Nicolas Amat

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I am currently a postdoctoral researcher at the IMDEA Software Institute, working on new solving techniques for Presburger arithmetic. I am interested in theoretical computer science, with a special interest in the theory and applications of decision procedures for formal verification. I completed my PhD at LAAS-CNRS, where I worked on new methods for taking advantage of Petri net reductions with an SMT-based model checker.

Education

2023 – on **Postdoctoral Researcher** | IMDEA Software Institute | Madrid, Spain
New solving techniques for Presburger arithmetic.

2020 – 2023 **PhD in Formal Methods** | LAAS-CNRS | Toulouse, France
A Polyhedral Framework for Reachability Problems in Petri Nets.

2019 – 2020 **MSc in Computer Science** | Univ. Grenoble Alpes & ENSIMAG | Grenoble, France
High-confidence Embedded and Cyberphysical Systems, Rank 1st/75 with highest honors.

2018 – 2019 **Master 1 in Computer Science** | ENSIMAG | Grenoble, France
Information Systems Engineering, Rank 1st/79.

2017 – 2018 **Bachelor of Mathematics and Computer Science** | ENSIMAG | Grenoble, France

Publications

Thesis

2023 **Amat, N**. PhD thesis: A Polyhedral Framework for Reachability Problems in Petri Nets. *INSA Toulouse*. https://theses.hal.science/tel-04458457v2

2020 **Amat, N**. Mater thesis: A New Approach for the Symbolic Model Checking of Petri nets. *University of Grenoble Alpes*.

Journal Papers

2023 **Amat, N**, Bouvier, P, Garavel, H. A Toolchain to Compute Concurrent Places of Petri Nets. *Petri Nets and Other Models of Concurrency (ToPNoC)*. 10.1007/978-3-662-68191-6_1

Amat, N, Dal Zilio, S, Le Botlan, D. Leveraging polyhedral reductions for solving Petri net reachability problems. *International Journal on Software Tools for Technology Transfer (STTT)*. 10.1007/s10009-022-00694-8.

2022 **Amat, N**, Berthomieu, B, Dal Zilio, S. A Polyhedral Abstraction for Petri Nets and its Application to SMT-Based Model Checking. *Fundamenta Informaticae (FI)*. 10.3233/FI-222134.

Conference Papers

2024 **Amat, N**, Le Botlan, D, Dal Zilio, S. Project and Conquer: Fast Quantifier Elimination for Checking Petri Nets Reachability. *International Conference on Verification, Model Checking, and Abstract Interpretation (VMCAI 2024)*. 10.1007/978-3-031-50524-9_5.

2023 **Amat, N**, Le Botlan, D, Dal Zilio, S. Automated Polyhedral Abstraction Proving. *Application and Theory of Petri Nets and Concurrency (Petri Nets 2023)*. 10.1007/978-3-031-33620-1_18.

Amat, N, Dal Zilio, S. SMPT: A Testbed for Reachability Methods in Generalized Petri Nets. *Formal Methods (FM 2023)*. 10.1007/978-3-031-27481-7_25.

2022 **Amat, N**, Dal Zilio, S, Hujsa, T. Property Directed Reachability for Generalized Petri Nets. *Tools and Algorithms for the Construction and Analysis of Systems (TACAS 2022)*. 10.1007/978-3-030-99524-9_28.

Amat, N, Chauvet, L. Kong: A Tool to Squash Concurrent Places. *Application and Theory of Petri Nets and Concurrency (Petri Nets 2022)*. 10.1007/978-3-031-06653-5_6.

2021 **Amat, N**, Dal Zilio, S, Le Botlan, D. Accelerating the Computation of Dead and Concurrent Places Using Reductions. *Model Checking Software (SPIN 2021)*. 10.1007/978-3-030-84629-9_3.

Amat, N, Berthomieu, B, Dal Zilio, S. On the Combination of Polyhedral Abstraction and SMT-Based Model Checking for Petri Nets. *Application and Theory of Petri Nets and Concurrency (Petri Nets 2021)*. 10.1007/978-3-030-76983-3_9.

