Clément Pit-Claudel

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I'm a PhD candidate at MIT working in Adam Chlipala's lab. My research focuses on programming languages, extensible compilers, and verification; my broader interests include systems engineering, hardware design languages, security, optimization, databases, and type theory. I built the first end-to-end verified compilation pipeline from high-level specifications to assembly language (POPL'15, SNAPL'17, IJCAR'20), the first verified compiler for a rule-based hardware design language with EHRs (PLDI'20), and multiple widely-used Coq tools (CoqPL'16, SLE'20).

Education

2014 – now **Massachusetts Institute of Technology** (Cambridge, USA), **MS 2016, PhD ongoing**
PhD thesis: *Modular proof-producing extraction for end-to-end verification*.
MS thesis: *Compilation using Correct-by-Construction Program Synthesis*, awarded a 🎖 **William A. Martin Memorial Thesis Award for Outstanding Thesis in CS**. Advised by Adam Chlipala.

2011 – 14 **École Polytechnique** (Palaiseau, France), ***Diplôme d'ingénieur* 2014, MSE 2016**
MSE specializing in computer science; undergraduate in mathematics and physics. **GPA**: 3.95.
Final project: *Fluid gaze typing*. 🎖 **Best Group Research Project, 2nd place**.

Selected publications

2021 **ASPLOS** **Effective Simulation & Debugging for High-Level Hardware Languages Using Software Compilers**
Clément Pit-Claudel, Thomas Bourgeat, Stella Lau, Arvind, Adam Chlipala.
Proc. 26th Intl. Conf. on Architectural Support for Programming Languages and Operating Systems (ASPLOS 2021).

2020 **SLE** **Untangling Mechanized Proofs**
Clément Pit-Claudel.
Proc. 13th ACM SIGPLAN Intl. Conf. on Software Language Engineering (SLE 2020). 🎖 **Distinguished artifact**.

IJCAR **Extensible Extraction of Efficient Imperative Programs with Foreign Functions, Manually Managed Memory, and Proofs**
Clément Pit-Claudel, Peng Wang, Benjamin Delaware, Jason Gross, Adam Chlipala.
International Joint Conference on Automated Reasoning (IJCAR 2020).

PLDI **The Essence of Bluespec: A Core Language for Rule-Based Hardware Design**
Thomas Bourgeat, **Clément Pit-Claudel**, Adam Chlipala, Arvind.
Proceedings of the ACM on Programming Languages (PLDI 2020).

2019 **ICFP** **Narcissus: Correct-by-Construction Derivation of Decoders and Encoders from Binary Formats**
Benjamin Delaware, Sorawit Suriyakarn, **Clément Pit-Claudel**, Qianchuan Ye, Adam Chlipala.
Proceedings of the ACM on Programming Languages (ICFP 2019).

2017 **SNAPL** **The End of History? Using a Proof Assistant to Replace Language Design with Library Design**
Adam Chlipala, Benjamin Delaware, Samuel Duchovni, Jason Gross, **Clément Pit-Claudel**, Sorawit Suriyakarn, Peng Wang, Katherine Ye.
2nd Summit on Advances in Programming Languages (SNAPL 2017).

2016 **CAV** **Trigger Selection Strategies to Stabilize Program Verifiers**
K. Rustan M. Leino and **Clément Pit-Claudel**.
Computer Aided Verification: 28th Intl. Conf. (CAV 2016).

CoqPL **Company-Coq: Taking Proof General one step closer to a real IDE**
Clément Pit-Claudel, Pierre Courtieu.
The Second International Workshop on Coq for PL (CoqPL 2016). Workshop paper.

2015 **POPL** **Fiat: Deductive Synthesis of Abstract Data Types in a Proof Assistant**
Benjamin Delaware, **Clément Pit-Claudel**, Jason Gross, Adam Chlipala.
Proc. 42nd ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2015).

See page 5 for a complete list of publications.

Research projects

Correct-by-construction refinement

Fiat is a library for the Coq proof assistant that lets users automatically refine declarative specifications into efficient functional programs. I wrote parts of the framework and examples and did the evaluation.

Narcissus is an extensible library of context-sensitive parser combinators, general enough to specify and automatically derive verified encoders and decoders for a wide range of binary formats like Ethernet, ARP, TCP, IP, etc. I wrote bit-manipulation libraries and data structures and did the integration and evaluation.

Extensible proof-producing compilers and binary code extraction

F2F is a program extraction framework for Coq that uses syntax-driven automation to derive correct-by-construction imperative programs from nondeterministic functional source code. I am the sole author.

Rupicola is a compiler-construction toolkit that lets users assemble verified domain-specific compilers from reusable translation lemmas, producing high-performance low-level code from unoptimized domain-specific functional models. I am the lead author.

