Jiaxin Lei

Contact Information

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Research Interests

Cloud Computing, Computer Networks, Reconfigurable Hardware, Systems for Machine Learning, Datacenter Infrastructure.

Education

The University of Texas at Arlington (transfer) Aug. 2023 - Present
Ph.D. Candidate in Computer Science Arlington, TX
Advisor: Professor Hui Lu

State University of New York at Binghamton Jan. 2019 - Aug. 2023
Ph.D. Candidate in Computer Science Binghamton, NY
Advisor: Professor Hui Lu

State University of New York at Binghamton Sep. 2017 - Dec. 2018
M.S. in Computer Science Binghamton, NY

Beijing University of Posts and Telecommunications Sep. 2013 - May. 2017
B.E. in Telecommunications Engineering with Management Beijing, China

Publications

Jiaxin Lei, Manish Munikar, Hui Lu, Jia Rao, "SmartNIC-assisted Network Packet Zero-Copying", *In Submission*, 2023.

Manish Munikar, **Jiaxin Lei**, Hui Lu, Jia Rao, "ECON: Expedited Container Overlay Network", *Under Review (OSDI '24)*, 2023.

Jiaxin Lei, Manish Munikar, Hui Lu, Jia Rao, "Accelerating Packet Processing in Container Overlay Networks via Packet-level Parallelism", In *37th IEEE International Parallel and Distributed Processing Symposium (IPDPS '23)*, St. Petersburg, FL, USA.

Manish Munikar, **Jiaxin Lei**, Hui Lu, Jia Rao, "PRISM: Streamlined Packet Processing for Containers with Flow Prioritization", In *42nd IEEE International Conference on Distributed Computing Systems (ICDCS '22)*, Bologna, Italy.

Jiaxin Lei, Manish Munikar, Kun Suo, Hui Lu, Jia Rao, "Parallelizing packet processing in container overlay networks", In *16th ACM European Conference on Computer Systems (EuroSys '21)*, Virtual.

Yu Sun, **Jiaxin Lei**, Seunghee Shin, Hui Lu, "Baoverlay: a block-accessible overlay file system for fast and efficient container storage", In *11th ACM Symposium on Cloud Computing (SoCC '20)*, Virtual.

Jiaxin Lei, Kun Suo, Hui Lu, Jia Rao, "Tackling parallelization challenges of kernel network stack for container overlay networks", In *11th USENIX Workshop on Hot Topics in Cloud Computing (HotCloud '19)*, Renton, WA, USA.

Research Experience

SmartNIC-assisted Kernel-User Network Packet Zero-copying

Kernel-user data copying contributes one of the largest overheads in the network packet processing. I introduced a SmartNIC-based zero-copying framework utilizing Nvidia Bluefield-2. This system splits packet headers and payloads, storing them in separate memory regions. The header is processed through kernel network stack, while the payload is 'zero-copied' directly to user applications. By eliminating the copying overhead, we can significantly improve network performance.

Expedited Container Overlay Networks

Container overlay networks, compared to bare-metal host networks, experience performance degradation due to multiple asynchronous stages. Our development, ECON, streamlines this by having all packets in a flow follow a consistent path, bypassing non-critical processing stages after recognizing a flow's ultimate destination. This approach has demonstrated improvements in container throughput by up to 121%, a reduction in average latency by up to 61%.

Streamlining Packet Processing with Flow Prioritization

In highly utilized systems, short-lived, latency-sensitive network flows can suffer from extended queuing delays due to the kernel network stack's inability to differentiate packet performance needs. We proposed PRISM – an innovative in-kernel method, which identifies the packets' priority early on and establishes a distinct, streamlined processing path for high-priority flows. As a result, we reduce latency for these flows by over 50% in heavily loaded systems.

Parallelizing Packet Processing at Packet-level

Even with state-of-the-art solutions like FALCON (device-level flow pipelining), a saturated single CPU core can still bottleneck a network flow. To address this, I developed MFLOW – a novel in-kernel packet-level steering technique. MFLOW evenly distributes a high-demand flow into several lightweight micro-flows across multiple CPU cores for parallel processing. Micro-benchmark tests reveal throughput improvements by 81% for TCP and 139% for UDP.

Pipelining Packet Processing at Device-level in Overlay Networks

Container overlay networks often underperform compared to host networks due to prolonged data processing paths. In response, I designed FALCON – a fast and balanced in-kernel solution that distributes the excessive software interrupts associated with various network devices onto multiple CPU cores for processing. Falcon enhances throughput by 300% for web serving applications and cuts tail latency by 53% for data caching applications.

Block-accessible Overlay File System for Container Storage

Overlay file systems often face extended write latencies as write operations on read-only container images require copying to a separate writable layer. Our solution, BAOVERLAY, is a block-accessible overlay file system that partitions files into fine-grained blocks, optimizing Copy-on-Write operations to involve only certain blocks instead of entire files. Tested with Linux Ext4 as the backing file system, BAOVERLAY markedly improved applications' I/O performance with up to 32x faster performance for 1KB files and 64x faster for 4MB files.

Talks

"Accelerating Packet Processing in Container Overlay Networks
via Packet-level Parallelism"

— In *IPDPS '23*, St. Petersburg, FL, USA May. 2023

"Accelerating Packet Processing in Container Overlay Networks"
— In *SUNY Binghamton Computer Science Department Seminar*
Binghamton, NY, USA Nov. 2022

"Parallelizing Packet Processing in Container Overlay Networks"
— In *EuroSys '21*, Virtual Apr. 2021

"Tackling parallelization challenges of kernel network stack for container overlay networks"
— In *HotCloud '19*, Renton, WA, USA Jul. 2019

Teaching Experience

Instructor – Lab Session and Partial Lectures Fall 2023
CSE 3320 Operating Systems (Undergraduate)
The University of Texas at Arlington Arlington, TX

Instructor – Lab Session and Partial Lectures Spring 2023
CS 350 Operating Systems (Undergraduate)
State University of New York at Binghamton Binghamton, NY

Instructor – Lab Session Fall 2022
CS 350 Operating Systems (Undergraduate)
State University of New York at Binghamton Binghamton, NY

Instructor – Lab Session Spring 2022
CS 350 Operating Systems (Undergraduate)
State University of New York at Binghamton Binghamton, NY

Teaching Assistant Fall 2021
CS 452/552 Introduction to Cloud Computing (Undergraduate/Graduate)
State University of New York at Binghamton Binghamton, NY

Instructor – Lab Session Spring 2021
CS 350 Operating Systems (Undergraduate)
State University of New York at Binghamton Binghamton, NY

Teaching Assistant Fall 2020
CS 452/580 Introduction to Cloud Computing (Undergraduate/Graduate)
State University of New York at Binghamton Binghamton, NY

Teaching Assistant Spring 2020
CS 480/580 Advanced Topics in Cloud Computing (Undergraduate/Graduate)
State University of New York at Binghamton Binghamton, NY

Instructor – Lab Session Fall 2019
CS 350 Operating Systems (Undergraduate)
State University of New York at Binghamton Binghamton, NY

Teaching Assistant Spring 2019

CS 550 Operating Systems (Graduate)
State University of New York at Binghamton — Binghamton, NY

Grant	Student Travel Grant for attending *IPDPS '23*	2023
	Student Travel Grant for attending *NSDI '23*	2023
	Student Travel Grant for attending *seL4Summit '19*	2019
	Student Travel Grant for attending *VEE '19*	2019
	Student Travel Grant for attending *ATC '19*	2019