Federico Parola

Ph.D

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Education

Oct 2020 – Jun 2024 **Ph.D. in Computer And Control Engineering**, *Politecnico di Torino*, Italy
Thesis: Orchestrating Edge Computing Services with Efficient Data Planes
Supervisor: Prof. Fulvio Risso
During my Ph.D., sponsored by TIM S.p.A., I focused on enabling high-performance and low-overhead communication between application modules and the end users, as well as providing effective mechanisms to share resources in data centers (with a focus on edge ones). To reach these goals I dug into the foundations of the Linux kernel, leveraged high-performance packet processing frameworks, such as XDP (powered by eBPF) and DPDK, and studied the possible evolutions of virtualization mechanisms (VMs and containers), such as Unikernels. During the programme I carried out projects in collaboration with TIM S.p.A, Rakuten Mobile, and Huawei Technologies.

Oct 2017 – Jul 2020 **Master's Degree in Computer Engineering**, *Politecnico di Torino*, Italy, *110/110 cum laude*
Thesis: Prototyping an eBPF-based 5G Mobile Gateway
Supervisor: Prof. Fulvio Risso

Oct 2014 – Oct 2017 **Bachelor's Degree in Computer Engineering**, *Politecnico di Torino*, Italy, *110/110 cum laude*

Professional experience

Nov 2023 – Present **Research Assistant**, *Politecnico di Torino*, Italy
I continue working on the topics addressed during my Ph.D. studies, including high-performance networking and efficient resource virtualization. I assist M.S. students with their thesis and contribute to national and European projects including project ELASTIC (`https://elastic-project.eu/`), where I'm leading a task on the creation of a lightweight service mesh interconnecting traditional VMs/containers and WebAssebly-based functions.

Oct 2020 – Present **Teaching Assistant**, *Politecnico di Torino*, Italy
Teaching assistant for the B.S. course Computer Networks and M.S. Software Networking.

Other experience

Jan 2023 – Sep 2023 **Visiting Scholar in the Department of Computer Science and Engineering**, *University of California, Riverside*, United States
I worked under the supervision of Prof. K. K. Ramakrishnan on the design and development of a novel virtualization mechanism combining low resource footprint, strong isolation and security, high-performance data plane, and low overhead service management. During this period I had the opportunity to dig into the details and leverage hardware-assisted virtualization mechanisms (e.g., Intel VMX) and explore novel operating system paradigms such as Unikernels.

Languages

Italian Native speaker
English C1 *Certified by IELTS test*

Computer skills

Languages

C/C++ *Advanced.* I have experience creating high-performance data structures (e.g., hash maps), handling memory allocation, inlining assembly, handling concurrency through locks or lockless algorithms, and interacting with hardware peripherals (virtio, NICs). I used C extensively to write eBPF programs. I used C++ mainly for control plane aspects (e.g., RESTful interfaces).

x86/64 assembly *Good.* I used x86 assembly mainly when working on unikernels, to tinker with low-level subsystems of the kernel (e.g., interrupt handling) and to interact with processor-specific technologies.

Python *Advanced.* Used to handle complex experiments and data collection/manipulation.

Bash *Good.* Used to automate the configuration of nodes for experiments.

Rust *Basic.* I'm currently studying Rust.

Java, JS, HTML, Lua *Good.* I used these languages during my bachelor's and master's courses.

Software and frameworks

eBPF *Advanced.* I used eBPF in multiple projects, mainly in the networking field to achieve high-performance packet processing through the XDP hook, but also to instrument the operating system through tracepoints, kprobes, etc. I am experienced with the `libbpf` C library.

DPDK *Advanced.* I used the DPDK (Data Plane Development Kit) to implement high-performance network functions and as a packet generator to test their performance. I worked on and extended F-stack, a user-space TCP/IP stack based on DPDK and the FreeBSD stack.

QEMU/KVM *Good.* I used QEMU/KVM to run and customize VMs especially when working with unikernels. I am familiar with KVM internals and can investigate performance bottlenecks (e.g., through `perf`).

Kubernetes *Good.* I used Kubernetes to deploy multiple applications and worked on its networking side contributing to a modular network provider based on eBPF.

