WOMEN IN NETWORKS: DR. ANDREA GOLDSMITH

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Andrea Goldsmith is Dean of the School of Engineering and Applied Science and the Arthur LeGrand Doty Professor of Electrical and Computer Engineering at Princeton University. During her career she has significantly advanced the state-of-the-art in wireless communication system design, founded several successful startups, and held leadership roles in academia, business, and government. Across these areas, she has been a powerful advocate for diversity and inclusion in STEM.

As a graduate student in the early 1990s, she was the first to determine the maximum data rate (Shannon capacity) of time-varying wireless channels, and that it was achieved by adaptive modulation, whereby the data rate and power are adapted to channel conditions. She also developed practical adaptive modulation and coding techniques that exploited these ideas to achieve close to these fundamental limits. She later extended these results to find the fundamental capacity limits as well as practical schemes to achieve these limits for time-varying multiple-antenna (MIMO) single-user and multi-user channels, which utilize the spatial domain to simultaneously transmit to/from multiple client devices. Her work was instrumental in demonstrating how these spatial dimensions are best utilized in wireless system design to maximize user data rates while ensuring robust performance. Technology in all current cellular and Wi-Fi systems utilize adaptive modulation and adaptive MIMO techniques.

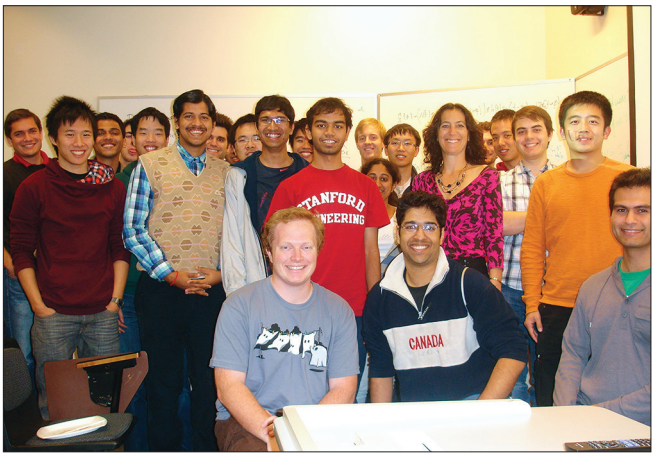
Goldsmith's lab also pioneered the use of machine learning (ML) to improve communication system performance. Her early work in this area utilized ML to equalize the channel for a molecular communication system, which encodes bits as acids (ones) and bases (zeros). These molecules propagate via diffusion, which is non-linear and introduces significant memory in the channel. These properties make it challenging to mitigate intersymbol interference using traditional equalization techniques. Goldsmith's group demonstrated that ML-based equalization resulted in a ten-fold improvement in data rates over existing equalization techniques. Her group then generalized these ideas to develop ML-based equalization for wireless communications, demonstrating that such techniques can "beat theory", meaning that ML-based equalization leads to better performance than that of the theoretically-optimal Viterbi equalizer when the channel is unknown or the processing has complexity constraints.

Other notable research contributions by Goldsmith include energy-constrained ad hoc wireless networks design. This work revisited the underlying principles of modulation, coding, multiple access, and routing when networked devices have a finite battery life such that they cannot be recharged. She has also made innovative contributions in analog-to-digital compression, demonstrating that sub-Nyquist sampling can be optimal in a joint optimization of sampling and compression. Her group also developed signal processing algorithms for neuroscience, with a focus on epilepsy, one of the most common neurological disorders. Their research uses signal processing techniques to allow more precise localization of seizure onset zones in the brain to facilitate better surgical treatments. This work combines tools from signal processing, information theory, graph theory, and time-series analysis. Her most recent work focuses on distributed learning, inference, and consensus among wireless networked devices, taking into account channel characteristics, resilience, privacy, and trust.

Goldsmith grew up in the San Fernando Valley of Southern California, where her mother was a cartoonist and character designer for the Rocky and Bullwinkle show. Her father was a professor of mechanical engineering at U.C. Berkeley. She attended Los Angeles public high schools but left a year and a half early by taking the proficiency exam. In lieu of high school, she took classes at the local junior college where she was inspired by her fantastic teachers in English, French, history, and algebra. A summer language program in Paris when she was 17 turned into a year of traveling through Europe, including significant time in Greece, where she learned the language through Greek Rembetiko songs. She reluctantly returned to the United States from that magical year in Europe to start college at U.C. Berkeley. She recalls being a good but not excellent student in math and science that first year due to her lack of preparation. She saw engineering as a way to make a positive difference in the world, but was discouraged by the sense that she did not belong in engineering, exacerbated by the lack of women engineers as peers, teachers, and mentors. She enjoyed her classes in politics, foreign languages, and philosophy, and considered switching her major from engineering to politics. A turning point was an algebra class where she encountered her first female teaching assistant. She did very well in the course and ultimately decided to continue in engineering. She was particularly interested in the mathematical side of engineering, including the underlying mathematics of communications and signal processing.

