Haoran Wan

35 Olden Street, Princeton, NJ, 08540
Email: haoran.w@princeton.edu ◇ Mobile: 609 366 6317 ◇ Personal Website ◇ Google Scholar ◇ Linkedin

Research Interest

My research focuses on systems and networks, with an emphasis on building networked systems that integrate information across layers and modules to improve system performance and application quality of service, with expertise in:

- Congestion control, buffer management, and network telemetry,
- Interactive video streaming, and WebRTC optimizations,
- 5G network, and cellular/Open-RAN architecture.

Education

- **Princeton University** — Princeton, New Jersey
  Ph.D. Candidate in Computer Science, Advisor: Kyle Jamieson — Jul. 2023 - Present
- **Nanjing University** — Nanjing, Jiangsu
  M.S. in Computer Science, Advisor: Wei Wang — Sep. 2019 - Jun. 2023
- **University of Electronic Science and Technology of China** — Chengdu, Sichuan
  B.Eng in Networking Engineering — Sep. 2015 - Jul. 2019
- **National Chiao Tung University** — Hsinchu, Taiwan
  Exchange Student in Electrical and Computer Engineering — Feb. 2017 - Jul. 2017

Selected Research Projects

Princeton University | *Research Assistant, Advisor: Kyle Jamieson* — July 2023 - Present

- **Project L4Span**: enabling ultra-low sojourn time in 5G network
  - Integrated the **low-latency, low-loss, and scalable (L4S)** packet marking mechanism on the **explicit congestion notification (ECN)** field into the 5G network with a sub-layer module to achieve ultra-low latency and good throughput utilization.
  - Designed a wireless channel capacity and sojourn time prediction module in the sub-layer to accommodate the ECN markings.
  - Built the flow classification and marking strategies for L4S flows (**TCP Prague, BBRv2/v3, SCReAM, etc.**) and classic flows (**TCP CUBIC, Reno, etc.**) to maintain a low buffer occupancy and high capacity utilization for both flow types.
  - Implemented L4Span in an open-source base station (srsRAN) with over 2000 lines of C++ code, and conducted comprehensive experiments using **SDR** as the radio unit, achieving over 95% sojourn time reduction while maintaining near line-rate throughput; published in **ACM CoNEXT 2025**.
- **Project Athena and Domino**: a cross-layer network measurement framework
  - Built first-of-its-kind millisecond-precision synchronization system correlating **Layer 1 to Layer 7** data to diagnose video conferencing QoE issues in the 5G networks.
  - Performed **deep WebRTC customization** to extract the real-time performance metrics (jitter buffer, freeze count, bandwidth estimation, etc.) and **Google Congestion Control** internals by directly modifying the source code.
  - Conducted a thorough analysis of video streaming over the 5G network, **discovering root causes of QoE degradation in 5G protocol stack** (HARQ ReTX jitters, etc.), identified optimization opportunities that can reduce video streaming jitters by 50%.
  - Developed an automatic impairment analysis framework to identify the root causes in the 5G network when the QoE degrades (jitter buffer drains, target bitrate drops); published in **ACM HotNets 2024 and ACM IMC 2025**.
- **Project NR-Scope**: a real-time practical 5G network telemetry tool
  - Developed a **5G phy-layer decoder with SDR** called NR-Scope, decoding the real-time control information for every user in every transmission time interval (0.5 ms) in the network, revealing both **uplink and downlink physical layer resources allocation to every user** in the 5G network; built customized worker pools to provide the real-time result.
  - Implemented on top of an open-source project (srsUE) with over 5500 lines of C++ code.
  - Demonstrated its usefulness with **cloud gaming adaptive bit rate** algorithm, achieving bit rate and frame rate improvement, and helped later research projects, such as WaveFlex (CoNEXT ’24), Athena (HotNet ’24), and Domino (IMC ’25); published in **ACM CoNEXT 2024**, **open-sourced** at https://github.com/PrincetonUniversity/NR-Scope.

Nanjing University | *Research Assistant, Advisor: Wei Wang* — Sept. 2019 - Jun. 2023

- **Project mmSilent:** a transformer-based general corpus silent speech recognition with mmWave radar
  - Proposed a **transformer-based neural network** backend with user-adaptive design to recognize users’ silent speech sentences using pure mmWave signal input, achieving a word error rate of 9.5% – comparable with video-based SOTA.
  - Developed a **multimodal data collection platform** concurrently collecting the video, speech, and mmWave radar data. The corpus is formed with $1000+$ daily conversation sentences, and we collected 21000+ samples as our dataset.
  - Designed a signal processing pipeline for user head localization and interference removal, evaluated the model across multiple usage scenarios, and trained the model with PyTorch; **published in ACM IMWUT 2023**.
- **Project ALT:** a neural network inference optimization framework
  - Proposed a deep compiler that performs joint **graph-level layout optimization** and **operator-level loop optimization**, providing a generic transformation module to manipulate layouts and loops with easy-to-use primitive functions.
  - Designed an auto-tuning module with a cost model that jointly optimizes graph-level data layouts and operator-level loops to improve the computation efficiency of both **single operators** (Conv2D, Conv3D, etc.) and **end-to-end neural network** (ResNet18, MobileNet-V2, BERT-base, etc.).

