Real-World 6 GHz Measurements

Monisha Ghosh
Professor, EE Department, University of Notre Dame
Policy Outreach Director, SpectrumX
mghosh3@nd.edu, https://sites.nd.edu/ghosh-lab/
https://www.spectrumx.org/

October 21, 2026

Disclaimer: Opinions expressed are my own and are not necessarily supported by my affiliated institutions.

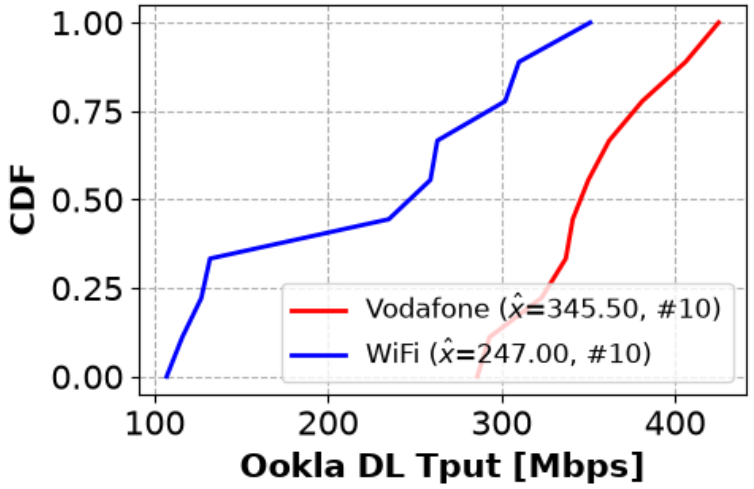
Acknowledgments: M. I. Rochman, S. Tusha, A. Tusha, H. Nasiri, J. Palathinkal, H. A. Shuvo, F. A. Gatsi

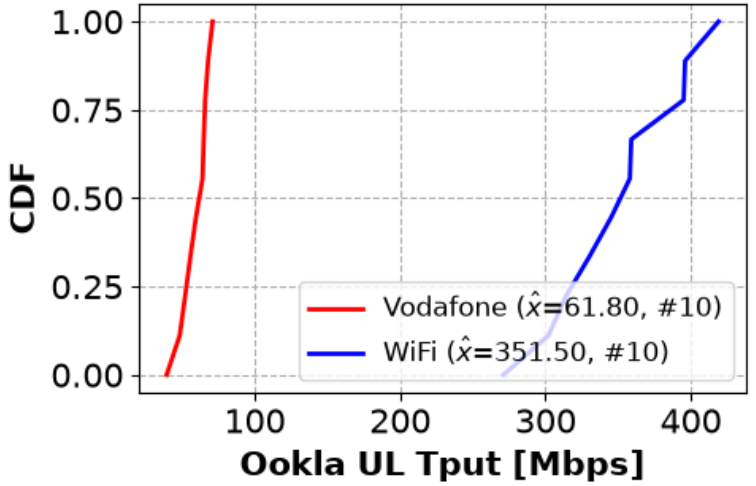
Our contributions: unbiased, real-world measurements