After graduating, Goldsmith took a job with a small start-up company, Maxim Technologies, which was working on defense communications. This was before widespread consumer networking or wireless technologies, so the defense arena was the center of interesting communications work. She worked there for three years on satellite and antenna array systems. The work, and the ability of her Ph.D. colleagues to tackle challenging technical problems, inspired her to pursue a graduate degree. She was accepted at U.C. Berkeley, where Professor Pravin Varaiya became her advisor. In the middle of her graduate work, Goldsmith attended the IEEE GLOBECOM conference where she met Larry Greenstein, a department head at Bell Labs who later offered her a summer internship at Crawford Hill, New Jersey, which she did for two summers. There she worked with Larry as well as Gerry Foschini, whose research played a key role in advancing MIMO technology and influenced the direction of her doctoral work.

After earning her Ph.D. at U.C. Berkeley in 1994, Goldsmith accepted a job as assistant professor at Caltech in Pasadena, returning to Southern California where she grew up. In 1999 she moved back to the Bay Area to join the electrical engineering department at Stanford. In 2006, she took a leave from Stanford to serve as co-founder and CTO of Quantenna Communications. Quantenna was founded to develop high-performance Wi-Fi chipsets based on the emerging 802.11n MIMO standard; Goldsmith wanted to demonstrate that the MIMO communication theory she had developed as an academic could actually make a difference in practical wireless systems. The company's Wi-Fi chipsets were the first to enable wireless



video distribution through the home, and remain the Wi-Fi performance leader to this day. She worked full-time building the company and its technology until returning to the Stanford faculty in 2008. After numerous ups and downs, Quantenna held an initial public offering in 2016 and was later acquired by ON Semiconductor. In 2010, Goldsmith co-founded a second company, now called Plume Wi-Fi. Plume develops cloud software and associated mesh network nodes to optimally adapt the parameters of in-home mesh Wi-Fi networks to changing user requirements, locations, and environmental conditions.

Beyond her research and startups, Goldsmith has served in numerous leadership and professional service roles. She is the founding chair of the IEEE Board of Directors Committee on Diversity and Inclusion. She served as President of the IEEE Information Theory Society in 2009, as founding chair of its student committee, and as founding Editor-in-Chief of the IEEE Journal on Selected Areas in Information Theory. She has also served on the Board of Governors, as a journal editor, and as a conference organizer for both the IEEE Information Theory and Communications Societies. At Stanford she served as chair of Stanford's Faculty Senate and for multiple terms as a senator, and on its Appointments and Promotions Advisory Board, Budget Group, Committee on Research, Planning and Policy Board, Commissions on Graduate and on Undergraduate Education, and Task Force on Women and Leadership. She currently serves as an independent director on the corporate boards of Intel, Medtronic, and Crown Castle. In 2021, she was appointed by President Biden to the President's Council of Advisors on Science and Technology.

As dean of engineering at Princeton, Goldsmith has undertaken a bold plan for growing the size and impact of the school. She also aspires for Princeton engineering to serve as a catalyst for entrepreneurship and innovation across the tri-state region, while also significantly strengthening its culture of inclusion and increasing the diversity of its faculty, students, and staff. As part of this plan, Princeton is growing the size of its engineering faculty by almost 50%, building an entirely new neighborhood with new buildings for engineering departments and interdisciplinary institutes, and building facilities and programs dedicated to innovation, entrepreneurship, and forging stronger ties with industry.

Goldsmith has received broad recognition for her work, including election to the U.S. National Academy of Engineering, the American Academy of Arts and Sciences, and the U.K. Royal Academy of Engineering. Other honors include the Marconi Prize, the ACM Sigmobile Outstanding Contribution Award, the IEEE Sumner Technical Field Award, the ACM Athena Lecturer Award, the ComSoc Armstrong Technical Achievement Award, the Kirchmayer Graduate Teaching Award, the WICE Mentoring Award, and the Silicon Valley/San Jose Business Journal Women of Influence Award. She is author of the book "Wireless Communications'' and co-author of the books "MIMO Wireless Communications," "Principles of Cognitive Radio," and "Machine Learning and Wireless Communications," all published by Cambridge University Press, as well as an inventor on 29 patents. Her "best results" are her two children Daniel and Nicole Salz, joint with co-creator Arturo Salz, her husband of three decades.