

TUDOR A. DUMITRAȘ

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RESEARCH INTERESTS

System security and dependability; Big Data techniques for analyzing the behavior of real-world systems; scalable infrastructures for data storage and analysis

PROFESSIONAL EXPERIENCE

Symantec Research Labs, Herndon, VA (Sr. Research Engineer) Nov 2010 – present
Designed and implemented the Worldwide Intelligence Network Environment (WINE), a platform for conducting *data intensive experiments in cyber security*; WINE was adopted by Symantec engineers and by five academic groups as a prime vehicle for empirical research. Used WINE in research published in top security conferences and reviewed in Forbes, eWeek, The Register, Slashdot and 10+ other news magazines.

Oracle Corporation, Redwood Shores, CA (Intern, supervised by Alan Downing) May – Jul 2008

VMware Inc., Palo Alto, CA (Intern, supervised by Bich Le and Suresh Ravor) May – Aug 2006

IBM Research, Hawthorne, NY (Intern, supervised by Daniela Roșu and Asit Dan) May – Aug 2005

Siemens Corporate Research, Princeton, NJ (Intern) May – Sep 2004

IBM Corporation, Paris, France (Intern) Apr – Jul 2001

EDUCATION

Carnegie Mellon University, Pittsburgh, PA
Ph.D. in Electrical and Computer Engineering (GPA: 4.0/4.0) December 2010
Advisor: Prof. Priya Narasimhan
Dissertation: Improving the Dependability of Distributed Systems through AIR Software Upgrades

M.S. in Electrical and Computer Engineering (GPA: 4.0/4.0) May 2003
Advisor: Prof. Radu Mărculescu

Ecole Polytechnique, Paris, France
Diplôme d'Ingénieur (Computer Science Major) July 2001

"Politehnica" University, Bucharest, Romania
B.S. in Computer Science July 2001

HONORS AND AWARDS

A.G. Jordan Award, Carnegie Mellon ECE Department (for outstanding Ph.D. thesis and service) 2011

John Vlissides Award, ACM SIGPLAN (for significant promise in applied software research) 2009

1st Place, ACM Student Research Competition, OOPSLA'09 2009

Research Grant, Amazon Web Services (for reducing upgrade failures via upgrades-as-a-service) 2009

Graduate Student Service Award, Carnegie Mellon University 2006

Best Paper Award, Asia and South Pacific Design Automation Conference 2003

Excellence scholarship, French government's EIFFEL program 1999–2001

PUBLICATIONS

Conference and Journal Papers (refereed)

- [1] T. Dumitraș and P. Narasimhan. 'A Study of Unpredictability in Fault-Tolerant Middleware.' *Elsevier Computer Networks (COMNET'12)*, Available online 29 October 2012, ISSN 1389-1286.

