CURRICULUM VITÆ

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Professor in Computer Science

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Birthday and birthplace: November 6, 1964; Modena (Italy).

Citizenship: Italian.

Known foreign languages: English and French.

Education:

(1993) PhD in Computer Science, University of Pisa (Italy);

(1988) Master (*Laurea*) degree in Computer Science, University of Pisa (Italy);

(1983) Scientific Lyceum (*Maturità Scientifica*) Diploma.

Past and current positions:

(2014-2015) Sabbatical year as Senior Research Scientist at IMDEA Software Institute;

(2000–) Full Professor in CS at the Dipartimento di Informatica, University of Verona;

(1998-2000) Associate Professor in CS at the Dip. Scientifico e Tecnologico, University of Verona;

(1995-1998) Assistant Professor in Computer Science at the Dip. di Informatica, University of Pisa;

(1993-1995) Post-doc at the Laboratoire d'Informatique (LIX), École Polytechnique, Paris (France).

Main research interests:

- Programming languages;
- Abstract interpretation and program analysis;
- Program design, transformation, optimisation;
- Language-based security and malware detection;
- Code protection: obfuscation, software watermarking, and fingerprinting;
- Computability, semantics and foundation of programming languages and systems;
- Logic, universal algebra, lattice theory, congruence lattices, and closure operators.

Institutional responsibilities:

(2018–) Head of the Computer Science Department of the Università degli studi di Verona.
(2013-2014) Member of the Board of Directors of the Università degli studi di Verona.
(2012-2014) Chair of the Italian National Scientific Qualification committee for Computer Science.
(2006-2012) Dean of the College of Science of the Università degli studi di Verona.
(2004-2006) Provost for Research at the Università degli studi di Verona.
(2004-2006) Member of the Evaluation Board of the Università degli studi di Verona.
(2001-2004) Provost for Education and E-learning at the Università degli studi di Verona.

Curriculum

Research interests:

I am mostly interested in abstract interpretation and formal methods with applications in any area of computer science, including: static program analysis, semantics, program synthesis, transformation and optimisation, language-based security, code protection, white-box crypto, malware analysis, verification, model checking, logic, constraint programming, universal algebra, and lattice theory. I am author of more than 120 publications in international journals and international conferences. In Google Scholar: 3070 citations, H-index 30, i10-index 66. The 20 most cited papers according to Google Scholar are: [18, 2, 68, 12, 64, 6, 9, 44, 7, 56, 16, 40, 13, 1, 53, 19, 8, 5, 24, 14]. The paper that has most marked my career is:

> R. Giacobazzi, F. Ranzato, and F. Scozzari. Making abstract interpretation complete.
> *Journal of the ACM*, 47(2):361-416, March 2000.

This paper introduced the problem of making abstract domains complete and provided the very first systematic method for minimally refining abstract domains to make them complete for Scott-continuous functions, therefore including all computable functions. This paper opened a field: the possibility of controlling completeness (and incompleteness) by tuning abstract domains. This allowed researchers to reduce false alarms by minimal abstract domain refinement but also inject alarms by morphing code in order to protect software from malicious reverse engineering.

Summary of main achievements:

Abstract interpretation: We introduced a number of transformations of abstract domains (see [7] for an early account) in order to tune their precision by: completeness refinement [58, 59, 60, 18, 67, 81], relational composition [52, 16, 17], complementation [51, 9], disjunctive completion [54, 13], Heyting Completion [57], Linear refinement [20], and compression [56, 30]. We also studied code transformations for improving the precision of a fixed abstraction [32]. Recent achievements concern decidable procedures for the analysis of the precision and completeness (viz., absence of false alarms) of analyses with respect to fixed programs and the recursive properties of precise abstract interpretations [93, 37, 38].

Static analysis: We introduced deductive bottom-up and compositional methods for static analysis of logic programs [2, 44, 47, 48, 4, 83] and constraint logic programs [42, 46, 6]. I introduced the notion of *abductive program analysis* in 1994 [50, 12], now used in industrial tools such as *Infer* by Facebook. Specific domains have been studied in these contexts, notably for type inference [1], numeric constraint optimisation [45], depth-k determinate computations, aliasing analysis for pipeline optimisations [39, 41], and approximation of indexed grammars [102]. We also developed the very first GPU-based implementation of an abstract interpreter based on weakly-relational numerical abstract domains (in particular octagons) in [77].

