UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

DOTTORATO DI RICERCA / PHD PROGRAM IN
INFORMATION TECHNOLOGY AND ELECTRICAL ENGINEERING

Activities and Publications Report

PhD Student: Simona De Vivo

Student DR number: DR996112

PhD Cycle: XXXVII
PhD Cycle Chairman: Prof. Stefano Russo

PhD program student's start date: 01/01/2022
PhD program student's end date: 31/12/2024

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PhD scholarship funding entity: MUR PON

General information

Simona De Vivo received in year 2021 the Master Science degree in Computer Engineering from the University of Napoli Federico II. She attended a curriculum in sustainable cybersecurity in IoT context within the PhD program in Information Technology and Electrical Engineering. She received a grant from Ministry of University and Research (MUR) under the "PON Dottorati di ricerca su tematiche dell'innovazione e green - Azione IV.5 (Green) (*)".

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1st	Virtualization technologies and their applications	Ad hoc course	5	Prof. Luigi De Simone	ITEE
1st	Statistical data analysis for science and engineering research	Ad hoc course	4	Prof. Roberto Pietrantuono	ITEE
1st	Scientific Programming and Visualization with Python	Advanced computer skills courses	2	Prof. Alessio Botta	ITEE
1st	Imprenditorialità Accademica	Ad hoc PhD courses on research enhancement, entrepreneurship and intellectual property	4	Prof. Pierluigi Rippa	ITEE
1st	Machine Learning for Science and Engineering Research	Ad hoc course	5	Proff. A. Corazza, F. Isgrò, R. Prevete, C. Sansone, G. Pezzulo	ITEE
1st	Data Security	MSc course	6	Prof. Roberto Natella	University of Naples Federico II
1st	Critical Data Visualization	MSc course	6	Prof. Robert Pietrantuono	University of Naples Federico II
1st	Data Week	Advanced computer skills courses - External course	1		International tech academy, entirely online
2nd	RTA – REAL TIME ANALYTICS MOD. C	External course	3	Giuseppe Scozia - Cyber Security Analyst	CY4GATE ACADEMY, link: https://www.cy4gate.com/it/formazione/academy/

2nd	RTA – REAL TIME ANALYTICS MOD. D	External course	3	Giuseppe Scozia - Cyber Security Analyst	CY4GATE ACADEMY, link: https://www.cy4gate.com/it/formazione/academy/

Attended PhD Schools

Year	School title	Location	Credits	Dates	Organization
1st	ARTISAN Summer School (Role and effects of ARTificial Intelligence in Secure ApplicatioNs)	Valence, Francia	6	4-7 July 2022	Université Grenoble Alpes LCIS, 50 - Francia

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Vivi la nostra Digital Innovation	0,4		ENEL Company	DIETI Department – Unina
1st	Rails Mid-Term Workshop	1	Proff. Valeria Vittorini, Lorenzo De Donato, Autilia Vitiello, Francesco Flammini, Denis Miglianico, Ruifan Tang	University of Naples Federico II, Italy Mälardalen University & Linnaeus University, Sweden, Alstom Transport, University of Leeds	RAILS
1st	Project Vāc: Can a Text-to-Speech Engine Generate Human Sentiments?	0,2	Prof. V.K. Gurbani	Illinois Institute of Technology - USA	ITEE
1st	Explainable Natural Language Inference	0,3	Dr. Marco Valentino	University of Naples Federico II, Italy	ITEE
1st	An Introduction to Deep Learning for Natural Language Processing	0,2	Dr. Marco Valentino	University of Naples Federico II, Italy	ITEE
1st	On using simple optimization techniques for tuning of UAVs	0,4	Prof. Dariusz Horla	Poznan University of Technology - Poland	ITEE
1st	Software Product Line Management and Software Versioning in SADAS	0,4	Dr. Roberto Mosca, Dr. Aniello Santorelli	University of Naples Federico II, Italy	ITEE
1st	Using Delays for control	0,2	Prof. Emilia Fridman	Tel Aviv University - Israel	ITEE
1st	Accelerated Deep Learning vie Efficient, Compressed	0,2	Prof. Marco Canini	University of Naples Federico II, Italy	ITEE

