Wen Wu, IEEE Senior Member

Associate Researcher
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RESEARCH INTEREST

- Holistic network virtualization: Network digital twin and network slicing
- Pervasive network intelligence: Networking for AI and AI for networking
- mmWave networking: Medium access control and beam alignment

EMPLOYMENT

- **Associate Researcher** **Nov. 2021 – Present**
  Frontier Research Center
  Peng Cheng Laboratory, Shenzhen, Guangdong, China

- **Postdoctoral Research Fellow** **Oct. 2019 – Aug. 2021**
  Department of Electrical and Computer Engineering
  University of Waterloo, Waterloo, Ontario, Canada
  Supervisor: Professor X. Shen

EDUCATION

- **Doctor of Philosophy, Electrical and Computer Engineering** **Sept. 2015 – Aug. 2019**
  University of Waterloo, Waterloo, Ontario, Canada
  Supervisor: Professor X. Shen
  Thesis: Design and Analysis of Beamforming in mmWave Networks

- **Master of Engineering, Communication and Information Systems** **Sept. 2012 – Jun. 2015**
  University of Science and Technology of China, Hefei, China
  Supervisor: Professor Guo Wei
  Thesis: Interference Alignment with Limited Feedback for Multiuser Interference Networks

- **Bachelor of Engineering, Information Engineering** **Sept. 2008 – Jun. 2012**
  South China University of Technology, Guangzhou, China
  Advisors: Professor Yuli Fu and Professor Wenyi Zhang
  Final Year Project: Performance Analysis of Monobit Digital Receivers

HONORS and AWARDS

- **Senior Member**, IEEE 2022
- **Senior Member**, China Institute of Communications 2022
- **Distinguished Researcher Position (Level-C)**, Peng Cheng Laboratory 2022
- Faculty of Engineering Graduate Scholarship Award, University of Waterloo 2019
- Graduate Scholarship, University of Waterloo 2015 – 2019
- International Doctoral Student Award, University of Waterloo 2015 – 2019
- Best Speaker Award, ECE Graduate Seminar Series, University of Waterloo 2015
- Guorui Scholarship, China Electronics Technology Corporation 14th Research Institute 2014
- China Scholarship for Encouragement, Ministry of Education of P. R. China 2010
- First Prize of South China University of Technology,
  Guangdong Province Undergraduate Contest in Physics Experiments Design 2010

PUBLICATION

Publication Statistics

- **1** book, **3** book chapters, **2** Canada patents, **1** China patent, **52** accepted/published papers (**30** journal papers and **22** conference papers), and **16** preprints
- Total number of citations: **1,090**, h-index: **16**, and i10-index: **26** (Source: Google Scholar, Date: Jun. 10, 2022)
- **First-authored papers**: **1** book chapter, **10** accepted/published papers (**6** journal papers and **4** conference papers), and **3** preprints (**2** journal papers and **1** conference paper)

Books

[B1] P. Yang, **W. Wu**, N. Zhang, and X. Shen, "Millimeter-Wave Networks: Beamforming Design and Performance Analysis," Springer Verlag, 2021. (ISBN-10: 3030886298, ISBN-13: 9783030886295)

Book Chapters

[BC1] **W. Wu**, Y. Tang, P. Yang, W. Zhang, and N. Zhang, "Collaborative Deep Neural Network Inference via Mobile Edge Computing," *Broadband Communications, Computing, and Control for Ubiquitous Intelligence*, pp. 263-190, Editors: L. Cai, B. L. Mark, and J. Pan, Springer, 2022. (ISBN-10: 3030980634, ISBN-13: 9783030980634)

[BC2] Q. Ye and **W. Wu**, "Network Slicing for 5G Networks and Beyond," *Broadband Communications, Computing, and Control for Ubiquitous Intelligence*, pp. 17-34, Editors: L. Cai, B. L. Mark, and J. Pan, Springer, 2022. (ISBN-10: 3030980634, ISBN-13: 9783030980634)

[BC3] Y. Tang and **W. Wu**, "Routing Algorithms for Heterogeneous Vehicular Networks," *Broadband Communications, Computing, and Control for Ubiquitous Intelligence*, pp. 105-124, Editors: L. Cai, B. L. Mark, and J. Pan, Springer, 2022. (ISBN-10: 3030980634, ISBN-13: 9783030980634)

Patents

[T1] X. Shen, **W. Wu**, M. Li, K. Qu, C. Zhou, W. Zhuang, and X. Li, "Systems and Methods for Cluster-Based Parallel Split Learning." Canada, 92011852PCT01, 2022/03/30. Patent Status: Pending.

[T2] W. Zhuang, K. Qu, **W. Wu**, M. Li, X. Shen, and X. Li, "Systems and Methods for AI Inference." Canada, 92014457PCT01, 2022/06/17. Patent Status: Pending.

[T3] 杨鹏, 黄芷璇, **吴稳**, "一种基于 VR 用户视点轨迹的 mmWave 接入点选择方法." China. Patent Status: Pending.

Preprints

[P1] **W. Wu**, M. Li, K. Qu, C. Zhou, X. Shen, W. Zhuang, X. Li, and W. Shi, "Split Learning over Wireless Networks: Parallel Design and Resource Management," submitted to *IEEE Journal on Selected Areas in Communications (**JSAC**)*, 2022.

