Victor Bahl

Technical Fellow – Research
Microsoft Research
MICROSOFT CORPORATION, Redmond, WA
https://www.microsoft.com/en-us/research/people/bahl/

I am a Technical Fellows at Microsoft (~227K full-time employees). My 35+ years of work experience includes 12 years in product engineering & advanced development and the rest in research & incubations. During this time, I have advised Microsoft CEOs Bill Gates & Steve Balmer, and continue to advise current CEO Satya Nadella and his senior leadership team on technical strategy and long-term vision related to networked systems. Recently I served as the CTO of a new business division called Azure for Operators that I co-founded. Previously, I served on Microsoft Research Redmond Lab Leadership Team overseeing 350+ researchers, engineers, and staff. Before that, I served on Microsoft Research Labs Global Leadership Team working directly with the head of MSR Labs on matters related to the health, technical strategy, and vibrant functioning of our world-wide Labs. I lead a group that executes our vision through research, new product incubations, industry partnerships, and associate policy engagement with governments and research institutions around the world.

I started networking research at Microsoft in 1997 and formally founded the *Networking Research Group* in 2001, later I expanded it to *Mobility & Networking Research Group* in 2010. Over the years I have delivered consistently and substantially. For example, we completely re-designed the Azure global data center network architecture (VL2/Q10) and several of its important components incl. Azure software load balancers, Azure software-defined wide-area network, and recently Azure remote direct memory access. Cloud providers have adopted our designs as de-facto industry standards. Working closely with a colleague in academia, I created a paradigm shift in cloud computing with the introduction of edge computing, which Microsoft comprehensively embraced with a $5B investment. My group has built bestselling devices incl.XBOX wireless controllers and cloud services incl. Mixer HypeZone, Open Network Emulator (cloud-scale network emulator), Embedded Social, cloud-based Cognitive Services, Rocket (video analytics engine), and AFO vRAN. Additional technologies I delivered include white space networking, which opened 180 MHz of US spectrum for unlicensed use. It is now set to provide broadband access to over two million US citizens living in rural areas. I developed the world's first Wi-Fi hotspot, first indoor Wi-Fi localization system, first wireless virtualization and multi-radio system. For seminal contributions, I have been honored with prestigious research & leadership awards including two IEEE's top awards in networking (2018 & 2019) and ACM lifetime achievement awards in mobile systems (2013) and in distinguished service and leadership (2019). My research has been cited extensively (h-index 105; 76K+ citations) and incorporated into multiple industry standards and commercial systems & products. I have over 200 US issued patents; many have led to significant business wins. I have given close to seventy keynotes and plenaries, five dozen seminars and two commencement speeches at a major public university (2018 & 2024).

My group members have graduated and become executives in product teams (incl. two corporate vice presidents, a distinguished engineer, and several partner-level FTEs); two are directors of major labs.; six are professors at top universities (incl. MIT, Cornell, UIUC, UCLA, UW, & UTA), a few took senior positions in Databricks, uber, Google & Amazon. We have published well over 600 papers, created a portfolio of over 500 patents, won numerous prestigious international awards, and received world-wide press accolades in over a thousand articles. We have engaged closely with academia and government organizations worldwide and funded significant research. Our software has been downloaded more than a million times and our academic tool kits have been used by over 1200 universities world-wide.