Preprints

2024 **Amat, N**, Dal Zilio, S, Le Botlan Didier, D. On the Complexity of Proving Polyhedral Reductions. *Submitted to Fundamenta Informaticae*.

Amat, N, Amparore, E, Berthomieu, B, Bouvier, P, Dal Zilio, S, Jensen, P, Jezequel, L, Kordon, F, Li, S, Paviot-Adet, E, Srba, J, Thierry-Mieg, Y, Wolf, K. Behind the Scene of the Model Checking Contest, Analysis of Results from 2018 to 2023. *Accepted at TOOLympics part of TACAS 2023*.

Poster

2024 **Amat, N**, Berthomieu, B, Dal Zilio, S, Le Botlan Didier, D. Polyhedral Reductions for Petri nets *Modélisation des Systèmes Réactifs (MSR)*. https://hal.science/hal-04355257

Open Science

Open-source Software

2020 – on **SMPT: The Satisfiability Modulo Petri Nets Model Checker** | github.com/nicolasAmat/SMPT
An SMT-based model checker for Petri nets focused on reachability problems that takes advantage of polyhedral reduction.

2020 – on **Kong: The Koncurrent places Grinder** | github.com/nicolasAmat/Kong
A tool to accelerate the computation of the concurrency relation of a Petri net using polyhedral reduction.

2022 – on **Octant: The Reachability Formula Projector** | github.com/nicolasAmat/Octant
A tool to project Petri net reachability properties on reduced nets using polyhedral reduction.

2022 – on **Reductron: The Polyhedral Abstraction Prover** | github.com/nicolasAmat/Reductron
A tool to automatically prove the correctness of polyhedral equivalences for Petri nets.

Education Materials

2023 **µSMPT: An SMT-based Model Checking Project** | github.com/nicolasAmat/uSMPT/
An educational project targeting Master and PhD students. The goal of this project is to showcase the application of SMT methods in system verification by developing a Petri net model-checker for the reachability problem.

Benchmark Suites

2023 **MCC Benchmark Contribution** | https://mcc.lip6.fr/2023/models.php
Contribution of 3 models (CryptoMiner, Murphy, PGCD) to the Model Checking Contest.

2022 **SMT-LIB Benchmark Contribution** | github.com/nicolasAmat/benchmark-submission
Contribution of 5 852 Quantifier-Free Linear Integer Arithmetic (QF-LIA) formulas to the SMT-LIB benchmark used at SMT-COMP.

Artifacts

2024 **Artifact for VMCAI 2024 Paper** | 10.5281/zenodo.7935153

2023 **Artifact for my Phd Thesis** | 10.5281/zenodo.8349545

Artifact for FM 2023 Paper | 10.5281/zenodo.7341425

2022 **Artifact for TACAS 2022 Paper** | 10.5281/zenodo.5863378

Awards & Honors

2023 **Bronze Medal** | Model Checking Contest 2023
My tool, SMPT, won a bronze medal in the “reachability” category of the Model Checking Contest 2023, an international competition of model-checking tools for the verification of concurrent systems.

2022 **Bronze Medal & 100% Confidence Award** | Model Checking Contest 2022
My tool, SMPT, won a bronze medal in the "reachability" category of the Model Checking Contest 2022. It also obtained the 100% confidence award.

2021 **Best Teaser Video Award** | Petri Nets 2021
For the teaser presentation of the paper: On the Combination of Polyhedral Abstraction and SMT-based Model Checking for Petri nets.

2019 **Persyval-lab Excellence Scholarship** | Labex PERSYVAL-LAB
Scholarship program for attracting exceptional candidates in the second year of one of its master's degree related to the Persyval-lab disciplines.