[P2] **W. Wu**, K. Qu, P. Yang, N. Zhang, X. Shen, and W. Zhuang, "Cost-Effective Two-Stage Network Slicing for Edge-Cloud Orchestrated Vehicular Networks," submitted to *Proc. IEEE/CIC International Conference on Communications in China (**ICCC**)*, Foshan, China, 2022.

[P3] J. Lin, P. Yang, **W. Wu**, N. Zhang, T. Han, and L. Yu, "Resource-Efficient Adaptive Query Scheduling for Low-Latency Edge Video Analytics," *IEEE Transactions on Mobile Computing (**TMC**)*, under revision, 2021.

[P4] Z. Mao, F. Hu, **W. Wu**, H. Wu, and X. Shen, "Joint Distributed Beamforming and Backscatter Cooperation for UAV-Assisted WPSNs," *IEEE Transactions on Wireless Communications (**TWC**)*, major revision, 2022.

[P5] H. Zheng, K. Xiong, **W. Wu**, P. Fan, Z. Zhong, and X. Shen, "Age of Information-Based Efficiency Design in Point-to-Point Communication Link," *IEEE Wireless Communications Letter (**WCL**)*, under revision, 2021.

[P6] Q. Liu, P. Yang, **W. Wu**, N. Zhang, and L. Yu, "Intelligent In-Network Queue Control for Fair and Low-Latency Packet Transmission," *IEEE Transactions on Cognitive Communications and Networking (**TCCN**)*, major revision, 2021.

[P7] X. Huang, C. Zhou, **W. Wu**, M. Li, H. Wu, and X. Shen, "Personalized QoE Enhancement for Adaptive Video Streaming: A Digital Twin-Assisted Scheme," submitted to **GLOBECOM**, 2022.

[P8] J. Xue, T. Zhang, **W. Wu**, H. Zhou, and X. Shen, "Sparse Big Data for Vehicular Network Traffic Flow Estimation: A Machine Learning Approach," submitted to *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, 2022.

[P9] C. Wang, P. Yang, J. Lin, **W. Wu**, and N. Zhang, "Object-Based Resolution Selection for Efficient Edge-Assisted Multi-Task Video Analytics," submitted to *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, 2022.

[P10] X. Zhuo, **W. Wu**, F. Qu, and X. Shen, "Value of Information-Based Packet Scheduling Scheme for AUVs in Underwater Acoustic Sensor Networks,"manuscript.

[P11] Z. Huang, P. Yang, N. Zhang, F. Lyu, Q. Li, **W. Wu**, and X. Shen, "Joint Viewpoint Prediction and Tile Selection for Mobile Virtual Reality," manuscript, 2022.

[P12] **W. Wu**, N. Zhang, and X. Shen, "Intelligent Two-Stage Network Slicing for Edge-Cloud Orchestrated Vehicular Networks," manuscript, 2022.

[P13] Z. Ma, **W. Wu**, F. Gao, and X. Shen, "Deep-Learned Non-Coherent Transmission for Massive Machine-Type Communications," manuscript, 2022.

[P14] J. Xue, Y. Xu, **W. Wu**, T. Zhang, Q. Shen, H. Zhou, and X. Shen, "Sparse Mobile Crowdsensing for Cost-Effective Traffic State Estimation via Transformer GNN," manuscript, 2022.

[P15] K. Qu, W. Zhuang, **W. Wu**, M. Li, X. Shen, and X. Li, "Edge-Assisted Cumulative DNN Inference in Intelligent IoT with Reinforcement Learning," manuscript, 2022.

[P16] K. Liu, W. Quan, N. Cheng, **W. Wu**, Z. Xu, L. Guo, D. Gao, and H. Zhang, "Reliable PPO-based Concurrent Multipath Transfer for Time-Sensitive Applications," manuscript, 2022.

Journal Papers

[J1] X. Shen, J. Gao, **W. Wu**, M. Li, C. Zhou, and W. Zhuang, "Holistic Network Virtualization and Pervasive Network Intelligence for 6G," *IEEE Communications Surveys and Tutorials (**COMST**)*, vol. 24, no. 1, pp. 1-30, 1st. Quart. 2022. (**Editor-in-Chief Invited Paper**)

[J2] X. Shen, J. Gao, **W. Wu**, K. Lyu, M. Li, W. Zhuang, X. Li, and J. Rao, "AI-assisted Network-slicing based Next-generation Wireless Networks," *IEEE Open Journal of Vehicular Technology (**OJVT**)*, vol. 1, no. 1, pp. 45–66, Jan. 2020. **(Editor-in-Chief Invited Paper, Citation: 134)**

[J3] **W. Wu**, C. Zhou, M. Li, H. Wu, H. Zhou, N. Zhang, X. Shen, and W. Zhuang, "AI-Native Network Slicing for 6G Networks," *IEEE Wireless Communications (**WCM**)*, vol. 29, no. 1, pp. 96–103, Feb. 2022.