Recognition & Awards

- DEANS AWARD FOR ACHIEVEMENT 2024, School of Engineering and Applied Science, University at Buffalo
- ACM SIGMOBILE TEST OF TIME AWARD 2022 for *pioneering edge computing*
- DISTINGUISHED ALUMNI AWARD 2020, Dept. of Electrical & Computer Eng., University of Massachusetts
- IEEE INFOCOM ACHIEVEMENT AWARD 2019 (INFCOM community's highest honor for technical contributions)
- ACM DISTINGUISHED SERVICE AWARD 2019 (ACM's highest honor for professional service & leadership)
- COMMENCEMENT SPEAKER 2018 & 2024, School of Engineering & Applied Sciences, University of Buffalo
- IEEE KOJI KOBAYASHI COMPUTERS & COMMUNICATIONS AWARD 2018 (top award in networking)
- SIGMOBILE TEST OF TIME AWARD 2018 for *pioneering a multi-radio system that increases the lifetime of IoT devices*
- DISTINGUISHED ALUMNI AWARD 2017, University at Buffalo (presented at CSE dept. 50th anniversary)
- SIGMOBILE TEST OF TIME AWARD 2016 for *pioneering a RF indoor location tracking system for mobile devices*
- BEST PAPER AWARDS: MOBICOM 2024; SEC 2020, MOBISYS 2013; SIGCOMM 2009; CONEXT 2008
- SIGMOBILE (LIFETIME) OUTSTANDING CONTRIBUTIONS AWARD 2013 (top award in mobile systems)
- IEEE OUTSTANDING LEADERSHIP & PROFESSIONAL SERVICE AWARD 2013, REGION 6 (US WEST, 50K+ members)
- UNIVERSITY DISTINGUISHED ALUMNI AWARD 2012, University of Massachusetts (presented at Boston City Hall)
- National Awards from the US Government:
  - TRANSPORTATION ACHIEVEMENT AWARD 2017 for Safety via Video Analytics, Institute of Transportation Engineers & Canadian Institute of Transportation Engineers
  - U.S. MAYORS' CHALLENGE AWARD 2016 for Pedestrian & Bicycle Safety (Safer People, Safer Streets Summit, Washington, D.C.)
  - U.S. FEDERAL COMMUNICAIONS COMISSION (FCC) OPEN INTERNET APP AWARD 2011
  - U.S. FCC PEOPLE'S CHOICE APP. AWARD 2011 for a Mobile Network Measurement System
- IEEE OUTSTANDING ENGINEER AWARD 2010, IEEE REGION 6 (Western US, 50,000+ members)
- AAAS FELLOW 2010, IEEE FELLOW 2008, ACM FELLOW 2003.
- SIGMOBILE DISTINGUISHED SERVICE AWARD 2001, Association of Computing Machinery
- Awards from Microsoft:
  - HACKATHON 2017 GRAND PRIZE WINNER (4,750 projects/18K participants from 400+ cities, 75 countries)
  - INDIVIDUAL PERFORMANCE AWARDS 2007, 2010, 2011, & 2021 (top performing employee)
  - Microsoft's nominee to IPO's NATIONAL INVENTOR OF THE YEAR AWARD 2006 (reached final four)
  - SENIOR LEADER BENCH PROGRAM, Executive management for high performing Microsoft employees 2005
- By the numbers:
  - Author/co-author of over **200 United States Patents** (175 issued)
  - **h-index: 105;** citation count: 76,000+ (120+ papers); top 10 papers have 30,000+ citations; (*Google Scholar*)
  - Over 70 keynote and plenary talks at major international conferences, symposiums & workshops
  - 60+ Distinguished seminars at MIT, Stanford, Berkeley, CMU, ETH, EPFL, UCL, UW, Yale, UTA, Wisconsin, UIUC, Rice, WUSTL, IIT-D…
  - **21 Doctoral Dissertation Committees** incl. MIT (5), Stanford, Cornell, Harvard, UMASS, UW (2), UIUC, UCSD (2), Duke, Yale, Rice (2), U. Toronto, U. Maryland, University of Roma, & Rutgers. **6 won awards**.
  - 1000+ press articles in mainstream media including The New York Times, Technology Review, EE Times, Ars Technica, Boston Globe, Seattle PI, Nature Electronics, Information Week, Network World, New Scientist, DataQuest, Wired News, Geekwire, KIRO TV, etc.
- FEATURED in People of Association of Computing Machinery (Feb. 19, 2015)
- ACM DISTINGUISHED SPEAKER (2007-11); IEEE COMMUNICATIONS SOCIETY DISTINGUISHED LECTURER (2007-10)
- CHAIR, ACM Outstanding Contributions Award Committee (1996-2011); ACM Fellows Selection Committee (2020-present); IEEE INFOCOM Achievement Award Committee (2018-present); IEEE Fellows Committee; +…
- IEEE Computer Society (2009-10, 12); Fellow, University of Buffalo Research Foundation, 1986-88
- PHD FELLOWSHIP Award, Digital Equipment Corporation (now Hewlett Packard) 1994-96

