Lorenzo Rosa

Email: lorenzo.rosa@unibo.it
Website: www.unibo.it/sitoweb/lorenzo.rosa/en
Twitter: _lorenzorosa
GitHub: github.com/ellerre

I am a Ph.D. student in Computer Science and Engineering at the University of Bologna, Italy. My supervisor is Prof. Antonio Corradi. I am interested in the system-level challenges of *cloud and edge computing*. My research project focuses on integrating innovative *kernel-bypassing* communication technologies in virtualized industrial applications, distributed between the network edge and the datacenter infrastructures (*cloud continuum*). My broader goal is to let application easily map their Quality of Service requirements to network capabilities. I am also a collaborator of the Cascade project, an edge computing platform for real-time machine intelligence, led by Prof. Ken Birman at Cornell University.

Education

University of Bologna — Bologna, Italy
Ph.D. in Computer Science and Engineering — 2020–Present
Advisor: Antonio Corradi

University of Bologna — Bologna, Italy
M.Sc. in Computer Engineering — 2017–2020
110/110 cum laude

University of Bologna — Bologna, Italy
B.Sc. in Computer Engineering — 2014–2017
110/110 cum laude

Research experience

Cornell University — Ithaca, NY, USA
Visiting scholar — Sept. 2019–Feb. 2020
Advisor: Ken Birman

Spindle: Techniques for Optimizing Atomic Multicast on RDMA, with Sagar Jha
This project investigated the problem of preserving the speed of modern networking technologies such as Remote Direct Memory Access (RDMA) across several software layers. We studied this issue on *Derecho*, an open-source library for atomic multicast, and proposed Spindle, a methodology that includes memory polling integrated with novel sender and receiver batching techniques, null-message send logic, and improved multi-thread synchronization. We obtained significant performance improvements both for the library itself and for an implementation of the OMG DDS protocol that we layered on Derecho for additional consistency guarantees.

Ongoing research projects

INSANE: Integrated and Selective I/O Acceleration at the Network Edge — 2022 - Present
Advisors: Antonio Corradi, Paolo Bellavista. With A. Garbugli.

INSANE is a general-purpose architecture for zero-copy I/O that decouples applications from specific network and storage technologies. Developers specify their Quality of Service (QoS) requirements through a simple, high-level interface. The system tries to satisfy those requirements by selecting the most suitable I/O technology available in the dynamically determined deployment environment. INSANE already offers a uniform access mechanism to a wide range of high-performance modern network technologies, including RDMA, DPDK, XDP, and TSN. Now, we are opening up our architecture to include other I/O technologies, e.g., NVMe-oF, GPU Direct, etc.

Supporting intelligent applications in heterogeneous edge environments 2022 - Present
Advisors: Ken Birman, Weijia Song

The *Cascade* platform is an ongoing effort by Cornell University to provide a new platform for hosting ML and AI edge applications. The platform is optimized to achieve sharply lower delay and substantially higher bandwidth than any existing platform, thanks to an efficient use of hardware accelerators like RDMA and GPUs. Because these options are not yet widespread in typical edge computing scenarios, we are exploring software alternatives, such as DPDK, and adapting them to preserve the original acceleration semantic for direct remote memory accesses.

Lightweight network stack virtualization for time-sensitive applications 2021 - Present
Advisors: Luca Foschini, Antonio Corradi. With A. Garbugli.

The emerging *edge computing* paradigm envisions a continuum of virtual resources between the traditional cloud and the network edge, which is potentially more suitable to meet the Quality of Service (QoS) requirements of performance-demanding applications. Yet, mission-critical applications such as those in manufacturing, automation, or automotive, rely on communication standards like the Time-Sensitive Networking (TSN) protocol and 5G to ensure a deterministic network behavior: in this context, virtualization might introduce unacceptable network perturbations. In this project, we investigate novel forms of network virtualization that can guarantee low-latency and deterministic network behavior for virtualized applications. Our goal is to integrate these techniques into widely-used tools such as Kubernetes.