[J4] **W. Wu**, N. Chen, C. Zhou, M. Li, X. Shen, W. Zhuang, and X. Li, "Dynamic RAN Slicing for Service-Oriented Vehicular Networks via Constrained Learning," *IEEE Journal on Selected Areas in Communications (**JSAC**)*, vol. 39 no. 7, pp. 2076–2089, July 2021. **(Citation: 26)**

[J5] **W. Wu**, P. Yang, W. Zhang, C. Zhou, and X. Shen, "Accuracy-Guaranteed Collaborative DNN Inference in Industrial IoT via Deep Reinforcement Learning," *IEEE Transactions on Industrial Informatics (**TII**)*, vol. 17, no. 7, pp. 4988–4998, July 2021.

[J6] **W. Wu**, N. Cheng, N. Zhang, P. Yang, K. Aldubaikhy, and X. Shen, "Performance Analysis and Enhancement of Beamforming Training in 802.11ad," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 69, no. 5, pp. 5293–5306, May 2020.

[J7] **W. Wu**, N. Cheng, N. Zhang, P. Yang, W. Zhuang, and X. Shen, "Fast mmwave Beam Alignment via Correlated Bandit Learning," *IEEE Transactions on Wireless Communications (**TWC**)*, vol. 18, no. 12, pp. 5894–5908, Dec. 2019. **(Citation: 48)**

[J8] **W. Wu**, N. Zhang, N. Cheng, Y. Tang, K. Aldubaikhy, and X. Shen, "Beef up mmWave Dense Cellular Networks with D2D-Assisted Cooperative Edge Caching," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 68, no. 4, pp. 3890–3904, Apr. 2019. **(Citation: 50)**

[J9] R. Ding, J. Chen, **W. Wu**, J. Liu, F. Gao, and X. Shen, "Packet Routing in UAV Multi-Hop Network: A Multi-agent Deep Reinforcement Learning Approach," *IEEE Transactions on Vehicular Technology (**TVT**)*, accepted, 2022.

[J10] Y. Wang, S. Wu, J. Jiao, **W. Wu**, Y. Wang, and Q. Zhang, "Age-Optimal Transmission Policy with HARQ for Freshness-Critical Vehicular Status Updates in Space-Air-Ground Integrated Networks," *IEEE Internet of Things Journal (**JIoT**)*, vol. 9, no. 8, pp. 57195729, Apr. 2022.

[J11] D. Yang, K. Gong, J, Ren, W. Zhang, **W. Wu**, and H. Zhang, "TC-Flow: Chained Flow Scheduling for Advanced Industrial Applications in Time-Sensitive Networks," *IEEE Network Magazine*, to appear, 2021.

[J12] Z. Ma, **W. Wu**, M. Jian, F. Gao, and X. Shen, "Joint Constellation Design and Multiuser Detection for Grant-Free NOMA," *IEEE Transactions on Wireless Communications (**TWC**)*, vol. 21, no. 3, pp. 1973–1988, Mar. 2022.

[J13] D. Han, W. Liao, H. Peng, H. Wu, **W. Wu**, and X. Shen, "Edge Caching with Cooperative Multicast Beamforming in Integrated Satellite-Terrestrial Networks," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 71, no. 3, pp. 3131–3143, Mar. 2022.

[J14] D. Wang, P. Qi, Y. Zhao, C. Li, **W. Wu**, and Zan Li, "Covert Wireless Communication with Noise Uncertainty in Space-Air-Ground Integrated Vehicular Networks," *IEEE Intelligent Transportation Systems Transactions (**TITS**)*, vol. 23, no. 3, pp. 2784–2797, Mar. 2022.

[J15] W. Zhang, D. Yang, **W. Wu**, H. Peng, N. Zhang, H. Zhang, and X. Shen, "Optimizing Federated Learning in Distributed Industrial IoT: A Multi-Agent Approach," *IEEE Journal on Selected Areas in Communications (**JSAC**)*, vol. 39, no. 12, pp. 3688–3703, Dec. 2021.

[J16] Y. Chen, N. Zhang, Y. Zhang, X. Chen, **W. Wu**, and X. Shen, "Energy Efficient Dynamic Offloading in Mobile Edge Computing for Internet of Things," *IEEE Transactions on Cloud Computing (**TCC**)*, vol. 9, no. 3, pp. 1050–1060, 2021. (**Citation: 123**)

[J17] Y. Chen, N. Zhang, Y. Zhang, X. Chen, **W. Wu**, and X. Shen, "TOFFEE: Task Offloading and Frequency Scaling for Energy Efficiency of Mobile Devices in Mobile Edge Computing," *IEEE Transactions on Cloud Computing (**TCC**)*, vol. 9, no. 4, pp. 1634–1644, 2021. (**Citation: 73**)

[J18] C. Yu, W. Quan, D. Gao, Y. Zhang, K. Liu, **W. Wu**, H. Zhang, and X. Shen, "Reliable Cybertwin-Driven Concurrent Multipath Transfer with Deep Reinforcement Learning," *IEEE Internet of Things Journal (**JIoT**)*, vol. 8, no. 22, pp. 16207–16218, 2021.

[J19] W. Zhang, D. Yang, H. Peng, **W. Wu**, W. Quan, H. Zhang, and X. Shen, "Deep Reinforcement Learning Based Resource Management for DNN Inference in Industrial IoT," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 70, no. 8, pp. 7605–7618, 2021.