- [2] L. Bilge and T. Dumitraş. 'Before We Knew It: An Empirical Study of Zero-Day Attacks in the Real World.' In *USENIX ACM Conference on Computer and Communications Security (CCS'12)*, Raleigh, NC, Oct 2012.
(**19%** acceptance rate)
- [3] T. Dumitraş and P. Efstathopoulos. 'The Provenance of WINE.' In *European Dependable Computing Conference (EDCC'12)*, Sibiu, Romania, May 2012.
(**34%** acceptance rate)
- [4] T. Dumitraş, E. Tilevich and P. Narasimhan. 'To Upgrade or Not To Upgrade: Impact of Online Upgrades Across Multiple Administrative Domains.' In *ACM Onward! Conference (Onward'10)*, Reno/Tahoe, NV, Oct 2010.
(**23%** acceptance rate for long papers)
- [5] T. Dumitraş and P. Narasimhan. 'Why Do Upgrades Fail And What Can We Do About It? Toward Dependable, Online Upgrades in Enterprise Systems.' In *ACM/IFIP/USENIX Conference on Middleware (Middleware'09)*, Urbana-Champaign, IL, Nov–Dec 2009.
(**19%** acceptance rate)
13 citations*
- [6] T. Dumitraş and P. Narasimhan. 'Got Predictability? Experiences with Fault-Tolerant Middleware.' In *ACM/IFIP/USENIX Conference on Middleware (Middleware'07)*, Newport Beach, CA, Nov 2007.
(**24%** acceptance rate)
- [7] P. Bogdan, T. Dumitraş and R. Mărculescu. 'Stochastic Communication: A New Paradigm for Fault-Tolerant Networks-on-Chip.' *Hindawi VLSI Design*, Special Issue on Networks-on-Chip, 2007.
37 citations
- [8] T. Dumitraş and P. Narasimhan. 'Fault-Tolerant Middleware and the Magical 1%.' In *ACM/IFIP/USENIX Conference on Middleware (Middleware'05)*, Grenoble, France, Nov–Dec 2005.
(**21%** acceptance rate)
13 citations
- [9] P. Narasimhan, T. Dumitraş, A. M. Paulos, S. M. Pertet, C. F. Reverte, J. G. Slember and D. Srivastava. 'MEAD: Support for Real-Time, Fault-Tolerant CORBA.' *Concurrency and Computation: Practice and Experience (CC:PS'05)*, vol. 17, no. 12, pp. 1527-1545, Oct 2005, Wiley and Sons.
70 citations
- [10] T. Dumitraş, S. Kerner and R. Mărculescu. 'Enabling On-Chip Diversity through Architectural Communication Design.' In *Asia and South Pacific Design Automation Conference (ASP-DAC'04)*, Yokohama, Japan, Jan 2004.
(**34%** acceptance rate for full papers)
- [11] T. Dumitraş and R. Mărculescu. 'On-Chip Stochastic Communication.' In *Design, Automation and Test in Europe Conference (DATE'03)*, Munich, Germany, Mar 2003.
(**17%** acceptance rate for full papers)
84 citations
- [12] T. Dumitraş, S. Kerner and R. Mărculescu. 'Towards on-chip fault-tolerant communication.' In *Asia and South Pacific Design Automation Conference (ASP-DAC'03)*, Kitakyushu, Japan, Jan 2003, pp. 225–232.
(**34%** acceptance rate for full papers)
Best Paper Award
146 citations
- Conference Papers (under review)**
- [13] T. Dumitraş, P. Efstathopoulos and D. Marino. 'A Field Study of Vulnerabilities and Attack Surfaces in Modern Operating Systems' Submitted to *IEEE/IFIP International Conference on Dependable Systems and Networks (DSN'13)*, Budapest, Hungary, Jun 2013.

* Citation counts retrieved on 19 December 2012 from Google Scholar.

- [14] E. Papalexakis, T. Dumitraş, P. Chau, A. Prakash and C. Faloutsos. ‘Spatio-temporal mining of software adoption & penetration.’ Submitted to *International World Wide Web Conference (WWW’13)*, Rio de Janeiro, Brazil, May 2013.

Book Chapters (refereed)

- [15] T. Dumitraş, D. Roşu, A. Dan and P. Narasimhan, ‘Ecotopia: An Ecological Framework for Change Management in Distributed Systems.’ In *Architecting Dependable Systems Vol. IV (ADS IV)*, C. Gacek, A. Romanovsky and R. de Lemos, eds., Springer-Verlag, 2007.

10 citations

- [16] T. Dumitraş, D. Srivastava and P. Narasimhan. ‘Architecting and Implementing Versatile Dependability.’ In *Architecting Dependable Systems Vol. III (ADS III)*, C. Gacek, A. Romanovsky and R. de Lemos, eds., Springer-Verlag, 2005.

18 citations

- [17] T. Dumitraş and R. Mărculescu. ‘On-Chip Stochastic Communication.’ In *Embedded Software for SoC*, A. Jerraya, S. Yoo, D. Verkest and N. When, eds., Kluwer, 2003, pp. 373-386.

Workshop Papers (refereed)

- [18] T. Dumitraş and P. Efstathopoulos. ‘Ask WINE: Are We Safer Today? Evaluating Operating System Security through Big Data Analysis.’ In *USENIX Workshop on Large-Scale Exploits and Emerging Threats (LEET’12)*, San Jose, CA, Apr 2012.

- [19] T. Dumitraş and I. Neamtiu. ‘Cloud Software Upgrades: Challenges and Opportunities.’ In *IEEE International Workshop on the Maintenance and Evolution of Service-Oriented and Cloud-Based Systems (MESOCA’11)*, Williamsburg, VA, Sep 2011.

