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RESEARCH INTEREST:

My research interest broadly involves combining signal processing algorithms and system architectures to solve real-world problems in wireless communication and sensing. Aspects of my research include ultra-massive MIMO systems for the next-generation high-speed wireless networks (i.e., 6G), and application of the RF-photonic techniques to ultra-wideband, low latency communication and sensing. Identifying funding opportunities relevant to the wireless industry and offering commercially feasible solutions are particularly motivating, as they put my decades of industry/product insight to productive use.

EDUCATION:

Ph.D. in Electrical Engineering, University of Connecticut, 1992
Dissertation: “Analysis and applications of Darwinian optimization algorithms in multi-dimensional spaces”

M.S. in Electrical Engineering, University of Connecticut, 1989
Thesis: “Visual signal processing properties of the clock-spike and eye muscle (CSEM) system of a dipteran fly”

B.S.E.E., Jiao-Tong University, 1985

EXPERIENCE: Three decades of R&D leadership in wireless and wireline communications

Research Professor, Department of Electrical and Computer Engineering, University of Delaware, 140 Evans Hall, Newark, DE 19711 (05/22-present)

- Co-founder and executive director of UD-WiSE, an ECE departmental interdisciplinary research center focusing on wireless communication and sensing using RF-photonic techniques.
- Write research proposals to NSF and private foundations
- Supervise graduate students

Chief Strategy Officer, Phase Sensitive Innovations, Inc., 116 Sandy Drive, Newark, DE 19713 (06/21-06/25)

Identified commercial potential of existing PSI IP portfolio and guide architectural innovation of photonic integrated circuits (PIC) for interception of 6G roadmap. Deliver technical presentations to wireless industry forums such as IWPC. Explore collaboration opportunities with Tier-1 equipment manufacturers.

Senior Director, Radio Algorithms Research, Futurewei Technologies, Bridgewater, NJ (09/14-01/21)

- Built the department from the ground up. Recruited high-caliber researchers from prominent industrial R&D entities (e.g., Bell Labs, NEC Labs, BRCM), sought for their proven depth in three complementary domains: signal processing, information theory and numerical optimization.
- Achieved sustained funding growth throughout the department's existence. Decided on new research directions and chartered new projects on an annual basis, driven by own judgement on market dynamics, external research trends, and product feasibility. In 2017, was among the first in the company to advocate joint communication and sensing as a key driver for 6G industry verticals, and a fertile target for AI application. Today, the 'Comm. & Sense' vision thus formulated is borne out by the industry and academia consensus on 6G. Projects included (but were not limited to) ultra-massive MIMO beamforming, ultra-reliable low latency communications (URLLC), physics-based wireless research, FDD massive MIMO.
- Obtained funding for and ran a successful external university/industry collaboration program from 2015 to 2020. Identified several collaboration topics that turned out fruitful. Among long-term partners were Phase Sensitive Innovations, Inc., Columbia, NYU Wireless, Berkley Wireless Research Center, among others.
- Obtained funding for and ran the Wireless Algorithms Internship Program for six consecutive summers (2015-2020). Screened intern candidates from top university research labs. Provided them with guidance on research methodology, directional decisions, and people skill, that contributed to post-Ph.D. employments of several interns by prominent US firms, e.g., AT&T Labs, Qualcomm, Marvel Technologies, Intel, and MathWorks.

Technical Manager (2012), Systems Group, Mobility Business Unit, Broadcom Corp. Mattawan, NJ (1/07-09/14)

- 3GPP LTE (a.k.a. 4G)
 - Receiver design and implementation, including iterative MIMO detector, Coordinated Multi-Point, channel estimation, sub-optimal rank-4, 256-QAM MIMO detector
 - Project Lead and DSP system architect of LTE C++ link level simulator with a multi-national team
- 3GPP GERAN (a.k.a. 2G)
 - Complete space-time equalizer algorithm spec (3GPP DARP Phase II)
 - Sole designer of an adaptive RF spur canceller for the low-IF receiver
 - Sole designer of a timing tracking algorithms for the dual-SIM feature
 - Project Lead of a successful effort to close performance gaps against competitors, resulting in timely shipping of 120 million chipsets

Lead Research Scientist, CTO's Office, Intel Mobility Group, Woodbridge, NJ (7/04-12/06)

- Explored advanced MIMO receiver architectures for coded-OFDM system for Intel's Wi-Fi and LTE products, including lattice-reduction based high-order MIMO receiver, uniform-decomposition based MIMO link adaptation, and an investigation on Tx diversity vs. maximal-likelihood receiver.
- Project Lead for the physical layer simulation of the WiMAX PHY
 - Architected and guided delivery of an end-to-end link level simulator that supports the system level simulation and customer engagement
 - Participated in defining system level simulation methodology, that translates link level results to network performance (spectral efficiency, coverage, outage probability, etc.)