Contributions & Impact – CTO Azure for Operators

I am one of the primary architects behind the formation of a new business division focused on the convergence of the telecommunications and the cloud industries. On the request of the CEO, I served as the CTO of the division named "Azure for Operators" from 2020 to 2024. I served on the LT of this 1600-person organization, with an annual budget of over $600 million, overseeing sales, marketing, engineering, program and product management. Formulated the vision for the group, engaged with international customers (telecom operators). Lead a group, called Office of the CTO, which produced cutting-edge technologies in OpenRAN, sustainability, advanced RAN features in Azure Far Edge, AI for network analysis and operations, and security and cloud management of telecommunication networks. Filed over 130 patents and built a campus-wide 5G software-only testbed. Gave dozens of keynotes with demos in industry and academic forums. Continued to pursue research (e.g. RAN Slicing, optical backbone slicing, Troubleshooting Assistant etc.) publishing research papers in top conferences.

Contributions & Impact – Microsoft Research (unordered)

- **Microsoft Rocket Video Analytics Platform for Urban Mobility, Retail & Enterprise** (2015 - 2019): was a highly scalable, geo-distributed hybrid-cloud real-time video analytics platform for accurately analyzing live video streams from cameras. We used Rocket to reduce accidents and congestion and to improve efficiency of movement on city roads. Rocket was deployed in Bellevue, Washington (Bellevue report), and as of Dec. 15, 2016 has been operating 24/7/365 covering five intersections, analyzing the number and direction of vehicles, pedestrians and bicyclist. Many other city jurisdictions requested us to deploy similar systems in their cities. We received two national awards (a Mayor's award and a DOT award) with lots of favorable media coverage. In late 2019 we released Microsoft Rocket to the public (GitHub code).

- **Edge Computing / Intelligent Edge / Hybrid Clouds (micro data centers, cloudlets)** (2009 - 2018): In collaboration with Mahadev Satyanarayanan (CMU), I envisioned, developed, & popularized edge computing, which has subsequently become a major technology extension of cloud computing. Published the first set of peer-reviewed papers that demonstrated how edge computing reduces latency and bandwidth to the cloud; reduces dependence on the Internet, and energy consumption of mobile and IoT devices. Introduced techniques for **cloud offloading** and **geo-distributed cloud analytics.** Microsoft's Azure IoT Edge & Data Box Edge, Amazon's AWS Outpost, IBM's Edge, Cisco's Fog, along with telecommunication companies and academic institutes have embraced our ideas. As of early 2022, the first two papers we published, in 2009 & 2010, have a citation count of 7250+. Also, I co-founded IEEE/ACM Symposium on Edge Computing and helped put together an NSF workshop on this topic. Currently working on **edge for telecommunications infra-structure** and **real-time video analytics hybrid-cloud service** for urban mobility and Vision Zero. Microsoft's CEO Satya Nadella publicly announced "Intelligent Edge" as a Microsoft IoT strategy with an investment of $5B. Received the **SIGMOBILE 2022 Test of Time Award** for this research.

- **The world's first urban white space network (WSN)** (2003-10): Led a small team of researchers that designed, built and deployed the world's first WSN, nick-named "WhiteFi", on Microsoft's Redmond campus on Oct. 16, 2009. Spearheaded Microsoft's spectrum management proposals to the FCC. Published seminal papers in top conferences, started conferences & workshops (SIGCOMM, DySPAN, INFOCOM's CWCN, MSR's CogNet), edited special issues of IEEE Journals, gave close to a dozen keynotes, influenced government policy world-wide (FCC, TRAI, SARFT, ANATEL etc.) & funding (NSF). Became the focus of world-wide press coverage. Co-led the MS team that had a significant hand in the Nov. 4, 2008 and Sept. 23, 2010 FCC ruling that opened 180 MHz+ of spectrum for unlicensed use in the United States. Microsoft has deployed more than **twenty large-scale WSNs world-wide** (search for "*Microsoft 4Africa*") **connecting >185,000 students/people to the Internet**. Microsoft's Airband initiative has promised to connect **two million people** in rural America by July 4, 2022**.