Verification: We studied the properties of complete abstractions of Kripke structures, proving the connection between Counter-Example Guided Abstraction Refinement (CEGAR) and complete refinements for abstract interpretation [63, 64, 82, 86], and also proved the intrinsic incompleteness of the state abstraction with respect to traces in *a la Kozen* temporal μ-calculi [65, 22]. More recently we studied the intrinsic differences between program analysis and program verification from a computability perspective [98] and the relation between inductive and co-inductive proof methods in presence of abstraction [99].

Security: We introduced the notion of *Abstract Non-Interference* as a generalisation of non-interference in language based security [68, 71, 26, 25, 35]. This allows to formally specify attack models as approximate analyses (static or dynamic) of programs. This notion has been extended towards concurrent and timed programming languages for catching covert channels such as the amount of timing and synchronisation leakage [74, 75, 78].

Code protection: We contributed to the introduction of the first semantic-based model for specifying code obfuscation algorithms [72, 73, 79, 24, 87, 88, 90, 91]. The idea is to view code obfuscation as a transformation making a (possibly dynamic) analysis (attacker) incomplete in the sense of abstract interpretation for the transformed program. This provides a comprehensive theory of obscurity for programming languages with a strong mathematical background [87, 29, 90]. Robust algorithms for code obfuscation [76] and SW watermarking [80] was derived systematically by specialising distorted interpreters driven by the attacker to defeat, with applications in in control/data code obfuscation and in code fingerprinting [89, 97].

***Big Code* analysis:** We introduced a mixed syntactic-semantic representation of code fragments in terms of *abstract symbolic automata* [94]. These automata, with corresponding operations for their transformation (e.g., minimisation, widening, etc) provide the foundation for similarity analysis and mining in large software enclaves. Current research involve their use in mining and learning phylogenetic patterns in large enclaves of malware code.

Malware analysis and detection: We contributed to the semantic-based analysis of metamorphic malware [84, 31]. Metamorphic signatures have been automatically extracted by abstract interpretation of a refined semantics modelling code evolution. In particular we introduced the notion of *regular metamorphism*, corresponding to abstractions of this semantics into finite state automata. We studied vulnerability aspects of *Address Space Layout Randomisation* procedures (ASLR), in particular in the Windows 7 OS. In this context he exploited an ASLR vulnerability to make compatible with Windows 7 an obfuscation technique based on memory relocations, implemented for the first time in the W32.Relock virus [28].

Semantics: We introduced the very first hierarchy of semantics for pure logic programs, based on abstract interpretation [53]. This work has been extended to resolution based-systems, including a number of resolution strategies [23]. We also studied semantic models for characterising control features in Prolog programs, such as: cut, backtracking, and arbitrary selection rules [40, 43, 3, 5]. We studied the semantics of programming languages form the point of view of systematic semantic design and observation power [62, 27]. In this field we applied systematic methods developed for domain construction to the design of semantics for programming languages as composition of abstractions of arbitrary transition systems, including trace models, compositional denotational models [55, 66], transfinite models of computation [19, 21], and logic-based models.

Lattice theory: Standard abstract interpretation theory is based on the isomorphism between the lattice of all abstractions on a given domain and the lattice of all its closure operators. The study of abstract interpretation theory have therefore lead to original results in the algebraic theory of closure operators on complete lattices. We proved the weakly relative pseudo-complemented structure of the lattice of all closure operators of a continuous lattice [8]. This is the theoretical foundation for abstract domain complementation in [9]. We introduced the notion of meet- and join-uniformity for closure operators on complete lattices and proved the relevance of uniformity for reasoning about adjoint closure systems [14, 33]. We contributed to prove an embedding of the lattice of complete congruences on a continuous lattice into the lattice of all its closure operators [11, 15]. This provides a way to extend most properties of the lattice of closure operators to the lattice of complete congruences on continuous lattices.

Granted awards:

(2017) Talento Award by the Madrid Regional Government.

(2013) Microsoft Research Software Engineering Innovation Foundation Award (SEIF Award).

(1993) Individual HCM Human Capital and Mobility Award at Ecole Polytechnique, FR.