- Coordinated design activities across New Jersey, California, Russia, Israel, and China

Senior Director, Design Center Manager, Intel Corp., Morganville, NJ (4/01-12/03)

- Led the Advanced R&D team of 8, designing and architecting various systems for networked consumer devices.
- Successful inception of the Advanced Access Architecture (AAA) project for multi-mode broadband access chipset. Obtained corporate funding for 10 people, to work on re-configurable silicon for integration into Intel Pentium platform
- Led Intel's single-carrier symmetrical DSL product efforts, that resulted in a bit-exact end-to-end firmware implementation on ARC DSP cores

Senior Staff Engineer, Level One Communications, Inc., continued as Intel after 1999, Morganville, NJ (6/98- 4/01)

- Led the algorithm team in the simulation for a dual-mode DSL architecture
- Wrote an end-to-end simulator for the ADSL standard, including TEQ, FEQ, bit allocation, etc. Also wrote MATLAB tools for finite length DFE performance bound calculations
- Designed and simulated a complete set of algorithms for channel probing and rate adaptation for Level One's SHDSL products

Member of Technical Staff, Globespan Semiconductor Inc. Red Bank, NJ (6/97-6/98)

- Designed near maximum-likelihood sequence estimation (MLSE) algorithms, including multiple reduced-complexity alternatives
- Wrote a C simulator that supports full-duplex adaptation with DFE and MLSE, for performance verification

Member of Technical Staff, AT&T (later Lucent) Microelectronics, Middletown, NJ (5/94-6/97)

- Designed/implemented key receiver components for the 56Kbps PCM modem, including DFE, receiver front-end filter, sample rate converter, and digital impairments compensation during training
- Designed/implemented a multi-tasking DSP OS kernel on Lucent's DSP1600 for multimedia application.
- Designed ISDN interface for V.34 modem on the central office side, implemented variable-phase sample rate converter
- Enhanced performance for several voice-band modems
 - V.34/V.32 receiver performance enhancements (DPSK receiver, fast echo path tracking, etc.).
 - V.27/V.29 fax fast retrain

Staff Engineer, DSP Software Engineering Inc., Bedford, MA (11/92-5/94)

- Voice compression techniques. Solely responsible for implementing world's first full-duplex G.728 LDCELP standard on a single TI C50 chip. Also participated in ITU activity on G.728, and supported integration efforts of Toshiba as the first customer
- Reduced-complexity realization of a Viterbi decoder for a TCM employed in a V.32bis soft modem

HONORS / APPOINTMENTS

Senior Member, IEEE, 2020

Invited Speaker at Princeton 5G Summit, Spring 2015

Governor William O'Neill Scholarship, 1986

PROFESSIONAL ACTIVITIES

Associate Editor, IEEE Communications Society Technology News (CTN)

Reviewer for IEEE conferences and journals.

SELECTED PROJECTS

Below is a selection of accomplished projects that I initiated and secured corporate investments for, either as a Project Manager (industry equivalent to Principal Investigator), or de facto leader by way of securing funding and guiding execution.

Futurewei Technologies

- [1] All-digital low-resolution AD/DA algorithms and architectures for millimeter wave (mmW) massive MIMO front end. It was a two-year, multi-national, internal-external collaboration project that I initiated and obtained full funding for
- [2] Optoelectronic beamformer for ultra-wideband massive MIMO communications (in collaboration with Phase Sensitive Innovation, Inc.). It was a successful two-year collaboration with Phase Sensitive Innovations, Inc. I was responsible for identifying the technology's breakthrough potential as early as 2015, winning over skeptical sponsors, and obtaining funding.
- [3] Link adaptation and power control algorithms for Ultra-Reliable Low Latency Communications (URLLC). I foresaw the practical benefits of the finite-blocklength information theory to base station adaptation and prioritized accordingly.
- [4] Physics-based wireless research for beyond-massive-MIMO beamforming techniques: building the next generation of wireless PHY from a wave theory of information (in collaboration with NYU Wireless)
- [5] Channel reconstruction and beamforming algorithms for FDD massive MIMO systems.
- [6] Distributed indoor non-line-of-sight (NLoS) localization with side information
- [7] Novel MIMO imaging radar waveform for multi-radar interference mitigation
- [8] Radar-communication spectral co-existence, and passive OFDM radar (external collaboration)

Broadcom Corp.