- **The world's first RF signal strength based indoor location determination system** (1999) Original papers have been cited over 10,500 times and in large part created the field of indoor positioning systems using commodity wireless LAN hardware. Several companies including Ekahau, Symbol, Nortel, Intel, Cisco, Nokia, NextNav, Google, and Microsoft have worked on commercializing similar system and many universities include this as

part of their course work, using it as a foundation for research in wireless systems that go beyond communications, and specifically in location and context aware systems. Awarded 12 U.S. and international patents and received **SIGMOBILE 2016 Test of Time Award** for this work. **This work created a popular thread of research on using RF signals for features other than communications.**

- **The first wake-on-wireless system** (2003) Introduced the notion of using a low power radio (as a control channel) to "wake up" the high-power system to improve its energy profile. The original MobiCom paper, cited over 500 times, opened a new thread of research and products incl. UMASS's Turduken, Intel's CoolSpots, MSR's Cell2Notify, Somniloquy, GreenUp etc. Awarded 4 US patents for this work. Our paper (850+ citations) received the **SIGMOBILE 2018 Test of time Award** and this work is the subject of the **IEEE 802.11ba** standard

- **Developed the first multi-radio mesh & wireless LAN system** (2003) Introduced important new design ideas on using multiple radios to improve the performance of wireless mesh networks, wireless LANs, and cell phones. These designs have proliferated deeply into the computer and telecommunication industry. Awarded 8 patents, published several papers with thousands of citations, and received considerable coverage from mainstream media for this work.

- **Designed & developed the first wireless virtualization architecture** (2002): Invented the first wireless virtualization architecture that enables a Wi-Fi card to connect to multiple networks simultaneously. Software downloads in the first year exceeded over 100,000 making it one of the most popular downloads in Microsoft Research's history. *Virtual Wi-Fi* became part of Windows 7 and Windows 8 and shipped to millions of users around the world. **It also powers** Window's (& other OS's) **implementation of Wi-Fi Direct.** Received many accolades from mainstream media. The design is fundamental to NSF's GENI WLAN virtualization efforts.

- **The world's first public Wi-Fi hotspot** (1999-2001): Deployed a Wi-Fi network in the Crossroads Shopping Center in Bellevue, Washington from June 11, 1999 to June 2001 (New York Times Article, Feb. 28, 2000). Today, the wireless edge server design is being used by all the major Wi-Fi equipment vendors (Aruba, Cisco, Meru, Broadcom etc.), beating out the competing IEEE 801.1x design. Published several papers, awarded 8 international patents & received significant press accolades.

- **Cognitive services for mobile computing** (2009 – 2012): Envisioned, developed, deployed and operated a *service-store* (**Project Hawaii**) that enabled developers to build sophisticated cloud-enhanced applications. Deployed a variety of cloud services (optical character recognition, speech-to-text, path prediction, social fabric, translation, relay, rendezvous, etc.) for Windows, Android, & IOS devices. Over 60 universities world-wide included our services in teaching senior and graduate-level mobile computing courses. **2015 onward the three major cloud providers commercialized similar services under the generic banner of cognitive services.**

- **60 GHz (mm-wave) wireless links in data centers (**2009-11): Demonstrated how mm-wave point-to-point links, built into top-of-the-rack (ToR) switches, can relieve congestion hot-spots in oversubscribed data center networks. Contrary to concerns about interference and link reliability, our design allowed many wireless links to operate concurrently at multi-Gbps rates. The design avoided rewiring costs in DCs and provided an intermediate step towards full bi-section bandwidth networks. The work resulted in multiple papers, patents, and was covered by popular press **including the New York Times** (July 14, 2012 issue).

- **Community mesh networking** (2003-07). Demonstrated mesh networking as an alternative broadband access technology in cities, neighborhoods, offices, and rural areas. Delivered keynotes & plenaries, and taught courses at premier conferences. Published multiple papers, awarded 8 international patents, received world-wide press coverage and accolades, and licensed our technology to several start-up companies. Put-together Microsoft's *Digital Inclusion Program* that provided $1.5M in research funding. Developed the **Mesh Networking Academic Resource Kits 2005 & 2007** as a teaching & research aid. Our kit was used by over 1200 Universities world-wide.

