



PhD in Information Technology and Electrical Engineering
Università degli Studi di Napoli Federico II

PhD Student: Ferdinando Marrone

Cycle: XXXIX

Training and Research Activities Report

Year: First

student signature

Ferdinando Marrone

Tutor: Prof. Stefano Avallone

tutor signature

Stefano Avallone

Date: October 31, 2024

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

1. Information:

- PhD student: Ferdinando Marrone
- DR number: DR997215
- Date of birth: 01/04/1981
- Master Science degree: Telecommunications Engineering
- University: University of Naples Federico II
- Doctoral Cycle: XXXIX
- Scholarship type: no scholarship
- Tutor: Prof. Stefano Avallone

2. Study and training activities:

Activity	Type ¹	Hours	Credits	Dates	Organizer	Certificate ²
Ensuring Electronic Reliability Against CERN's Radiation Environment	Seminar	2	0,4	01/12/2023	Prof. Francesco Fienga	Y
Study on ns-3, IEEE 802.11ax amendment, network slicing, WiFi power management and Target Wake Time	Research		5	1/11/2023 – 31/12/2023		
Costituzione e sovranismo digitale	Seminar	3	0,6	30/01/2024	Dott.ssa Antonia Maria Acerno	Y
Study on ns-3, network slicing, Intel Labs NetworkGym framework	Research		4	1/01/2024 – 29/02/2024		
Strategic Orientation for STEM Research & Writing	Course	24	5	07-15/12/2023, 12-19/01, 09-23/02/2024	Sig.ra Adriana D'Auria	Y
Virtualization technologies and their applications	Course	22	5	08-10-15-19-24-25-29-	Prof. Luigi De Simone	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

				31/01/2024, 05-07- 26/02/2024		
Hands-on Network Intrusion Detection via Machine and Deep Learning	Course	14	4	09-11-16-17-18/01/2024	Dott. Antonio Montieri	Y
Un modello sostenibile per l'equilibrio tra ricerca, innovazione e startup	Seminar	2	0,4	17/04/2024	Dott. Massimo Varrone	N
WHAT IF AI helped build collective values?	Seminar	5	1	19/04/2024	Dott.ssa Sabrina Sacco	N
Study on ns-3, IEEE 802.11be amendment, WiFi network slicing design. Review of an article on the simulation of IoT technologies for the journal "Computer networks"	Research		6	1/03/2024 – 30/04/2024		
Using Deep Learning properly	Course	12	4	23-25-30/01/2024, 01-06-08/02/2024	Dott. Andrea Apicella	Y
I pilastri della trasformazione digitale	Course	12	3	20-22-25-26/3/2024, 4-5/4/2024	Prof. Nicola Mazzocca	Y
Study on the design and implementation of WiFi network slicing in ns-3. Review of an article on the simulation of IoT technologies for the journal "Computer networks"	Research		4	1/05/2024 – 30/06/2024		
Social Network Analysis: Methods	Seminar	2	0,4	07/06/2024	Prof. Giancarlo	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

and Applications					Sperli	
Introduction to Large Language Models: Evolution and the current state	Seminar	2	0,4	10/06/2024	Prof. Giancarlo Sperli	Y
5G & digital transformation: a view from an unconventional perspective (5G Academy)	Seminar	4	0,8	10/05/2024	Prof.ssa Antonia Maria Tulino	Y
Regolazione in tema di intelligenza artificiale alla luce dell'AI Act (5G Academy)	Seminar	5	1	13/05/2024	Prof.ssa Antonia Maria Tulino	Y
Generative AI for software engineering: strategies, impacts, and practical applications (5G Academy)	Seminar	5	1	29/05/2024	Prof.ssa Antonia Maria Tulino	Y
Intelligenza artificiale e regole del mercato (5G Academy)	Seminar	2	0,4	14/05/2024	Prof.ssa Antonia Maria Tulino	Y
Sustainable IT: Strategies and best practices for a green engineering future (5G Academy)	Seminar	5	1	27/05/2024	Prof.ssa Antonia Maria Tulino	Y
Verso una gestione intelligente delle risorse idriche con il supporto dell'innovazione digitale (5G Academy)	Seminar	1	0,2	14/05/2024	Prof.ssa Antonia Maria Tulino	Y
Machine Deception	Seminar	1	0,2	23/05/2024	Prof.ssa Alessandra Rossi	Y
Resource management and orchestration for	Seminar	1	0,2	27/06/2024	Prof. Marcello Cinque	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

mixed-criticality cloud/distributed systems						
IEEE Authorship and Open Access Symposium: Tips and Best Practices to Get Published from IEEE Editors	Seminar	2	0,4	07/05/2024	Eszter Lukács, Judy Brady (IEEE)	N
Study on implementation of WiFi network slicing in ns-3. Simulations and performance check of the implemented algorithm	Research		4	1/07/2024 – 31/08/2024		
Innovation and Entrepreneurship	Course	12	4	12-14-19-21-26/06/2024	Prof. Pierluigi Rippa	Y
Topological Signal Processing and Learning	Seminar	1	0,2	17/07/2024	Prof.ssa Antonia Maria Tulino	Y
From ACE Technologies to Sustainable, Accessible and Equitable Urban Mobility: An Optimization Journey	Seminar	2	0,4	16/09/2024	Prof.ssa Stefania Santini	Y
TA Springer Nature & CARE - CRUI: Research Integrity	Seminar	1	0,2	8/10/2024	Elisa Magistrelli (Springer Nature)	Y
Author Journey - Transformative Agreement Springer Nature & CARE CRUI	Seminar	1	0,2	9/10/2024	Elisa Magistrelli (Springer Nature)	Y
IEEE Horizons: Exploring 5G/6G Innovations	Seminar	3	0,6	22/10/2024	IEEE	Y
IEEE Authorship	Seminar	1,5	0,3	24/10/2024	IEEE	Y