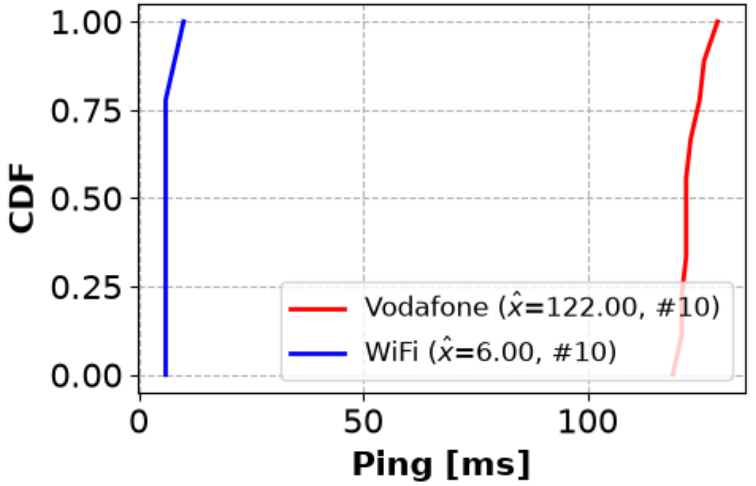
- Starting in 2023, my research group has been engaged in careful measurements of deployed Wi-Fi 6E in 6 GHz to understand coverage and potential for interference to fixed link incumbents and comparison with mid-band 5G.
  - University of Michigan, ~ 16,000 Wi-Fi 6E APs, all LPI
  - University of Notre Dame, ~ 900 SP Wi-Fi 6e APS in the stadium + hundreds of LPI APs in buildings
  - Measurements in many urban areas, including airports worldwide.
- Our main contributions are:
  - Detailed technical report on 6 GHz: https://sites.nd.edu/ghosh-lab/2026/08/31/new-technical-report-released-real-world-6-ghz-spectrum-wi-fi-deployment-analysis/
  - A first of its kind detailed data set of labeled indoor and outdoor measurements of SP and LPI APs.
    - https://sigcap.spectrumx.org/
  - Comparison of 6 GHz, 5 GHz and cellular performance when the Notre Dame stadium is at full capacity with 80,000 attendees.
  - Detailed analyses of coexistence of outdoor SP with indoor LPI under different conditions: fully occupied stadium and empty stadium.
  - Building Entry Loss measured with real APs.

6 GHz measurements in the mezzanine

- Collected detailed measurements directly on Vodafone and connected to Passpoint
- Vodafone: NSA, 5G in n78, 100 MHz + 4G in b7, 20 MHz
- Passpoint: 160 MHz on 6 GHz
- As shown below, downlink over cellular is better, but uplink and latency performance over Passpoint is far better: important for AI workloads.