OSes

Linux *Advanced.* I am familiar with multiple user-space Linux tools from monitoring (`top`, `htop`, `sar`, `perf`) to network configuration (`ip`, `tc`). I have a deep knowledge of Linux kernel internals and am familiar with navigating its source code. I am particularly experienced in the lower layers of the network stack (NIC drivers, NAPI), interrupts management with softirqs and work queues, monitoring with `perf`, and extending the kernel with eBPF and modules. Ubuntu is my daily driver.

Windows *Good.* I use Windows sporadically, mainly to use Office suite programs.

Projects

Polycube Polycube is a framework to create fast network services running in the Linux kernel with eBPF, by chaining simple network functions such as firewalls, bridges, and routers. I acted as a main maintainer of the project for multiple years, fixing bugs, reviewing PRs, and contributing with architectural and performance improvements. I used the Polycube in multiple projects, including a prototype 5G UPF and a CNI plugin for Kubenetes. (`https://github.com/polycube-network/polycube`)

XSKNF I wrote this framework to simplify the development of network functions leveraging AF_XDP socket for packet I/O. The framework allows programmers to simply specify a packet processing function and handles aspects such as multi-core scalability and socket configuration. (`https://github.com/FedeParola/xsknf`)

eBPF-based SYN Flood Detector A simple proof-of-concept TCP SYN flood detector that leverages eBPF to track the number of pending TCP connections and identify the possible sources of an attack. The tool optionally allows to mitigate the attack through XDP-level packet drop. (`https://github.com/FedeParola/ebpf-synflood-detector`)

Publications

[1] Mirco Barone, Federico Parola, Fulvio Risso, and Davide Miola. Achieving linear cpu scaling in wireguard with an efficient multi-tunnel architecture. In *Netdev 0x18, THE Technical Conference on Linux Networking*, 2024.

[2] Anvaya B. Narappa, Federico Parola, Shixiong Qi, and K. K. Ramakrishnan. Z-stack: A high-performance dpdk-based zero-copy tcp/ip protocol stack. In *2024 IEEE 30th International Symposium on Local and Metropolitan Area Networks (LANMAN)*, pages 100–105, 2024.

[3] Davide Miola, Fulvio Risso, and Federico Parola. Measuring the cost of the linux network stack in real-time. In *2024 IEEE 10th International Conference on Network Softwarization (NetSoft)*, pages 295–303, 2024.

[4] Federico Parola, Roberto Procopio, Roberto Querio, and Fulvio Risso. Comparing user space and in-kernel packet processing for edge data centers. *SIGCOMM Comput. Commun. Rev.*, 53(1):14–29, apr 2023.

[5] Francesco Monaco, Giuseppe Ognibene, Federico Parola, and Fulvio Risso. Enabling scalable sfcs in kubernetes with ebpf-based cross-connections. In *2022 IEEE Conference on Network Function Virtualization and Software Defined Networks (NFV-SDN)*, pages 33–38, 2022.

[6] Federico Parola, Leonardo Di Giovanna, Giuseppe Ognibene, and Fulvio Risso. Creating disaggregated network services with ebpf: the kubernetes network provider use case. In *2022 IEEE 8th International Conference on Network Softwarization (NetSoft)*, pages 254–258, 2022.

[7] Federico Parola, Roberto Procopio, and Fulvio Risso. Assessing the performance of xdp and af_xdp based nfs in edge data center scenarios. In *Proceedings of the 17th International Conference on Emerging Networking EXperiments and Technologies*, CoNEXT '21, page 481–482, New York, NY, USA, 2021. Association for Computing Machinery.

[8] Federico Parola, Fulvio Risso, and Sebastiano Miano. Providing telco-oriented network services with ebpf: the case for a 5g mobile gateway. In *2021 IEEE 7th International Conference on Network Softwarization (NetSoft)*, pages 221–225, 2021.

[9] Federico Parola, Sebastiano Miano, and Fulvio Risso. A proof-of-concept 5g mobile gateway with ebpf. In *Proceedings of the SIGCOMM '20 Poster and Demo Sessions*, SIGCOMM '20, page 68–69, New York, NY, USA, 2021. Association for Computing Machinery.