[J20] C. Zhou, **W. Wu**, H. He, P. Yang, F. Lyu, N. Cheng, and X. Shen, "Deep Reinforcement Learning for Delay-Oriented IoT Task Scheduling in Space-Air-Ground Integrated Network," *IEEE Transactions on Wireless Communications (**TWC**)*, vol. 20, no. 2, pp. 911-925, 2021.

[J21] S. Gu, Y. Wang, N. Wang, and **W. Wu**, "Intelligent Optimization of Availability and Communication Cost in Satellite-UAV Mobile Edge Caching System with Fault-Tolerant Codes," *IEEE Transactions on Cognitive Communications and Networking (**TCCN**)*, vol. 6, no. 4, pp. 1230-1241, 2020.

[J22] M. Gao, B. Ai, Y. Niu, **W. Wu**, P. Yang, F. Lyu, and X. Shen, "Efficient Hybrid Beamforming with Anti-Blockage Design for High-Speed Railway Communications," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 69, no. 9, pp. 9643–9655, 2020.

[J23] P. Yang, F. Lyu, **W. Wu**, N. Zhang, L. Yu, and X. Shen, "Edge Coordinated Query Configuration for Low-Latency and Accurate Video Analytics," *IEEE Transactions on Industrial Informatics (**TII**)*, vol. 16, no. 7, pp. 4855–4864, 2020.

[J24] K. Aldubaikhy, **W. Wu**, Q. Ye, and X. Shen, "Low-Complexity User Selection Algorithm for Multiuser Transmission in mmWave WLANs," *IEEE Transactions on Wireless Communications (**TWC**)*, vol. 19, no. 4, pp. 2397–2410, 2020.

[J25] K. Aldubaikhy, **W. Wu**, N. Zhang, N. Cheng, and X. Shen, "mmWave IEEE 802.11ay for 5G Fixed Wireless Access," *IEEE Wireless Communications (**WCM**)*, vol. 27, no. 2, pp. 88–85, 2020.

[J26] Y. Tang, P. Yang, **W. Wu**, J. W. Mark, and X. Shen, "Interference Mitigation via Cross-Tier Cooperation in Heterogeneous Cloud Radio Access Networks," *IEEE Transactions on Cognitive Communications and Networking (**TCCN**)*, vol. 6, no. 1, pp. 201–213, 2020.

[J27] B. Zheng, M. Wen, S. Lin, **W. Wu**, F. Chen, F. Ji, and H. Yu, "Design of Multi-Carrier LBT for LAA&WiFi Coexistence in Unlicensed Spectrum," *IEEE Network*, vol. 34, no. 1, pp. 76–83, 2020.

[J28] Y. Tang, N. Cheng, **W. Wu**, Y. Dai, M. Wang, and X. Shen, "Delay-Minimization Routing for Heterogeneous VANETs with Machine Learning based Mobility Prediction," *IEEE Transactions on Vehicular Technology (**TVT**)*, vol. 68, no. 4, pp. 3967–3979, 2019. (**Citation: 104**)

[J29] X. Liu, Y. Liu, N. Zhang, **W. Wu**, and A. Liu, "Trajectory of Unmanned Aerial Vehicles for Efficient Data Acquisition: A Matrix Filling Approach," *IEEE Internet of Things Journal (**JIoT**)*, vol. 6, no. 2, pp. 1829–1840, 2019. (**ESI Highly Cited Paper**)

[J30] R. Ding, Y. Xu, F. Gao, X. Shen, and **W. Wu**, "Deep Reinforcement Learning for Router Selection in Network with Heavy Traffic," *IEEE Access*, vol. 7, pp. 37109–37120, 2019.

Conference Papers

[C1] **W. Wu**, Q. Shen, K. Aldubaikhy, N. Cheng, N. Zhang, and X. Shen, "Enhance the edge with beamforming: Performance analysis of beamforming-enabled WLAN", in *Proc. International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks Workshop (**WiOpt Workshop**)*, Shanghai, China, May 7–11, 2018.

[C2] **W. Wu**, Q. Shen, M. Wang, and X. Shen,"Performance Analysis of IEEE 802.11.ad Downlink Hybrid Beamforming", in *Proc. IEEE International Conference on Communications (**ICC**)*, Paris, France, May 21–25, 2017.

[C3] **W. Wu**, X. Li, H. Yin, C. Zhang, and G. Wei,"A Joint Real Grassmannian Quantization Strategy for SISO IA with Limited Feedback," in *Proc. IEEE International Symposium on Personal, Indoor and Mobile Radio Communications (**PIMRC**)*, Washington, USA, Sep. 2–5, 2014.

[C4] **W. Wu**, X. Li, H. Yin, C. Zhang, and G. Wei, "A Joint Real Grassmannian Quantization Strategy for MIMO Interference Alignment with Limited Feedback", in *Proc. International Conference on Computer Communications and Networks Workshop (**ICCCN Workshop**)*, Shanghai, China, Aug. 4–7, 2014.

[C5] J. Chen, R. Ding, **W. Wu**, J. Liu, F. Gao, and X. Shen, "Multi-Agent Learning Based Packet Routing in Multi-Hop UAV Relay Network", in *Proc. IEEE International Conference on Communications (**ICC**)*, Seoul, South Korea, May 16–20, 2022.