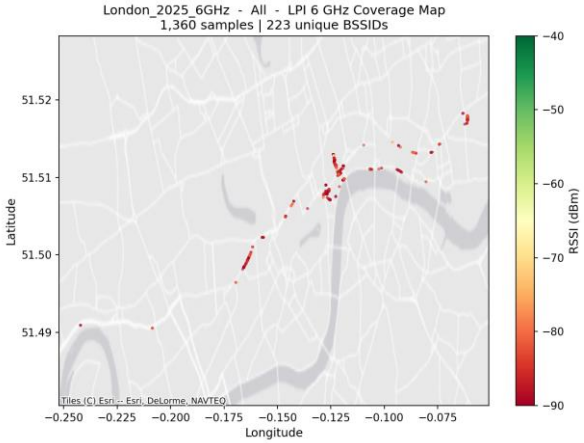


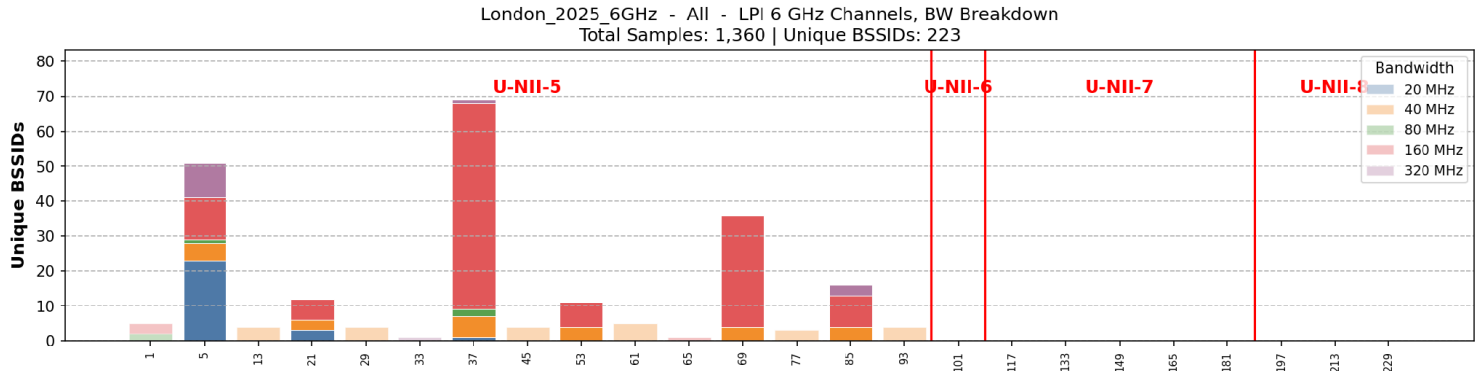


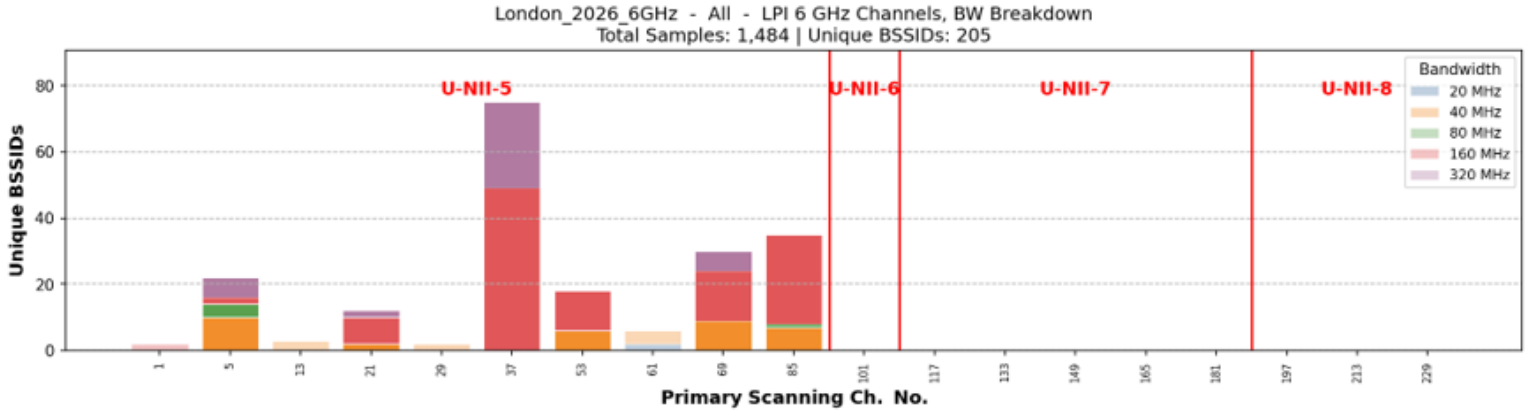


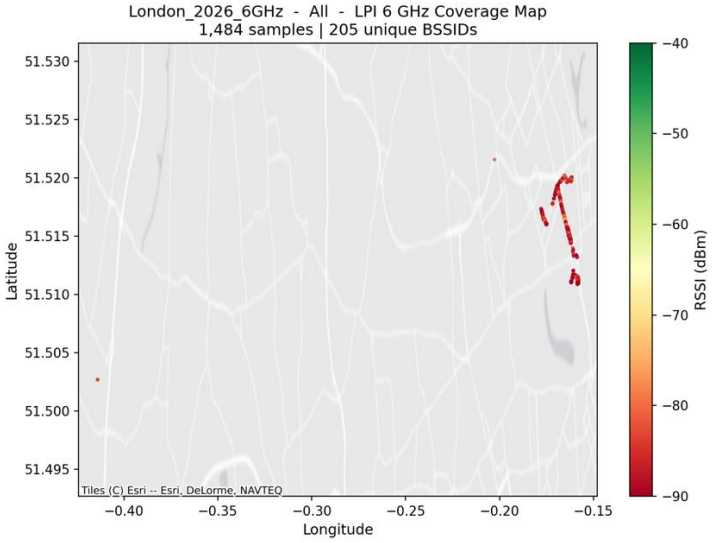
6 GHz measurements in London, 2025 and 2026

