left unfulfilled due to lack of budget.

6 Budget requested for the coming year 2024

The budget for 2024 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 3280€ .
- There will be three trips of one week to attend to the workshop meeting QPL 2024, including PhD students, with an expected cost of 6000€ .
- There will be two trips of one week from Innsbruck to Nancy to attend the 9th meeting, with an expected cost of 2760€ .

Hence the total budget for 2024 will be of 12040€ , of which 9280€ will be provided by the associate team. The co-funding on the Austrian side will concern a total amount of 2760€ .