A distributed shared-memory abstraction for function composition in serverless environments 2020 - 2021
Advisors: Antonio Corradi, Armir Bujari. With A. Sabbioni.

DIFFUSE proposes an innovative infrastructural support for the *Function as a Service* serverless paradigm. It enables the efficient and transparent composition of functions by relying on pluggable middleware support, which uses shared memory to convey messages among platform components potentially distributed across the network.

Selected publications

L. Rosa and A. Garbugli, "Poster: INSANE–A Uniform Middleware API for Differentiated Quality using Heterogeneous Acceleration Techniques at the Network Edge", *2022 IEEE 41st International Conference on Distributed Computing Systems (ICDCS)*, July 2022

S. Jha, **L. Rosa**, and K. Birman, "Spindle: Techniques for Optimizing Atomic Multicast on RDMA", *2022 IEEE 41st International Conference on Distributed Computing Systems (ICDCS)*, July 2022

W. Song, Y. Yang, T. Liu, A. Merlina, T. Garret, R. Vitenberg, **L. Rosa**, A. Awatramani, Z. Wang, and K. Birman, "Cascade: An Edge Computing Platform for Real-time Machine Intelligence", *2022 Workshop on Advanced tools, programming languages, and PLatforms for Implementing and Evaluating algorithms for Distributed systems (ApPLIED '22)*, July 2022

A. Garbugli, **L. Rosa**, L. Foschini, A. Corradi, and P. Bellavista, "A Framework for TSN-enabled Virtual Environments for Ultra-Low Latency 5G Scenarios", *2022-IEEE International Conference on Communications (ICC)*, May 2022

A. Sabbioni, **L. Rosa**, A. Bujari, L. Foschini, and A. Corradi, "DIFFUSE: A DIstributed and decentralized platForm enabling Function composition in Serverless Environments", *Computer Networks*, Volume 210, 2022

L. Rosa, W. Song, L. Foschini, A. Corradi, and K. Birman, "DerechoDDS: Strongly Consistent Data Distribution for Mission-Critical Applications", *2021 IEEE Military Communications Conference (MILCOM)*, Dec. 2021

A. Sabbioni, **L. Rosa**, A. Bujari, L. Foschini, and A. Corradi, "A Shared Memory Approach for Function Chaining in Serverless Platforms", *2021 IEEE Symposium on Computers and Communications (ISCC)*, Sept. 2021

Teaching

- **Teaching Assistant** at University of Bologna — Fall 2021, 2022
  Computer Networks
- **Teaching Assistant** at University of Bologna — Spring 2018
  Software Engineering
- **Teaching Assistant** at University of Bologna — Spring 2018, 2019, 2022
  Foundations of Computer Science (Java)

Talks and conferences

I have presented my papers, in person or remotely, at CARS'21, MILCOM'21, ICC'22, and ICDCS'22.

I have presented in person the poster *INSANE–A Uniform Middleware API for Differentiated Quality using Heterogeneous Acceleration Techniques at the Network Edge* at ICDCS'22.

I have served as a tutor for the demo *Derecho: Blindingly Fast RDMA Replication for Cloud and Edge Services* at the *AI Sys* workshop (SOSP'19).

Technical strengths

Programming Languages. I have mostly worked with the C, C++, and Java languages since the start of my BSc. Occasionally, I have also used Rust, Python, and C#.

Operating systems and software frameworks. I have mostly worked and interacted with Linux-based systems. As a researcher in kernel-bypassing technologies, I am familiar with user-level networking stacks, communication libraries and SDKs (DPDK, RDMA *Verbs*), and network device drivers.

Spoken languages. I am proficient in English (CEFR level C1 - IELTS 7.5). I am a native Italian speaker.

References

- Prof. Antonio Corradi
  Full Professor
  Dept. of Computer Science and Engineering
  University of Bologna, Italy
  antonio.corradi@unibo.it
- Prof. Ken Birman
  Full Professor
  Dept. of Computer Science
  Cornell University, USA
  ken@cs.cornell.edu