Samuel MIMRAM

French nationality
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Research topics

Concurrency, rewriting theory, category theory, algebraic topology, denotational semantics, programming languages.

Positions

2018–...	Professeur in LIX laboratory (École Polytechnique)
2017–2018	Professeur chargé de cours in LIX laboratory (École Polytechnique)
2014–2017	Maître de conférences in LIX laboratory (École Polytechnique)
2010–2014	Researcher in LIST/LMeASI team (CEA)
2009–2010	Postdoctoral research in LIST/LMeASI team (CEA)

Education

2016	Habilitation à diriger des recherches
2005–2008	PhD thesis in PPS team (CNRS / Université Paris Diderot)
2004–2005	Master Parisien de Recherche en Informatique (eq. MSc)
2002–2005	École Normale Supérieure de Lyon
2000–2002	Classes préparatoires in mathematics (MPSI/MP), with specialty in computer science (Lycée Henri IV, Paris)
2000	Baccalauréat S (eq. A-level) mention Bien (Lycée Carnot, Paris)

Participation to research projects

2023–2026	ANR CoREACT *Coq-based rewriting: executable and applied CT*
2022–2025	AID-CIEDS FARO *Fondements algorithmiques des essaims de drones*
2021–2025	ANR LambdaComb *A cartographic quest between lambda-calculus, logic, and combinatorics*
2021–2025	ANR S3 *Species, syntax and semantics*
2014–2018	ANR CATHRE *Categories, homotopy and rewriting*
2011–2015	ESF RN ACAT *Applied and computational algebraic topology*
2011–2015	ANR REVER *Programming reversible recoverable systems*
2009–2012	ANR PANDA *Parallel and distributed analysis*
2008–2010	ANR CHOCO *Curry-Howard for concurrency*
2005–2008	ANR INVAL *Invariants algébriques*
2005–2006	ACI GEOCAL *Géométrie du calcul*

Teaching

2015–...	Teaching at École polytechnique:
2019–...	*Computational logic* (M1, X)
2015–...	*Fondements de l'Informatique: logique, modèles, calculs* (L3, X, TD)
2016–2019	*Programmation d'applications concurrentes et distribuées* (L3, X TD)
2015–2017	*Programmation avancée* (L3, X, TD)
2009–2018	*Lambda-calculi and categories* (M1, MPRI, TD)
2014	Orals in CS for admission to École Normale Supérieure (Ulm)
2006–2009	Monitorat at Université Paris Diderot: *Programmation système* (L3, TD) *Automates finis* (L2, TD) *Introduction à l'informatique et la programmation* (L1, TD)
2005–2006	Computer science "colles" in MPSI (Lycée Janson de Sailly, Paris)

PhD students

2024–2027	Bruno Drieux (co-supervised with Olivia Caramello) *Automatic transposition of ordinary topos theory results to the relative setting*
2024–2027	Yorgo Chamoun (co-supervised with Emmanuel Haucourt) *Ensembles précubiques et variétés différentiables*
2024–2027	Louise Leclerc *Une théorie homotopique des types dirigés*
2022–2025	Émile Oleon *Méthodes par réecriture en théorie des types homotopiques*
2022–2025	Elies Harington (co-supervised with Thomas Seiller) *Modèles polynomiaux de la logique linéaire dans les catégories supérieures*
2020–2023	Aly-Bora Ulusoy (co-supervised with Emmanuel Haucourt) *A syntactic approach to the directed semantics of programs*
2017–2020	Cédric Ho Thanh (co-supervised with Pierre-Louis Curien) *Opetopes: Syntactic and Algebraic Aspects*
2017–2020	Simon Forest (co-supervised with Yves Guiraud) *Computational descriptions of higher categories*
2017–2020	Thibaut Benjamin (co-supervised with Eric Finster) *A type theoretic approach to weak omega-categories and related higher structures*
2016–2019	Jérémy Ledent (co-supervised with Éric Goubault) *Geometric Semantics for Asynchronous Computability*

