

# Curriculum Vitae

Michele Loreti

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## 1 Education

**May 1997** *Laurea in Scienze dell'Informazione, summa cum laude*, l'Università degli studi di Roma "La Sapienza", Italy. Title of the thesis: *Esecuzione ed Analisi di Algebre di Processo tramite Reti di Petri*.

**January 2002** *PhD in Mathematical Logic and Theoretical Computer Science*, Dipartimento di Matematica of Università di Siena. Title of the thesis: *Languages and Logics for Network Aware Programming*.

## 2 Academic Positions

**2001-2002** PostDoc (Assegno di Ricerca), Dipartimento di Sistemi e Informatica, Università di Firenze

**From 1 November 2002** Researcher (INF/01), Facoltà di Scienze Matematiche Fisiche e Naturali, Università di Firenze.

**2012,2016** Visiting Professor at *IMT Institute for Advanced Studies*, Lucca.

## 3 Research interests

Michele Loreti's research activity is focused on the study of formal tools for specifying and verifying qualitative and quantitative properties of concurrent and distributed systems.

### Qualitative and quantitative semantics of process calculi

Michele Loreti contributed to the definition of process specification languages introduced for modelling specific class of systems like service-oriented architectures (with the calculi SCC and CasPiS) and, more recently, autonomous and adaptive systems (SCEL and CARMA). These calculi are equipped with the appropriate linguistic constructs that permits modelling the specific aspects of the systems of interest. Michele Loreti also contributed to the definition of a unifying framework to provide the semantics of process algebras, including their quantitative variants useful for modeling quantitative aspects of behaviours. This framework, that has been used to defined the stochastic semantics of the above mentioned languages, has been the starting point for the definition of tools for supporting the quantitative analysis of systems. Moreover, thanks to the use of this general framework, a new class of behavioural equivalences have been introduced to support comparison of different (possible alternative) models of the same system.

## Logics, tools and methodologies for system verification

To specify properties of concurrent and distributed systems it is useful to use the appropriate operators that simply the description of some class of properties. Michele Loreti contributed to the definition of MoMo, a modal logic specifically designed for dealing with resource management and mobility aspects of concurrent behaviours, and MoSL+, its stochastic variant, together with the appropriate algorithms for their model-checking. Subsequently, these logics have been adapted in order to describe properties of service-oriented systems. Moreover, they have been also used to specify and verify properties of distributed and adaptive systems. However, these systems typically consists of a large number of agents that interact with each other. Classical model-checking techniques, due to state space explosion, can not always be applied to this class of systems. For this reason, Michele Loreti worked on new methodologies based on statistical model-checking, mean-field analysis and on-the-fly technique have been proposed to analyse systems with a large number of agents. Finally, to capture at the logical level the interplay between process behaviour and spatial aspects of computation, Michele Loreti contributed to the definition of the appropriate logic where modalities describe neighbourhood and surroundings.

## Development of tools for system analysis and deployment

Michele Loreti contributed to development of many tools that can be used to support qualitative and quantitative analysis of systems modelled via one of the process calculi described above. Among these tools we mention here TAPAs, jSAM and the CARMA Eclipse Plug-In. TAPAs, and its Eclipse version eTAPAs, provides tools for supporting specification and analysis of concurrent systems via Process Algebras. In TAPAs properties can be verified by checking equivalences between concrete and abstract system descriptions, or by model checking temporal formulae over the obtained LTS. jSAM is an Eclipse plugin integrating a set of tools for stochastic analysis of concurrent and distributed systems specified using process algebras. jSAM integrates a statistical model-checker, an on-the-fly model-checker and mean-field techniques to handle large scaled systems. Finally, CARMA Eclipse Plug-In supports specification and analysis of Collective Adaptive Systems in CARMA. This plug-in is based on an high-level specification language that simplifies the task of modelling for users who are unfamiliar with process algebra and similar formal notations.

To support deployment of systems modelled via process specification languages, it is crucial to have runtime environments implementing the linguistic constructs used to model and to reason about specific classes of systems. In this context, Michele Loreti contributed to the definition of IMC, a Java framework for implementing distributed applications possibly with code mobility. This framework has been used to develop runtime environments for many calculi. Here we mention in particular, JCaspis, a Java framework that can be used to develop application based on CaSPis in Java. More recently, Michele Loreti developed jRESP, a framework that support programming simulating autonomic and adaptive systems according to the SCEL paradigm. This framework provides a large set of API that permit to represent behaviors, knowledge and aggregations according to specific policies, and to support programming context-awareness, self-awareness and adaptation.