[C6] E. Cui, W. Zhang, D. Yang, **W. Wu**, and F. Lyu, "Resource-Efficient DNN Training and Inference for Heterogeneous Edge Intelligence in 6G," in *Proc. IEEE International Conference on High Performance Computing and Communications Workshop (**HPCC Workshop**)*, Haiko, China, Dec. 20–22, 2021.

[C7] Z. Mao, F. Hu, Q. Li, **W. Wu**, and X. Shen, "Joint Distributed Beamforming and Backscatter Cooperation for UAV-Assisted WPSNs", in *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, Madrid, Spain, Dec. 7–11, 2021.

[C8] C. Zhou, H. Wu, M. He, **W. Wu**, N. Cheng, and X. Shen, "Adaptive Access Mode Selection in Space-Ground Integrated Vehicular Networks", in *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, Madrid, Spain, Dec. 7–11, 2021.

[C9] J. Lin, P. Yang, **W. Wu**, N. Zhang, T. Han, and L. Yu, "Edge Learning for Low-Latency Video Analytics: Query Scheduling and Resource Allocation", in *Proc. IEEE International Conference on Mobile Ad-Hoc and Smart Systems (**MASS**)*, Auburn, United States, Oct. 4–7, 2021.

[C10] Z. Huang, P. Yang, N. Zhang, F. Lyu, Q. Li, **W. Wu**, and X. Shen, "QoE-driven Mobile 360 Video Streaming: Predictive View Generation and Dynamic Tile Selection", in *Proc. IEEE/CIC International Conference on Communications in China (**ICCC**)*, Xiamen, China, Jul. 28–30, 2021.

[C11] Z. Ma, **W. Wu**, F. Gao, and X. Shen,"Multi-Task Learning Aided Joint Constellation Design and Multiuser Detection for GF-NOMA", in *Proc. IEEE International Conference on Communications (**ICC**)*, Montreal, Canada, June 14–23, 2021.

[C12] W. Zhang, D. Yang, **W. Wu**, H. Peng, W. Quan, H. Zhang, and X. Shen, "Spectrum and computing resource management for federated learning in distributed industrial IoT", in *Proc. IEEE International Conference on Communications Workshop (**ICC Workshop**)*, Montreal, Canada, June 14–23, 2021.

[C13] W. Zhang, D. Yang, H. Peng, **W. Wu**, W. Quan, H. Zhang, and X. Shen, "Deep Reinforcement Learning Based Resource Management for DNN Inference in IIoT", in *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, Taipei, Taiwan, Dec. 7–11, 2020. (**Popular Article**)

[C14] W. Wang, C. Zhou, H. He, **W. Wu**, W. Zhuang, and X. Shen, "Cellular Traffic Load Prediction with LSTM and Gaussian Process Regression", in *Proc. IEEE International Conference on Communications (**ICC**)*, Taipei, Taiwan, Jun. 7–11, 2020.

[C15] C. Zhou, **W. Wu**, H. He, P. Yang, F. Lyu, N. Cheng, and X. Shen, "Delay-aware IoT Task Scheduling in Space-air-ground Integrated Network", in *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, Waikoloa, United States, Dec. 9–13, 2019.

[C16] M. Gao, B. Ai, Y. Niu, **W. Wu**, P. Yang, F. Lyu, and X. Shen, "Edge Caching and Content Delivery with Minimized Delay for both High-Speed Train and Local Users", in *Proc. IEEE Global Communications Conference (**GLOBECOM**)*, Waikoloa, United States, Dec. 9–13, 2019.

[C17] C. Zhou, H. He, P. Yang, F. Lyu, N. Cheng, **W. Wu**, and X. Shen, "Deep RL-based Trajectory Planning for AoI Minimization in UAV-assisted IoT", in *Proc. IEEE International Conference on Wireless Communications and Signal Processing (**WCSP**)*, Xi'an, China, Oct. 23–25, 2019. **(Popular Article)**

[C18] M. Gao, B. Ai, Y. Niu, **W. Wu**, P. Yang, F. Lyu, and X. Shen, "On Hybrid Beamforming of mmWave MU-MIMO System for High-Speed Railways", in *Proc. IEEE International Conference on Communications (**ICC**)*, Shanghai, China, May 20–24, 2019.

[C19] Y. Tang, P. Yang, **W. Wu**, J. W. Mark, and X. Shen, "Cooperation-based Interference Mitigation in Heterogeneous Cloud Radio Access Networks", in *Proc. IEEE International Conference on Communications (**ICC**)*, Shanghai, China, May 20–24, 2019. (**Invited for fast-track journal publication** in IEEE Transactions on Cognitive Communications and Networking (TCCN))

[C20] F. Lyu, P. Yang, W. Shi, H. Wu, **W. Wu**, N. Cheng, and X. Shen, "Online UAV Scheduling Towards Throughput QoS Guarantee for Dynamic IoVs", in *Proc. IEEE International Conference on Communications (**ICC**)*, Shanghai, China, May 20–24, 2019.

[C21] K. Aldubaikhy, **W. Wu**, and X. Shen, "BF-PDVG: Hybrid Beamforming and User Selection for UL MU-MIMO mmWave Systems", in *Proc. IEEE Global Communications Conference Workshop (**GLOBECOM Workshop**)*, Abu Dhabi, UAE, Dec. 9-13, 2018.

