UNIVERSITÀ DEGLI STUDI DI NAPOLI FEDERICO II

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

Activities and Publications Report

PhD Student: Marco Barletta

Student DR number: DR995851

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

PhD program student's start date: 01/11/2021
PhD program student's end date: 31/10/2024

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PhD scholarship funding entity:
Università Federico II

General information

Marco Barletta received in year 2021 the Master Science degree in Computer Engineering from the University of Napoli Federico II. He attended a curriculum in real-time systems within the PhD program in Information Technology and Electrical Engineering. He received a grant from Università Federico II.

Study activities

Attended Courses

Year	Course Title	Type	Credits	Lecturer	Organization
1st	Real-Time Industrial Systems	MSc course	6	Prof. Marcello Cinque	Polytechnic School
1st	Quantum Information	MSc course	6	Prof. Angela Sara Cacciapuoti	Polytechnic School
1st	Virtualization Technologies and their Applications	Ad hoc course	5	Dr. Luigi De Simone	ITEE
1st	Statistical Data Analysis for Science and Engineering Research	Ad hoc course	4	Prof. Roberto Pietrantuono	ITEE
1st	Imprenditorialità Accademica	Ad hoc course	4	Prof. Pierluigi Rippa	Polytechnic School
2nd	IoT Data Analysis	Ad hoc course	4	Dr. Raffaele Della Corte	ITEE
2nd	How to boost your Ph.D.	Ad hoc course	4	Prof. Antigone Marino	Polytechnic School
3rd	Strategic orientation for STEM research and writing	Ad hoc course	5	Dr. Chie Shin Fraser	ITEE

Attended Seminars

Year	Seminar Title	Credits	Lecturer	Lecturer affiliation	Organization
1st	Second Quantum Revolution: innovation trends and expected industrial impacts.	0.4	Dr. Antonio Manzalini	TIM, Turin, Italy	ITEE
1st	Qiskit: state of the art and tools for Quantum Computers from IBM.	0.4	Dr. Federico Accetta	IBM Italia	ITEE
1st	Possible Quantum Machine Learning Approaches in HEP.	0.4	Dr. Michele Grossi	CERN, Geneve, Switzerland, Openlab QTI	ITEE
1st	Threat Hunting Essentials	0.4	Dr. Artem Artemov	Group-IB	ITEE
1st	GDPR basics for	0.4	Dr. Rigo	European Research	ITEE

	computer scientists.		Wenning	Consortium for Informatics and Mathematics	
1st	Designing Quantum Algorithms.	0.4	Prof. Michele Amoretti	University of Parma, Italy	ITEE
1st	All roads lead to WebRTC: an introduction to Janus.	0.4	Dr. Lorenzo Miniero	Meetecho	ITEE
1st	Complexity and the City: transitioning towards the smart cities of the future	0.2	Prof. Luis Bettencourt	Mansueto Institute for Urban Innovation at the University of Chicago	Città della Scienza.
1st	IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	0.3	Dr. Paolo Bonato, Eszter Lukacs, Judy Brady	IEEE	IEEE
1st	Potential and challenges of next generation railway signaling systems: Moving Block and Virtual Coupling	0.2	Eng. Joelle Aoun	TU Delft	ITEE
1st	Project Vāc: Can a Text-to-Speech Engine Generate Human Sentiments?"	0.2	Prof. V.K. Gubani	Illinois Institute of Technology	DIETI and Department of Physics Ettore Pancini.
1st	From basic principles in spintronics to some recent developments toward spin-orbitronics	0.2	Dr. Vincent Cros	Unité Mixte de Physique, CNRS, Thales, Université Paris-Saclay.	Scuola Superiore Meridionale
1st	Ethics and Politics of A.I.	0.2	Prof. Mark Coekelbergh	University of Vienna	DIETI and Department of Physics Ettore Pancini.
1st	Explainable Natural Language Inference	0.3	Dr. Marco Valentino	University of Manchester, United Kingdom and Idiap Research Institute, Switzerland	ITEE
1st	An Introduction to Deep Learning for Natural Language Processing	0.2	Dr. Marco Valentino	University of Manchester, United Kingdom and Idiap Research	ITEE