- [20] T. Dumitraş and I. Neamtiu. ‘Experimental Challenges in Cyber Security: A Story of Provenance and Lineage for Malware.’ In *USENIX Workshop on Cyber Security Experimentation and Test (CSET’11)*, San Francisco, CA, Aug 2011.

- [21] T. Dumitraş and D. Shou. ‘Toward a standard benchmark for computer security research: The Worldwide Intelligence Network Environment (WINE).’ In *EuroSys Workshop on Building Analysis Datasets and Gathering Experience Returns for Security (BADGERS’11)*, Salzburg, Austria, Apr 2011.

12 citations

- [22] T. Dumitraş, J. Tan, Z. Gho and P. Narasimhan, ‘No More HotDependencies: Toward Dependency-Agnostic Upgrades in Distributed Systems.’ In *Workshop on Hot Topics in System Dependability (HotDep’07)*, Edinburgh, Scotland, Jun 2007.

12 citations

- [23] T. Dumitraş, D. Roşu, A. Dan and P. Narasimhan. ‘Impact-Sensitive Framework for Dynamic Change-Management.’ In *DSN Workshop on Architecting Dependable Systems (WADS’06)*, Philadelphia, PA, Jun 2006.

- [24] T. Dumitraş, P. Narasimhan. ‘An Architecture for Versatile Dependability.’ In *DSN Workshop on Architecting Dependable Systems (WADS’05)*, Florence, Italy, Jun 2004.

Other Publications

- [25] T. Dumitraş, D. Shou and C. Leita. ‘Benchmarking Computer Security Using WINE,’ In *Poster Session at IEEE Symposium on Security and Privacy (Oakland’11)*, Oakland, CA, May 2011.

- [26] T. Dumitraş, D. Shou, C. Leita and M. Dacier. ‘Benchmarking Computer Security Using WINE,’ In *Poster Session at International Symposium on Recent Advances in Intrusion Detection (RAID’11)*, Menlo Park, CA, Sep 2011.

- [27] T. Dumitraş, I. Neamtiu and E. Tilevich. ‘Report on the Second ACM Workshop on Hot Topics in Software Upgrades.’ *ACM SIGOPS Operating Systems Review (OSR’10)*, vol. 44, no. 4, Dec 2010.

- [28] T. Dumitraş. ‘Improving the Dependability of Distributed Systems through AIR Software Upgrades.’ *Ph.D. Thesis*, Carnegie Mellon University, Dec 2010.
Committee: P. Narasimhan (advisor), G. Ganger, B. Maggs, A. Dan.

- [29] T. Dumitraş and P. Narasimhan. ‘Upgrades-as-a-Service in Distributed Systems.’ In *Work-in-Progress Session at FAST’10*, San Jose, CA, Jan 2010.
- [30] T. Dumitraş and P. Narasimhan. ‘Toward Upgrades-as-a-Service in Distributed Systems.’ In *Poster Session at Middleware’09*, Urbana-Champaign, IL, Nov–Dec 2009.
- [31] T. Dumitraş. ‘Dependable, Online Upgrades in Distributed Systems,’ In *Doctoral Symposium at OOPSLA’09*, Orlando, FL, Oct 2009 (**John Vlissides Award**).
- [32] T. Dumitraş. ‘Dependable, Online Upgrades in Distributed Systems,’ In *ACM Student Research Competition at OOPSLA’09*, Orlando, FL, Oct 2009 (**First Place**).
- [33] T. Dumitraş, I. Neamtiu and E. Tilevich, co-editors. *Proceedings of HotSWUp’09*, Orlando, FL, Oct 2009.
- [34] T. Dumitraş, F. Eliassen, K. Geihs, H. Muccini, A. Polini and T. Ungerer. ‘Testing Run-time Evolving Systems.’ In *Self-Healing and Self-Adaptive Systems, Dagstuhl Seminar 09201*, May 2009.
- [35] T. Dumitraş, D. Dig and I. Neamtiu, co-editors. *Proceedings of HotSWUp’08*, Nashville, TN, Oct 2008.
- [36] T. Dumitraş, A. Hanemann, B. Kratz and J. Pathak, co-editors. *Proceedings of the IBM Ph.D. Student Symposium at ICSOC’07*, Vienna, Austria, Sep 2007.
- [37] T. Dumitraş. ‘Dependency-Agnostic Online Upgrades in Distributed Systems,’ In *Student Forum at DSN’07*, Edinburgh, Scotland, Jun 2007.
- [38] A. Hanemann, B. Kratz, T. Dumitraş, and N. Mukhi, co-editors. *Proceedings of the IBM Ph.D. Student Symposium at ICSOC’06*, Chicago, IL, Dec 2006.
- [39] T. Dumitraş, M. Lee, P. Quinones, A. Smailagic, D. Siewiorek and P. Narasimhan. ‘Eye of the Beholder: Phone-Based Text-Recognition for the Visually-Impaired.’ In *Poster Session at ISWC’06*, Montreux, Switzerland, Oct 2006, pp. 145–146.
- [40] T. Dumitraş. ‘On-Chip Stochastic Communication.’ *M.S. Thesis*. Carnegie Mellon University, May 2003. Committee: R. Mărculescu (advisor), P. Narasimhan.

