Muhammad Sulaiman

Personal Website | GitHub | LinkedIn

m4sulaim@uwaterloo.ca

Waterloo, ON, Canada | Mobile: (226) 978-5211

Profile

Final-year Ph.D. candidate at the University of Waterloo, working on **AI-native orchestration and management of 5G mobile networks**. I specialize in **reinforcement learning** and have extensive experience with **advanced deep learning methods**, including graph neural networks, transformers, and Bayesian neural networks, with applications to dynamic network orchestration, resource allocation, and data-driven simulators (digital twins). I have also a developed network monitoring framework and engineered a **production-grade ML pipeline** (Spark, Hadoop, Kafka, Elasticsearch) to process large-scale network data and support real-time learning and inference. My research has resulted in **several peer-reviewed publications** in leading IEEE venues and has been recognized with **multiple Best Paper Awards**.

Education

- **Ph.D. in Computer Science | University of Waterloo** — Waterloo, Canada
  Area of research: AI-native network operation and management — *Jan. 2022 – Present*
  CGPA: 96.7/100, Supervisor: Raouf Boutaba
  Expected Graduation: Sept. 2026
- **Master's of Mathematics in Computer Science | University of Waterloo** — Waterloo, Canada
  Area of research: AI-native network operation and management — *Sept. 2020 – Jan 2022*
  CGPA: 96.7/100, Supervisor: Raouf Boutaba
  Fast-tracked to Ph.D (degree not conferred)
- **Bachelor of Eng. in Electrical Eng. | National University of Sciences and Technology** — Islamabad, Pakistan
  Area of research: Deep-Learning for Activity Recognition using WiFi CSI — *Sept. 2015 – Jul. 2019*
  CGPA: 3.89/4, Project advisor: Seyd Ali Hassan

Experience

- **Ericsson, Ottawa**
  AI/ML Software Development Intern — *May 2025 - Dec 2025*
  Projects: AI-native Link Adaptation
- **Rogers Communications / MITACS, Waterloo**
  MITACS Research Intern — *May 2021 - Dec 2024*
  Projects: 5G-ELITE – AI-driven 5G Network Slice Operations & Management,
  Production-Grade ML Pipelines for Network Data
- **Hardware Lab, University of Waterloo**
  PhD Research Assistant — *Sept. 2020 – May 2025*
  Projects: Containerized 5G Testbeds for Real-time Experimentation,
  Data-Driven Network Simulation (Digital Twins),
  AI for Dynamic Network Orchestration,
  Reinforcement Learning for Resource Optimization
- **Information Processing and Transmission Lab, NUST**
  Undergraduate Research Assistant — *Jun. 2018 - Aug. 2018*
  Projects: Deep Learning for Activity Recognition using WiFi CSI

Projects

- **Containerized 5G Testbeds for Real-time Experimentation** | Docker, Kubernetes, srsRAN, OAI, Free5GC, Open5GS, UERANSIM, USRP SDRs, OvS, ONOS, P4, SteamVR/MetaQuest
  - Automated deployment of full-scale, containerized testbeds and cloud-gaming/VR use-cases to enable reproducible experimentation and validation of intelligent algorithms under realistic workloads.
  - Reduced testbed deployment times from ~2 days to under 30 minutes.
  - [GitHub Repo], [VR Gaming Demo]

- **Data-Driven Network Simulation (Digital Twins)** | Bayesian Neural Networks, Transformers, RNNs
  - Built data-driven simulators (digital twins) of 5G networks, enabling accurate prediction of network behavior under varying loads and configurations.
  - Proposed a novel flow-level chain-of-VNFs model for scalable and generalizable performance modeling.
  - Achieved 57× faster execution than packet-level simulators while reducing delay estimation error by 96.5%.
  - [Dataset-1], [Dataset-2], [Workshop], Publications: [1, 6, 7]
- **Reinforcement Learning for Resource Optimization** | Constrained RL, Primal-dual Optimization
  - Designed and validated reinforcement learning and primal–dual optimization algorithms for end-to-end resource allocation under QoS constraints in 5G networks.
  - Achieved up to 21.9% reduction in resource usage over state-of-the-art RL baselines.
  - [Workshop], Publications: [1, 8]
- **AI Native Link Adaptation** | Deep Learning, Reinforcement Learning
  - Leveraged advanced AI algorithms to enable real-time modulation and coding scheme (MCS) selection to maximize throughput in 5G Radio Access Network (RAN).
  - [Press release]
- **Production-Grade ML Pipeline for Network Data** | Spark, Hadoop, Kafka, Elasticsearch, Kubernetes
  - Engineered scalable big-data pipeline for ingesting and analyzing large-scale network telemetry data from Rogers.
  - Designed adaptive monitoring frameworks that dynamically adjust collection granularity to reduce overhead.
  - Demonstrated scalability to 50 concurrent slices with consistent ingestion times (2.25–2.75 ms) and reduced monitoring overhead by up to 76% while preserving accuracy.
  - [Data Processing Pipeline], Publications: [2]
- **AI for Dynamic Network Orchestration** | Multi-agent DRL, Ray RLlib, Stable Baselines, Graph Attention Networks
  - Designed AI-based methods for 5G service admission control and network function placement.
  - Leveraged multi-agent DRL and graph attention networks to achieve optimal admission and placement while generalizing to out-of-distribution scenarios.
  - Improved service admission ratio by 42% and theoretically proved an upper bound on worst-case performance.
  - Publications: [3, 4, 5, 9]
- **Deep Learning for Activity Recognition using WiFi CSI** | Convolutional Neural Networks, GNU Radio, MATLAB
  - Designed device-free activity recognition framework leveraging WiFi Channel State Information (CSI).
  - Combined real-time signal processing in MATLAB with CNN-based inference.
  - Achieved 95.1% activity recognition accuracy across 7 classes, outperforming RNN-based baselines.
  - [GitHub Repo], Publications: [10]

Publications

JOURNAL ARTICLES

[1] **M. Sulaiman**, M. Ahmadi, B. Sun, N. Saha, M. A. Salahuddin, R. Boutaba, and A. Saleh, "MicroOpt: Model-driven Slice Resource Optimization in 5G and Beyond Networks," *IEEE Transactions on Network and Service Management (TNSM)*, 2025. [PDF].