- [9] LTE link level simulation platform Proposer, Project Manager, and Software Architect of Broadcom's organic end-to-end C++ link level simulator. Led a multi-site team from NJ, CA, and Israel.
- [10] Advanced receiver design and optimization Delivery of iterative detection-decoding algorithms for the baseband chips for 2G and 4G handsets.

Intel Corp.

- [11] MIMO soft de-mapper based on lattice reduction, for Intel's Wi-Fi products
- [12] Link adaptation based on uniform channel decomposition (UCD) for Intel's LTE products
- [13] Advanced Access Architecture (AAA) project for multi-mode broadband access chipset. Obtained corporate funding for 10 people, to work on re-configurable silicon for integration into Intel Pentium platform

SELECTED PATENTS

- [1] 6000269US01: N. Prasad, M. M. U. Chowdhury and **X.-F. Qi**, “Methods and Apparatus for Channel Reconstruction in Intelligent Surface Aided Communications”, filed on 8/13/2020
- [2] 6000253PCT01: E. Balti, A.M. Shteiman and **X.-F. Qi**, “System and Method for Map-Assisted Location Estimation”, filed on 12/1/2020
- [3] 6000226PCT01: A.M. Shteiman and **X.-F. Qi**, “Beam-Time Hopping modulation for automotive radars”, filed on 10/12/2020
- [4] 6000141PCT01: G. Yue and **X.-F. Qi**, “Methods and Apparatus for Channel Estimation and Precoding with Incomplete Channel Observation and Channel State Information Feedback”, filed on 5/11/2020
- [5] 6000189PCT02: G. Yue and **X.-F. Qi**, “Apparatus and Methods for Multi-Domain Conversions of High Dimensional Channel Statistics”, filed on 8/25/2020
- [6] 6000108PCT02: K. Gao, A.M. Shteiman, L. Mailaender, **X.-F. Qi**, “Iterative random search for optimal one-bit precoding in massive MIMO downlink”, filed on August 26, 2020,
- [7] 6000085PCT01: A.M. Shteiman, **X.-F. Qi**, “Predictive ADC array for MIMO receiver”, filed Oct. 29, 2019
- [8] 6000108US01: K. Gao, A.M. Shteiman, **X.-F. Qi**, “Iterative random search for optimal one-bit precoding in massive MIMO downlink”, filed on October 28, 2019
- [9] 10,404,342: G. Yue, B. Zhang, **X.-F. Qi**, “Multiuser MIMO for large antenna systems with hybrid beamforming”, September 3, 2019
- [10] 10,320,061: G. Yue, **X.-F. Qi**, “High dimensional (HiDi) radio environment characterization and representation”, June 11, 2019
- [11] 10,270,625: G. Yue, **X.-F. Qi**, “Hardware virtualization for mean and variance estimations of QAM symbols”, April 23, 2019
- [12] 10,211,844: A. M. Shteiman, **X.-F. Qi**, “Minimum search length analog to digital converter”, February 19, 2019
- [13] 10,205,491: A. M. Shteiman, **X.-F. Qi**, “System and method for large scale multiple input multiple output communications”, February 12, 2019
- [14] 10,148,329: G. Yue, **X.-F. Qi**, “Adaptively grouped user equipment multicasting and beamforming”, December 4, 2018
- [15] 10,079,629: W. Ao, G. Yue, **X.-F. Qi**, “Apparatus and method for pre-coding data based on channel statistics”, December 4, 2018
- [16] 10,045,352: G. Yue, **X.-F. Qi**, “Channel estimation in large scale MIMO systems using iterative location based spatial filtering”, August 7, 2018
- [17] 10,020,922: G. Yue, **X.-F. Qi**, “High dimensional (HiDi) radio environment characterization and representation”, July 10, 2018
- [18] 9,979,445: A. M. Shteiman, **X.-F. Qi**, “Digital to analog converter apparatus, system, and method with quantization noise that is independent of an input signal”, May 22, 2018
- [19] 9,917,723: G. Yue, **X.-F. Qi**, “Efficient methods and recursive/scalable circuit architectures for QAM symbol mean and variance estimations”, March 13, 2018
- [20] 9,900,112: A. M. Shteiman, **X.-F. Qi**, “Method for calibration of a MIMO array based on an opportunistic signal”, February 20, 2018
- [21] 9,800,384: A. M. Shteiman, **X.-F. Qi**, “System and method for multi-source channel estimation”, October 24, 2017
- [22] 9,768,928: G. Yue, **X.-F. Qi**, “High dimensional (HiDi) radio environment characterization and representation”, September 19, 2017
- [23] US20080152027A1: S. Kalluri, **X.-F. Qi**, Keith A. Holt, “OFDM receiver and method for decoding ofdm symbols of two or more data streams with reduced multiplication operations”, Feb 1, 2011
- [24] US8077796B2: **X.-F. Qi** and K. Holt, “Methods and arrangements for communicating in a multiple input multiple output system”, December 13, 2007
- [25] US20060217937A1: C. Han, A. Dandawate, **X.-F. Qi**, “Reflectometer with echo canceller”, September 28, 2006