- May 2025: King’s College area
- October 2026: Hilton Metropole area
- Key takeaways:
  - 2025: 175 AX vs 47 BE (79% / 21%)
  - 2026: 79AX vs 105 BE (43% / 57%); 38% of BE is 320 MHz wide









6 GHz Notre Dame (ND) Stadium Deployment

- The ND stadium consists of an open bowl area and three adjacent buildings anchored to the south, east, and west sides.
- There are three distinct environments: outdoors in the bowl area, indoors near windows in floors 7 - 9 of Corbett and Duncan, and indoor interior in floors 1 - 6 of the two building.
- About **900 SP Wi-Fi 6E APs** (Aruba AP-634) are installed outdoors in the stadium bowl: two SP APs are placed within a case and mounted on the handrail that splits the stadium section.

Measurement locations.

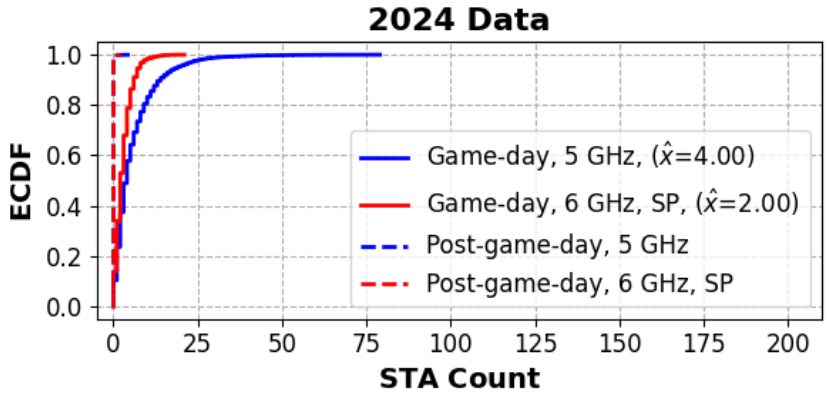
Measurement Environment.

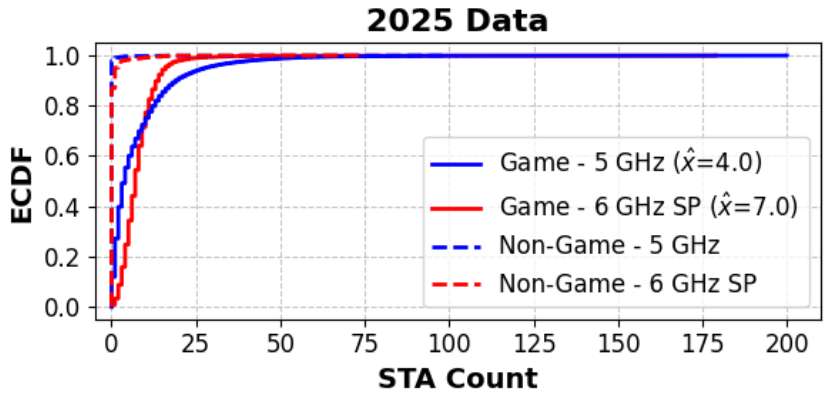
Environment	Description
Out (Stadium Bowl)	The open area of the stadium bowl, with SP deployments
II (Indoor Interior)	Floors 1 - 2, Duncan Student Center, with concrete walls and no windows facing the stadium.
INW (Indoors near Windows)	Floors 7 - 9, Duncan Student Center and Corbett Family Hall, featuring long hallways with large double-pane low-E windows and glass doors to the stadium bowl.

(a) Stadium bowl. (b) APs mounted on a handrail.

Wi-Fi 6E deployment at ND stadium.