Hardware design languages: semantics and verification

Kôika is a rule-based hardware design language with cycle-accurate semantics formalized in Coq. It features high-level abstractions inherited from Bluespec, executable semantics proven to refine one-rule-at-a-time execution, and a formally-verified compiler that generates circuits with good performance. I am one of two lead authors; I formalized the semantics in Coq and designed and verified the compiler to circuits.

Cuttlesim is a fast cycle-accurate simulator for Kôika that beats state-of-the-art RTL simulators by a factor 2 to 5 by leveraging high-level information to minimize redundant work. Cuttlesim generates C++ models that are readable enough to enable hardware debugging and testing using traditional software tools. I am the lead author.

Tooling for interactive theorem provers

Alectryon is a literate-programming system for Coq that produces interactive visualizations of Coq proofs. Alectryon offers a new way to write, communicate, and preserve proofs, combining the flexibility of procedural proof scripts and the intelligibility of declarative proofs. I am the sole author.

Teaching experience

2016 — **Massachusetts Institute of Technology**
Designed labs, taught recitations, prepared debriefings for MIT's *Fundamentals of Programming* class (6.009); received 65 student reviews with an average teaching rating of 6.8/7 and 55 perfect teaching scores, and was awarded a 🎖 **Frederick C. Hennie III Teaching Award in Recognition of Outstanding Contributions to Departmental Teaching**. **4 month** teaching assistantship

2011–12 — **Association Tremplin**
Designed AP-level mathematics, physics, and computer science classes and taught over 60 motivated teenagers across three high schools from low-income neighborhoods. Classes were intended to encourage college applications, boost student confidence, and increase preparedness. Over 95% of the students completed the program successfully. **7 months** civil service in Seine-Saint-Denis, France

Research & industry experience

2017 — **INRIA (Prosecco team, supervised by Cătălin Hriţcu)**
Implemented **reflective pattern-matching tactics** for F*; contributed to research on **effect erasure**; rewrote F*'s **IDE protocol and state machine** to implement a full-fledged IDE; built a **literate programming** system for F*; assembled **web-based builds of F* and Z3**. **3 months** internship in Paris, France

2015 **Microsoft Research (RISE group, supervised by K. Rustan M. Leino)**
Improved the predictability and robustness of the *Dafny* program verifier, generating custom triggers to prevent spurious quantifier instantiations and matching loops. **3 months** internship in Redmond, WA

2013 **华为 | Huawei**
Designed and implemented a fast upper body limb detection and tracking engine based on Bayesian inference in graphical models. **6 weeks** internship in Shenzhen, China

École Polytechnique (LIX, supervised by Stéphane Graham-Lengrand)
Improved the performance of the *Psyche* theorem prover by extending its DPLL module to allow restarts.
3 months research project in Palaiseau, France

Entrepreneurship

2013 – 17 **Launched *YìXué Chinese Dictionary***, a paid English-Chinese dictionary for Windows Phone. YìXué sold over 1000 copies, achieved a 4.7★ rating with over 200 reviews, and was featured three times on Microsoft's app store.

2009 – now **Launched and maintained *Create Synchronicity***, an open source backup & synchronization app (**450k downloads, 2k daily users**, translated to 30 languages). Featured in *PC Magazine*'s *Best free software of 2011* and *Computer Bild*'s *Open Source DVD*.

Community service, mentorship, and outreach

Co-chairing CAV2021's artifact evaluation committee.

Served in the artifact evaluation committees of **POPL'16 and '18**, on the student program committe of **IEEE S&P'19**, and reviewed for **NASA's Formal Methods Symposium**, the **Journal of Statistical Computation and Simulation**, and the **Journal of Functional Programming**.

Volunteered at **PLDI'18** and **SPLASH'18**.

Mentored **six undergraduate and two MS-level MIT students** for periods of six to eighteen months, providing guidance and hands-on software design and verification experience (2014-2020).

Held **walk-in office hours** for early-undergraduate alumni of *Association Tremplin*, a French non-profit working to encourage high-school students from disadvantaged neighborhoods to pursue a higher education (2012; 4 hours per week for 7 months).

Co-organized the 26th French national session of the European Youth Parliament (2009), authoring grant proposals to raise 20k€, securing sponsorships and in-kind contributions, and hosting 150 participants for a 4-days workshop.

Awards

Distinguished artifact, *Untangling Mechanized Proofs*, ACM SIGPLAN International Conference on Software Language Engineering (2020).

William A. Martin Memorial Thesis Award for Outstanding Thesis in CS, *Compilation using Correct-by-Construction Program Synthesis*, MIT (2016).

