Qiang Liu

Ph.D. Candidate

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Summary

Ph.D. candidate with proven experience in designing and developing wireless networking and computing systems in industrial research labs. Strong track record of publications on wireless networking, edge computing, network slicing, LTE/5G, computer networks, and machine learning in top-tier conferences.

Education

The University of North Carolina at Charlotte — *Charlotte, NC, United States*

Ph.D. in Electrical Engineering, GPA: 4.0/4.0 — *Aug. 2016 – Present*

University of Electronic Science and Technology of China — *Chengdu, SC, China*

M.S. in Communication and Information System, GPA: 3.5/4.0 — *Sep. 2013 – May 2016*

Research Experience

Nokia Bell Labs — *Murray Hill, NJ*

Research Intern — *Jun. 2020 – Aug. 2020*

- Developed and implemented end-to-end network slicing platform that integrates domain managers in RAN, TN, and CN, with open-source platforms, e.g., OAI, ODL, OMEC.
- Designed cross-domain resource orchestration framework for orchestrating virtual resources to network slices and proposed novel safe deep reinforcement learning (DRL) approach that violates no slice SLAs during the online learning.
- Improved the performance of network resource utilization under the requirements of slice SLAs. Submitted to IEEE INFOCOM.

Toyota InfoTech Lab — *Mountain View, CA*

Research Intern — *Jan. 2020 – May 2020*

- Designed and implemented edge-assisted real-time dynamic layer for high-definition map that allows connected vehicles to cooperatively sense, detect, and track surrounding objects, e.g. pedestrians and vehicles, in subseconds.
- Developed end-to-end simulation platform that integrates on-vehicle processing, 5G uplink transmission, server computation, and downlink broadcasting, that enables large-scale evaluations in automotive edge computing.
- Improved data freshness of the dynamic layer with new machine learning based solution that enables context-aware vehicle scheduling and resource allocation on edge servers. Submitted to IEEE INFOCOM.

Facebook Reality Lab — *Redmond, WA*

Research Intern — *May 2019 – Nov. 2019*

- Designed and implemented mobile-edge-cloud computing simulator with realistic deployment of cellular networks and Facebook computing infrastructure, which allows nation-wide evaluation of edge computing deployment in terms of momentary costs, QoS, and service coverage.
- Evaluated and profiled the performance of Facebook AR/VR algorithms and applications, e.g., computer vision and LiveMaps, on Facebook infrastructure production tiers.
- Improved mobile AR/VR quality of experience (QoE) with reduced end-to-end service latency by designing new network-aware AR protocol and dynamic server selection algorithm.

UNC Charlotte — *Charlotte, NC*

Research Assistant — *Aug. 2016 – May 2019*

- Designed cross-domain resource orchestration frameworks with machine learning techniques, e.g., Bayesian optimization, Gaussian process regression, and DRL, that enable model-free and dynamic orchestration of virtual radio, transport and computing resources for network slices. Significantly improved performance of network slicing and published papers in IEEE ICDCS and ACM MOBIHOC.
- Developed and implemented dynamic end-to-end network slicing system with our designed resource virtualization solutions on OpenAirInterface LTE platform, OpenDayLight-based software defined network (SDN), and CUDA GPU parallel computing platform. The system allows real-time virtual resource management for network slicing in cellular edge computing networks.
- Designed cross-layer dynamic adaptive protocol for mobile augmented reality (MAR) that allows MAR users to adjust their AR configurations, e.g., frame rate, frame resolution, and computation model, according to availability of networking and computing resources under dynamic cellular edge computing networks. Published papers in IEEE INFOCOM and IEEE ICNP.
- Developed and implemented edge-assisted MAR system with computation offloading, Mininet network simulator, and GPU computing platform in hierarchical edge cloud computing networks.
- Designed energy-efficient resource managements, e.g., user scheduling, cell sleep mode, and cooperative beamforming, for heterogeneous cellular networks (HetNets), cloud radio access networks (C-RAN) and mobile edge computing (MEC). Published papers in IEEE TGCN, IEEE GLOBECOM, and IEEE ICC. Won the best paper award in IEEE ICC 2019.