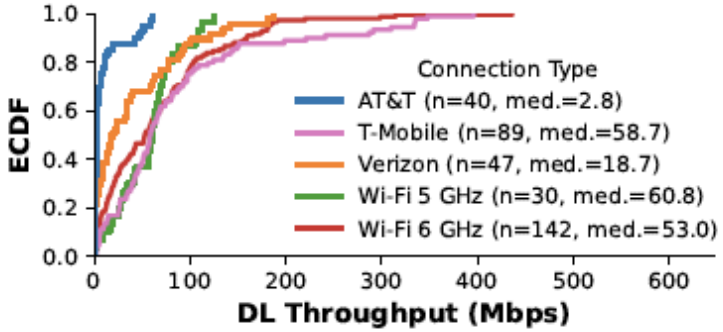
Comparison between 2024 and 2025

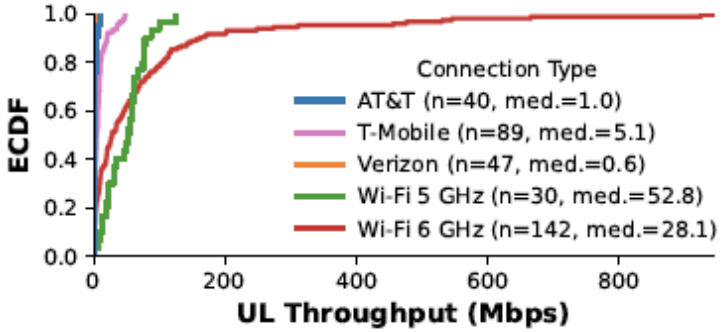


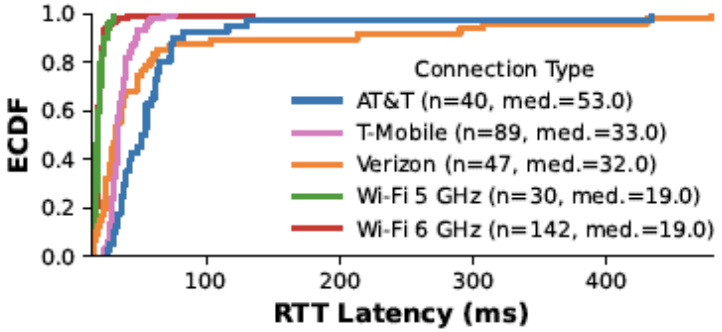


- **Key Takeaways:**
  - The median STA Count (number of devices per timestamp connected to an AP) more than tripled over one year indicating rapid adoption of 6 GHz.
  - The maximum STA count increased from 24 to 179.

Comparison in the stadium between Wi-Fi and cellular



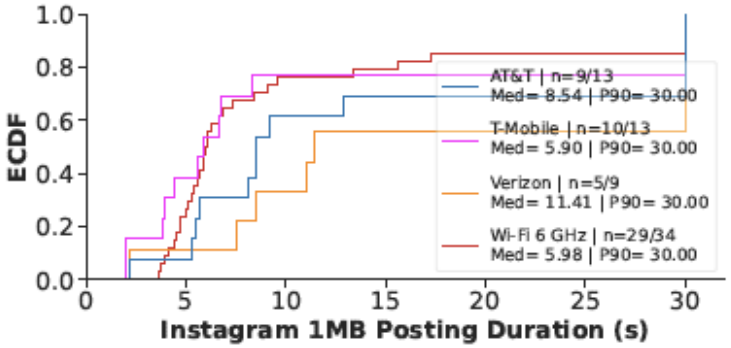




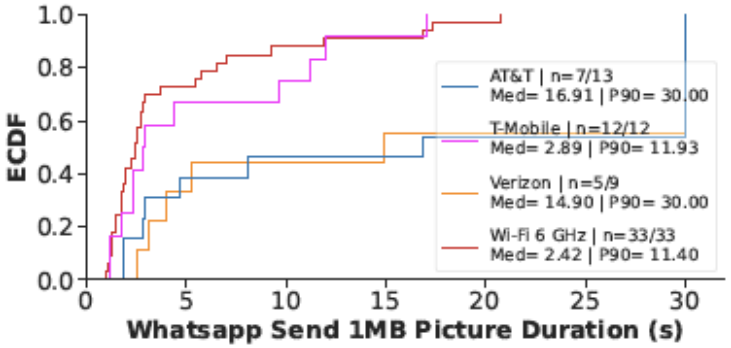
Measurement environment: Ookla speedtests, the stadium has a 5G DAS for T-Mobile

- **Key Takeaway:** Measurements with a full stadium (~80,000) indicate that Wi-Fi offers improved uplink and latency over all cellular carriers. Downlink throughput of only TMO is marginally better due to the DAS.