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

and Open Access Symposium: Tips and Best Practices to Get Published from IEEE						
Performance evaluation of <i>SlicingScheduler</i> implemented in ns-3. Preparation of the conference paper “Wi-Fi Network Slicing Through OFDMA” submitted to IEEE Wireless Communications and Networking Conference (WCNC)	Research		3	1/09/2024 – 31/10/2024		

- 1) Courses, Seminar, Doctoral School, Research, Tutorship
- 2) Choose: Y or N

2.1. Study and training activities - credits earned

	Courses	Seminars	Research	Tutorship	Total
Bimonth 1	0	0,4	5	0	5,4
Bimonth 2	10	0,6	4	0	14,6
Bimonth 3	4	1,4	6	0	11,4
Bimonth 4	7	6	4	0	17
Bimonth 5	4	0,2	4	0	8,2
Bimonth 6	0	1,7	3	0	4,7
Total	25	10,3	26	0	61,3
Expected	30 - 70	10 - 30	80 - 140	0 – 4.8	

3. Research activity:

Research topic

Time-critical communication has become a key requirement for many recent applications, such as industrial control systems or real-time applications. A working group called IEEE 802.1 Time Sensitive Networking was established to address these demands, but current implementations are essentially all based on Ethernet as the networking medium.

My research activity focuses on enhancing wireless technologies to support Time-Sensitive Networking (TSN). Extending TSN functionality to the wireless domain is challenging because of the

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

communication medium's unreliability and traditional contention-based medium access control schemes.

Methodology

I have conducted an in-depth analysis of solutions that can enable the TSN paradigm on wireless networks. Deterministic scheduling of wireless resources and guaranteed channel access are crucial elements. For this reason, I started by studying the latest Wi-Fi standards (IEEE 802.11ax and IEEE 802.11be), which include features like Orthogonal Frequency Division Multiple Access (OFDMA) and Target Wake Time (TWT), which can help to reduce the probability of collisions among multiple stations. The solution I identified is to carry out network slicing in Wi-Fi via OFDMA.

Network slicing consists of partitioning network resources into virtual and physical portions with customized characteristics, optimized for a specific type of application. The research activity on this topic is conducted in collaboration with Intel Labs researchers. First, I evaluated state-of-the-art solutions designed for cellular networks including one implemented in the Intel Labs NetworkGym framework [1]. Then, I conducted an extensive literature review on Wi-Fi network slicing, finding that most works use airtime as a resource to be allocated to slices [2, 3]. The next step was to design an OFDMA scheduler called *SlicingScheduler*, starting from the one available in ns-3 which serves STAs in a round robin fashion [4]. The goal is to share resources in time and frequency between slices in proportion to predefined ratios, which also identify a priority in terms of more stringent delay requirements. The aim is also to ensure isolation between slices while allowing the dynamic reuse of allocated but unused resources. To achieve good modularization, the design was divided into phases (per-slice requested and target RUs estimation, inter-slice scheduling, intra-slice scheduling, scheduling feasibility in IEEE 802.11ax/be, A-MPDU preparation and slice ratio update).

The thus-designed scheduler was implemented in the ns-3 simulator to evaluate its performance.

Results

Throughput, latency, and packet loss performance have been evaluated in scenarios of a single station participating in different slices and multiple stations with varying combinations of flows belonging to different slices. Simulations performed in ns-3 showed that the proposed method achieves effective OFDMA scheduling, ensuring that slices meet their performance requirements. It is shown that the algorithm allows the schedule of the resources for the slices proportionally to the requested ratios, allowing the reuse of the resources allocated but not used dynamically as designed.

Furthermore, the results show that the approach effectively controls latency as well as enables increased throughput for higher-priority slices.

References

- [1] https://intellabs.github.io/networkgym/environments/mx_network_slicing/cellular_network_slicing.html#cards-mx-cellular-slicing
- [2] M. Richart, J. Baliosian, J. Serrat, J. -L. Gorricho and R. Aguero, "Slicing With Guaranteed Quality of Service in WiFi Networks," in IEEE Transactions on Network and Service Management, vol. 17, no. 3, pp. 1822-1837, Sept. 2020
- [3] K. Zia, A. Chiumento, P. Havinga, R. Riggio and Y. Huang, "QoS Aware Slice Resource Management Using Deep Reinforcement Learning in IoT Networks," 2023 19th International

Training and Research Activities Report

PhD in Information Technology and Electrical Engineering

Cycle: XXXIX

Author: Ferdinando Marrone

Conference on Distributed Computing in Smart Systems and the Internet of Things (DCOSS-IoT), Pafos, Cyprus, 2023, pp. 150-154

[4] P. Imputato and S. Avallone, "Adaptive Scheduling for Downlink OFDMA in IEEE 802.11ax," European Wireless 2023; 28th European Wireless Conference, Rome, Italy, 2023, pp. 168-173

4. Research products:

F. Marrone, P. Imputato, S. Avallone, "Wi-Fi Network Slicing Through OFDMA" IEEE Wireless Communications and Networking Conference (WCNC), 24–27 March 2025, Milan, Italy (submitted)

5. Conferences and seminars attended

IEEE Horizons: Exploring 5G/6G Innovations, 22/10/2024 Northeastern University, Silicon Valley Campus 75 E. Santa Clara Street Suite 150 San Jose, CA (*I attended remotely*)

6. Activity abroad:

7. Activity in partner companies:

8. Tutorship