SELECTED PUBLICATIONS

- [1] **X.-F. Qi** and D. W. Prather, "Space-Time Radio Signal Processing by Photonic BeamSpace Computing," in *Handbook of Statistics 54: Multidimensional Signal Processing*, A. S. R. Srinivasa Rao, K. V. Mishra, and G. R. Arce, Eds. Elsevier, to be published, 2026
- [2] M. S. Ullah, D. W. Prather, and **X.-F. Qi**, "BIRC: BeamSpace interference rejection with beam selection for uplink massive-MIMO at mmWave," *IEEE Open Journal of the Communications Society*, vol. 6, pp. 9158-9169, 2025, doi: <https://doi.org/10.1109/OJCOMS.2025.3625731>
- [3] **X.-F. Qi** and M. S. Ullah, "Effect of beam selection on the uplink spectral efficiency of distributed MIMO," presented at the Biennial Symp. on Communications (BSC), Sherbrooke, Canada, Jun. 4, 2025.
- [4] S. I. Chowdhury, H. Sinigaglio, M. S. Ullah, S. Shi, **X.-F. Qi**, J. N. Mait, G. J. Schneider, J. Murakowski, and D. W. Prather, "Coherently distributed RF antenna arrays using photonic links," *Optics Express*, vol. 33, pp. 36919-36929, 2025, doi: <https://doi.org/10.1364/OE.562685>.
- [5] **X.-F. Qi**, J. A. Murakowski, G. J. Schneider, D. W. Prather, "C-RAN at Millimeter Wave and Above: Full-BeamSpace Radio Access Architecture," 2023 32nd Wireless and Optical Communications Conference (WOCC), Newark, NJ, USA, 2023, pp. 1-6
- [6] D. W. Prather, S. Galli, G. J. Schneider, S. Shi, J. A. Murakowski, **X.-F. Qi**, C. Schuetz, "Fourier-optics based opto-electronic architectures for simultaneous multi-band, multi-beam, and wideband transmit and receive phased arrays", *IEEE Access*, 2021
- [7] A. Molev-Shteiman and **X.-F. Qi**, "Beam-Time Hopping modulation for automotive imaging radars interference mitigation," *Proc. COMCAS 2021*, Tel Aviv, Israel, November 2021
- [8] A. Molev-Shteiman and **X.-F. Qi**, "Clock compression for SAR ADC array with Gaussian input vector," *Proc. COMCAS 2021*, Tel Aviv, Israel, November 2021
- [9] N. Prasad, M. M. U. Chowdhury and **X.-F. Qi**, "Channel Reconstruction in Intelligent Surface aided Communications," *Proc. IEEE COMSNETS 2021*
- [10] M. Dajer, Z. Ma, L. Piazzzi, N. Prasad, B. Sheen, **X.-F. Qi**, J. Yang, and G. Yue (corresponding author), "Reconfigurable intelligent surface: design the channel – a new opportunity for future wireless network," *ScienseDirect open access journal Digital Communications and Networks (DCN)*, 2020
- [11] D. Bedheka, N. Prasad, Z. Ma, L. Piazzzi and **X.-F. Qi**, "IRS Aided Communication Model for Compact MIMO Systems," *Proc. ICC 2021*
- [12] K. Gao, A. Molev-Shteiman, L. Mailaender, **X.-F. Qi**, "Iterative random search for optimal one-bit precoding in massive MIMO downlink," *Proc. WCNC 2021*
- [13] A. Molev-Shteiman, **X.-F. Qi**, L. Mailaender, N. Prasad and B. M. Hochwald, "New equivalent model of a quantizer with noisy input and its applications for MIMO system analysis and design," *IEEE Access*, vol. 8, pp. 162601-162624, 2020
- [14] G. Yue and **X.-F. Qi**, "High Dimensional channel characteristics and multi-Domain conversions for massive MIMO," *Proc. GLOBECOM 2020*
- [15] G. Yue and **X.-F. Qi**, "Adaptive grouped physical layer multicasting and beamforming for massive MIMO", *Proc. VTC-Fall 2020*
- [16] G. Yue, B. Zhang, and **X.-F. Qi**, "Joint beam management and user scheduling for massive MIMO with hybrid beamforming and limited feedback", *Proc. VTC-Fall 2020*
- [17] N. Prasad, **X.-F. Qi**, and A. Molev-Shteiman, "Optimizing resolution adaptive massive MIMO networks," *Proc. INFOCOM 2020*
- [18] G. Yue and **X.-F. Qi**, "Efficient methods and architectures for mean and variance estimations of QAM symbols", In *Proceedings of IEEE Wireless and Optical Communication Conference (WOCC)*, Newark, NJ, May 2020 (Invited)
- [19] J. Choi, J. Sung, N. Prasad, **X.-F. Qi**, B. L. Evans, and A. Gatherer, "Base station antenna selection for low-resolution ADC systems," *IEEE Tran. Comm.* Vol. 68, Issue 3, pp. 1951-1965, March 2020
- [20] N. Prasad and **X.-F. Qi**, "A decoupling property in low-resolution MIMO-OFDM systems and its applications," *Proc. ComsNets 2020*