Other students

Kelton OBrien (2025, M2 internship), Hugo Salou (2025, L3 internship), William Hasley (2025, L3 internship), Hugo Barreiro (2024-2025, M1 research project), Rémy Germe (2024-2025, M1 research project), Samar Rahmouni (2023, M1 research project), Camil Champin (2023, L3 internship), Dylan Laird (2023, L3 internship), Yorgo Chamoun (2022-2023, M1 research project), Émile Oleon (2021, M2 internship), Peixin You (2022, bachelor thesis), Sébastien Draux (2021-2022, M1 research project), Peixin You (2021, bachelor research project), Aly-Bora Ulusoy (2020, M2 internship), Guillaume Paya-Monet (2020, bachelor thesis), Klara Nosan (2019-2020, M1 research project), Eric Finster (2015-2016, post-doc), Cinzia Di Giusto (2012-2013, post-doc), Paul-Elliot Angles d'Auriac (2012, M1 internship), Tobias Heindel (2011-2012, post-doc)

Service to the research community

PC	MFPS 2023, IWC 2021, FoSSaCS 2021, SYCO 2019, ACT 2019, SYCO 2018, HDRA 2018, IWC 2018, CALCO 2017, HDRA 2017, HDRA 2016, HDRA 2015, IWC 2015, JFLA 2013
PhD jury	Thomas Jan Mikhail (2025), Luc Chabassier (2025), Diana Kessler (2025), Rémy Di Guardia (2024), Antoine Allioux (2023), Cameron Calk (2022), Antonin Delpeuch (2022, reviewer), Chaitanya Leena Subramaniam (2021), Zeinab Galal (2021), Léonard Guetta (2021), Jules Chouquet (2019, reviewer), Clement Jacq (2019), Marie Kerjean (2018), Clovis Eberhart (2018, reviewer), Matteo Acclavio (2016, reviewer), Nohra Hage (2016, reviewer), Fabio Zanassi (2015)
Reviews	LICS, CONCUR, ESOP, FOSSACS, SAS, MFPS, JFLA, APLAS, FSCD, RTA, HSCC, QPL, NFM, HDRA, TCS, ANR projects, HCERES evaluations
Selection com.	Polytechnique (5), USPN
Responsibilities	President of the department (since 2023) Vice-president of the department (2020-2023) Responsible for the *Foundations of computer science* IPP M1 (since 2020) Responsible for 3rd year in CS at École Polytechnique (2018-2023) Co-responsible for the LHC workgroup at GdR IFM (since 2018) Member of the office commission (2017-2025) Head of the Cosynus team (since 2016)

Computer skills

Languages	OCaml, Agda, C, Java, Python, javascript, HTML, CSS
Other	Developing free software (Liquidsoap), former Debian developer

Miscellaneous

Languages	French (mother tongue), English (fluent), Italian (notions), German (notions), Korean (notions)
Hobbies	Piano

Publications

Conference proceedings

[1] Eliès Harington and Samuel Mimram. "∞-Categorical Models of Linear Logic". In: *10th International Conference on Formal Structures for Computation and Deduction (FSCD 2025)*. Ed. by Maribel Fernández. Vol. 337. Leibniz International Proceedings

in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2025, 23:1–23:20. DOI: 10.4230/LIPIcs.FSCD.2025.23.

[2] Samuel Mimram and Émile Oleon. "Coherent Tietze Transformations of 1-Polygraphs in Homotopy Type Theory". In: *10th International Conference on Formal Structures for Computation and Deduction (FSCD 2025)*. Ed. by Maribel Fernández. Vol. 337. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2025, 30:1–30:17. DOI: 10.4230/LIPIcs.FSCD.2025.30.