Academic Service (Reviewer)

2023 International Conference on Formal Structures for Computation and Deduction (**FSCD 2023**)

Science of Computer Programming (**SCP**)

2022 ACM Transactions on Embedded Computing Systems (**TECS**)

International Journal on Software Tools for Technology Transfer (**STTT**)

2020 Workshop on Models for Formal Analysis of Real Systems (**MARS 2020**)

Teaching

2022 – 2023 **SAT / SMT Solving** | PhD students & 2nd year graduate | 6 h
National School of Civil Aviation (ENAC), Toulouse, France

Advanced Time Models | 2nd year graduate | 8 h
Paul Sabatier University, Toulouse, France

Functional Programming in OCaml | 1st year graduate | 11 h
National Institute of Applied Sciences (INSA), Toulouse, France

Regular Expressions | 3rd year undergraduate | 5 h
National Institute of Applied Sciences (INSA), Toulouse, France

Algorithmic and Data Structures in ADA | 1st year undergraduate | 24 h
National Institute of Applied Sciences (INSA), Toulouse, France

2021 – 2022 **Advanced Time Models** | 2nd year graduate | 8 h
Paul Sabatier University, Toulouse, France

Discrete Event Systems, Modeling and Analysis | 1st year graduate | 32 h
Paul Sabatier University, Toulouse, France

Implementation Techniques for Discrete Event Systems | 1st year graduate | 30 h
Paul Sabatier University, Toulouse, France

2020 – 2021 **Algorithmic and Data Structures in ADA** | 1st year graduate | 26 h
National Institute of Applied Sciences (INSA), Toulouse, France

Student Supervision

2021 **Louis Chauvet** | 3rd year undergraduate | 3 months
National Institute of Applied Sciences (INSA), Toulouse, France

Sarah Moreau | 2nd year undergraduate | 2 months
National Polytechnic Institute (INP), Toulouse, France

Talks

2023 Automated Proof of Polyhedral Abstraction for Petri Nets, *M2F Seminar at LaBRI*, Bordeaux, France

What is polyhedral reduction?... and how we use it to accelerate the verification of reachability problems for Petri nets, *IMDEA Software Institute*, Madrid, Spain.

Computing Linear Inductive Invariants for Petri Nets using Property Directed Reachability, *GT AFSEC – CT SED*, Paris, France.

Property Directed Reachability for Generalized Petri Nets, *IFSE: journées FAC*, Toulouse, France.

2022 What is Polyhedral Reduction? ... and how we use it to accelerate the verification of reachability problems, *MTV Seminar at LaBRI*, Bordeaux, France

Computing Linear Inductive Invariants for Petri Nets using Property Directed Reachability, *GT VERIF*, Bordeaux, France

2021 On the Combination of Polyhedral Abstraction and SMT-Based Model Checking for Petri Nets, *IFSE: journées FAC*, Toulouse, France.

Une approche polyédrique pour la vérification SMT de réseaux de Petri, *GT AFSEC – GDR GPL*, Virtual.

Experience

2020 **LAAS-CNRS & INRIA** | Master Thesis |Toulouse & Grenoble, France
I started developing SMPT, a model-checker for access problems in Petri nets. I proposed a first combination of polyhedral reductions with SMT-based methods and I was particularly interested in the problem of concurrent places.

2019 **ARM Ltd.** | Linux Kernel Developer | Cambridge, UK
I made a set of modifications to Arm's Mali GPU driver to enable it to run on User-Mode Linux (UML), a compiled Linux kernel that can be executed in user-space as a simple program. I also proposed a Linux kernel patch to provide direct memory access (DMA) and devicetree compatibility on UML.

2019 **LIG - Grenoble Informatics Laboratory** | Introduction to Laboratory Research
I have carried out a formalization of separation logic using the Isabelle/HOL proof assistant, as well as the proof of formula rewriting results from a paper entitled "The Bernays-Schönfinkel-Ramsey Class of Separation Logic on Arbitrary Domains".

2017 **IRIT - Toulouse Institute of Computed Science Research** | Crypto Developer Intern
I have made some security enhancements to XPIR, an open source program that allows a user to secretly download an item from a database (the database server knows it has sent an item to the user, but does not know which one). Such a protocol is called Private Information Retrieval (PIR), and in XPIR's case it is based on homomorphic encryption.