	and Managed Communication				
1 st	AR for remote use of measurement instrumentation	0,4	Prof.ssa Annalisa Licardo, Dr. Francesco Bonavolontà	University of Naples Federico II, Italy	ITEE
1 st	Fixed Wireless Access: Site Engineering, Implementation and Legal Regulations	1,2	Ing. Angela Delugan, Ing. Marco Fazzari, Luca Mazza	Fastweb S.p.A.	DIETI Department - Unina
1 st	Population and medical genomics applications to human traits and diseases	0,2	Prof. Nicole Soranzo	University of Cambridge	Computational and Quantitative Biology PhD - UNINA
1 st	QoE management in 5G networks	0,4	Prof. Luigi Atzori	Telecommunication University of Cagliari	DIETI Department - Unina
1 st	Reference standards for next generation sequencing assays on cytological samples: A worldwide ring trial study	0,2	Dott. Pasquale Pisapia	University of Naples Federico II, Italy	DIETI Department - Unina
1 st	Switched differential algebraic equations: jumps and impulses	0,2	Prof. Stephan Trenn	University of Groningen, NL	ITEE
1 st	Thermoacoustic for renewable energies	0,2	Elio Di Giulio	University of Naples Federico II, Italy	DIETI Department - Unina
1 st	Vine robots: design challenges and unique opportunities	0,2	Dr. Nicholas Naclerio	University of California Santa Barbara - USA	ITEE
1 st	Wireless collaborative intelligent with goal-oriented communications	0,4	Yulin Shao	Electrical and Electronic Engineering, Imperial College London.	5G Academy's
1 st	Introduction to Intellectual Property Management	0,4	Alessandro Marroni	NOKIA	5G Academy's
1 st	Privacy-Preserving Machine Learning	0,4	Dr. Vittorio Prodomo	University of Naples Federico II, Italy	DIETI Department - Unina
1 st	Connecting the dots: Investigating an APT campaign using Splunk	0,4	Dr. Antonio Forzieri	University of Naples Federico II, Italy	DIETI Department - Unina
1 st	Privacy and Data Protection	0,4	Dr. Stefano Mele	Gianni & Origoni	DIETI Department - Unina
1 st	Cybercrime and	0,4	Dr. Pierluigi	ENISA	DIETI Department -

	Information warfare: national and international actors		Paganini		Unina
1 st	Digital Forensics	0,4	Artem Artemov	Group-IB company	DIETI Department - Unina
1 st	From Cyber Situational Awareness to Adaptive Cyber Defense: Leveling the Cyber Playing Field	0,4	Prof. Massimiliano Albanese	*George Mason University - USA*	ITEE
2nd	Computational Design of Mechanically Flexible Organics	0,2	Associate Professor Qiang Zhu	External seminar at the University of North Carolina at Charlotte	Associate Professor Dong Dai – University of Delware
2nd	DGAP: Efficient Dynamic Graph Analysis on Persistent Memory	0,4	Ing. Abdullah Al Raqibul Islam, Ing. Elliot Kolker-Hicks	External seminar at the University of North Carolina at Charlotte	Associate Professor Dong Dai – University of Delware
2nd	Multi-robot Control of Heterogeneous Herds	0,2	Eduardo Montiliano	Associate Professor, Department of Informatics and Systems Engineering, Universidad de Zaragoza, Spain	COLLOQUIA SSM - SCHOOL FOR ADVANCED STUDIES
2nd	Machine Learning and Security	0,4	Dott. Fabio De Gaspari	Universita' di Roma 'La Sapienza'	Universita' di Roma 'La Sapienza'
2nd	L'AI Generativa e il futuro della scrittura di codice	0,2	Dott. Pietro Liguori	University of Naples Federico II	CRIT srl
2nd	How to Publish Under the CARE-CRUI Open Access Agreement with IEEE	0,3	Prof. Nino Grizzuti, Eszter Lukacs, Prof. Stefano Bianco	CRUI-CARE and University of Naples Federico II, IEEE Client Services Manager, CRUI-CARE and INFN, member of CARE Group	CARE-CRUI and IEEE
2nd	Traffic Engineering with Segmented Routing: optimally addressing popular use cases	0,2	Prof. Pascal Merindol	University of Strasbourg - France, - Department of Department Mathematics and Computer Science	DIETI Department - Unina
2nd	Comprehensive Exploration of Sparse Accumulator for SpGEMM	0,2	Ing. Abdullah Al Raqibul Islam	External seminar at the University of North Carolina at	Associate Professor Dong Dai – University of Delware