## Research Projects

Michele Loreti has been the coordinator of the project *Strumenti formali ed automatici di supporto alla programmazione di codice mobile* Funded by Università degli Studi di Firenze within the Young Researchers Initiative 2000. Moreover, he has contributed to the following national and international research projects:

**1999-2001** Teoria della Concorrenza, Linguaggi di Ordine Superiore e Strutture di Tipi (TOSCA)  
MURST programma di ricerca di interesse nazionale

- 1999-2001** Software Architectures and Languages to coordinate Distributed Mobile Components (SALADIN) MURST programma di ricerca di interesse nazionale
- 2000-2001** Sistemi di assegnazione di tipo per analisi e verifica di programmi, Gruppo Nazionale per le Strutture Algebriche, Geometriche e le loro Applicazioni (CNR)
- 2000-2001** Strumenti formali ed automatici di supporto alla programmazione di codice mobile, Young Researcher Initiative, Università degli Studi di Firenze
- 2001-2003** Sistemi di assegnazione di tipo per analisi e verifica di programmi, (continuazione progetto 2000), Gruppo Nazionale per le Strutture Algebriche, Geometriche e le loro Applicazioni (CNR)
- 2001-2003** Models, Calculi and Languages for Network Aware Programming (NAPOLI) MURST programma di ricerca di interesse nazionale
- 2001-2003** Network Aware Programming and Interoperability (NAPI), Microsoft Research
- 2002-2005** Mobile Calculi based on Domains (MIKADO) Funded by EU proactive initiative FET-Global Computing (Contract IST-2001-32222)
- 2002-2005** Architectures for Mobility (AGILE) Funded by EU proactive initiative FET-Global Computing (Contract IST-2001-32747)
- 2005-2007** Fondamenti Logici dei Sistemi Distribuiti e Codice Mobile, MIUR Programma di Ricerca di Interesse Nazionale.
- 2005-2009** Software Engineering for Service-Oriented Overlay Computers (SENSORIA) Funded by the European Union as an Integrated Project in the 6th framework program as part of the Global Computing Initiative (Contract IST-2005-16004).
- 2008-2010** Performability-Aware Computing: Logiche, Modelli e Linguaggi (PaCo), MIUR Programma di Ricerca di Interesse Nazionale.
- 2010-2014** Autonomic Service-Component Ensembles (ASCENS), Funded by the European Union as an Integrated Project (IP) in 7th Framework Programme (FP7) and part of Future Emerging Technologies initiative (Contract 257414)
- 2013-2016** CINA: Composizionalità, Interazione, Negoziazione, Autonomia per la società ICT futura. Programma di Ricerca di Interesse Nazionale, Funded by MIUR.
- 2013-2017** A Quantitative Approach to Management and Design of Collective and Adaptive Behaviours (QUANTICOL). Funded by European Union in FOCAS Initiative.

## 4 Supervisions

From 2001 to 2016, Michele Loreti has been supervisor of more than 100 bachelor and master thesis (Computer Science degrees at University of Firenze: Laurea in Informatica, Laurea Magistrale in Informatica, Laurea Specialistica in Scienze e Tecnologia dell'Informazione, Laurea in Scienze dell'Informazione).

Michele Loreti supervised the following PhD students:

- Daniele Falassi (co-supervised with Rocco De Nicola)
- Francesco Calzolari
- Liliana D'Errico
- Yehia Abd Alrahman (co-supervised with Rocco De Nicola)

## 5 Teaching activities

List of taught courses in official courses of studies:

- Introduction to Computer Science (Master degrees at Università di Firenze, 1999-2003,2005-2006,2008-2011)
- Network Laboratory (Computer Science degrees at Università di Firenze, 2002-2005)
- Network Programming (Computer Science degrees at Università di Firenze, 2002-2008)
- Formal methods for Programming Languages (Computer Science degrees at Università di Firenze, , 2004-2009)
- Compilers (Computer Science degrees at Università di Firenze, 2009-2011)
- Ensemble-oriented programming of self-adaptive systems (PhD course at AWASS Summer School 2013, Lucca, Italy)
- Formal Methods (Computer Science degrees at Università di Firenze, 2012-2016)
- Networks (Computer Science degrees at Università di Firenze, 2012-2016)
- Introduction to Computer Programming and Programming Methodology (PhD course at IMT Lucca, 2012-2016)
- Principles of Model-checking (PhD course at Gran Sasso Science Institute, 2014-2016)
- Development of Distributed Applications with jRESP (*Bachelor Students* at DTU, 2016)

## 6 Other Activities

Michele loretì has been

- Member of *editorial board* of *The Journal of Logical and Algebraic Methods in Programming*, Elsevier
- Co-chair of *1st International Workshop on FORmal methods for the quantitative Evaluation* (FORECAST 2016)
- Co-chair of *15th Italian Conference on Theoretical Computer Science* (ICTCS 2015)
- Co-chair of *10th International Symposium on Trustworthy Global Computing* (TGC 2015)
- Co-Scientific director of Open Problems in Concurrency Theory (OPCT 2014)
- General Chair of 8th International Federated Conference on Distributed Computing Techniques (DisCoTec), Firenze from 3 to 6 of June 2013
- member of organizing committee of PLI (*Principles, Logics, and Implementations of high-level programming languages*), Firenze September 2001.
- member of program committees for:
  - *19th International Conference on Coordination Models and Languages* (COORDINATION 2017)
  - *14th International Workshop on Quantitative Aspects of Programming Languages and Systems* (QAPL 2016)

- *26th Conference on Concurrency Theory (CONCUR 2015)*
- *3rd IEEE International Workshop on Formal Methods Integration (FMi 2015)*
- *8th International Conference on Performance Evaluation Methodologies and Tools (ValueTools 2014)*
- *2nd IEEE International Workshop on Formal Methods Integration (FMi 2014)*
- *16th International Conference on Coordination Models and Languages (COORDINATION 2014)*
- *9th International Symposium on Trustworthy Global Computing (TGC 2014)*
- *3rd Workshop On GRAPH Inspection and Traversal Engineering (GRAPHITE 2014)*
- *7th International Conference on Performance Evaluation Methodologies and Tools (ValueTools 2013)*
- *International Conference on Integrating Formal Methods (2012, 2013)*
- *1st International Workshop on Formal Methods for Self-Adaptive Systems (2012)*
- *7th European Performance Engineering Workshop (2010)*
- *Workshop on Agent Based Computing (2007, 2008, 2010,2011)*
- *Coordination Models, Languages and Architectures of Symposium on Applied Computing (SAC'09 e SAC'10)*
- reviewers of many international conferences and journals
- member of the following committee of Computer Science Program at Università di Firenze:
  - *Computer Laboratories*, devoted to the design, coordination and management of Computer Laboratories of the Computer Science Program;
  - *E-Learning and distance education*, devoted to the design of a distance degree program in Computer Science;
  - *Stages*, to coordinate relationships between students and business companies.
- member of the *Scientific Board* of PhD program in *Computer Science and Applications*, Dipartimento di Sistemi e Informatica, Università di Firenze,
- member of the *Board of Discipline* of Università di Firenze.

## 7 Publications

### 7.1 Journal Papers

- 2016      CIANCIA, V., LATELLA, D., LORETI, M., AND MASSINK, M. Model Checking Spatial Logics for Closure Spaces. *Logical Methods in Computer Science* 12 (2016)
- CHITI, F., FANTACCI, R., LORETI, M., AND PUGLIESE, R. Context-aware wireless mobile autonomic computing and communications: research trends and emerging applications. *IEEE Wireless Commun.* 23, 2 (2016), 86–92
- 2015      BERNARDO, M., DE NICOLA, R., AND LORETI, M. Revisiting bisimilarity and its modal logic for nondeterministic and probabilistic processes. *Acta Inf.* 52, 1 (2015), 61–106
- BOREALE, M., BRUNI, R., DE NICOLA, R., AND LORETI, M. CaSPiS: a calculus of sessions, pipelines and services. *Mathematical Structures in Computer Science* 25, 3 (2015), 666–709