[2] N. Saha, N. Shahriar, **M. Sulaiman**, N. Limam, R. Boutaba, and A. Saleh, "Monarch: Monitoring Architecture for 5G and Beyond Network Slices," *IEEE Transactions on Network and Service Management (TNSM)*, 2024. [PDF].

[3] M. Ahmadi, A. Moayyedi, **M. Sulaiman**, M. A. Salahuddin, R. Boutaba, and A. Saleh, "Generalizable 5G RAN/MEC Slicing and Admission Control for Reliable Network Operation," *IEEE Transactions on Network and Service Management (TNSM)*, 2024. [PDF].

[4] **M. Sulaiman**, A. Moayyedi, M. Ahmadi, M. A. Salahuddin, R. Boutaba, and A. Saleh, "Coordinated Slicing and Admission Control Using Multi-Agent Deep Reinforcement Learning," *IEEE Transactions on Network and Service Management (TNSM)*, 2022. [PDF].

CONFERENCE PROCEEDINGS

[5] **M. Sulaiman**, B. Sun, M. A. Salahuddin, R. Boutaba, and A. Saleh, "Data-driven Online Slice Admission Control and Resource Allocation for 5G and Beyond Networks," *arXiv*, 2025 (Under review at INFOCOM '26). [PDF].

[6] H. Ahmed, S. Mostafa, **M. Sulaiman**, R. Boutaba, and M. Youssef, "vChainNet: Accurate and Scalable End-to-End Slice Modeling for 5G and Beyond Networks," *To appear in: International Conference on Wireless Networks and Mobile Communications (WINCOM)*, 2026.

[7] **M. Sulaiman**, B. Sun, M. A. Salahuddin, R. Boutaba, and A. Saleh, "vNetRunner: Per-VNF Slice Modeling for 5G and Beyond Networks," in Proceedings of IEEE/IFIP Network Operations and Management Symposium (NOMS), 2025. [PDF].

[8] **M. Sulaiman**, M. Ahmadi, M. A. Salahuddin, R. Boutaba, and A. Saleh, "Generalizable Resource Scaling of 5G Slices using Constrained Reinforcement Learning," in Proceedings of IEEE/IFIP Network Operations and Management Symposium (NOMS), 2023. [PDF].

[9] **M. Sulaiman**, A. Moayyedi, M. A. Salahuddin, R. Boutaba, and A. Saleh, "Multi-Agent Deep Reinforcement Learning for Slicing and Admission Control in 5G C-RAN," in Proceedings of IEEE/IFIP Network Operations and Management Symposium (NOMS), 2022. [PDF].

[10] **M. Sulaiman**, S. A. Hassan, H. Jung, "True Detect: Deep Learning-based Device-Free Activity Recognition using WiFi," in Proceedings of the IEEE Wireless Communications and Networking Conference Workshops (WCNCW), 2020. [PDF].

Teaching

- **Teaching Assistant**
  - **CS115 Introduction to Computer Science** — *Course homepage*
  - **CS136 Elementary Algorithm Design and Data Abstraction** — *Course homepage*
  - **CS456 Computer Networks** — *Instr: Prof.Mohammad Ali Salahuddin*
  - **CS485: Foundations of Machine Learning** — *Instr: Prof. Shai Ben David*

Awards

- Received the **best paper award** from IEEE Communications Society Technical Committee on Network Operation and Management, **2025**.
- Won the conference **best paper award** at the Network Operations and Management Symposium, 2023.
- Won the conference **best paper award** at the Network Operations and Management Symposium, 2022.
- Awarded **travel grant** for Network Operations and Management Symposium, held in Budapest, Hungary.
- Received **Cheriton Scholarship**. Awarded to top 5 students based on scholastic excellence.
- Received the **Entrance Award** of David Cheriton School of Computer Science, University of Waterloo.
- Received **principal's appreciation certificate** for excellent academic performance, NUST, Pakistan.

Certifications

- **Machine Learning (2018)** – Issued by Stanford University.
- **Convolutional Neural Networks (2019)** – Issued by DeepLearning.AI.
- **Structuring Machine Learning Projects (2019)** – Issued by DeepLearning.AI.
- **Improving Deep Neural Networks: Hyperparameter Tuning, Regularization, and Optimization (2019)** – Issued by DeepLearning.AI.
- **Neural Networks and Deep Learning (2019)** – Issued by DeepLearning.AI.

Skills

AI	Torch, Tensorflow, Stable Baselines, RLlib, CNNs, Transformers, GNNs, Attention Nets.
Programming	C/C++, Python, Bash, Git, MATLAB/R
Networking	Linux networking, Open vSwitch, ONOS, P4
Open RAN	OpenAirInterface, srsRAN, UERANSIM, Free5GC, Open5GS, USRP SDRs, GNU Radio
Data	Spark, Hadoop, Elasticsearch, Pandas
Cloud	OpenStack, Kubernetes, Docker