				Charlotte	
2nd	Accelerating Serverless Computing via Intelligent Resource Harvesting	0,2	Ing. Hanfei Yu	External seminar at the University of North Carolina at Charlotte	Associate Professor Dong Dai – University of Delware
2nd	Uncovering Bottleneck in HPC I/O Stack through Instrumenting Low-level System Stats	0,2	Ing. Md Hasanur Rashid	University of Delware - External seminar at the University of North Carolina at Charlotte	Associate Professor Dong Dai – University of Delware
3rd	Analytic center selection of optimization-based controllers for robot ecology	0,2	Prof. Gennaro Notomista	University of Waterloo	Prof. Bruno Siciliano DIETI - Unina
3rd	Sustainable IT: Strategies and Best practices for A green engineering future	1	Annalisa Di Leva, Dimitri Cuomo, Benedetta Ramazzotti, Tiziano Marcozzi	Capgemini	5G ACADEMY'S
3rd	Regolazione in tema di intelligenza artificiale alla luce dell'AI ACT	1	Dott.ssa Elvira Raviele	Ufficio di Gabinetto MIMIT	5G ACADEMY'S
3rd	Generative AI for Software Engineering: Strategies, Impacts, and Practical Applications	1	Annalisa Di Leva, Cynthia Cuvi, Giulia Favale, Alessio Zoccoli	Capgemini	5G ACADEMY'S
3rd	Real-time Resource Management for Adaptive Embedded Systems and Applications	0,2	Prof. Dipl.-Ing. Dr. Gerhard Fohler	Technical University of Kaiserslautern, Germany	DIETI Department - Unina
3rd	Resource management and orchestration for mixed-criticality cloud/distributed systems	0,2	Dr-Ing. Gautam Gala	Technical University of Kaiserslautern, Germany	DIETI Department - Unina
3rd	From ACE Technologies to Sustainable, Accessible and Equitable Urban Mobility: An Optimization Journey	0,4	Prof. Mauro Salazar	Eindhoven University of Technology, Eindhoven, Netherlands	DIETI Department - Unina

Research activities

Simona De Vivo participated in the research on sustainable cybersecurity-related topics, focusing on advancing cybersecurity in Internet of Things (IoT) environments. Her research addressed critical challenges posed by IoT systems, including their susceptibility to security threats, constraints in computational and energy consumption, and the scarcity of high-quality training data for security models.
In particular, she developed innovative, energy-efficient, and lightweight solutions for intrusion detection systems (IDS) tailored IoT devices. Her work leveraged artificial intelligence (AI) techniques, including Federated Learning and User Profiling, to detect and mitigate threats while preserving data privacy and minimizing resource consumption, aligning with Industry 5.0 sustainability goals.
Her research efforts resulted in the design and implementation of *DDoShield-IoT*, a versatile testbed for evaluating IDS performance in IoT scenarios. This framework facilitates the generation of high-quality datasets, the simulation of realistic IoT traffic, and the integration of diverse machine learning models, ensuring scalability and reproducibility. Additionally, her proposed two-stage anomaly detection methodology demonstrated efficient and scalable approaches to IoT security, validated through real-world applications, such as the European CyberSEAS project focused on Smart Grid infrastructures.
These contributions were extensively evaluated against state-of-the-art solutions, showcasing significant improvements in detection accuracy, energy efficiency, and adaptability to heterogeneous IoT environments, thereby advancing the field of sustainable cybersecurity.