[C22] K. Aldubaikhy, Q. Shen, M. Wang, **W. Wu**, X. Shen, O. Aboul-Magd, Y. Xin, R. Sun, and E. Au, "MAC layer design for concurrent transmissions in millimeter wave WLANs", in *Proc. IEEE/CIC International Conference on Communications in China (**ICCC**)*, Qingdao, China, Oct. 22–24, 2017.

FUNDING APPLICATION ASSISTANCE

[F1] **Proactive User-centric Networking for Next Generation Wireless Communications**
Funded by NSERC Collaborative Research and Development Grant
PI: Professor X. Shen
Industrial partner: Huawei Canada
My contributions: Milestone scheduling, activity planning, and monthly meeting with industrial cooperators.

[F2] **High Efficiency Wireless LAN MAC Layer Design**
Funded by NSERC Collaborative Research and Development Grant
PI: Professor X. Shen
Industrial partner: Huawei Canada
My contributions: Milestone deliver and monthly meeting with industrial cooperators.

SELECTED SEMINARS AND PRESENTATIONS

[P1] RAN Slicing for Vehicular Networks,
Invited Talk – Huazhong University of Science and Technology, Xidian University, Xi'an Jiaotong University, June, 2022.

[P2] RAN Slicing for Vehicular Networks,
IEEE 5th International Conference on Electronics Technology (ICET) – University of Electronic Science and Technology of China, May 13-16, 2022.

[P3] Network Slicing for Service-Oriented Vehicular Networks,
International Workshop on Mobile Edge Computing and Security – Peng Cheng Laboratory & University of Electronic Science and Technology of China, Jan. 8-9, 2022.

[P4] RAN slicing for Vehicular Networks: Perspectives of AI and Optimization,
Huawei Workshop on Next Generation Networks: Theory and Technologies – Department of Electrical and Computer Engineering, University of Waterloo, Apr. 8, 2021.

[P5] Dynamic RAN Slicing for Service-Oriented Vehicular Networks via Constrained Learning,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Oct. 22, 2020.

[P6] AI-assisted Next Generation Wireless Networks,
UW & Huawei Workshop – Department of Electrical and Computer Engineering, University of Waterloo, Jul. 25, 2019.

[P7] Design and Analysis of Beamforming in mmWave Networks,
ECE PhD Seminar – Department of Electrical and Computer Engineering, University of Waterloo, Jul. 22, 2019.

[P8] Design and Analysis of Beamforming in mmWave Networks,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Jul. 15, 2019.

[P9] Design and Analysis of mmWave Edge Networks,
Graduate Research Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Sept. 26, 2018.

[P10] Design and Analysis of mmWave Edge Networks,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Sept. 4, 2018.

[P11] Enhance the Edge with Beamforming: Performance Analysis of Beamforming-Enabled WLAN,
IEEE WiOpt Workshop – International Symposium on Modeling and Optimization in Mobile, Ad Hoc, and Wireless Networks, Shanghai, China, May 7–11, 2018.

[P12] Advanced Beamforming in Millimeter-Wave WLAN,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Sept. 19, 2017.

[P13] Dynamic Beamforming in Millimeter-Wave Networks,
Graduate Research Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Aug. 9, 2017.

[P14] Dynamic Beamforming in Millimeter-Wave Networks,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Jul. 19, 2017.

[P15] Performance Analysis of IEEE 802.11ad Downlink Hybrid Beamforming,
IEEE ICC – IEEE International Conference on Communications, Paris, France, May 21–25, 2017.

[P16] Millimeter Wave Communications: A Survey,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Feb. 9, 2016.

[P17] Interference Alignment with Limited Feedback in Multiuser Interference Networks,
Graduate Research Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Dec. 2, 2015.

[P18] Interference Alignment with Limited Feedback in Multiuser Interference Networks,
BBCR Seminars – Department of Electrical and Computer Engineering, University of Waterloo, Oct. 15, 2015.

[P19] A Joint Real Grassmannian Quantization Strategy for MIMO Interference Alignment with Limited Feedback,
ICCCN Workshop – IEEE International Conference on Computer Communications and Networks Workshop, Shanghai, China, Aug. 4–7, 2014.

RESEARCH EXPERIENCES

Department of Electrical and Computer Engineering, University of Waterloo, Canada
Postdoctoral Research Fellow, Broadband Communications Research (BBCR) Laboratory

■ Artificial Intelligence for Next Generation Wireless Networks (1 JSAC, 1 TII, I WCM and 2 EIC invited papers)

- ***Edge Intelligence for Wireless Networking*** **Mar. 2020 – Oct. 2021**
  - Design edge intelligence solutions for multi-dimensional resource management and differentiated service provisioning, especially in highly dynamic network environments
  - Develop edge intelligence protocols for large-scale wireless networks with distributed data storage, computing, and communication resources.
- ***Intelligent Network Slicing for Vehicular Networks*** **Sept. 2019 – Oct. 2021**
  - Cooperate with Huawei Canada Co. to investigate next generation vehicular networks
  - Design a dynamic radio access network (RAN) slicing framework to support Internet of vehicles services with different quality of service (QoS) requirements, adapting to spatial-temporally varying vehicle traffic
  - Develop novel machine learning algorithms to make real-time RAN slicing decisions while satisfying multi-fold slice QoS requirements.
- ***Edge Inference for Industrial IoT*** **Sept. 2019 – Sept. 2020**
  - Designed a collaborative inference framework by leveraging on-board and edge computing resources to reduce deep neural network inference service delay
  - Designed a sampling rate adaption mechanism for IoT devices to reduce the amount of offloaded sensing data volume

– Proposed a deep reinforcement learning based scheduling algorithm to make the optimal sampling rate adaption and resource allocation decisions.