- [21] A. Molev-Shteiman, **X.-F. Qi**, “Maximal entropy reduction algorithm for SAR ADC clock compression,” *Proc. COMCAS 2019*, Tel Aviv, Israel, 2019
- [22] A. Molev-Shteiman, L. Mailaender, **X.-F. Qi**, “Distributed massive MIMO channel estimation and channel database assistance,” *Proc. COMCAS 2019*, Tel Aviv, Israel, 2019
- [23] N. Prasad, Q. Zhang, **X.-F. Qi**, “Channel reconstruction via quadratic programming in massive MIMO Networks,” *Proc. WiOpt 2019*
- [24] G. Yue, B. Zhang, **X.-F. Qi**, and L. J. Cimini Jr., “Generalized JSMD with enhanced interference management for massive MIMO systems,” *Proc. WCNC'19*, Marrakech, Morocco, 2019
- [25] S. Galli, G. J. Schneider, S. Shi, J. A. Murakowski, **X.-F. Qi**, M. Kermalli, D. W. Prather, “A novel opto-electronic architecture for large multi-band and multi-beam phased arrays,” *Proc. WCNC'19*, Marrakech, Morocco, 2019
- [26] N. Prasad, **X.-F. Qi**, A. Gatherer, “Optimizing beams and bits: a novel approach for massive MIMO base-station design,” *ICNC 2019*: 970-976
- [27] N. Prasad, **X.-F. Qi**, “Downlink multi-user MIMO scheduling with performance guarantees,” *Proc. WiOpt 2018*
- [28] A. Molev-Shteiman, S. Galli, L. Mailaender, **X.-F. Qi**, “The effect of diversity combining on ISI in massive MIMO,” in *Proc. 2018 IEEE 88th Vehicular Technology Conference (VTC-Fall)*, 2018
- [29] L. Mailaender, A. Molev-Shteiman, **X.-F. Qi**, “Direct positioning with channel database assistance,” in *Proc. ICC 2018*
- [30] G. J. Schneider, J. A. Murakowski, S. Shi, M. Kermalli, S. Galli, **X.-F. Qi**, D. W. Prather, “Multiuser-MIMO transmitter based on optical polar-vector modulators,” *IEEE Photonics Technology Letters*, v.30, issue 2, pp. 1834-1837, 2018
- [31] F. Wang, S. Shi, G. J. Schneider, P. Yao, C. Schuetz, J. M, **X.-F. Qi**, M. Kermalli, X. Liu, D. W. Prather, “Photonic generation of high fidelity RF sources for mobile communications,” *J. Lightwave Tech. vol. 35, no. 18, September 15, 2017*
- [32] **X.-F. Qi** and K. Holt, “A lattice-reduction-aided soft demapper for high-rate coded MIMO-OFDM systems”, *IEEE SP Letters*, Vol. 14, No. 5, May 2007
- [33] **X.-F. Qi**, F. Palmieri, “Theoretical analysis of evolutionary algorithms with an infinite population size in continuous space. Part I: Basic properties of selection and mutation,” *IEEE Trans. Neural Networks* 5(1): 102-119 (1994)
- [34] **X.-F. Qi**, F. Palmieri, “Theoretical analysis of evolutionary algorithms with an infinite population size in continuous space. Part II: Analysis of the diversification role of crossover,” *IEEE Trans. Neural Networks* 5(1): 120-129 (1994)