Tutoring and supplementary teaching activities

- April 2022, Teaching Assistant, University of Naples Federico II, Naples, Italy, Laboratorio di MATLAB e SIMULINK per l'Ingegneria Elettrica (BSc course) (5h).
- September - December 2024 Teaching Assistant, University of Naples Federico II, Naples, Italy, Data Security (MSc course), S.S.D.: ING-INF/05, Tutor: Prof. Roberto Natella, CdL Data Science (14h).
- Academic year 2021/22, MSc Thesis Co-advisor, Emulation of Embedded Networks for the Analysis of Intrusion Detection Systems, Luigi Sgambato, University of Naples Federico II.
- Academic year 2022/23, MSc Thesis Co-advisor, Study and Analysis of SIEM Platforms in the IoT Field, Marisanna Nelli, University of Naples Federico II.
- Academic year 2022/23, BSc Thesis Co-advisor, Simulation and Analysis of Cyber Attacks on IoT Systems through Anomaly Detection, Raffaele Imperato, University of Naples Federico II.
- Academic year 2023/24, MSc Thesis Co-advisor, Leveraging Anomaly Detection for Smart Grid Security via Federated Learning and User Profiling, Vittorio Niola, University of Naples Federico II.
- Academic year 2023/24, MSc Thesis Co-advisor, Training Strategy for Intrusion Detection Systems (IDS) with Augmented Data, Luigi Cerrato, University of Naples Federico II.

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	39	9,5	36	0,2
2nd	6	2,5	39	0
3rd	0	4	47	0,56

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
2nd and 3rd	University of North Carolina at Charlotte, Charlotte, North Carolina, USA.	Professor and Dean Bojan Cukic, Associate Professor Dong Dai	June 8th, 2023 – February 1st, 2024 (8 months)	Research on Federated Learning for Intrusion Detection in IoT environment. Joint preparation of the scientific paper "DDoShield-IoT: A Testbed for Simulating and Lightweight Detection of IoT Botnet DDoS Attacks", presented at DCCS 2024: The 3rd International Workshop on Dependable Computing for Complex Systems, Co-located with DSN 2024, June 24 - 27, Brisbane, Australia.
2nd and 3rd	DigitalPlatforms S.p.A, Roma, Italy	Dr. Claudio Contini, DP Founder & CEO	- February 8th to April 30th, 2023 - May 1st to June 7th, 2023 - February 1st to March 31st, 2024 (6 months)	On-field experiments on the use and characteristics of SIEM platforms. Evaluation of two SIEM platforms, Real-Time Analytics (RTA) and LimaCharlie. Analysis of public IoT datasets and real-world data provided by Digital Platforms S.p.A.

PhD Thesis

In the PhD thesis, Simona De Vivo addresses the critical cybersecurity challenges posed by the Internet of Things (IoT), a milestone of Industry 4.0 that enables physical devices connection to the Internet, thus allowing real-time communication and decision-making. The rapid proliferation of IoT systems, encompassing diverse resource-constrained devices, has exposed them to sophisticated attacks, among which, Denial of Service (DoS) and Distributed Denial of Service (DDoS) are of considerable relevance and danger. These challenges are exacerbated by the sustainability and resilience goals emphasized in Industry 5.0, which traditional security solutions—such as rule-based intrusion detection systems (IDS) and security information and event management (SIEM)—struggle to fulfill. De Vivo's work seeks to bridge this gap by developing innovative, lightweight, and adaptable cybersecurity strategies tailored to the unique requirements of IoT environments.