Huawei 2012 Labs *Chengdu, China*

Engineer Intern *Nov. 2014 – Apr. 2015*

- Implemented and evaluated advanced physical layer algorithms toward 5G, e.g., multi-user multiple-input multiple-output (MU-MIMO) beamforming and novel waveforms.
- Implemented RAN full-stack protocols, e.g., MAC, RLC and PDCP, and integrated into Huawei 5G system level simulator.

Publications

Submissions

- **Q. Liu**, T. Han, L. Xie, B. Kim, "LiveMap: Real-Time Dynamic Map in Automotive Edge Computing", submitted to *IEEE International Conference on Computer Communications* (**INFOCOM**), Vancouver, Canada, May 2021
- **Q. Liu**, T. Han, N. Choi, "SafeSlicing: Exploring Optimal Network Slicing without Violating Service Level Agreement", submitted to *IEEE International Conference on Computer Communications* (**INFOCOM**), Vancouver, Canada, May 2021

Conferences

- **Q. Liu**, T. Han, E. Moges, "EdgeSlice: Slicing Wireless Edge Computing Network with Decentralized Deep Reinforcement Learning", in *IEEE International Conference on Distributed Computing Systems* (**ICDCS**), Singapore, Dec. 2020 (acceptance rate: **18%**)
- **Q. Liu**, T. Han, N. Zhang, Y. Wang, "DeepSlicing: Deep Reinforcement Learning Assisted Resource Allocation for Network Slicing", in *IEEE Globe Communications Conference* (**GLOBECOM**), Taipei, Taiwan, Dec. 2020
- **Q. Liu**, T. Han, "DIRECT: Distributed Cross-Domain Resource Orchestration in Cellular Edge Computing", in *ACM International Symposium on Mobile Ad Hoc Networking and Computing* (**MOBIHOC**), Catania, Italy, Jul. 2019 (acceptance rate: **23.7%**)
- **Q. Liu**, T. Han, "VirtualEdge: Multi-Domain Resource Orchestration and Virtualization in Cellular Edge Computing", in *IEEE International Conference on Distributed Computing Systems* (**ICDCS**), Dallas, TX, Jul. 2019 (acceptance rate: **19.6%**)
- **Q. Liu**, T. Han, "DARE: Dynamic Adaptive Mobile Augmented Reality with Edge Computing", in *IEEE International Conference on Network Protocols* (**ICNP**), Cambridge, UK, Sep. 2018 (acceptance rate: **17.8%**)
- **Q. Liu**, S. Huang, J. Opadere, T. Han, "An Edge Network Orchestrator for Mobile Augmented Reality", in *IEEE International Conference on Computer Communications* (**INFOCOM**), Honolulu, HI, Apr. 2018 (acceptance rate: **19.2%**)
- J. Opadere, **Q. Liu**, N. Zhang, T. Han, "Joint Computation and Communication Resource Allocation for Energy-Efficient Mobile Edge Networks", in *IEEE International Conference on Communications* (**ICC**), Shanghai, China, May 2019 **(Best Paper Award)**
- **Q. Liu**, T. Han, "Energy-Efficient On-demand Cloud Radio Access Networks Virtualization", in *IEEE Globe Communications Conference* (**GLOBECOM**), Abu Dhabi, UAE, Dec. 2018
- **Q. Liu**, T. Han, N. Ansari, "Joint Radio and Computation Resource Management for Low Latency Mobile Edge Computing", in *IEEE Globe Communications Conference* (**GLOBECOM**), Abu Dhabi, UAE, Dec. 2018
- J. Opadere, **Q. Liu**, T. Han, "Energy-Efficient RRH Sleep Mode for Virtual Radio Access Networks", in *IEEE Globe Communications Conference* (**GLOBECOM**), Singapore, Dec. 2017
- S. Huang, **Q. Liu**, T. Han, N. Ansari, "Data-Driven Network Optimization in Ultra-Dense Radio Access Networks", in *IEEE Globe Communications Conference* (**GLOBECOM**), Singapore, Dec. 2017
- **Q. Liu**, G. Wu, Y. Guo, Y. Zhang, S. Hu, "Energy Efficient Resource Allocation for Control Data Separated Heterogeneous-CRAN", in *IEEE Globe Communications Conference* (**GLOBECOM**), Washington DC, Dec. 2016
- **Q. Liu**, T. Han, G. Wu, "Computing Resource Aware Energy Saving Scheme for Cloud Radio Access Networks", in *IEEE Sustainable Computing and Communications* (**SustainCom**), Atlanta, GA, Oct. 2016