- LATELLA, D., LORETI, M., AND MASSINK, M. On-the-fly PCTL fast mean-field approximated model-checking for self-organising coordination. *Sci. Comput. Program.* 110 (2015), 23–50
- 2014 BERNARDO, M., DE NICOLA, R., AND LORETI, M. Revisiting Trace and Testing Equivalences for Nondeterministic and Probabilistic Processes. *Logical Methods in Computer Science* 10, 1 (2014), 1–16
- BERNARDO, M., GEBLER, D., AND LORETI, M. Report on OPCT 2014. *Bulletin of the EATCS* 114 (2014)
- DE NICOLA, R., LORETI, M., PUGLIESE, R., AND TIEZZI, F. A formal approach to autonomic systems programming: The SCEL Language . *ACM Transactions on Autonomous and Adaptive Systems* 9, 2 (2014), 7:1–7:29
- BERNARDO, M., DE NICOLA, R., AND LORETI, M. Relating strong behavioral equivalences for processes with nondeterminism and probabilities. *Theoretical Computer Science* 546 (2014), 63–92
- 2013 BERNARDO, M., DE NICOLA, R., AND LORETI, M. A uniform framework for modeling nondeterministic, probabilistic, stochastic, or mixed processes and their behavioral equivalences. *Inf. Comput.* 225, 1 (2013), 29–82
- 2008 DE NICOLA, R., AND LORETI, M. Modelling global computations with Klaim. *Philosophical Transactions of the Royal Society of London A: Mathematical, Physical and Engineering Sciences* 366, 1881 (2008), 3737–3745
- DE NICOLA, R., AND LORETI, M. Multiple-Labelled Transition Systems for nominal calculi and their logics. *Mathematical Structures in Computer Science* 18, 1 (2008), 107–143
- CALZOLAI, F., DE NICOLA, R., LORETI, M., AND TIEZZI, F. TAPAS: A Tool for the Analysis of Process Algebras. *T. Petri Nets and Other Models of Concurrency* 1 (2008), 54–70
- 2007 DE NICOLA, R., KATOEN, P., LATELLA, D., LORETI, M., AND MASSINK, M. Model checking mobile stochastic logic. *Theor. Comput. Sci.* 382, 1 (2007), 42–70
- 2006 BETTINI, L., DE NICOLA, R., AND LORETI, M. Implementing Mobile and Distributed Applications in X-Klaim. *Scalable Computing: Practice and Experience* 7, 4 (2006)
- 2004 BETTINI, L., DE NICOLA, R., AND LORETI, M. Formulae Meet Programs Over the Net: A Framework for Correct Network Aware Programming. *Autom. Softw. Eng.* 11, 3 (2004), 245–288
- DE NICOLA, R., AND LORETI, M. A modal logic for mobile agents. *ACM Trans. Comput. Log.* 5, 1 (2004), 79–128

## 7.2 Proceedings of Refereed Conferences

- 2016 ALRAHMAN, Y. A., DE NICOLA, R., AND LORETI, M. Programming of CAS Systems by Relying on Attribute-Based Communication. In *Leveraging Applications of Formal Methods, Verification and Validation: Foundational Techniques - 7th International Symposium, ISoLA 2016, Imperial, C* (2016), T. Margaria and B. Steffen, Eds., vol. 9952 of *Lecture Notes in Computer Science*, pp. 539–553

ALRAHMAN, Y. A., DE NICOLA, R., AND LORETI, M. On the Power of Attribute-Based Communication. In *Formal Techniques for Distributed Objects, Components, and Systems - 36th IFIP WG 6.1 International Conference, FORTE 2016* (2016), E. Albert and I. Lanese, Eds., vol. 9688 of *Lecture Notes in Computer Science*, Springer, pp. 1–18

HILLSTON, J., AND LORETI, M. CARMA Eclipse Plug-in: A Tool Supporting Design and Analysis of Collective Adaptive Systems. In *Quantitative Evaluation of Systems - 13th International Conference, QEST 2016, Quebec City, QC, Canada, August 23-25, 2016, Proceedings* (2016), G. Agha and B. V. Houdt, Eds., vol. 9826 of *Lecture Notes in Computer Science*, Springer, pp. 167–171