TALKS

Keynotes

‘Field data available at Symantec Research Labs,’ **ASPLOS-EXERT’11** Mar 2011

Tutorials

‘Benchmarking Computer Security through WINE,’ **ACM CCS’11** Oct 2011

Paper presentations

‘The Provenance of WINE,’ **EDCC’12** May 2012

‘Evaluating Operating System Security through Big Data Analysis,’ **LEET’12** Apr 2012

‘Experimental Challenges in Cyber Security,’ **CSET’11** Aug 2011

‘Impact of Online Upgrades Across Multiple Administrative Domains,’ **Onward’10** Oct 2010

‘Why Do Upgrades Fail and What Can We Do About It?,’ **Middleware’09** Dec 2009

‘Dependable, Online Upgrades in Enterprise Systems,’ **ACM Student Research Competition** Oct 2009

‘Dependable, Online Upgrades in Enterprise Systems,’ **OOPSLA’09 Doctoral Symposium** Oct 2009

‘Got Predictability? Experiences with Fault-Tolerant Middleware,’ **Middleware’07** Nov 2007

‘Toward Dependency-Agnostic Upgrades in Distributed Systems.’ **HotDep’07** Jun 2007

‘Dependency-Agnostic Online Upgrades in Distributed Systems,’ **DSN’07 Student Forum** Jun 2007

‘Impact-Sensitive Framework for Dynamic Change-Management,’ **DSN WADS’06** Jun 2006

‘Fault-Tolerant Middleware and the Magical 1%,’ **Middleware’05** Nov 2005

‘An Architecture for Versatile Dependability,’ **DSN WADS’04** Jun 2004

‘On-Chip Stochastic Communication,’ **DATE’03** Mar 2003

‘Towards On-Chip Fault-Tolerant Communication,’ **ASP-DAC’03** Jan 2003

Invited talks

‘Before we knew it: An empirical study of zero-day attacks in the real world’

- **ISACA North America joint ISRM / IT GRC conference** (invited “hot topics” talk) Oct 2012

'The Worldwide Intelligence Network Environment (WINE)'	
▪ Duke (host: Bruce Maggs)	Oct 2012
▪ University of North Carolina (host: Mike Reiter)	Oct 2012
▪ NC State (host: Ting Yu)	Oct 2012
▪ Stanford Security Seminar (host: Ankur Taly)	May 2012
▪ Rutgers (host: Tina Eliassi-Rad)	Mar 2012
▪ Princeton (host: Jennifer Rexford)	Mar 2012
▪ Virginia Tech (host: Eli Tilevich)	Mar 2012
▪ University of Maryland (host: Michael Hicks)	Nov 2011
▪ UC Riverside (host: Iulian Neamtiu)	Apr 2011
'Improving the end-to-end dependability of distributed systems'	
▪ USC (host: Ramesh Govindan)	Jan 2011
▪ Purdue (host: Cristina Niţă-Rotaru)	Jul 2010
▪ UIUC (host: Indranil Gupta)	Jun 2010
▪ VMware (host: Orran Krieger)	Jun 2010
▪ Stevens Institute of Technology (host: Hong Man)	Apr 2010
▪ Caltech (host: Adam Wierman)	Apr 2010
▪ UCLA (host: Carlo Zaniolo)	Apr 2010
▪ IBM Research, Almaden (host: Joseph Slember)	Mar 2010
▪ Microsoft Research, Silicon Valley (host: Mihai Budiu)	Feb 2010
▪ HP Labs (host: Lucy Cherkasova)	Feb 2010
▪ IBM Research, T.J. Watson (host: Peter Sweeney)	Jan 2010
▪ AT&T Labs (hosts: Matti Hiltunen and Rick Schlichting)	Jan 2010
'Toward Dependable, Online Upgrades in Enterprise Systems'	
▪ Software Engineering Institute , Carnegie Mellon University (host: Charles Weinstock)	Jun 2009
▪ EPFL , Switzerland (host: Willy Zwaenepoel)	May 2009
▪ Vanderbilt University (host: Aniruddhā Gokhāl�)	Oct 2008
▪ Oracle Corporation (host: Alan Downing)	Jun 2008
▪ Cambridge University , UK (host: Jon Crowcroft)	Jun 2007
▪ Newcastle University , UK (host: Graham Morgan)	Jun 2007
'Why Do Upgrades Fail and What Can We Do About It?,' Dagstuhl Seminar 09201	May 2009
'Patch Management Sandboxing,' VMware Inc. (host: Suresh Ravoore)	Jul 2006
'Distributed, Impact-Sensitive Dynamic Change-Management'	
▪ CNRS-LAAS , France (host: Jean-Charles Fabre)	Dec 2005
▪ IBM Research (host: Asit Dan)	Aug 2005