				Institute, Switzerland	
1st	Using Delays For Control	0.2	Prof. Emilia Fridman	Tel Aviv University, Israel	ITEE
1st	A day in the life of a chief data officer	0.3	Roberto Maranca	Schneider Electric	DIETI and Department of Physics Ettore Pancini.
1st	Privacy-preserving machine learning	0.4	Dr. Vittorio Prodomo	Federico II Univerisity of Naples	ITEE
2nd	Connecting the dots: Investigating an APT campaign using Splunk	0.4	Dr. Antonio Forzieri	Splunk	ITEE
2nd	Crash Course on Data Excellence – Part I	0.2	Dr. Roberto Maranca	Schneider Electric	DIETI and Department of Physics Ettore Pancini
2nd	How to manage up	0.2	Adam Schmidt	IEEE computer society	IEEE
2nd	Publishing Open Access IEEE Journal Articles under Care CRUI Agreement in Italy	0.2	Eszter Lukacs	IEEE	IEEE
2nd	Privacy and data protection	0.4	Dr. Stefano Mele	Gianni & Origoni	ITEE
2nd	Automated Offensive Security: intelligence is all you need.	0.2	Prof. Simon Pietro Romano	Federico II Univerisity of Naples	DIETI and Department of Physics Ettore Pancini
2nd	Digital Forensics	0.4	Dr. Artem Artemov	Group-IB	ITEE
2nd	Game Theory for Information Engineering	0.6	Prof. Leonardo Badia	University of Padova	ITEE
2nd	From Cyber Situational Awareness to Adaptive Cyber Defense: Leveling the Cyber Playing Field	0.4	Prof. Massimiliano Albanese	George Mason University	ITEE
2nd	Industry 4.0 Fundamentals in Bosch Applications	2	Eng. Bruni Martino	Bosch	Politecnico di Bari
2nd	How to Publish Under the CARE-CRUI Open Access Agreement with IEEE	0.3	Nino Grizzuti, Eszter Lukacs, Stefano	CARE-CRUI and Unina, IEEE, CARE-CRUI and INFN	CARE-CRUI and IEEE

			Bianco		
3rd	I finished my PhD, but what can I do now? The Marie-Sklodowska Curie Actions	0.2	Dr Narciso M. Quijada	University of Salamanca	Department of Agricultural Sciences

Research activities

Marco Barletta participated in the research on cloud-native mixed-criticality systems. He focused on the assessment and design of container orchestration systems for next-generation cyber-physical systems and mission-critical systems, including Industry 4.0, 5G networks, and Software Defined Vehicles.

In particular, the research covered the following topics: i) analysis of failure modes and injection methods for container orchestration systems, ii) analysis of timing characteristics of container orchestration systems in non-nominal conditions, iii) models for the management and placement of mixed-criticality applications in heterogeneous environments, iv) monitoring strategies for real-time containers.

The contributions of his research are: i) a model for mixed-criticality orchestration, ii) a failure and timing analysis of container orchestration systems in non-nominal conditions, and iii) the design and development of a set of solutions (based upon the proposed model) to improve the resilience, timeliness, and isolation from interference of containers and container orchestration systems.

Marco's research introduces a failure mode classification for container orchestration systems, and shows that even a single error can disrupt a cluster. Furthermore, the research shows that an orchestration system may take tens of seconds to scale a service or handle a failure, compromising the application service level objectives (SLOs).

The proposed solutions include architectural designs for SLO-aware orchestration and partitioned containers. The implemented prototypes improve the resilience of critical services, the timing and failure isolation of orchestration times and containers compared to state of the art.