[3] Camil Champin, Samuel Mimram, and Émile Oleon. "Delooping Generated Groups in Homotopy Type Theory". In: *9th International Conference on Formal Structures for Computation and Deduction (FSCD 2024)*. Ed. by Jakob Rehof. Vol. 299. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2024, 6:1–6:20. DOI: 10.4230/LIPIcs.FSCD.2024.6. eprint: 2405.03264v1.

[4] Elies Harington and Samuel Mimram. "Polynomials in homotopy type theory as a Kleisli category". In: *Electronic Notes in Theoretical Informatics and Computer Science* Volume 4 - Proceedings of MFPS XL, 11 (2024). DOI: 10.46298/entics.14786. eprint: 2411.09950.

[5] Samuel Mimram and Emile Oleon. "Delooping cyclic groups with lens spaces in homotopy type theory". In: *Proceedings of the 39th Annual ACM/IEEE Symposium on Logic in Computer Science*. LICS '24. Tallinn, Estonia: Association for Computing Machinery, 2024. DOI: 10.1145/3661814.3662077. eprint: 2405.10149.

[6] Samuel Mimram. "Categorical Coherence from Term Rewriting Systems". In: *8th International Conference on Formal Structures for Computation and Deduction (FSCD 2023)*. Ed. by Marco Gaboardi and Femke van Raamsdonk. Vol. 260. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2023, 16:1–16:17. DOI: 10.4230/LIPIcs.FSCD.2023.16.

[7] Samuel Mimram and Émile Oleon. "Division by Two, in Homotopy Type Theory". In: *7th International Conference on Formal Structures for Computation and Deduction (FSCD 2022)*. Ed. by Amy P. Felty. Vol. 228. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl – Leibniz-Zentrum für Informatik, 2022, 11:1–11:17. DOI: 10.4230/LIPIcs.FSCD.2022.11.

[8] Eric Finster et al. "A cartesian bicategory of polynomial functors in homotopy type theory". In: *Proceedings 37th Conference on Mathematical Foundations of Programming Semantics, MFPS 2021, Hybrid: Salzburg, Austria and Online, 30th August - 2nd September, 2021*. Ed. by Ana Sokolova. Vol. 351. EPTCS. 2021, pp. 67–83. DOI: 10.4204/EPTCS.351.5.

[9] Samuel Mimram and Aly-Bora Ulusoy. "Syntactic Regions for Concurrent Programs". In: *Proceedings 37th Conference on Mathematical Foundations of Programming Semantics, MFPS 2021*. Ed. by Ana Sokolova. Vol. 351. EPTCS. 2021, pp. 184–199. DOI: 10.4204/EPTCS.351.12.

[10] Thibaut Benjamin and Samuel Mimram. "Suspension et Fonctorialité: Deux Opérations Implicites Utiles en CaTT". In: *Journées Francophones des Langages Applicatifs*. 2019.

[11] Simon Forest and Samuel Mimram. "Describing free ω-categories". In: *34th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS)*. 2019. DOI: 10.1109/LICS.2019.8785687.

[12] Cédric Ho Thanh, Pierre-Louis Curien, and Samuel Mimram. "A Sequent Calculus for Opetopes". In: *34th Annual ACM/IEEE Symposium on Logic in Computer Science (LICS)*. 2019. DOI: 10.1109/LICS.2019.8785667.

[13] Jérémy Ledent and Samuel Mimram. "A Sound Foundation for the Topological Approach to Task Solvability". In: *30th International Conference on Concurrency Theory (CONCUR 2019)*. Ed. by Wan Fokkink and Rob van Glabbeek. Vol. 140. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2019, 34:1–34:15. DOI: 10.4230/LIPIcs.CONCUR.2019.34.

[14] Simon Forest and Samuel Mimram. "Coherence of Gray Categories via Rewriting". In: *3rd International Conference on Formal Structures for Computation and Deduction (FSCD 2018)*. Ed. by Hélène Kirchner. Vol. 108. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2018, 15:1–15:16. DOI: 10.4230/LIPIcs.FSCD.2018.15.