Invited talks in the last 10 years:

(2019) Hacking program analysis: a systematic approach to code protection. *7th International Workshop on Verification and Program Transformation (VPT2019)*. Genova April 2, 2019.
(2017) Abstract Interpretation for Program Security. *24th Static Analysis Symposium*, August 30th - September 1st, 2017, New York City, NY, USA.
(2015) Analysing Completeness in Program Analysis. *ETH Workshop on Software Correctness and Reliability*, October 2-3, 2015, ETH Zürich.
(2015) Protecting Code by Obfuscation. *PROLE 2015* Spanish Conf. on Programming and Computer Languages. Santander, Spet. 15-17.
(2014) Obscuring Code - Unveiling and Veiling Information in Programs. *16th Int. Symp. on Principles and Practice of Declarative Programming* (ACM PPDP 2014) and *24th Int. Symp. on Logic-Based Program Synthesis and Transformation* (LOPSTR 2014). Canterbury, UK., September 8-11, 2014.
(2012) Software Security by Obscurity - A Programming Language Perspective. *6th Int. Conference on Information Systems, Technology and Management*. Communications in Computer and Information Science 285, Springer Verlag, pp. 427-432, 2012. Grenoble, March 28-30, 2012.
(2011) Algebraic Structures in Program Understanding: A Case Study in Program Protection. *11th Biennial IQSA Meeting Quantum Structures*, 23 - 27 July, Cagliari (Italy).
(2010) Abstract Interpretation-Based Protection. *11th Int. Conference on Verification, Model Checking, and Abstract Interpretation* VMCAI 2010, Madrid, Spain, January 17-19, 2010.

Contribution to early career of researchers:

I have been advisor of 15 PhD students at the following institutions: Université de Paris VII, U. of Siena, Ben-Gurion U., and U. of Verona. The most representative ones in terms of career follow-up are: Dr. F. Scozzari: now Associate Prof. U. of Chieti-Pescara. Dr. S. Genaim: now Associate Prof. Universidad Complutense de Madrid. Prof. I. Mastroeni: now Associate Prof. U. of Verona and winner of the best PhD thesis award in Theoretical Computer Science by the Italian Chapter of EATCS in 2005. Dr. D. Zanardini: now Associate Prof. at UPM. Dr. M. Dalla Preda: now Associate Prof. U. of Verona, winner of the QINETIQ Award for research contributions with strong practical applications in 2006 and receiving the Special mention from the a EATCS (European Association for Theoretical Computer Science) for PhD thesis in theoretical computer science. Mila was among the youngest PI being granted by the MIUR FIRB 2013, with 522,743€ for the project FACE (Formal Avenue for Chasing malwarE). Dr. E. Visentini (Senior SW Eng. at Reply). Dr. Durica Nikolić (Senior SW Eng. at Avaloq).

Scientific organisation (a selection):

(2018) Chair of the Shonan Meeting No. 115: *Intensional and extensional aspects of computation: From computability and complexity to program analysis and security*, Shonan Village Japan, Jan. 21-25, 2018.
(2017) Program Chair of the N40AI – *Next 40 Years of Abstract Interpretation* workshop co-located with POPL 2017 in Paris, Jan. 21st, 2017, celebrating the publication of Cousot & Cousot POPL'77 seminal paper on abstract interpretation and chair and organiser of the *40 Years of Abstract Interpretation – An Interview with Patrick Cousot*, at POPL 2017.
(2012-2015) Steering Committee of *ACM Symp. on Principles of Programming Languages (POPL)*. Co-author of: D. Dreyer, J. Field, R. Giacobazzi, M. Hicks, S. Jagannathan, M. Sagiv, P. Sewell, P. Wadler. Principles of POPL. *SIGPLAN Notices* 48(4S): 12-16, 2013. DOI.
(2014) Chair of the Dagstuhl Seminar 14241 on *Challenges in analysing executables: Scalability, Self-modifying code and Synergy*, June 9–13, 2014.
(2013) Program Chair of *14th Verification, Model Checking, and Abstract Interpretation (VMCAI'13)*.
(2013) General Chair of *40th ACM Symposium on Principles of Programming Languages (POPL'13)*.
(2011) Editor of the Special Issue on the *3rd Int. Workshop on Programming Language Interference and Dependence - PLID 2007*, in *Mathematical Structures in Computer Science* 61(6), 2011.
(2008) Chair of the *30 Years of Abstract Interpretation (30YAI)* workshop in honor of Patrick Cousot, January 09, joint with POPL 2008, San Francisco USA.
(2008-2014) Editor of the *Central European J. of Computer Science*, by Springer-Verlag.