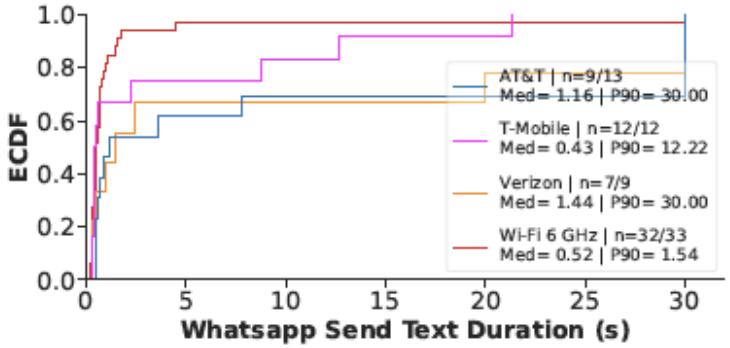
Comparison in the stadium between Wi-Fi and cellular, WhatsApp performance



(a) Instagram 1 MB Post



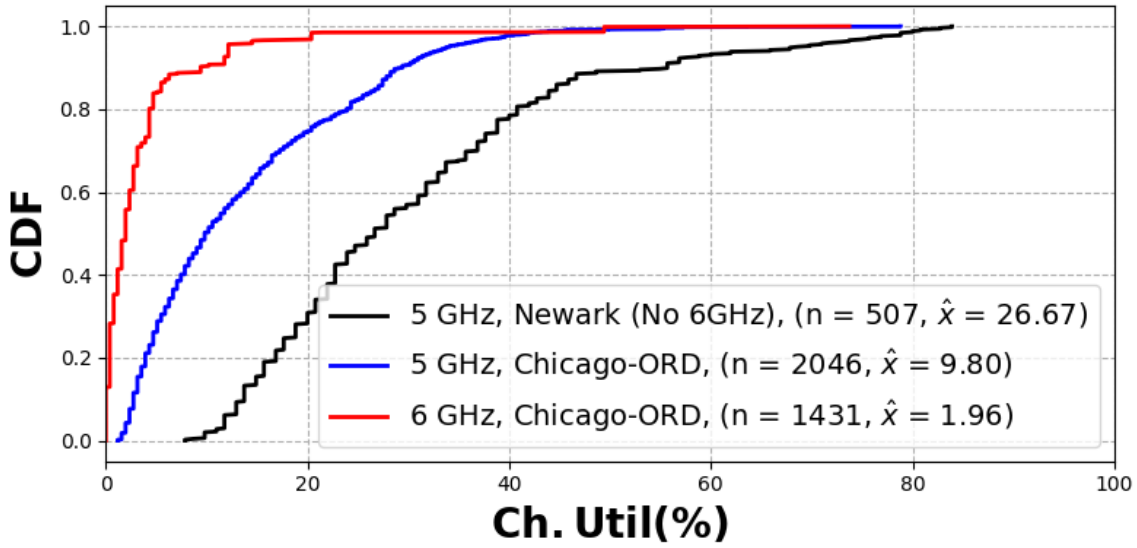
(b) WhatsApp 1 MB Image



(c) WhatsApp Text

- **Key Takeaway:** Measurements with a full stadium (~80,000) indicate that Wi-Fi offers better end-user performance using apps like Instagram and WhatsApp.

Wi-Fi Usage at Chicago ORD vs. Newark EWR



Airport	Considered SSIDs	Frequency	BW
Chicago ORD	_Free_ORD_Wi-Fi, Boingo Hotspot	6 GHz	40 MHz
Chicago ORD	_Free_ORD_Wi-Fi, Boingo Hotspot	5 GHz	40 MHz
Newark	_Free EWR Wi-Fi Boingo Hotspot	5 GHz	40 MHz

- Considering only airport SSIDs, it is clear that 6 GHz deployments in airports can relieve congestion on 5 GHz while adding more capacity.
- Mid-band NR was not available in either location, even in n41 (2.5 GHz)
- Highly unlikely that 6 GHz cellular will penetrate indoors. Allocating the upper half to cellular will severely disadvantage dense deployments such as airports.