[15] Éric Goubault, Jérémy Ledent, and Samuel Mimram. "Concurrent Specifications Beyond Linearizability". In: *22nd International Conference on Principles of Distributed Systems (OPODIS 2018)*. Vol. 125. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2018, 28:1–28:16. DOI: 10.4230/LIPIcs.OPODIS.2018.28.

[16] Éric Goubault, Jérémy Ledent, and Samuel Mimram. "On the Impossibility of Detecting Concurrency". In: *32nd International Symposium on Distributed Computing (DISC 2018)*. Ed. by Ulrich Schmid and Josef Widder. Vol. 121. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2018, 50:1–50:4. DOI: 10.4230/LIPIcs.DISC.2018.50.

[17] Eric Finster and Samuel Mimram. "A type-theoretical definition of weak ω-categories". In: *2017 32nd Annual ACM/IEEE Symposium on Logic in Computer Science (LICS)*. 2017, pp. 1–12. DOI: 10.1109/LICS.2017.8005124. arXiv: 1706.02866.

[18] Philippe Malbos and Samuel Mimram. "Homological Computations for Term Rewriting Systems". In: *1st International Conference on Formal Structures for Computation and Deduction (FSCD 2016)*. Ed. by Delia Kesner and Brigitte Pientka. Vol. 52. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2016, 27:1–27:17. DOI: 10.4230/LIPIcs.FSCD.2016.27.

[19] Florence Clerc and Samuel Mimram. "Presenting a Category Modulo a Rewriting System". In: *26th International Conference on Rewriting Techniques and Applications (RTA 2015)*. Ed. by Maribel Fernández. Vol. 36. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2015, pp. 89–105. DOI: 10.4230/LIPIcs.RTA.2015.89.

[20] Éric Goubault, Samuel Mimram, and Christine Tasson. "From Geometric Semantics to Asynchronous Computability". English. In: *Distributed Computing*. Ed. by Yoram Moses. Vol. 9363. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2015, pp. 436–451. DOI: 10.1007/978-3-662-48653-5_29.

[21] Samuel Mimram. "Presenting Finite Posets". In: *Proceedings 8th International Workshop on Computing with Terms and Graphs, Vienna, Austria, July 13, 2014*. Ed. by Aart Middeldorp and Femke van Raamsdonk. Vol. 183. Electronic Proceedings in Theoretical Computer Science. Open Publishing Association, 2015, pp. 1–17. DOI: 10.4204/EPTCS.183.1.

[22] Olivier Bouissou, Alexandre Chapoutot, and Samuel Mimram. "Set-based Simulation for Design and Verification of Simulink Models". In: *Embedded Real Time Software and Systems (ERTS)*. 2014.

[23] Éric Goubault, Tobias Heindel, and Samuel Mimram. "A Geometric View of Partial Order Reduction". In: *Electronic Notes in Theoretical Computer Science* 298.0 (2013). Proceedings of the Twenty-ninth Conference on the Mathematical Foundations of Programming Semantics, MFPS XXIX, pp. 179–195. DOI: 10.1016/j.entcs.2013.09.013.

[24] Yves Guiraud, Philippe Malbos, and Samuel Mimram. "A Homotopical Completion Procedure with Applications to Coherence of Monoids". In: *24th International Conference on Rewriting Techniques and Applications (RTA 2013)*. Ed. by Femke van Raamsdonk. Vol. 21. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2013, pp. 223–238. DOI: 10.4230/LIPIcs.RTA.2013.223.

[25] Samuel Mimram and Cinzia Di Giusto. "A Categorical Theory of Patches". In: *Electronic Notes in Theoretical Computer Science* 298.0 (2013). Proceedings of the Twenty-ninth Conference on the Mathematical Foundations of Programming Semantics, MFPS XXIX, pp. 283–307. DOI: 10.1016/j.entcs.2013.09.018. arXiv: 1311.3903.