(2007) Editor of the Special Issue of *11th Static Analysis Symp.*, *Sci. of Comp. Prog.* 64(1):1-184, 2007.
(2004) Program Chair of the *SAS2004, 11th Int. Static Analysis Symp.*, and General Chair of *6th ACM Int. Conf. on Principles and Practice of Declarative Programming (ACM-PPDP'04)*, *20th ACM Workshop on Partial Evaluation and Semantics-Based Program Manipulation (ACM-PEPM'04)*, *Int. Symp. on Logic-based Program Synthesis and Transformation (LOPSTR'04)*. Verona, Italy.
(1993-2016) Steering Committee of *The Static Analysis Symposium (SAS)*.

Current projects: I was PI in National (Italian) and International (EU) research projects for a total budget of more than 1.800.000€ from 2005 to 2018[1]. The main active projects are:

ASPRA: *Analysis of Program Analyses*, funded by MIUR – Italian Ministry of Science, 863,000€, 2019-2022. Abstract interpretation and coinductive up-to techniques are well established formal methods for analysing and verifying code. Both approaches rely on abstractions in order to make, respectively, the analysis scalable and correctness proofs simpler. The ASPRA project aims at bridging these two fields from the perspective of the code properties that best fit a given abstraction. In program analysis this is related to the rate of false alarms, while in up-to techniques it concerns the chance of effectively devising a simplified proof. The idea of ASPRA is to analyse program analysis, i.e., to lift program analysis from properties of programs to properties of program analysers and verifiers.

ATEN: *Cyberspace Surveillance Technologies*, funded by Fondazione Cariverona, 413,000€, 2018-2021. The surveillance and control of the physical space represent the first barrier against physical threats. Nowadays, attacks to the cyberspace can cause as much damage as attacks to the physical space. The actors of the cyberspace are software systems, either benign or malicious, connected through networks. Cyberspace surveillance means to collect and monitor complex and potentially unknown software systems, such as malware, and to analyse their behaviour in order to recognise and prevent potential threats. Standard signature detection-based anti-malware are limited in scope and precision and can be easily foiled by reengineering or obfuscating code. ATEN wants to exploit this weakness by developing new methods and technologies for the automated analysis of large repositories of code in order to extract malware correlations. We are interested in code similarities both in design and in semantics. Design correlations provide information for establishing connections between actors, useful in attribution of responsibilities in computer forensics. Semantic correlations are useful for early threat detection and in malware analysis and reverse engineering.

Industrial innovation:

(2017–) Scientific advisor of Cythereal Inc. Cythereal is based on [94] and a patented technology that performs deep static and dynamic analyses for automatically determining code similarities in x86 binary executables for early malware detection and threat analysis. Cythereal is based in Lafayette, Louisiana (USA) and selected for incubation in TOPXIGHT Labs by Valmiki 504 LLC venture capital.

(2010-2018) Co-founder of JULIA s.r.l., a spin-off company of the U. of Verona, originating from my group, for the commercialisation of a general purpose Java analyser. JULIA is a complex software tool ($\sim$200K lines of Java Code) based on Abstract Interpretation for the fully automatic analysis of Java and Android apps. JULIA was subcontractor in the U.S. Air Force Research Laboratory/RITM Contract No. FA8750-12-C-0174, $291,000.00, through the U. of Washington. JULIA is now part of the Corvallis Group and has been awarded by the *Talento delle Idee* prize by Unicredit Bank and selected as one of the best 9 innovative projects in the area of ICT in the Working Capital Competition by Telecom Italia. Julia is now part of the Corvallis Group.

[1] In the Italian system, the PhD and Post-Doc positions are mostly supported by internal funds by the University.

Major collaborations (a selection):

(May–June 2016 & April 2017) Visiting Prof. at U. of Hawaii in Manoa, Honolulu, USA.

(March–May 2015) MERIT Visiting Scholar at the Department of Computing and Information Systems, University of Melbourne, Australia.

(Nov. 2014–Oct. 2015) Full-time Senior Faculty position as Research Scientist at IMDEA Software Institute, Madrid Spain.