Conclusions and key takeaways for 6 GHz

- **Embrace propagation and building losses at 6 GHz instead of fighting it.**
  - Lower power, dense deployments indoors will serve connectivity needs better compared to high-power, outdoor cellular deployments.
  - Improved coexistence with incumbents.
  - Even 3.4 – 4 GHz cellular has poor indoor coverage, unless deployed indoors.
  - **DO NOT** repeat the mmWave mistake: 6 GHz is much lower in frequency but shares many characteristics of mmWave propagation.
  - Larger antenna arrays will be of limited use.

- **Explore hybrid sharing**
  - Cellular outdoors, Wi-Fi indoors in 6 and 7 GHz should be explored: again exploiting building loss instead of wasting energy trying to overcome it.

- **Learn from real-world experience in 6 GHz and 3 GHz**
  - Wi-Fi 6E/7 is very mature in the U.S. and is exceeding performance of cellular at 3 GHz in dense outdoor deployments like stadiums.
  - Indoor cellular performance even at 3 GHz is not meeting expectations, unless deployed indoors.

Papers on 6 GHz

- H. I. Nabil, M. I. Rochman, S. M. Shuvo, J. R. Palathinkal and M. Ghosh, “App-Based Performance Characterization of Cellular and Wi-Fi Networks in Dense Stadium Deployment,” accepted to ACM Mobicom Wintech 2026. https://arxiv.org/abs/2607.16008
- S. Dogan-Tusha, A. Tusha, M. I. Rochman, H. Nasiri, J. R. Palathinkal, M. Atkins and M. Ghosh, "Evaluation of Indoor/Outdoor Sharing in the Unlicensed 6 GHz Band," *2025 IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN)*, London, United Kingdom, 2025, pp. 1-9, doi: 10.1109/DySPAN64764.2025.11115954. https://arxiv.org/abs/2505.18359
- S. Doğan-Tusha, A. Tusha, M. I. Rochman, H. Nasiri and M. Ghosh, "Spectrum Sharing Characterization Using Smartphones: Exploring 6 GHz Sharing Through Large-Scale Wi-Fi 6E Measurements," in *IEEE Communications Magazine*, vol. 63, no. 2, pp. 70-76, February 2025, doi: 10.1109/MCOM.001.2400325.
- S. Dogan-Tusha, A. Tusha, H. Nasiri, M. I. Rochman and M. Ghosh, "Spectrum Sharing in 6 GHz: How is it working out?," *2024 IEEE 25th International Workshop on Signal Processing Advances in Wireless Communications (SPAWC)*, Lucca, Italy, September 2024, pp. 791-795, doi: 10.1109/SPAWC60668.2024.10694058.
- M. Ghosh, "Evolution of Sharing in 6 GHz," in *IEEE Wireless Communications*, vol. 30, no. 5, pp. 4-5, October 2023, doi: 10.1109/MWC.2023.10325444
- S. Dogan-Tusha, A. Tusha, H. Nasiri, M. I. Rochman and M. Ghosh, "Indoor and Outdoor Measurement Campaign for Unlicensed 6 GHz Operation with Wi-Fi 6E," *2023 26th International Symposium on Wireless Personal Multimedia Communications (WPMC)*, Tampa, FL, USA, 2023, pp. 1-6, http://dx.doi.org/10.1109/WPMC59531.2023.10338962
- S. Dogan-Tusha, M. I. Rochman, A. Tusha, H. Nasiri, J. Helzerman and M. Ghosh, “Evaluating the interference potential in 6 GHz: an extensive measurement campaign of a dense indoor Wi-Fi 6E network,” WiNTECH ‘23, Proceedings of the 17th ACM Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization, October 6, 2023, https://dl.acm.org/doi/abs/10.1145/3615453.3616518