[26] Olivier Bouissou, Alexandre Chapoutot, and Samuel Mimram. "HySon: Set-based simulation of hybrid systems". In: *Rapid System Prototyping (RSP), 2012 23rd IEEE International Symposium on*. 2012, pp. 79–85. DOI: 10.1109/RSP.2012.6380694.

[27] Lisbeth Fajstrup et al. "Trace Spaces: An Efficient New Technique for State-Space Reduction". In: *Programming Languages and Systems*. Ed. by Helmut Seidl. Vol. 7211. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2012, pp. 274–294. DOI: 10.1007/978-3-642-28869-2_14. arXiv: 1204.0414.

[28] David Baelde, Romain Beauxis, and Samuel Mimram. "Liquidsoap: A High-Level Programming Language for Multimedia Streaming". In: *SOFSEM 2011: Theory and Practice of Computer Science*. Ed. by Ivana Černá et al. Vol. 6543. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2011, pp. 99–110. DOI: 10.1007/978-3-642-18381-2_8. arXiv: 1104.2681.

[29] Romain Beauxis and Samuel Mimram. "A Non-Standard Semantics for Kahn Networks in Continuous Time". In: *Computer Science Logic (CSL'11) - 25th International Workshop/20th Annual Conference of the EACSL*. Ed. by Marc Bezem. Vol. 12. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2011, pp. 35–50. DOI: 10.4230/LIPIcs.CSL.2011.35. arXiv: 1108.5062.

[30] Richard Bonichon et al. "Rigorous Evidence of Freedom from Concurrency Faults in Industrial Control Software". In: *Computer Safety, Reliability, and Security*. Ed. by Francesco Flammini, Sandro Bologna, and Valeria Vittorini. Vol. 6894. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2011, pp. 85–98. DOI: 10.1007/978-3-642-24270-0_7.

[31] Samuel Mimram. "Computing Critical Pairs in 2-Dimensional Rewriting Systems". In: *Proceedings of the 21st International Conference on Rewriting Techniques and Applications*. Ed. by Christopher Lynch. Vol. 6. Leibniz International Proceedings in Informatics (LIPIcs). Dagstuhl, Germany: Schloss Dagstuhl–Leibniz-Zentrum fuer Informatik, 2010, pp. 227–242. DOI: 10.4230/LIPIcs.RTA.2010.227. arXiv: 1004.3135.

[32] Samuel Mimram. "Focusing in Asynchronous Games". In: *Programs, Proofs, Processes*. Ed. by Fernando Ferreira et al. Vol. 6158. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2010, pp. 331–341. DOI: 10.1007/978-3-642-13962-8_37. arXiv: 1004.3134.

[33] Samuel Mimram. "The Structure of First-Order Causality". In: *Logic In Computer Science, 2009. LICS '09. 24th Annual IEEE Symposium on*. 2009, pp. 212–221. DOI: 10.1109/LICS.2009.19. arXiv: 0908.3994.

[34] David Baelde and Samuel Mimram. "De la webradio lambda à la λ-webradio". Français. In: *JFLA (Journées Francophones des Langages Applicatifs)*. INRIA. Étretat, France, 2008, pp. 47–62.

[35] Paul-André Melliès and Samuel Mimram. "Asynchronous Games: Innocence Without Alternation". In: *CONCUR 2007 – Concurrency Theory*. Ed. by Luís Caires and VascoT. Vasconcelos. Vol. 4703. Lecture Notes in Computer Science. Springer Berlin Heidelberg, 2007, pp. 395–411. DOI: 10.1007/978-3-540-74407-8_27. arXiv: 0706.1118.

Journal articles

[1] Thibaut Benjamin, Eric Finster, and Samuel Mimram. "Globular weak ω-categories as models of a type theory". In: *Higher Structures* 8.2 (2024), pp. 1–69. DOI: 10.21136/HS.2024.07. arXiv: 2106.04475.