(May–Oct. 2014) Visiting Research Scientist at IRDETO Canada, working in white-box cryptography, software security and protection. Most relevant publications are [91, 93].

(Feb.–April 2014) Visiting Professor in CS at the department of Computer Science of the University of Louisiana at Lafayette USA. Most relevant publication is [94].

(Nov.–Dec. 2010 & May–July 2011) Full-time Visiting Professor position in CS at the Département d'Informatique (DI) of the École Normale Supérieure in Paris.

(May & June 2009) Full-time Visiting Professor position in CS at the Computer Science Department of the Universidad Complutense de Madrid (UCM).

(June–Aug. 2008) Full-time Visiting Professor position in CS at the Département d'Informatique (DI) of the École Normale Supérieure in Paris.

(May & June 2000 & June & July 2002 & Aug.–Sept. 2006) Visiting researcher at the Laboratoire d'Informatique (LIX), École Polytechnique.

(May & June 1999) Visiting Professor at the Department of Computer Science, KAIST – Korean Advanced Institute of Science and Technology, Taejon, South Korea.

(Dec. 1997) Visiting researcher at the Department of Computer Science, The University of Melbourne.

(Nov. & Dec. 1997) Visiting Professor at the Department of Mathematics and Computer Science, Ben-Gurion University of Negev, Beer-Sheva, Israel.

Commissions of trust:

(2012–) Board of evaluation of the Italian Minister of Research and Education (MIUR): Programma Operativo Nazionale Ricerca & Competitività (PON02 & PON03), budget: 150.000.000€.

(2005-2011) Hiring Committee for Assistant, Associate and Full Professors (tenured) of the Univeristy of Catania, Cagliari, Padova, Pisa, and Verona.

(2005–) Member of the evaluation committee of the EPSRC – Engineering and Physical Sciences Research Council (UK), the Israel Science Foundation (IL), the United States-Israel Binational Science Foundation (IL), the Estonian Science Foundation (EE), the Georgian's Shota Rustaveli National Science Foundation, and the Portuguese Foundação para a Ciência e a Tecnologia.

(2005–) Committee for habilitation for professor in France: Université Paris-Dauphine for Dr. M. Martel and Dr. L. Mauborgne; École Normale Supérieure de Cachan for D. Cachera, Université de Grenoble for D. Monniaux, and École Normale Supérieure in Paris for Dr. X. Rival.

(2004-2008) Member of the advisory board for the selection of projects within the research and innovation activities of the Italian Ministry M.A.P. *Ministero delle Attivtà Produttive*, ICT area.

(2000-2011) Member in PhD defences in the PhD programme in *Mathématique et Informatique* at École Poytechnique; *Informatique* at IRISA, U. de Rennes (FR); *Informatique* at INRIA Sophia Antipolis (FR); *Informatique* at LORIA, Institut National Polytechnique de Lorraine.

(2000-2004) Selection board for foreign students applying for the major in Computer Science at the École Normale Supérieure (ENS-Europe 00-01 and 01-02, Sélection Int. en Sciences 02-03 and 03-04).

Teaching:

I have more that 20 years of experience in university-level (undergraduate and graduate) teaching in CS, with responsibility of courses in: Programming, automata and formal languages, computability and complexity, program verification, compilers, program analysis, security, and code protection. Below the list of the major courses in CS.

(2017) Professor of *Code Obfuscation: a Hacking view on program analysis and understanding* at PhD and Master School in CS at the U. Politécnica de Madrid.

(2015-2018) Professor of *Malware analysis and design* graduate level in CS of the U. of Verona;

(2010-2015) Professor of *Semantics based code protection* at the 1st, 2nd, 3rd, 5th, 6th, 7th, 8th, and 10th ACM International Summer School on Information Security and Protection — ISSISP

(2008) Professor for the PhD course on *Software Protection* at UCM (U. Complutense de Madrid);

(2003-2017) Professor of *Prog. Languages & Compilers*, undergraduate major in CS of the U. of Verona.