LORETI, M., AND HILLSTON, J. Modelling and Analysis of Collective Adaptive Systems with CARMA and its Tools. In *Formal Methods for the Quantitative Evaluation of Collective Adaptive Systems - 16th International School on Formal Methods for the Design of Computer* (2016), M. Bernardo, R. D. Nicola, and J. Hillston, Eds., vol. 9700 of *Lecture Notes in Computer Science*, Springer, pp. 83–119

CIANCIA, V., LATELLA, D., LORETI, M., AND MASSINK, M. Spatial Logic and Spatial Model Checking for Closure Spaces. In *Formal Methods for the Quantitative Evaluation of Collective Adaptive Systems - 16th International School on Formal Methods for the Design of Computer* (2016), M. Bernardo, R. D. Nicola, and J. Hillston, Eds., vol. 9700 of *Lecture Notes in Computer Science*, Springer, pp. 156–201

2015 LATELLA, D., LORETI, M., MASSINK, M., AND SENNI, V. On StocS: A Stochastic Extension of SCEL. In *Software, Services, and Systems - Essays Dedicated to Martin Wirsing on the Occasion of His Retirement from the Chair of Programming and Software Engi* (2015), R. D. Nicola and R. Hennicker, Eds., vol. 8950 of *Lecture Notes in Computer Science*, Springer, pp. 619–640

LATELLA, D., LORETI, M., AND MASSINK, M. Investigating Fluid-Flow Semantics of Asynchronous Tuple-Based Process Languages for Collective Adaptive Systems. In *Coordination Models and Languages - 17th IFIP WG 6.1 International Conference, COORDINATION 2015, Held as Part of the 10th International Federated Con* (2015), T. Holvoet and M. Viroli, Eds., vol. 9037 of *Lecture Notes in Computer Science*, Springer, pp. 19–34

LLUCH-LAFUENTE, A., LORETI, M., AND MONTANARI, U. A Fixpoint-Based Calculus for Graph-Shaped Computational Fields. In *Coordination Models and Languages - 17th IFIP WG 6.1 International Conference, COORDINATION 2015, Held as Part of the 10th International Federated Con* (2015), T. Holvoet and M. Viroli, Eds., vol. 9037 of *Lecture Notes in Computer Science*, Springer, pp. 101–116  
**(Best paper at DisCoTec 2015)**

LATELLA, D., LORETI, M., AND MASSINK, M. On-the-fly Fluid Model Checking via Discrete Time Population Models. In *Computer Performance Engineering - 12th European Workshop, EPEW 2015, Madrid, Spain, August 31 - September 1, 2015, Proceedings* (2015), M. Beltrán, W. J. Knottenbelt, and J. T. Bradley, Eds., vol. 9272 of *Lecture Notes in Computer Science*, Springer, pp. 193–207

NENZI, L., BORTOLUSSI, L., CIANCIA, V., LORETI, M., AND MASSINK, M. Qualitative and Quantitative Monitoring of Spatio-Temporal Properties. In *Runtime Verification - 6th International Conference, RV 2015 Vienna, Austria, September 22-25, 2015. Proceedings* (2015), E. Bartocci and R. Majumdar, Eds., vol. 9333 of *Lecture Notes in Computer Science*, Springer, pp. 21–37