- Evaluated on a variety of hardware, including **CPU, GPU and Mobile CPU**, achieved 1.5× speedup on single operator and 1.4× speedup on end-to-end inference performance, built on top of Apache TVM; published in **ACM EuroSys 2023**.

- **Project Acoustic Sensing:** a series of work on acoustic sensing and localization
  - Explored a variety of acoustic sensing scenarios, such as vital sign sensing, device-based localization with COTS acoustic sensors on mobile phones and Raspberry Pis, achieving state-of-the-art sensing performance.
  - Proposed a new signal design, achieving submillimeter-level location accuracy and thermal detection; published in **ACM IMWUT 2022**, and won the **Distinguished Paper Award**.
  - Designed and implemented a room-scale multi-target respiration detection system; published in IEEE INFOCOM 2021.

Selected Publications

- L4Span: Spanning Congestion Signaling over NextG Networks for Interactive Applications
  Haoran Wan, Kyle Jamieson. ACM CoNEXT 2025.
- Automated, Cross-Layer Root Cause Analysis of 5G Video-Conferencing Quality Degradation
  Fan Yi, **Haoran Wan**, Kyle Jamieson, Oliver Michel. ACM IMC 2025.
- NR-Scope: A Practical 5G Standalone Telemetry Tool
  Haoran Wan, Xuyang Cao, Alexander Marder, Kyle Jamieson. ACM CoNEXT 2025
- USee: Ultrasound-based Device-free Eye Movement Sensing
  Wen Cheng, Mingzhi Pang, **Haoran Wan**, Shichen Dong, Dongxu Liu, Wei Wang. SECON 2024. **Best Paper Award**.
- Athena: Seeing and Mitigating Wireless Impact on Video Conferencing and Beyond
  Fan Yi, **Haoran Wan**, Kyle Jamieson, Jennifer Rexford, Yaxiong Xie, Oliver Michel. ACM HotNet 2024.
- Multi-user Room-scale Respiration Tracking using COTS Acoustic Devices
  Haoran Wan, Shuyu Shi, Wenyu Cao, Wei Wang, Guihai Chen. ACM TOSN 2023.
- SCALAR: Self-Calibrated Acoustic Ranging for Distributed Mobile Devices
  Lei Wang, **Haoran Wan**, Ting Zhao, Ke Sun, Shuyu Shi, Haipeng Dai, Guihai Chen, Haodong Liu, Wei Wang. IEEE TMC 2023.
- ALT: Boosting Deep Learning Performance by Breaking the Wall between Graph and Operator Level Optimizations
  Zhiying Xu, Jiafan Xu, Hongding Peng, Wei Wang, Xiaoliang Wang, **Haoran Wan**, Haipeng Dai, Yixu Xu, Hao Cheng, Kun Wang, Guihai Chen. ACM EuroSys 2023.
- mSilent: Towards General Corpus Silent Speech Recognition using COTS mmWave Radar
  Shang Zeng, **Haoran Wan**, Shuyu Shi, Wei Wang. ACM Ubicomp/IMWUT 2023.
- VECTOR: Velocity Based Temperature-field Monitoring with Distributed Acoustic Devices
  Haoran Wan, Lei Wang, Ting Zhao, Ke Sun, Shuyu Shi, Haipeng Dai, Guihai Chen, Haodong Liu, Wei Wang. ACM Ubicomp/IMWUT 2022. **Distinguished Paper Award**.
- RespTracker: Multi-user Room-scale Respiration Tracking with Commercial Acoustic Devices
  Haoran Wan, Shuyu Shi, Wenyu Cao, Wei Wang, Guihai Chen. IEEE INFOCOM 2021.

Honors and Awards

- IEEE SECON Best Paper Award - Dec. 2024
- ACM IMWUT Distinguished Paper Award - Sept. 2022
- Outstanding graduate students of Nanjing University - Dec. 2021
- Huawei Graduate Scholarship - Nov. 2021
- Principal Special Scholarship for Graduate Students - Nov. 2019
- Second Class People's Scholarship - Nov. 2016, 2018
- Undergraduate China National Scholarship, Nov. 2017

Skills Summary

- **Languages:** C/C++, Python, MATLAB, Go, Java
- **Tools:** Pytorch, Scikit, Numpy, Hugging Face, Git, SDR
- **Knowledge:** TCP/IP, Congestion Control, 5G Protocol Stack, Linux, Android, Machine Learning

Teaching Experience

- COS 418 Distributed Systems — Princeton University
  Graduate teaching assistant — Sep. 2025 - Dec. 2025
- Digital Logic Design and Computer Organization — Nanjing University
  Graduate teaching assistant — Sep. 2021 - Jan. 2022
- Digital Circuit and Digital System Experiment — Nanjing University
  Graduate teaching assistant — Sep. 2020 - Jan. 2021