(2000-2013) Professor of *Static Analysis and Code Protection* graduate level in CS of the U. of Verona;

(1999–) Professor of *Formal Languages, Automata, Computabilty and Complexity*, undergraduate major in CS of the U. of Verona;

(1997) Professor of *Abstract Interpretation and Program Analysis* at PhD level at the Ben-Gurion U.;

(1995-1999) Teaching Assistant in *Programming Languages* (20h) and *Object Oriented Programming*, undergraduate major in CS of the University of Pisa.

(1993) Professor of *Logic program analysis* at D.E.A.– I.M.A. (Informatique, Mathématiques et Applications) of Ecole Polytechnique, l'Ecole Normale Sup., and U. de Paris VI, VII e XI.

(1989-1990) Teaching Assistant in *Numerical Analysis* and *Programming Languages* at the Military Academy of Modena Italy, for the courses 170 and 171 "Allievi Ufficiali" (Army Military Officers).

List of publications

Journals

[1] R. Barbuti, R. Giacobazzi. A Bottom-up Polymorphic Type Inference in Logic Programming. *Science of Computer Programming*, 19(3):281–313, Elsevier Science Pub., Amsterdam Dicembre 1992. DOI.

[2] R. Barbuti, R. Giacobazzi, and G. Levi. A General Framework for Semantics-based Bottom-up Abstract Interpretation of Logic Programs. *ACM Transactions on Programming Languages and Systems*, 15(1):133–181, ACM Press, New York Gennaio 1993. DOI.

[3] R. Barbuti, M. Codish, R. Giacobazzi, and G. Levi. Modelling Prolog Control. *Journal of Logic and Computation*, 3(6):579–603, Oxford University Press, Oxford Dicembre 1993. ISSN 0955-792X. DOI.

[4] B.M. Chang, K.M. Choe, and R. Giacobazzi. Improving execution models of logic programs by two-phase abstract interpretation. *Journal of the Electronics and Telecommunications Research Institute (ETRI)*. 16(4):27-47, ETRI Taejon, Korea Gennaio 1995. ISSN 1225-6463.

[5] R. Barbuti, M. Codish, R. Giacobazzi, and M. Maher. Oracle Semantics for PROLOG. *Information and Computation*, 122(2):178-200, Academic Press, Orlando FL Novembre 1995. ISSN 0890-5401. DOI.

[6] R. Giacobazzi, S. Debray, and G. Levi. Generalized Semantics and Abstract Interpretation for Constraint Logic Programs. *Journal of Logic Programming*, 25(3):191-248, Elsevier North-Holland, New York Dicembre 1995. ISSN 0743-1066. DOI.

[7] G. Filé, R. Giacobazzi, F. Ranzato. A Unifying View on Abstract Domain Design. C. Hankin, H.R. Nielson and P. Wegner editors, Computing Surveys Symposium on Models of Programming Languages and Computation. *ACM Computing Surveys*, 28(2):333-336, ACM Press, New York Giugno 1996. DOI.

[8] R. Giacobazzi, C. Palamidessi, F. Ranzato. Weak Relative Pseudo-Complements of Closure Operators. *Algebra Universalis*, 36(3):405-412, Birkhäuser, Basilea Dicembre 1996. DOI.

[9] A. Cortesi, G. Filé, R. Giacobazzi, C. Palamidessi, and F. Ranzato. Complementation in Abstract Interpretation. *ACM Transactions on Programming Languages and Systems*, 19(1):7-47, ACM Press, New York Gennaio 1997. DOI.

[10] E. Zaffanella, R. Giacobazzi, and G. Levi. Abstracting Synchronization in Concurrent Constraint Programming. *Journal of Functional and Logic Programming*, 1997(6), The MIT Press, Cambridge Mass. Novembre 1997. ISSN 1080-5230.

[11] R. Giacobazzi and F. Ranzato. On the least complete extension of a complete subsemilattice. *Algebra Universalis* 38(3):235-237, Birkhäuser, Basilea 1997. ISSN 0002-5240. DOI.

[12] R. Giacobazzi. Abductive analysis of modular logic programs. *Journal of Logic and Computation*, 8(4):457-484, Oxford University Press, Oxford Agosto 1998. ISSN 0955-792X. DOI.

[13] R. Giacobazzi and F. Ranzato. Optimal domains for disjunctive abstract interpretation. *Science of Computer Programming*, 32(1-3):177-210, Elsevier Science Pub., Amsterdam Agosto 1998. ISSN 0167-6423. DOI.