- **Enterprise & data center network management** (2005-10): Developed a unique end-to-end approach for diagnosing performance issues in large-scale networks. We reduced the diagnoses time from days to minutes improving customer SLAs. My big idea was to automatically create an **inference graph** by extracting a per-application **service dependency graph** via passively observing packet flows & then do iterative analysis to

pinpoint the problematic component. This idea has withstood the test of time as it created a new path for research in diagnosing large networks. Our system is actively used in XBox Live services (*Service Graphs*)

▪ **Co-designed & built the world's first commodity multimedia adapter for PCs** (1992). The hardware / software combination had real-time audio-video codec and image rendering capabilities. It was used world-wide for research in high-speed (ATM, FDDI) and packet video networks (Sequoia 2000, BERKOM, BAGnet & MBONE) and successfully productized by Digital Equipment Corporation via multiple prohects (*FullVideo* series)

Contributions & Impact – Azure, XBOX & WINDWS

Below is a sample of substantial technologies I have delivered to Microsoft engineering / product groups. These technologies were developed under my direction / watch. Several of these have defined or redefined significant parts of our industry (see "Awards").

1) **XBOX Mixer HypeZone (2017-18):** a highly scalable service that inexpensively analyzes video game streams in real-time to connect spectators to the top-performing streamers closest to winning the game. Our technology does not require modifications to the game. The XBOX Mixer team at Microsoft launched the HypeZone on Dec. 12, 2017 with their most popular PUBG game and received rave reviews for it. In just under 75 days, HypeZone increased Mixer's customer base by over 10% and it is still going strong. Parts of this technology are now being incubated as a separate business unit.

2) **Azure Cloud-Scale Network Emulator (2016-2017):** a high-fidelity, cloud-scale emulator that is routinely used by Azure network engineers to validate and reduce the risk of new network designs, major network architecture changes, network firmware/hardware upgrades and network configuration updates. They use it as a realistic test environment for developing network automation tools and for developing our in-house switch operating system called SONIC. CrystalNet was critical in enabling the migration of Microsoft Azure's regional backbones to a new standardized architecture with zero user impacting incidents, even though production traffic flowed through the network continuously during the migrations.

3) **Microsoft Embedded Social (2015-17):** a highly-scalable, highly-reliable Azure service that gives application developers complete access to a full social network stack, which they can tailor to their application, something they cannot do with the existing large social networks. Embedded Social powers the social features in the Windows 10 Creator's Update Remix 3D, a new Microsoft community where Windows users can share their 3D creations. It also powers the social features of several important Microsoft & non-Microsoft mobile applications incl. *OneBusAway.* As of December 1, 2017, Embedded Social was servicing ~18 million users.

4) **Azure Bandwidth Variable Transceivers for Microsoft Global Optical Networks (2015-16):** my team built a monitoring tool for one of the world's largest optical network to understand the behavior of the physical layer. Our analysis convinced Azure Networking to purchased bandwidth variable transceivers, which when fully deployed will upgrade 99 percent of the our 100 Gbps network segments to operate at 150 Gbps by simply changing the modulation at the two ends. This is expected to significantly improve the efficiency and capacity of Azure's optical networking without incurring big expenses of changing the fiber and/or intermediate amplifiers.

5) **Azure Pricing Tool (2015**): we built and transferred an automatic and comprehensive software service that compares the performance and cost of Azure to other cloud providers along various standard and non-standard metrics under various conditions. Azure changed the pricing methodology of its core services based on the output of our service.

6) **Windows Azure Network State Service (2013-2014)** – maintains the states of all network devices for all network management applications. NSS is deployed world-wide in all Microsoft Azure data centers. As of January 2014, it was managing more than a million links and 25,000 network devices. Azure Networking Corporate Vice President publicly called it the fundamental building block for Microsoft cloud networking.

7) **Azure's Wide Area Software Defined Network (2013-14)** - a centralized traffic engineering software system that led to an improvement of the inter-DC WAN bandwidth utilization from ~40% to over 90%+, thus freeing tens of thousands of servers and saving Microsoft millions of dollars annually.

8) **XBOX One Wireless Controller Protocol (2013-14)** - a high throughput, low latency, energy efficient propriety protocol between the XBOX One console and controllers. It won numerous accolades of mainstream press as the best controller in the gaming market.

9) **XBOX Service Graphs** (**2012**) – (Project name **Sherlock**) - a distributed dependency extraction technology, reduced performance diagnostics in enterprise & data center networks from days to minutes helping meet customer SLAs. A significant number of network diagnostic tools followed the approach (of dependency extraction and inference graphs) pioneered by Sherlock.