- ALRAHMAN, Y. A., DE NICOLA, R., LORETI, M., TIEZZI, F., AND VIGO, R. A calculus for attribute-based communication. In *Proceedings of the 30th Annual ACM Symposium on Applied Computing, Salamanca, Spain, April 13-17, 2015* (2015), R. L. Wainwright, J. M. Corchado, A. Bechini, and J. Hong, Eds., ACM, pp. 1840–1845
- ABEY WickRAMA, D. B., SERBEDZIJA, N. B., AND LORETI, M. Monitoring and visualizing adaptation of autonomic systems at runtime. In *Proceedings of the 30th Annual ACM Symposium on Applied Computing, Salamanca, Spain, April 13-17, 2015* (2015), R. L. Wainwright, J. M. Corchado, A. Bechini, and J. Hong, Eds., ACM, pp. 1857–1860
- CIANCIA, V., GRILLETTI, G., LATELLA, D., LORETI, M., AND MASSINK, M. An Experimental Spatio-Temporal Model Checker. In *Software Engineering and Formal Methods - SEFM 2015 Collocated Workshops: ATSE, HOFM, MoKMaSD, and VERY\*SCART, York, UK, September 7-8, 2015, Revised* (2015), D. Bianculli, R. Calinescu, and B. Rumpe, Eds., vol. 9509 of *Lecture Notes in Computer Science*, Springer, pp. 297–311
- BORTOLUSSI, L., DE NICOLA, R., GALPIN, V., GILMORE, S., HILLSTON, J., LATELLA, D., LORETI, M., AND MASSINK, M. CARMA: Collective Adaptive Resource-sharing Markovian Agents. In *Proceedings Thirteenth Workshop on Quantitative Aspects of Programming Languages and Systems, QAPL 2015, London, UK, 11th-12th April 2015*. (2015), N. Bertrand and M. Tribastone, Eds., vol. 194 of *EPTCS*, pp. 16–31
- 2014 HILLSTON, J., AND LORETI, M. Specification and Analysis of Open-Ended Systems with CARMA. In *Agent Environments for Multi-Agent Systems IV - 4th International Workshop, E4MAS 2014 - 10 Years Later, Paris, France, May 6, 2014, Revised Selected* (2014), D. Weyns and F. Michel, Eds., vol. 9068 of *Lecture Notes in Computer Science*, Springer, pp. 95–116
- DE NICOLA, R., LORETI, M., MORICETTA, A., PUGLIESE, R., SENNI, V., TIEZZI, F., AND ALBERTO, L.-L. Programming and Verifying Component Ensembles. In *From Programs to Systems. The Systems perspective in Computing - ETAPS Workshop, FPS 2014, in Honor of Joseph Sifakis*. (2014), S. Bensalem, Y. Lakhnech, and A. Legay, Eds., vol. 8415 of *Lecture Notes in Computer Science*, Springer, pp. 69–83
- LATELLA, D., LORETI, M., MASSINK, M., AND CIANCIA, V. Specifying and Verifying Properties of Space. In *Theoretical Computer Science - 8th IFIP TC 1/WG 2.2 International Conference, TCS 2014, Rome, Italy, September 1-3, 2014. Proceed* (2014), J. Díaz, I. Lanese, and D. Sangiorgi, Eds., vol. 8705 of *Lecture Notes in Computer Science*, Springer, pp. 222–235
- LORETI, M., MARGHERI, A., PUGLIESE, R., AND TIEZZI, F. On Programming and Policing Autonomic Computing Systems. In *Leveraging Applications of Formal Methods, Verification and Validation. Technologies for Mastering Change - 6th International Symposium, ISoLA 2014, P* (2014), T. Margaria and B. Steffen, Eds., vol. 8802 of *Lecture Notes in Computer Science*, Springer, pp. 164–183
- CIANCIA, V., GILMORE, S., LATELLA, D., LORETI, M., AND MASSINK, M. Data Verification for Collective Adaptive Systems: Spatial Model-Checking of Vehicle Location Data. In *Eighth IEEE International Conference on Self-Adaptive and Self-Organizing Systems Workshops, SASOW 2014, London, United Kingdom, September 8-12, 2014* (2014), IEEE Computer Society, pp. 32–37