[14] R. Giacobazzi and F. Ranzato. Uniform Closures: Order-theoretically reconstructing logic program semantics and abstract domain refinements. *Information and Computation*, 145(2):153-190, Academic Press, Orlando FL Settembre 1998. ISSN 0890-5401. DOI.

[15] R. Giacobazzi and F. Ranzato. Some properties of complete congruence lattices. *Algebra Universalis*, 40(2):189-200, Birkhäuser, Basilea 1998. ISSN 0002-5240. DOI.

[16] R. Giacobazzi and F. Scozzari. A logical model for relational abstract domains. *ACM Transactions on Programming Languages and Systems*, 20(5):1067-1109, ACM Press, New York Settembre 1998. ISSN 0164-0925. DOI.

[17] R. Giacobazzi and F. Ranzato. The reduced relative power operation on abstract domains. *Theoretical Computer Science*, 216(1-2):159-211, Elsevier Science Pub., Amsterdam Marzo 1999. ISSN 0304-3975. DOI.

[18] R. Giacobazzi, F. Ranzato, and F. Scozzari. Making abstract interpretations complete. *Journal of the ACM*, 47(2):361-416, 2000. ACM Press, New York. ISSN 0004-5411. DOI.

[19] R. Giacobazzi and I. Mastroeni. Non-standard semantics for program slicing. *Higher-Order and Symbolic Computation (formely LISP and Symbolic Computation)*. 16(4):297-339. 2003. Kluwer Academic Publishers ISSN 1388-3690. DOI.

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[21] R. Giacobazzi and I. Mastroeni. Transforming semantics by abstract interpretation. *Theoretical Computer Science*. 337(1-3):1-50. 2005. ISSN 0304-3975. DOI.

[22] R. Giacobazzi and F. Ranzato. Incompleteness of States w.r.t. Traces in Model Checking. *Information and Computation*, 204(3):376-407, 2006. DOI.

[23] P. Cousot, R. Cousot and R. Giacobazzi. Abstract Interpretation of Resolution-Based Semantics. *Theoretical Computer Science*, 410(46):4724–4746, 2009. DOI.

[24] M. Dalla Preda and R. Giacobazzi. Semantic-based Code Obfuscation by Abstract Interpretation. *Journal of Computer Security*, 17(6):855-908, 2009. DOI.

[25] R. Giacobazzi and I. Mastroeni. A Proof System for Abstract Non-Interference. *Journal of Logic and Computation*, 20: 449-479. 2010. DOI.

[26] R. Giacobazzi and I. Mastroeni. Adjoining classified and unclassified information by abstract interpretation. *Journal of Computer Security*, 18(5):751–797. 2010. DOI.

[27] I. Mastroeni and R. Giacobazzi. An Abstract Interpretation-based Model for Safety Semantics. *Journal of Computer Mathematics* 88 (4): 665–694. March 2011. DOI.

[28] A. Fortunato, M. Passuello and R. Giacobazzi. Relock-based vulnerability in Windows 7. *Virus Bulletin*, pp.16-20, VB August 2011. ISSN 1749-7027.

[29] C. Collberg, J. Davidson, R. Giacobazzi, Y. Gu, A. Herzberg, and F. Wang. Towards Digital Asset Protection - Position paper. In Expert Opinions of the *IEEE Intelligent Systems*. 26(6):8-13, 2011. DOI.

[30] R. Giacobazzi and F. Ranzato. Correctness Kernels of Abstract Interpretations. *Information and Computation*, Volume 237, October 2014, Pages 187–203. DOI.

[31] M. Dalla Preda, R. Giacobazzi, and S. Debray. Unveiling Metamorphism by Abstract Interpretation of Code Properties. *Theoretical Computer Science*. Volume 577(27):74-97 2015. DOI.

[32] R. Giacobazzi and I. Mastroeni. Making abstract models complete. *Mathematical Structures in Computer Science* 26(4):658-701 2016. DOI.

[33] I. Mastroeni and R. Giacobazzi. Weakening additivity in adjoining closures. *Order* 33:503–516, Springer-Verlag 2016. DOI.

[34] R. Giacobazzi, I. Mastroeni, and M. Dalla Preda. Maximal incompleteness as obfuscation potency. *Formal Aspects of Computing* 29(1):3-31, Springer-Verlag, 2017. DOI.

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