10) **Bing's Network Failure Recovery Technology (2012)** - reduced the recovery time for the common data center network failures from a few hours to tens of minutes (another version of Project Sherlock)

11) **Windows RT Firmware TPM (2011-12)** - enabled Microsoft to run software written for Intel® TPM on ARM TrustZone® thus enabling the widely used BitLocker and DirectAccess features and a new security feature called Virtual Smart Cards on Surface class devices.

12) **Windows Server GreenUp (2011-12)** – delivers significant power & monetary savings for enterprise customers by enabling seamless remote access to sleeping desktop machines. Shipped as a feature in Microsoft Systems Center product

13) **Windows Server Network Virtualization Technology (2011)** - enabled Windows to provide seamless connectivity between Microsoft's data centers and customers' on-premise networks. Our design heavily influenced the Hyper V network virtualization feature that shipped in Windows Server 2012.

14) **Windows Azure Software Load Balancer (2011)** – shifted load balancing to end-nodes already present in the cloud. Reduced cost by a factor of 15 [$60K versus $1M] by removing dependence on expensive hardware load balancers and improved cloud manageability.

15) **Windows Azure TCP for Data Center Networking (2010-12)** - improved performance of data center networks without incurring cost for expensive (big-buffer) hardware switches. It is implemented in our core networking stack and deployed in Azure data centers world-wide.

16) **Windows Azure Q10 Network (2009-10) -** hailed as one of the most significant recent advances in computer science, our CLOS network design led to an 80x improvement in dollars/Mbit/sec over previous designs. It has enabled blockbuster features such as highly-scalable Windows Azure Flat Network Storage. The researcher who developed this is now the Corporate Vice President and head of Azure Networking.

17) **Windows Virtual Wi-Fi (2009)** – allows an IEEE 802.11 miniport driver to connect to, or host, multiple simultaneous connections on a single wireless interface. Starting with Windows 7, it enabled concurrent corporate and guest access, range extension, and Internet gateway functionality. Before shipping, our prototype was downloaded 500,000+ times becoming one of the most popular MSR software download. **Wi-Fi Direct,** which ships in every Windows device (and in other OSs), uses Virtual Wi-Fi.

18) **NDIS WLAN extensions in Windows 2000, Windows XP, Vista & Windows 7 & 8 –** is the first set of industry-leading Network Device Interface Specification (NDIS) Wireless LAN (WLAN) OIDs (similar to IOCTLs) that enhanced the interface exposed by WinSock to program Wi-Fi cards. This led to the successful Windows Native Wi-Fi program, which has lasted over 15 years.

Several additional projects e.g. cloud services for mobile (**Project Hawaii**), virtual compass, mesh networking, indoor localization (**RADAR**) etc. have influenced the design of various commercial products. Other recent success stories from my group include **Torch -** cloud testing for concurrency bugs (2017) and **Optimized DNN for CNTK** (2017). Early in my career at Microsoft, I led the initiative to bring Wi-Fi to the entire Microsoft Redmond Campus.

Non-MSFT Shipping Technologies & Impact on Standards

Technologies shipped in Digital's (now Hewett Packard) products and IEEE Standards

- **Digital's FullVideo** & **FullVideo Supreme (1992-95),** a special projects initiative that turned into a flagship audio/video multimedia hardware-software product for VAX, Alpha, and Pentium systems

- **Digital's Multimedia Library (1990-92)** an advanced development effort that became a stand-alone video compression and image rendering software library, shipping with every Ultrix and VMS machine

- **Image Rendering (1989-91)** state of art algorithms, shipped in several of Digital's graphic chips

- **Influence on IEEE 802.11 Standards**
    - IEEE 802.11ba is based on my MobiCom 2003 paper "Wake on Wireless"
    - IEEE 802.11e incorporates ideas from my distributed weighted fair scheduling algorithm
    - IEEE 802.11s incorporates my ideas on multiple radios and fast channel switching, and
    - IEEE 802.15 (Bluetooth) local positioning incorporates my signal strength matching techniques

Service Contributions

ACM DISTINGUISHED SERVICE AWARD 2018 - citation: *for significant and lasting service to the broad community of mobile computing and wireless networking, and for building strong linkages between academia, industry, and government agencies.*