Research Assistant, Broadband Communications Research (BBCR) Laboratory

■ **Design and Analysis of Beamforming in mmWave Networks (1 TWC and 2 TVT papers)**

- ***Beam Alignment for mmWave Communications*** **Sept. 2017 – Aug. 2019**
  - Proved that received signal strength among nearby beams in the beam alignment process is correlated in the multipath channel
  - Proposed a machine learning based fast beam alignment algorithm by leveraging correlation structure among beams and the prior knowledge on the channel fluctuation to reduce beam alignment latency
  - Analyzed theoretical performance to validate the proposed algorithm is asymptotically optimal.
- ***Cooperative Edge Caching for mmWave Dense Networks*** **Sept. 2016 – Dec. 2018**
  - Proposed a device-to-device assisted cooperative edge caching policy by cooperatively utilizing cache resources of users and nearby small base stations to enhance caching performance
  - Derived closed-form expressions of backhaul offloading gain and content retrieval delay in mmWave dense networks based on stochastic network information
  - Analyzed the impacts of network density and practical directional antennas on the performance of the proposed caching policy.
- ***Medium Access Control (MAC) Protocol for Beamforming Training*** **Sept. 2015 – Aug. 2019**
  - Collaborative research with Huawei Canada Co.
  - Proposed an analytical model to evaluate MAC performance of beamforming training protocol in IEEE 802.11ad standard
  - Derived the closed-form expressions of protocol performance, including successful training probability, network throughput and training latency
  - Developed an enhancement scheme to improve beamforming training efficiency by tuning protocol parameters with respect to user density.

University of Science and Technology of China, China

Research Assistant, Wireless Information Network Laboratory

■ **Interference Alignment in Wireless Networks**

- ***Interference Alignment with Limited Feedback*** **Mar. 2013 – Jun. 2015**
  - Analyzed the impact of limited feedback on interference alignment algorithms by deriving the average interference leakage in different wireless channels
  - Proposed a joint real Grassmannian quantization strategy to reduce the overhead of feedback information
  - Analyzed the theoretical performance of the proposed strategy based on chordal distance analysis
  - Analyzed the impact of channel estimation error on the interference alignment performance.
- ***Performance Analysis of Monobit Digital Receivers*** **Feb. 2012 – Jun. 2012**
  - Analyzed the theoretical performance of optimal and suboptimal algorithms of the monobit digital receiver
  - Validated the theoretical results of two algorithms via simulations.

TEACHING AND MENTORING EXPERIENCES

Teaching Experiences

- **Teaching Assistant, University of Waterloo** **Jan. 2017 – Apr. 2017**
  Undergraduate course: Numerical Methods (ECE 204A)
  Duties: Dealing with the problems students have during and after the classes, and marking assignments and final exam.
- **Certificate of ExpecTAtions Teaching Assistant (TA) Training Workshop** **Sept. 2015**
  Department of Electrical and Computer Engineering, University of Waterloo
  The workshop involves:
  - Two short lectures consisting of surprise and prepared topics
  - A marking exercise under the guidance of two departmental mentors.

- **Teaching Assistant, University of Science and Technology of China Sept. 2013 – Jan. 2014**
  Undergraduate course: Digital Signal Processing (00618701)
  Duties: Instructing students on group projects, preparing and delivering tutorials, answering students' questions, assisting in preparation and grading of exams.

Mentoring Experiences

- Haina Zheng, PhD student at the Beijing Jiaotong University May 2021 – Mar. 2022
  Project: Age of Information-Based Efficiency Design in Point-to-Point Communication Link
- Ruijing Ding, PhD student at the Tsinghua University Aug. 2021 – Present
  Project: Packet Routing in UAV Multi-Hop Network: A Multi-agent Deep Reinforcement Learning Approach
- Xiaoxiao Zhuo, PhD student at the Zhejiang University Mar. 2021 – Mar. 2022
  Project: Value of Information-Based Packet Scheduling Scheme for AUVs in Underwater Acoustic Sensor Network
- Zhi Mao, PhD student at the Jilin University Mar. 2021 – Mar. 2022
  Project: Joint distributed beamforming and backscatter cooperation for UAV-assisted WPSNs
- Conghao Zhou, PhD student at University of Waterloo Sept. 2018 – Oct. 2021
  Project: Deep reinforcement learning for delay-oriented IoT task scheduling in SAGINs
- Zehao Zhang, undergraduate co-op student at the University of Waterloo Apr. 2021 – Aug. 2021
  Project: Implementation and design of a federated learning algorithm design for wireless networks.
- Dairu Han, PhD student at the Nanjing University of Science and Technology Nov. 2019 – May 2021
  Project: Joint cache placement and multicast beamforming design in integrated satellite-terrestrial networks.
- Weiting Zhang, PhD student at the Beijing Jiaotong University Nov. 2019 – Nov. 2020
  Project: Deep reinforcement learning based resource management for industrial IoT networks.
- Zhe Ma, PhD student at the Tsinghua University Nov. 2019 – Nov. 2020
  Project: Joint constellation design and multiuser detection for grant-free NOMA
- Meilin Gao, PhD student at the Beijing Jiaotong University Sept. 2017 – Dec. 2019
  Project: Efficient hybrid beamforming design for high-speed railway communications.
- Chuqing Hu, undergraduate co-op student at the University of Waterloo Jan. 2020 – Apr. 2020
  Project: Implementation of a learning based resource management algorithm for vehicular networks.