Journals

- **Q. Liu**, T. Han, N. Ansari, "Learning-Assisted Secure End-to-End Network Slicing for Cyber-Physical Systems", in *IEEE Network Magazine*, vol. 34, no. 3, pp. 37-43, May 2020
- J. Opadere, **Q. Liu**, T. Han, N. Ansari, "Energy-efficient Virtual Radio Access Networks for Multi-Operators Cooperative Cellular Networks", in *IEEE Transactions on Green Communications and Networking* (**TGCN**), vol. 3, no. 3, pp. 603-614, Sep. 2019
- **Q. Liu**, T. Han, N. Ansari, "Energy-Efficient On-demand Resource Provisioning in Cloud Radio Access Networks", in *IEEE Transactions on Green Communications and Networking* (**TGCN**), vol. 3, no. 4, pp. 1142-1151, Jul. 2019
- **Q. Liu**, T. Han, N. Ansari, G. Wu, "On Designing Energy-Efficient Heterogeneous Cloud Radio Access Networks", in *IEEE Transactions on Green Communications and Networking* (**TGCN**), vol. 2, no. 3, pp. 721-734, May 2018

Workshops and Demos

- **Q. Liu**, T. Han, "When Network Slicing meets Deep Reinforcement Learning", in *ACM International Conference on emerging Networking EXperiments and Technologies* (**CoNEXT**) Student Workshop, Orlando, FL, Dec. 2019
- **Q. Liu**, T. Han, "Demo Abstract: Themis: Cross-Domain Resource Orchestration and Virtualization in Cellular Computing Networks", in *IEEE International Conference on Network Protocols* (**ICNP**), Cambridge, UK, Sep. 2018
- **Q. Liu**, S. Huang, T. Han, "Demo Abstract: Fast and Accurate Object Analysis at the Edge for Mobile Augmented Reality", in *ACM/IEEE Symposium on Edge Computing* (**SEC**), San Jose, CA, Oct. 2017
- **Q. Liu**, S. Huang, Y. Deng, T. Han, "Demo Abstract: MExR: Mobile Edge Resource Management for Mixed Reality Applications", in *IEEE International Conference on Computer Communications* (**INFOCOM**), Atlanta, GA, Apr. 2017

Courses

Wireless Communication and Networking, Stochastic Signals and Systems, Digital Signal Process, Signal Detection and Estimation, Graph Theory, Digital Communications, Probability Theory, Information Theory, Internet of Things

Honors

2019 **Best Paper Award,** IEEE ComSoc on Transmission, Access, and Optical Systems (TAOS) and IEEE ICC
2019 **Outstanding Graduate Student Award,** UNC Charlotte
2019 **Graduate and Professional Student Government Travel Award,** UNC Charlotte
2018 **Student Travel Grant Award,** IEEE International Conference on Network Protocols (ICNP)
2017 **Student Travel Grant Award,** ACM/IEEE Symposiumon Edge Computing (SEC)
2016 **Excellent Graduate Student Award,** University of Electronic Science and Technology of China (UESTC)
2015 **Bronze Medal Award,** 5G Algorithm Innovation Competition

Skills

Programming Python, C/C++, Matlab
Frameworks Software Defined Radio, OpenAirInterface 5G, CUDA, OpenFlow, SDN, Docker, Mininet, NS-3, PyTorch, TensorFlow

Services

- Reviewer for IEEE Journal on Selected Areas in Communications, 2020
- Reviewer for IEEE Transactions on Cognitive Communications and Networking, 2020
- Reviewer for Elsevier Measurement, 2020
- Reviewer for IEEE Transactions on Communications, 2020
- Reviewer for IEEE Transactions on Wireless Communications, 2019
- Reviewer for IEEE Access, 2018, 2019, 2020
- Reviewer for IEEE Communication Letters, 2017, 2018, 2019, 2020
- Reviewer for Elsevier Computer Communications, 2019, 2020
- Reviewer for Elsevier Computer Networks, 2019, 2020
- Reviewer for IEEE Globe Communications Conference, 2018, 2019
- Reviewer for IEEE International Conference on Communications, 2018, 2019