Board Membership

- COMPUTING FOR ALL, President of the Board (2015 – Present)
- UNIVERSITY OF CALIFORNIA SAN DIEGO - Council of Advisors to the Dean (221 – present)
- NSF AI INSTITUTE FOR FUTURE EDGE NETWORKS AND DISTRIBUTED INTELLIGENCE - Advisory Board (2021 – Present)
- NSF AI INSTITUTE FOR EDGE COMPUTING LEVERAGING NEXT GENERATION NETWORKS – Advisory Board (2021 – Present)
- UNIVERSITY OF DELAWARE – Advisor, Dept. of Computer & Information Sciences (2022 – present)
- OPEN NETWORK FOUNDATION, Board Member (2021 – 2024)
- WASHINGTON UNIVERSITY ST. LOUIS – Advisor, Dept. of Computer Science & Engineering, (2017 – 2020)
- UNIVERSITY OF MARYLAND – Advisor, Institute for Systems Research, School of Engineering, (2013 – 2015)
- MASSACHUSETTS INSTITUTE OF TECHNOLOGY – Advisor, Wireless Research Center, CSAIL (2012 – 2015)

Award Committees

- The Marconi Prize Selection Council (2022 – present)
- ACM Fellow Selection Committee (2020 – present)
- SIGCOMM Lifetime Achievement Award Committee (2023)
- SIGMOBILE Outstanding Contributions (Lifetime Achievement) Award Committee (2014 – Present)
- IEEE INFOCOMM Achievement Awards Committee (2019 – present)
- IEEE Technical Committee on Cyber-Physical Systems Technical Achievement Award (2021 – present)
- IEEE Fellows Selection Committee (2011-2014)

Founded / Co-founded.

- **Co-founded ACM SIGMOBILE (Special Interest Group on Mobility of Systems, Users, Data and Computing)**. SIGMOBILE (1996 – present) is a non-profit professional organization that promotes research in a broad spectrum of topics sharing mobility as the common theme. I built this international organization from scratch. Managed MobiCom, MobiSys, SenSys and MobiHoc and brought HotMobile, UbiComp and SEC conferences under its fold. Instituted prestigious awards (Outstanding Contributors Award & RockStar Award) and international chapters. Members include researchers, academicians, practitioners, and government officials.

- **Founded ACM MobiSys (International Conference on Mobile Systems, Applications and Services).** MobiSys (2003 – present) is the most prestigious mobile systems conference in the world. Architected a deal between the two largest computer science organizations. Authored the bylaws governing the conference, which were then used by other joint events (e.g. NSDI, SenSys). Chair of the Steering Committee since inception in 2003.

- **Founded ACM GetMobile** (formally called **Mobile Computing and Communications Review**) (1997) GetMobile is a quarterly scientific Newsletter that contains peer-reviewed papers, standards reports, RF related health articles, conference and workshop reports, opinion columns, news stories etc. related to wireless communications and mobility. 1200+ subscribers worldwide. Editor-in-chief for 5 years, now a Senior Advisor to the editorial board

- **Co-founded** (& served on **steering committee**)
    - IEEE/ACM Symposium on Edge Computing (SEC) (2016 - Present)

- ○ IEEE International Symposium on Dynamic Spectrum Access Networks (DySPAN) (2005 - 2016)
- ○ ACM Conference on Embedded Networked Sensor Systems (SenSys) (2003 - 2010)
- ○ International Conference on COMmunication Systems & NETworkS (COMSNET) (2009 -2012)
- ○ IEEE International Symposium of Wireless Communication Systems and
- ○ ACM Mobile Cloud Computing and Services Workshop (MCS) (2010- 2015)

- ▪ **Chair of MobiCom Steering committee** since 2001 & member of the committee since inception. Have provided 25+ years of continuous leadership to one of the most cited conferences in computer science. I am also its longest serving TPC member (since inception)

PhD Thesis Committees / Graduate Student Advising. 6 best dissertation awards.