RESEARCH EXPERIENCE

The Worldwide Intelligence Network Environment (WINE) 2010 – present
<http://www.symantec.com/WINE>

Built WINE, Symantec's platform for conducting *data intensive experiments in cyber security* [**BADGERS'11**, **LEET'12**, **EDCC'12**]. Designed WINE from the ground up for collecting, sampling and aggregating petabyte-size data sets and for supporting experiments at scale. The current WINE users include five academic research teams and several Symantec engineers.

Conducted several research studies using WINE, for example to *identify zero-day attacks* in the real world and to measure their duration [**CCS'12**].

AIR Software Upgrades in Distributed Systems (Ph.D. Dissertation) 2007 – 2010
 Identified the leading causes of *both planned and unplanned downtime* resulting from software upgrades, which account for 66%–86% of the total service unavailability in distributed systems [**Middleware'09**]. Defined the *AIR properties* (atomicity, isolation, runtime-testing) for dependable software upgrades in the

cloud; identified the anomalies that may occur when relaxing these properties, such as *mixed-version race conditions* [**Onward'10**]. Defined methods for benchmarking the dependability of upgrade techniques.

Transparent Adaptation in Fault-Tolerant Middleware

2003 – 2006

<http://www.ece.cmu.edu/~mead/>

Introduced mechanisms for resource-aware adaptation to crash, communication and timing faults (e.g., switching between active and passive replication on-the-fly, automatic configuration knobs) [**Middle-ware'05, ADS III**]. Developed the *MEAD system*, which served as the main fault-tolerance platform for the DARPA-ARMS II and DARPA-PCES II programs [**CC:PS'05**]. Conducted empirical study of *unpredictability* in 16 distributed systems relying on fault-tolerant middleware [**COMNET'12**].

On-Chip Stochastic Communication (M.S. Thesis)

2001 – 2003

Proposed new communication paradigm for *networks on chip*, based on randomized gossip. This approach marks a departure from traditional chip design by providing fault tolerance at the system level, through the design of the communication protocol [**ASP-DAC'03, DATE'03, VLSI Design'07**].

DISCUSSIONS AND REVIEWS OF WORK

- **CCS'12 paper:** featured in Forbes, eWEEK, The Register, Slashdot, Schneier on Security, Dark Reading, SC Magazine, Ars Technica, Threat Post, Channelnomics, Tech Target, CSO Magazine, Info Security Magazine, Security Affairs
- **LEET'12 paper:** featured in the editorial ('Musings') of the August edition of USENIX ;login:

STUDENTS MENTORED

Symantec Research Labs, SRL Graduate Fellowships

2011–2012

- **Leyla Bilge:** Characterizing Zero-Day Attacks in the Real World (Bilge later joined Symantec Research Labs as a full time employee)
- **Jiyong Jang:** Scalability of Static and Dynamic Malware Analysis Techniques