- LATELLA, D., LORETI, M., MASSINK, M., AND SENNI, V. Stochastically timed predicate-based communication primitives for autonomic computing. In *Proceedings of 12th Quantitative Aspects of Programming Languages and Systems (QAPL)* (2014), N. Bertrand and L. Bortolussi, Eds., vol. 154 of *Electronic Proceedings in Theoretical Computer Science*, Open Publishing Association, pp. 1–16
- LATELLA, D., LORETI, M., AND MASSINK, M. On-the-fly Probabilistic Model Checking. In *Proc. of 7th Interaction and Concurrency Experience* (2014), I. Lanese, A. L. Lafuente, A. Sokolova, and H. Vieira, Eds., *Electronic Proceedings in Theoretical Computer Science*, p. To appear
- LATELLA, D., LORETI, M., AND MASSINK, M. On-the-fly Fast Mean-Field Model-Checking. In *Trustworthy Global Computing*, M. Abadi and A. L. Lafuente, Eds., *Lecture Notes in Computer Science*. Springer International Publishing, 2014, pp. 297–314
- BERNARDO, M., DE NICOLA, R., AND LORETI, M. Group-by-Group Probabilistic Bisimilarities and Their Logical Characterizations. In *Trustworthy Global Computing*, M. Abadi and A. L. Lafuente, Eds., *Lecture Notes in Computer Science*. Springer International Publishing, 2014, pp. 315–330
- 2013 BERNARDO, M., DE NICOLA, R., AND LORETI, M. The Spectrum of Strong Behavioral Equivalences for Nondeterministic and Probabilistic Processes. In *Proceedings 11th International Workshop on Quantitative Aspects of Programming Languages and Systems, QAPL 2013* (2013), L. Bortolussi and H. Wiklicky, Eds., vol. 117 of *Electronic Proceedings in Theoretical Computer Science*, pp. 81–96
- DE NICOLA, R., FERRARI, G. L., LORETI, M., AND PUGLIESE, R. A Language-Based Approach to Autonomic Computing. In *Formal Methods for Components and Objects, 10th International Symposium, FMCO 2011* (2013), B. Beckert, F. Damiani, F. S. de Boer, and M. M. Bonsangue, Eds., vol. 7542 of *Lecture Notes in Computer Science*, Springer, pp. 25–48
- 2012 BERNARDO, M., DE NICOLA, R., AND LORETI, M. Revisiting Trace and Testing Equivalences for Nondeterministic and Probabilistic Processes. In *Foundations of Software Science and Computational Structures - 15th International Conference, FOSSACS 2012* (2012), L. Birkedal, Ed., vol. 7213 of *Lecture Notes in Computer Science*, Springer, pp. 195–209
- GJONDREKAJ, E., LORETI, M., PUGLIESE, R., TIEZZI, F., PINCIROLI, C., BRAMBILLA, M., BIRATTARI, M., AND DORIGO, M. Towards a Formal Verification Methodology for Collective Robotic Systems. In *Formal Methods and Software Engineering - 14th International Conference on Formal Engineering Methods, ICFEM 2012* (2012), T. Aoki and K. Taguchi, Eds., vol. 7635 of *Lecture Notes in Computer Science*, Springer, pp. 54–70
- GJONDREKAJ, E., LORETI, M., PUGLIESE, R., AND TIEZZI, F. Modeling adaptation with a tuple-based coordination language. In *Proceedings of the ACM Symposium on Applied Computing, SAC 2012* (2012), S. Ossowski and P. Lecca, Eds., ACM, pp. 1522–1527
- 2011 D’ERRICO, L., AND LORETI, M. Context Aware Specification and Verification of Distributed Systems. In *Trustworthy Global Computing - 6th International Symposium, TGC 2011* (2011), R. Bruni and V. Sassone, Eds., vol. 7173 of *Lecture Notes in Computer Science*, Springer, pp. 142–159

- BERNARDO, M., DE NICOLA, R., AND LORETI, M. Uniform Labeled Transition Systems for Nondeterministic, Probabilistic, and Stochastic Process Calculi. In *Proceedings First International Workshop on Process Algebra and Coordination, PACO 2011* (2011), L. Aceto and M. R. Mousavi, Eds., vol. 60 of *Electronic Proceedings in Theoretical Computer Science*, pp. 66–75
- 2010 CALZOLAI, F., AND LORETI, M. Simulation and Analysis of Distributed Systems in Klaim. In *Coordination Models and Languages, 12th International Conference, COORDINATION 2010* (2010), D. Clarke and G. A. Agha, Eds., vol. 6116 of *Lecture Notes in Computer Science*, Springer, pp. 122–136
- BERNARDO, M., DE NICOLA, R., AND LORETI, M. Uniform Labeled Transition Systems for Nondeterministic, Probabilistic, and Stochastic Processes. In *Trustworthy Global Computing - 5th International Symposium, TGC 2010* (2010), M. Wirsing, M. Hofmann, and A. Rauschmayer, Eds., vol. 6084 of *Lecture Notes in Computer Science*, Springer, pp. 35–56
- D’ERRICO, L., AND LORETI, M. Property-Preserving Refinement of Concurrent Systems. In *Trustworthy Global Computing - 5th International Symposium, TGC 2010* (2010), M. Wirsing, M. Hofmann, and A. Rauschmayer, Eds., vol. 6084 of *Lecture Notes in Computer Science*, Springer, pp. 222–236
- 2009 D’ERRICO, L., AND LORETI, M. Assume-Guarantee Verification of Concurrent Systems. In *Coordination Models and Languages, 11th International Conference, COORDINATION 2009* (2009), J. Field and V. T. Vasconcelos, Eds., vol. 5521 of *Lecture Notes in Computer Science*, Springer, pp. 288–305
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## 8 Tools and Software

