Kangle(Phil) Mu

4th-year Ph.D. Candidate in Wireless Communications | Northwestern University

Email: kangle.mu@northwestern.edu **Phone**: (734) 546-4957 **Address**: Evanston, IL

LinkedIn: www.linkedin.com/in/kangle-mu-8b343a224

EDUCATION

- 2022-2027(Expected): Ph.D., Northwestern University, GPA: 3.98/4
- 2020-2022: M.S., University of Michigan, Ann Arbor, GPA: 3.92/4
- 2016-2020: B.S., Xidian University, GPA: 3.90/4

SKILLS

5G-NR 3GPP standards: RRC MAC
Communication Theory Stochastic processes (Lecturer)
linear Algebra Probability Game Theory
AI/ML Deep Reinforcement Learning
Python C Matlab TensorFlow NetSim (5G simulator)

RESEARCH

(On-going) Improving Group Handover in 5G NR and Modeling of 5G RACH

Keywords: **5G-NR, RACH, RRC, MAC**

- Studied current 3GPP 5G-NR standards (TS 38.331/38.211/38.212/38.213) for UE attachment (RRC) and contention-based RACH (MAC).
- Developed an analytical model to characterize handover delay when large UE groups contend on PRACH; derived the expected backoff delay.
- Proposed a lightweight estimator that closely matches simulation while avoiding intensive computation, enabling practical tuning of PRACH (e.g., backoff-window settings) to mitigate access congestion.
- Proposed two dynamic random backoff algorithms with applicability to 5G-NR and future releases; patent filings in progress.

Machine Learning-based Adaptive Mobile Video Streaming

Keywords: **AI/ML, Deep Reinforcement Learning**

- Designed a Deep RL-based agent for adaptive video streaming. Explored a novel playback speed adaptation (nearly imperceptible) alongside with the traditional bitrate adaptation for video streaming applications. The playback speed is slowed down when necessary (e.g., under poor network conditions).
- Implemented A3C (deep reinforcement learning) using Tensorflow. Video demo [Link]
- Presented at IEEE INFOCOM 2021, and published on IEEE Transactions on Mobile Computing.

Enhancing Efficiency of Intermittent Wireless Spectrum

Keywords: **Spectrum Sharing, CBRS, Economics**

- Explored two solutions to mitigate the impact of intermittency on shared spectrum (e.g., the CBRS band):
  (1) allowing reduced incumbent protection and
  (2) pooling multiple intermittent bands to decrease overall intermittency.
- Developed economic models for these approaches and analyzed potential market outcomes.
- Presented at IEEE ICC 2024, NSF Spectrum Week 2024, and IEEE DySPAN 2024 (Best Paper Award).

Spectrum Sharing Strategies for Local Wireless Services

Keywords: **Spectrum Sharing, SCMs, Economics**

- Analyzed spectrum sharing strategies among local providers with coverage overlaps, enabled by IEEE 1900.5.2 Spectrum Consumption Models (SCMs).
- Revealed complex market dynamics, highlighting the need for careful regulatory interventions to optimize spectrum usage. market outcomes.
- Presented at IEEE WiOPT 2024 (Best Student Paper Award) and IEEE DySPAN 2025.

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PUBLICATIONS Google Scholar

1. **K. Mu**, R. Berry et al., "Compete or Coordinate? Analysis of Spectrum Sharing Strategies for Local Wireless Services," IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), 2025.

2. W. Lehr, R. Berry, C. Caicedo, I. Kadota, **K. Mu**, Z. Xie, I. Tamin "Automating spectrum sharing: A bottom-up approach and research agenda," Telecommunications Policy, 2025.

3. **K. Mu**, R. Berry et al., "Impact of Geographical Separation on Spectrum Sharing Markets," IEEE International Symposium on Modeling and Optimization in Mobile, Ad hoc, and Wireless Networks (WiOpt), 2024.
   BEST PAPER AWARD

4. W. Lehr, R. Berry, C. Caicedo, I. Kadota, **K. Mu**, Z. Xie, I. Tamin "Automating Spectrum Sharing from the Ground Up," Research Conference on Communications, Information & Internet Policy (TPRC), 2024.

5. **K. Mu**, R. Berry, "Market Impacts of Relaxed Incumbent Protection in Spectrum Sharing," IEEE ICC Workshop - Next Generation Spectrum Sharing Technology, 2024.

6. **K. Mu**, R. Berry, "Market Impacts of Pooling Intermittent Spectrum," IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN), 2024.
   BEST PAPER AWARD

7. N. Khan, **K. Mu**, V. Subramanian, "Backward and Forward Inference in Interacting Independent-Cascade Processes: A Scalable and Convergent Message-Passing Approach," arXiv, 2023.

8. J. Zheng, Y. Zhang, T. H. Luan, **K. Mu**, G. Li, M. Dong, Y. Wu, "Digital twin enabled task offloading for IoVs: A learning-based approach", IEEE Transactions on Network Science and Engineering, 2023.

9. **K. Mu**, T. H. Luan et al., "AMIS-MU: Edge Computing based Adaptive Video Streaming for Multiple Mobile Users," IEEE Transactions on Mobile Computing, 2022.

10. J. Zheng, **K. Mu**, T. H. Luan et al., "Device Placement for Autonomous Vehicles using Reinforcement Learning," IEEE International Conferences on Internet of Things, 2021.

11. **K. Mu**, T. H. Luan et al., "AMIS: Edge Computing based Adaptive Mobile Video Streaming," in Proceedings of IEEE INFOCOM, 2021.