[2] Simon Forest and Samuel Mimram. "Free precategories as presheaf categories". In: *Theory and Applications of Categories* 41.24 (2024), pp. 785–824.

[3] Pierre-Louis Curien, Cédric Ho Thanh, and Samuel Mimram. "Type theoretical approaches to opetopes". In: *Higher structures* 6.1 (2022), pp. 80–181. DOI: 10.21136/HS.2022.02.

[4] Simon Forest and Samuel Mimram. "Rewriting in Gray categories with applications to coherence". In: *Mathematical Structures in Computer Science* 32.5 (2022), pp. 574–647. DOI: 10.1017/S0960129522000299. arXiv: 2109.05369.

[5] Simon Henry and Samuel Mimram. "Tietze Equivalences as Weak Equivalences". In: *Applied Categorical Structures* (2021). DOI: 10.1007/s10485-021-09662-w. arXiv: 2101.03591.

[6] Eric Goubault and Samuel Mimram. "Directed Homotopy in Non-Positively Curved Spaces". In: *Logical Methods in Computer Science* Volume 16, Issue 3 (2020). DOI: 10.23638/LMCS-16(3:4)2020. arXiv: 1908.06684.

[7] Éric Goubault, Samuel Mimram, and Christine Tasson. "Geometric and combinatorial views on asynchronous computability". In: *Distributed Computing* (2018). DOI: 10.1007/s00446-018-0328-4.

[8] Pierre-Louis Curien and Samuel Mimram. "Coherent Presentations of Monoidal Categories". In: *Logical Methods in Computer Science* 13.3 (2017). DOI: 10.23638/LMCS-13(3:31)2017. arXiv: 1705.03553.

[9] Éric Goubault, Samuel Mimram, and Christine Tasson. "Iterated Chromatic Subdivisions are Collapsible". English. In: *Applied Categorical Structures* (2014), pp. 1–42. DOI: 10.1007/s10485-014-9383-6.

[10] Samuel Mimram. "Towards 3-Dimensional Rewriting Theory". In: *Logical Methods in Computer Science* 10.1 (2014), pp. 1–47. DOI: 10.2168/LMCS-10(2:1)2014. arXiv: 1403.4094.

[11] Éric Goubault and Samuel Mimram. "Formal Relationships Between Geometrical and Classical Models for Concurrency". In: *Electronic Notes in Theoretical Computer Science* 283.0 (2012). Proceedings of the workshop on Geometric and Topological Methods in Computer Science (GETCO), pp. 77–109. DOI: 10.1016/j.entcs.2012.05.007. arXiv: 1004.2818.

[12] Samuel Mimram. "The Structure of First-Order Causality (extended version)". In: *Mathematical Structures in Computer Science* 21 (01 2011), pp. 65–110. DOI: 10.1017/S0960129510000459. arXiv: 1101.4813.

Books

[1] Dimitri Ara et al. *Polygraphs: From Rewriting to Higher Categories*. London Mathematical Society Lecture Note Series. Cambridge University Press, 2025. DOI: 10.1017/9781009498968. eprint: 2312.00429.

[2] Samuel Mimram and Romain Beauxis. *The Liquidsoap book*. Independently published, 2021.

[3] Samuel Mimram. *PROGRAM = PROOF*. Independently published, 2020.

[4] Lisbeth Fajstrup et al. *Directed Algebraic Topology and Concurrency*. Springer International Publishing, 2016. DOI: 10.1007/978-3-319-15398-8.

Thesis

[1] Samuel Mimram. *Geometric Models of Concurrent Computations*. Habilitation à diriger des recherches. 2016.

[2] Samuel Mimram. "Sémantique des jeux asynchrones et réécriture 2-dimensionnelle". PhD thesis. Équipe Preuves Programmes Systèmes (PPS), Université Paris 7, 2009.