**SAM: Stochastic Analyser for Mobility** SAM is a command-line tool, developed in OCaml, that supports the stochastic analysis of mobile and distributed systems specified in STOKLAIM. SAM can be used for: executing interactively specifications; simulating stochastic behaviours; model checking formulae of MoSL, a stochastic logic for mobility.

**MarCaSPiS: Markovian CaSPiS** SoSL-MC permits verifying whether a given MARCASPiS specification satisfies or not a SoSL formula. The idea is to use an existing state-based stochastic model-checkers, the Markov Reward Model Checker (MRMC), and wrapping them in the SoSL model-checking algorithm. SoSL-MC, which is implemented in OCAML, permits analysing the execution of MARCASPiS programs and generating their reachability graphs. Moreover, after loading a MARCASPiS specification and a formula, it verifies, by means of one or more calls to MRMC, the satisfaction of the formula by the specification.

**TAPAs: Tool for Process Algebra** TAPAs is a tool that can be used to support the use of process algebras to specify and analyze concurrent systems. Systems are described as process algebras terms that are then mapped to Labelled Transition Systems (LTSs). Properties can be verified by checking equivalences between concrete and abstract system descriptions, or by model checking temporal formulae over the obtained LTS. A key feature of TAPAs, that makes it particularly suited for teaching, is that it maintains a consistent double representation as term and as graph of each system. After a change in the graphic notation the updating is automatic, but when a modification concern of the textual notation the updating is on request.

**JavaMM** JavaMM is a tool that can be effectively used to support students in their first approach to the Java language, according to the philosophy of "structured programming before object oriented programming". Indeed, this environment allows the student to learn the basics of the Java language without necessarily knowing the object-oriented features of the language itself, and the teacher to propose new tests by making use of a graphical test editor.

**IMC and JDpi** IMC is a Java software framework for building infrastructures to support the development of applications for systems where mobility and network awareness are key issues. The framework is particularly useful to develop run-time support for languages oriented towards global computing. It enables platform designers to customize communication protocols and network architectures and guarantees transparency of name management and code mobility in distributed environments. IMC has been employed for developing a Java prototype implementation of a run-time system for the distributed Pi calculus, JDpi. JDpi is a Java framework that can be used to develop distributed applications following the paradigm introduced by the distributed  $\pi$ -calculus ( $D\pi$  in short). The framework provides Java classes to develop processes that can migrate between nodes and communicate over channel, with a semantics derived from  $D\pi$ .

**jRESP** jRESP is a runtime environment, developed in Java, that aims at providing programmers with a framework that permits developing autonomic and adaptive systems programmed in SCEL. SCEL is a process algebraic language that provides abstractions explicitly supporting autonomic computing systems in terms of *Behaviors*, *Knowledge* and *Aggregations*, according to specific *Policies*. jRESP provides a set of API that permits using the SCEL paradigm in Java programs. This allows programmers to experiment with SCEL primitives that are integrated in a standard and well known programming language.

**Eclipse CARMA plug-in** This is an Eclipse plug-in developed for supporting specification and analysis of CAS in CARMA. In this plug-in, CARMA systems are specified by using an appropriate high-level language for designers of CAS, named the CARMA Specification Language. This is mapped to the process algebra, and hence will enable qualitative and quantitative analysis of CAS during system development by enabling a design workflow and analysis pathway. The intention of this high-level language is not to add to the expressiveness of CARMA, which we believe to be well-suited to capturing the behaviour of CAS, but rather to ease the task of modelling for users who are unfamiliar with process algebra and similar formal notations.

**jSSTL** jSSTL is a Java tool for the specification and verification of SSTL. This tool, developed in Java, consists of a Java library (jSSTL API) and a front-end, integrated in ECLIPSE.