Frederick C. Hennie III Teaching Award in Recognition of Outstanding Contributions to Departmental Teaching, 6.009 *Fundamentals of Programming*, MIT (2016).

Robert B. Guenassia Award, MIT (2015).

Programming Languages Mentoring Workshop travel grant, POPL (2015).

2nd place, *École Polytechnique*'s ***Best Group Research Project***, for research on webcam-based gaze tracking (2013).

2nd place, Microsoft France's ***App Awards***, a mobile development contest, for *YìXué Chinese Dictionary* (2013).

3rd place, Computer Science **competitive entrance exam** of the *École Normale Supérieure* (*ENS Ulm*) (2011).

4th place, **French Olympiads in Mathematics, Paris division** (2008).

Extra-curricular activities

Blogged about mathematics, programming, and formal verification; got featured in the *Code Project's Insider* daily newsletter.

Launched a twitter feed about Chinese linguistics and etymology, with over 500 subscribers.

Launched or contributed to many free software projects since 2012, including plugins and translations for Rockbox (a free audio player firmware), **documentation tools** for Coq and F*, and **Emacs packages** for bibliography management, syntax checking, and various research languages (wrote biblio.el, ESH, company-coq, F*-mode, and boogie-friends; co-maintained Flycheck and Proof-General).

Languages: **French** (mother tongue, French citizen), **English** (fluent), **Spanish**, **Chinese**, **Japanese** (basic).

Invited talks, site visits, and conference and workshop presentations

Extensible Extraction of Efficient Imperative Programs

2020 Jan. Online invited talk, *Cambium seminar* at INRIA.
2020 Dec. Online invited talk, *Principles of programming & verification seminar* at Boston University.
2020 July Online conference presentation, *IJCAR 2020*.

The Essence of Bluespec — A Core Language for Rule Based Hardware Design

2020 Dec. Online invited talk, *Circuit IR compilers and tools seminar*.
2020 Sept. Online progress report to Sandia National Labs at MIT.
2020 July Online invited talk, *Computer architecture & programming abstractions seminar* at Cornell.
2020 July Online discussion, *PRL reading group* at Northeastern University.
2020 June Online conference presentation, *PLDI 2020*.

Kôika: A Core Hardware Language with Cycle-accurate Semantics

2019 Oct. Technology demonstration to Sandia National Labs at MIT.
2019 Oct. Workshop presentation, *New england systems verification day* at MIT.

Narcissus: Correct-by-Construction Derivation of Decoders and Encoders from Binary Formats

2019 Aug. Conference presentation, *ICFP 2019*.
2019 Aug. Invited talk at INRIA.
2018 Oct. Workshop presentation, *New england systems verification day* at MIT.
2018 June Lightning talk, *DeepSpec workshop at PLDI 2018*.

Proof-Producing Extraction of Binary Encoders/Decoders

2018 June Invited talk at BedRock Systems.

Deductive Synthesis of Abstract Data Types in a Proof Assistant

2017 May Guest lecture at MIT.

Compilation Using Correct-by-Construction Program Synthesis

2016 June Site visit for DARPA's High assurance cyber military systems (HACMS) at MIT.
2016 May Lightning talk, *Programming languages offsite* at MIT.
2016 April Lightning talk, *Specialist meeting on verified trustworthy software systems* at the Research Institute in Automated Program Analysis and Verification at Imperial College.

Trigger Selection Strategies to Stabilize Program Verifiers

2016 July Conference presentation, *CAV 2016*.
2016 July Invited talk at INRIA.

Company-Coq: Taking Proof General one step closer to a real IDE

2016 Jan. Workshop presentation, *CoqPL workshop at POPL 2016*.

Quantifiers meet their match(ing loop): new techniques and tools for dealing with unpredictable performance in Dafny

2015 Sept. End-of-internship talk at Microsoft Research.

All publications

2021 **ASPLOS** **Effective Simulation & Debugging for High-Level Hardware Languages Using Software Compilers**
Clément Pit-Claudel, Thomas Bourgeat, Stella Lau, Arvind, Adam Chlipala.
Proc. 26th Intl. Conf. on Architectural Support for Programming Languages and Operating Systems (ASPLOS 2021).

CoqPL **Automated Synthesis of Verified Firewalls**
Shardul Chiplunkar, **Clément Pit-Claudel**, Adam Chlipala.
The Seventh International Workshop on Coq for PL (CoqPL 2021). Workshop paper.

CoqPL **An experience report on writing usable DSLs in Coq**
Clément Pit-Claudel, Thomas Bourgeat.
The Seventh International Workshop on Coq for PL (CoqPL 2021). Workshop paper.