Tutoring and supplementary teaching activities

Sistemi Operativi, SSD: ING-INF/05, Tutor: prof. Marcello Cinque, CdL Ingegneria Informatica

Credits summary

PhD Year	Courses	Seminars	Research	Tutoring / Supplementary Teaching
1st	25	5.5	36.5	0
2nd	8	5.3	41.6	1
3rd	5	0.2	52.9	0

Research periods in institutions abroad and/or in companies

PhD Year	Institution / Company	Hosting tutor	Period	Activities
1st	Nokia Bell Labs (Stuttgart, Germany)	Catello Di Martino	01/06/2022-30/09/2022	Research on use Industry 4.0 orchestration use cases. Joint scientific paper preparation "SLA-driven software orchestration in Industry 4.0". Preparation of patent application "SLA-Driven Orchestration of Software Containers".
2st	University of Illinois at Urbana-Champaign (Champaign, IL, USA)	Ravishankar K. Iyer	12/04/2023-22/12/2023	Research on resilience of orchestration systems. Fault-injection experiments on Kubernetes. Joint scientific paper preparation "Mutiny! How does Kubernetes fail, and what can we do about it?"

PhD Thesis

As critical computing systems grow increasingly complex, hardware components are being replaced with software ones and embedded systems evolve into powerful mixed-criticality platforms hosting components at different criticality levels. Container orchestration systems streamline the management of software components, increasing resilience and offering a flexible, automated, and cost-effective use of computing resources. Hence, recent research has explored virtualization and cloud-native technologies in mission-critical environments. However, these systems were not originally designed to meet the diverse non-functional requirements and heterogeneous hardware configurations typical of industrial settings.

In the thesis, Marco Barletta investigates whether it is possible to use container orchestration systems in critical environments. In particular, the contributions of the thesis are threefold: i) it introduces a model for mixed-criticality orchestration, ii) it performs a failure and timing analysis to assess the behavior of container orchestration systems in non-nominal conditions, and iii) it proposes a set of solutions to improve the resilience, timeliness, and isolation from interference for both container orchestration systems and containers.

The analysis shows that even a single error can disrupt a cluster, leading to overloads and service disruptions. Moreover, under heavy orchestration loads, an orchestration system may take tens of seconds to scale a service or handle a failure, compromising the service level objectives (SLOs). The proposed solutions include designs and methods for SLO-aware orchestration and designs for partitioned containers. The implemented prototypes demonstrate that SLO-aware orchestration improves the resilience of critical services and provides stable orchestration times and that partitioned containers guarantee improved timing and failure isolation.

Research products

Research results appear in 2 papers published in international journals, 10 contributions to international conferences, *1* patent.

List of scientific publications

International journal papers

M. Barletta, M. Cinque, and C. Di Martino
"SLA-Driven Software Orchestration in Industry 4.0"
IEEE Internet of Things Magazine
Vol. 5 (4), pp. 136-141, 2022, DOI: 10.1109/IOTM.001.2200216

M. Barletta, M. Cinque, L. De Simone, and R. Della Corte
"Criticality-aware monitoring and orchestration for containerized industry 4.0 environments"
ACM Transactions on Embedded Computing Systems,
Vol. 23 (1), pp. 1-28, 2024, DOI:10.1145/3604567

International conference papers

M. Barletta, M. Cinque, and R. Della Corte
"Hierarchical Scheduling for Real-Time Containers in Mixed-Criticality Systems"
32nd IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW)
Wuhan, China, Oct. 2021, pp. 286-287, IEEE, DOI: 10.1109/ISSREW53611.2021.00082

M. Barletta, M. Cinque, L. De Simone, and R. Della Corte
"Achieving isolation in mixed-criticality industrial edge systems with real-time containers"
34th Euromicro Conference on Real-Time Systems (ECRTS 2022)
Modena, Italy, July 2022, pp. 15:1-15:23, Schloss-Dagstuhl-Leibniz Zentrum für Informatik,
DOI:10.4230/LIPIcs.ECRTS.2022.15