Institute EURECOM, semester projects

2011–2012

- **Lorenzo Randé, Abdalla Taha:** Decentralized Location Sharing for Smartphones (resulted in open-source project: <https://github.com/ada86/geo-kadoh>)
- **Fakhruddin Roomi, Siva Prem, Ishrat Naveed:** Upgrades-as-a-Service in Cloud Computing Environments
- **Pierre Guillemot, Alexandre Lachèze:** *KadOH*: Distributed Hash Table for the Emerging Mobile Platforms (resulted in open-source project: <http://jinroh.github.com/kadoh/>)
- **Eetu Korhonen:** Upgrades-as-a-Service in Cloud Computing Environments

Carnegie Mellon University, Master of Software Engineering practicum

2012

- **Javier Santisteban, Sakshi Dhawan, Mingjie Liu:** Preventing Mixed-Version Race Conditions through Smart Load Balancing

Carnegie Mellon University, undergraduate research in ECE and INI

2007–2010

- **Jiaqi Tan, Zhengheng Gho:** Dependency-Agnostic Upgrades in Distributed Systems (contributed to Tan's and Gho's first publication, in HotDep'07)
- **Sreevishnu Byraker:** Characterizing and Predicting the Evolution of Irregular Workloads for Popular Web Sites

TEACHING EXPERIENCE

Introduction to Computer Systems (teaching assistant for Profs. R. Bryant and D. O'Hallaron) Fall 2006

Held weekly recitation and office hours for a sophomore-level class of 150 students. Designed and graded homeworks and exams. TA Course Evaluation: 3.93/4.00.

Fault-Tolerant Distributed Systems (teaching assistant for Prof. P. Narasimhan) Spring 2006
Gave guest lecture on the experimental evaluation of fault-tolerant middleware systems in a graduate-level class of 30 students. Designed experimental plan. Guided seven class projects.

Dependable Embedded Systems (teaching assistant for Prof. P. Koopman) Fall 2005
Selected discussion topics for a graduate-level class with 20 students. Led discussions on distributed time-keeping and on synchrony models for distributed systems.

Electromagnétisme (teaching assistant for Prof. C. Florea) Spring 2001
Guided lab work for a section of 20 students from an introductory course in electromagnetism at the *Ecole Supérieure d'Ingénieurs en Electronique et Electrotechnique* (ESIEE), Paris, France.

PROFESSIONAL CONTRIBUTIONS

The Worldwide Intelligence Network Environment (WINE) 2012
<http://www.symantec.com/WINE>

Built the WINE platform for conducting data intensive experiments in cyber security. WINE provides the cyber security research community with samples of field-gathered data, collected on millions of hosts worldwide, and with the infrastructure for conducting experiments at scale. Five research groups have conducted or scheduled WINE experiments in 2012, and the reference data sets defined in these experiments remain available for future research and independent verification.

The International Workshop on Hot Topics in Software Upgrades (HotSWUp) 2008–2013
<http://www.hotswup.org/>

Co-founded the HotSWUp series of workshops, which bring together researchers from multiple domains (e.g., systems, programming languages, software engineering, databases) who are interested in software upgrades. Through its first five editions, co-located with OOPSLA, ICDE, ICSE and USENIX ATC, HotSWUp has succeeded in establishing a focused research community and in engaging the software industry.

PC Chair: HotSWUp 2008–2009; ICSOC Ph.D. Symposium 2006–2007

PC Member: USENIX HotSWUp'13; IFIP DAIS'13; SERENE'13; ACM/IFIP/USENIX Middleware'12; IEEE CLOUD'12; ECDM'12; ISSRE Fast Abstracts'10

Reviewer: IEEE Transactions on Dependable and Secure Computing (TDSC); IEEE Transactions on Computers (TC); ACM Object-Oriented Programming, Systems, Languages and Applications Conference (OOPSLA) 2010; International Journal of Computer Networks (COMNET); Distributed Computing; IBM Journal of Research and Development; ACM Transactions on the Web (TWEB); Service-Oriented Computing and Applications; IEEE Transactions on Very Large Scale Integration Systems (TVLSI); Architecting Dependable Systems Vol. V; IEEE Pervasive Computing.

Outreach Activities

- President, ECE Graduate Student Organization, CMU
- Founder and president, Romanian Students Association, CMU

PROFESSIONAL AFFILIATIONS

Member of ACM, IEEE, USENIX.

LANGUAGES

Fluent in English, French and Romanian. Reading and basic conversation skills in Italian.

REFERENCES

Available upon request.