VOLUNTEER EXPERIENCES

- **Group Coordinator, BBCR AI Research Group (10 members) Mar. 2019 – Oct. 2021**
  Duties: Organizing group members to do advanced research, developing technologies for next generation wireless networks, discussing research ideas with group members, discussing with the researchers of industrial partner, Huawei, Canada about the project progress, organizing biweekly group meetings and backup meeting files, and collecting meeting notes and writing minutes.
- **IEEE Student Branch Chair,**
  University of Science and Technology of China May 2013 – May 2014
  Duties: Organizing a number of IEEE on-campus events for undergraduate and graduate students, hosting research seminars on new technologies, inviting distinguished professors to share research experience, organizing volunteers for IEEE conferences, and attracting new IEEE student members.
- **Conference Volunteer, IEEE VTC-Fall 2017, Toronto, Canada Sept. 24–27, 2017**

PROFESSIONAL SERVICES

Editor

- Associate Editor, *Springer Peer-to-Peer Networking and Applications*, since 2022
- Lead Guest Editor, *Hindawi Wireless Communications and Mobile Computing*, special issue on "AI-Empowered Resource Orchestration for QoS Provisioning in 6G", 2022
- Guest Editor, *China Communications*, special issue on "IoT Intelligence Empowered by End-Edge-Cloud Orchestration", 2022
- Editorial Board, *Frontiers in Internet of Things*, special section on "IoT Services and Applications", 2022
- Editorial Board, *Frontiers in Communications and Networks*, special section on "Data Science for Communications", 2022
- Editorial Board, *Frontiers in High Performance Computing*, special section on "Architecture and Systems", 2022
- Book Board, *Springer Nature*, Track on "Machine Learning", 2022

Conference Organization

- Workshop TPC Co-Chair, *IEEE INFOCOM* Workshop on "Pervasive Network Intelligence for 6G Networks (PerAI-6G)", 2022
- Workshop TPC Co-Chair, *IEEE HPCC* Workshop on "Distributed Intelligence for Future High Performance Unmanned Mobile Systems (DIFUS)", 2021.
- Track Co-Chair, *EAI CollaborateCom* Track on "Internet of Things", 2021
- Workshop Co-Chair, *IEEE IPCCC* Workshop on "Edge Intelligence for 6G Networks (EI)", 2021

Technical Program Committee
- IJCAI 2022 Workshop on Trustworthy Federated Learning (FL-IJCAI'22)
- IEEE ICC 2022
- IEEE ICC 2022 Workshop on DDNIS
- IEEE ICNC 2019
- IEEE WCSP 2019
- IEEE VTC-Fall 2020, 2021
- IEEE VTC-Fall 2020, 2022 Workshop

Session Chair
- Heterogeneous Networks, VTC-Fall 2017, Toronto, Canada, Sept. 23–24, 2017

Reviewer of Refereed Journals and Conferences
- IEEE Communication Magazine (CM)
- IEEE Wireless Communications Magazine (WCM)
- IEEE Network Magazine (NET)
- ACM/IEEE Transactions on Networking (TON)
- IEEE Journal on Selected Areas in Communications (JSAC)
- IEEE Transactions on Mobile Computing (TMC)
- Transactions on Parallel and Distributed Systems (TPDS)
- IEEE Transactions on Wireless Communications (TWC)
- IEEE Transactions on Cloud Computing (TCC)
- IEEE Transactions on Communications (TCOM)
- IEEE Transactions on Industrial Informatics (TII)
- IEEE Internet of Thing Journal (IoTJ)
- IEEE Transactions on Vehicular Technology (TVT)
- IEEE Transactions on Cognitive Communications and Networking (TCCN)
- Transactions on Big Data (TBD)
- IEEE Open Journal of the Communication Society (OJCOMS)
- IEEE Communication Letters (CL)
- IEEE Wireless Communication Letters (WCL)
- IEEE Access
- Information Processing and Management
- Springer Wireless Networks (WN)
- Wiley ETRI Journal
- Wiley IET Communications
- Elsevier Computer Networks (CN)
- Hindawi Wireless Communications and Mobile Computing (WCMC)
- SAGE International Journal of Distributed Sensor Networks (DSN)
- IEEE International Symposium on Information Theory (ISIT) 2022
- IEEE Global Communications Conference (GLOBECOM) 2020, 2021
- IEEE International Conference on Communications (ICC) 2021, 2022
- IEEE Vehicular Technology Conference (VTC) 2020
- IEEE International Conference on Computing, Networking and Communications (ICNC) 2019
- IEEE International Conference on Wireless Communications and Signal Processing (WCSP) 2014, 2019

CONTACT INFORMATION OF PROFESSIONAL REFERENCES

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