M. Barletta, M. Cinque, L. De Simone, and R. Della Corte,
"Achieving isolation in mixed-criticality industrial edge systems with real-time containers (Artifact)"
34th Euromicro Conference on Real-Time Systems (ECRTS 2022)
Modena, Italy, July 2022, pp. 1:1-1:12, Schloss-Dagstuhl-Leibniz Zentrum für Informatik,
DOI:10.4230/DARTS.8.1.1

M. Barletta, M. Cinque, L. De Simone, and R. Della Corte,
"Introducing k4. 0s: a Model for Mixed-Criticality Container Orchestration in Industry 4.0"
2022 IEEE Intl Conf on Dependable, Autonomic and Secure Computing, Intl Conf on Pervasive Intelligence and Computing, Intl Conf on Cloud and Big Data Computing, Intl Conf on Cyber Science and Technology Congress (DASC/PiCom/CBDCom/CyberSciTech)
Falerna, Italy, September 2022, pp. 1-6, IEEE, DOI: 10.1109/DASC/PiCom/CBDCom/Cy55231.2022.9927896.

M. Barletta, M. Cinque, L. De Simone, R. Della Corte, G. Farina, D. Ottaviano
"RunPHI: Enabling Mixed-criticality Containers via Partitioning Hypervisors in Industry 4.0"
2022 IEEE International Symposium on Software Reliability Engineering Workshops (ISSREW)
Charlotte, NC, USA, October 2022, pp. 134-135, IEEE, DOI: 10.1109/ISSREW55968.2022.00058.

M. Barletta, M. Cinque, L. De Simone, R. Della Corte, G. Farina, and D. Ottaviano
"Partitioned Containers: Towards Safe Clouds for Industrial Applications"
2023 53rd Annual IEEE/IFIP International Conference on Dependable Systems and Networks - Supplemental Volume (DSN-S)

Porto, Portugal, June 2023, pp. 84-88, IEEE, DOI: 10.1109/DSN-S58398.2023.00029.

M. Barletta, L. De Simone, R. D. Corte and C. Di Martino,
"Failover Timing Analysis in Orchestrating Container-based Critical Applications"
2024 19th European Dependable Computing Conference (EDCC)
Leuven, Belgium, April 2024, pp. 81-84, IEEE, DOI: 10.1109/EDCC61798.2024.00026

M. Barletta, M. Cinque, D. De Vita,
"Orchestrating Mixed-Criticality Cloud Workloads in Reconfigurable Manufacturing Systems"
2024 19th European Dependable Computing Conference – Fast Abstracts and Student Forum Proceedings
Leuven, Belgium, April 2024, pp. 81-84, IEEE, DOI:10.48550/arXiv.2403.19042

M. Barletta, M. Cinque, C. Di Martino, Z. Kalbarczyk and R. Iyer,
"Mutiny! How Does Kubernetes Fail, and What Can We Do About It?"
2024 54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN),
Brisbane, Australia, June 2024, pp. 1-14., IEEE, DOI: 10.1109/DSN58291.2024.00016

M. Barletta, M. Cinque, C. Di Martino, Z. Kalbarczyk and R. Iyer,
"Mutiny! How Does Kubernetes Fail, and What Can We Do About It? (Artifact)"
2024 54th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN),
Brisbane, Australia, June 2024, DOI: 10.5281/zenodo.10275036

Patents and/or spin offs

Patent: WO2024175183A1 - "SLA-Driven Orchestration of Software Containers". Inventors: Catello Di Martino, Marco Barletta, September 2024.
The invention includes the differentiated management during orchestration of applications with different criticality levels. The orchestrator reconfigures network resources and migrates a service when an SLA violation is predicted or detected. The different criticality levels rely on different replication schemes and active/passive backup replicas to guarantee the SLAs.

Date ____14/10/2024_____

PhD student signature 

Supervisor signature