2020 **SLE** **Untangling Mechanized Proofs**
Clément Pit-Claudel.
Proc. 13th ACM SIGPLAN Intl. Conf. on Software Language Engineering (SLE 2020). **Distinguished artifact**.

IJCAR **Extensible Extraction of Efficient Imperative Programs with Foreign Functions, Manually Managed Memory, and Proofs**
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International Joint Conference on Automated Reasoning (IJCAR 2020).

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Thomas Bourgeat, **Clément Pit-Claudel**, Adam Chlipala, Arvind.
Proceedings of the ACM on Programming Languages (PLDI 2020).

2019 **ICFP** **Narcissus: Correct-by-Construction Derivation of Decoders and Encoders from Binary Formats**
Benjamin Delaware, Sorawit Suriyakarn, **Clément Pit-Claudel**, Qianchuan Ye, Adam Chlipala.
Proceedings of the ACM on Programming Languages (ICFP 2019).

ESOP **Meta-F* : Proof Automation with SMT, Tactics, and Metaprograms**
Guido Martínez, Danel Ahman, Victor Dumitrescu, Nick Giannarakis, Chris Hawblitzel, Cătălin Hriţcu, Monal Narasimhamurthy, Zoe Paraskevopoulou, **Clément Pit-Claudel**, Jonathan Protzenko, Tahina Ramananandro, Aseem Rastogi, Nikhil Swamy.
Proc. 28th European Symposium on Programming (ESOP 2019).

2018 **SETTA** **Correct-by-Construction Implementation of Runtime Monitors Using Stepwise Refinement**
Teng Zhang, John Wiegley, Theophilos Giannakopoulos, Gregory Eakman, **Clément Pit-Claudel**, Insup Lee, Oleg Sokolsky.
Proc. 4th International Symposium on Dependable Software Engineering: Theories, Tools, and Applications (SETTA 2018).

ML **ML as a Tactic Language, Again**
Guido Martínez, Danel Ahman, Victor Dumitrescu, Nick Giannarakis, Chris Hawblitzel, Cătălin Hriţcu, Monal Narasimhamurthy, Zoe Paraskevopoulou, **Clément Pit-Claudel**, Jonathan Protzenko, Tahina Ramananandro, Aseem Rastogi, Nikhil Swamy.
ML family workshop at ICFP 2018 (ML 2018). Workshop paper.

2017 **SNAPL** **The End of History? Using a Proof Assistant to Replace Language Design with Library Design**
Adam Chlipala, Benjamin Delaware, Samuel Duchovni, Jason Gross, **Clément Pit-Claudel**, Sorawit Suriyakarn, Peng Wang, Katherine Ye.
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CoqPL **Company-Coq: Taking Proof General one step closer to a real IDE**
Clément Pit-Claudel, Pierre Courtieu.
The Second International Workshop on Coq for PL (CoqPL 2016). Workshop paper.

(MS thesis) **Compilation Using Correct-by-Construction Program Synthesis**
Clément Pit-Claudel.
Master's Thesis at MIT. **William A. Martin Memorial Thesis Award for Outstanding Thesis in CS**.

2015 **POPL** **Fiat: Deductive Synthesis of Abstract Data Types in a Proof Assistant**
Benjamin Delaware, **Clément Pit-Claudel**, Jason Gross, Adam Chlipala.
Proc. 42nd ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL 2015).

(Tech report) **Outlier Detection in Heterogeneous Datasets using Automatic Tuple Expansion**
Clément Pit-Claudel, Zelda Mariet, Rachael Harding, Sam Madden.
Technical report.

Key

This publication received an award.

This publication received the "Artifacts Evaluated" badge (used in some conferences that do not distinguish between "functional" and "reusable").

This publication received the "Artifacts Evaluated – Functional" badge: "*The artifacts associated with the research are found to be documented, consistent, complete, exercisable, and include appropriate evidence of verification and validation.*"

This publication received the "Artifacts Evaluated – Reusable" badge: "*The artifacts associated with the paper are of a quality that significantly exceeds minimal functionality. That is, they have all the qualities of the Artifacts Evaluated – Functional level, but, in addition, they are very carefully documented and well-structured to the extent that reuse and repurposing is facilitated. In particular, norms and standards of the research community for artifacts of this type are strictly adhered to.*" (not all conferences offer this badge; all my eligible papers received it).

References

Adam Chlipala	**Arvind**	**Rustan Leino**	**Zachary Tatlock**
MIT CSAIL	MIT CSAIL	Amazon	University of Washington
adamc@csail.mit.edu	arvind@csail.mit.edu	leino@amazon.com	ztatlock@cs.washington.edu