The first thesis contribution was conducted in collaboration with Digital Platforms S.p.A and presents two existing SIEMs, RTA and LimaCharlie, in a comparative evaluation aimed at finding their applicability in the context of IoT. Despite both showing promising performance, these solutions are insufficient when the case involves sophisticated DDoS attacks due to the rule-based nature of their detection process. The analysis highlights the necessity of integrating machine learning (ML) techniques to enhance their detection accuracy and adaptability. In light of this, the research advances a lightweight IDS designed for IoT networks characterized by constrained resources. Using a K-Means clustering model, this IDS achieves real-time detection of DoS attacks in an onboard train network while maintaining low energy consumption. Experimental results show its efficacy, achieving approximately 90% accuracy with a power consumption of only 1.5W, aligning with Industry 5.0's focus on sustainability by balancing high performance with minimal resource usage. To further enhance IoT cybersecurity, De Vivo, as an outcome of her period abroad at the University of North Carolina at Charlotte, introduces the DDoShield-IoT framework, a versatile IDS testbed for developing and evaluating ML-based IDS solutions. Using Docker containers and the NS-3 simulator, this framework generates realistic traffic patterns and supports the integration of diverse ML models, enabling comprehensive performance analyses in scalable IoT settings. Also, its ability to generate realistic traffic addressed the scarcity of high-quality IoT datasets, proposing a Data Augmentation strategy, that combines real-world traffic data with synthetic data generated by the DDoShield-IoT testbed. This approach therefore enriches the training datasets and enhances the detection capabilities of ML models, especially against zero-day attacks.

Finally, to overcome privacy and sustainability issues, the thesis presents a novel intrusion detection methodology that combines User Profiling with Federated Learning (FL), which consists of clustering IoT devices based on traffic patterns and applying FL to improve anomaly detection while preserving privacy and reducing energy consumption. The effectiveness of this methodology is proven in a real-world scenario, in the context of the European CyberSEAS project, which aims at protecting Smart Grid critical infrastructures.

These contributions not only bridge current limitations in IoT security but also fulfill the principles of Industry 5.0, providing a sound basis for future research and innovation in this key area.

Research products

Research results appear in 4 contributions to international conferences.

List of scientific publications

International conference papers

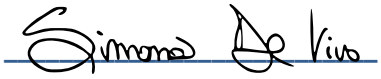
[1] Pietro Liguori, Cristina Improta, Simona De Vivo, Roberto Natella, Bojan Cukic, Domenico Cotroneo,
Can NMT understand me? towards perturbation-based evaluation of NMT models for code generation,
1st International Workshop on Natural Language-based Software Engineering,
Pittsburgh, Pennsylvania, May 2022, pp. 59-66, Association for Computing Machinery, DOI:
10.1145/3528588.3528653

[2] Alessandra Rizzardi, Raffaele Della Corte, Jesús F. Cevallos M., Vittorio Orbinato, Simona De Vivo, Sabrina Sicari,
RailRED: a Node-RED-Based Framework for Modeling Train Control Management Systems,
2024 20th International Conference on Wireless and Mobile Computing, Networking and Communications (WiMob),
Paris, France, 2024, October 2024, pp. 671-674, IEEE, DOI: 10.1109/WiMob61911.2024.10770345.

[3] Simona De Vivo, Islam Obaidat, Dong Dai, Pietro Liguori
DDoShield-IoT: A Testbed for Simulating and Lightweight Detection of IoT Botnet DDoS Attacks
54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks Workshops (DSN-W)
Brisbane, Australia, June 2024, pp. 1-8, IEEE, DOI: 10.1109/DSN-W60302.2024.00014.

[4] Simona De Vivo, Pietro Liguori
Simulation Environment for the Evaluation of Lightweight Intrusion Detection Systems
34th International Symposium on Software Reliability Engineering Workshops (ISSREW)
Florence, Italy, October 2023, pp. 132-135, IEEE, DOI: 10.1109/ISSREW60843.2023.00061.

Date 12/12/2024

PhD student signature 

Supervisor signature