1. ZHUQI LI, *Cross-layer Optimization for Video Delivery on Wireless Networks* (Princeton University– Dec. 2022)
2. BO HU, *System Abstractions for Scalable Application Development at the Edge* (Yale University– Dec. 2022)
3. VIKRAM IYER, *Creating the Internet of Biological and Bio-Inspired Things* (University of Washington – August 2021) **SIGMOBILE 2022 Doctoral Dissertation Award** (now at University of Washington)
4. RACHEE SINGH, *Traffic Engineering in Planet-Scale Cloud Network* (U. Massachusetts, Amherst – May 2021) – **Honorable Mention SIGCOMM 2022 Doctoral Dissertation Award (**now at U. of Wisconsin Madison)
5. RAJALAKSHMI NANDAKUMAR, *Computational Wireless Sensing at Scale* (University of Washington – 2019) - **SIGMOBILE 2021 Doctoral Dissertation Award** (now at Cornell University)
6. MANIKANTA KOTARU, *Harnessing nature to make wireless positioning practical & accurate* (Stanford – 2019)
7. SHADI ABDOLLAHIAN NOGHABI, *Building Large-scale Systems for Latency-sensitive Applications (*UIUC – 2018) **UIUC David J. Kuck Outstanding Doctoral Dissertation Award** (Senior Researcher at Microsoft Research)
8. CLAYTON W. SHEPARD, *Design & Implementation of Many-Antenna Wireless Systems* (Rice Univ – Sept 2017)
9. SHUBHAM JAIN, *Design of Inertial & Camera Sensing for Smart Intersections* (Rutgers University – June 2017)
10. TIFFANY YUAN CHEN**,** *Interactive Object Recognition and Search over Mobile Video* (MIT – June 2017)
11. FADEL ADIB, *RF as a Sensing Modality for Wireless Networks* (MIT – August 2016) **ACM SIGMOBILE 2019 Doctoral Dissertation Award** (now at MIT Media Lab.)
12. ROBERT LIKAMWA, *Vision Sensing Pipeline for Efficiency & Privacy* (Rice University - 2016)
13. HAITHAM HASSANIEH, *The Sparse Fourier Transform: Theory & Practice* (MIT- October 2015) **ACM 2016 Doctoral Dissertation Award (**now at EPFL)
14. HARIHARAN SHANKAR RAHUL, *Improving Spectrum Utilization in Wireless Networks* (MIT- August 2012)
15. JUSTIN MANWEILER, *Building Blocks for Tomorrow's Mobile App Store* (Duke University - June 2012)
16. ROHAN N. MURTY, *Opportunistic Wireless Network Architectures* (Harvard University – June 2011**)**
17. YUVRAJ AGARWAL, *Aggressively Duty-Cycled Platforms to Achieve Energy Efficiency* (UCSD - 2009)
18. IQBAL MOHOMED, *Interactive Content Adaptation* (University of Toronto – October 2008)
19. SRIKANTH KANDULA, *Increasing the Robustness of Networked Systems* (MIT- July 2008)
20. YUAN YUAN, *Enabling Dynamic Spectrum Allocation in Cognitive Radio Networks* (UMD College Park – 2007)
21. RANVEER CHANDRA, *A Virtualization Architecture for Wireless Network Cards* (Cornell University – Sept. 2005)
22. ANAND BALACHANDRAN, *Incorporating Location Awareness in Public-Area Wireless Networks* (UCSD- 2003)
23. CHIARA PETRIOLI, *Energy Conserving Protocols for Wireless Comm.* (Univ. of Roma "La Sapienza" – June 1998)

Noteworthy Positions (Professional Service)

- ▪ (FOUNDING MEMBER MICROSOFT TECHNICAL LEADERS COMMUNITY ADVISORY COUNCIL (2019 – present)
- ▪ MICROSOFT RESEARCH REDMOND LAB LEADERSHIP TEAM overseeing 250+ researchers, engineers & staff (2017 - 2020)
- ▪ (FOUNDING) ASSOCIATE EDITOR, ACM Transactions on Internet of Things (2018 - present)
- ▪ (FOUNDING) ASSOCIATE EDITOR, IEEE Transactions on Service Computing (2017 - 2019)
- ▪ (FOUNDING) ADVISORY BOARD MEMBER, IEEE Internet of Things Journal (2013 - present)
- ▪ (FOUNDING) EDITORIAL BOARD MEMBER, Foundations and Trends in Networking (2004 – 2018)
- ▪ FOUNDER & CHAIR, MICROSOFT MOBILE & NETWORKED SYSTEMS TECHNICAL COMMUNITY for senior leaders (2011-14),

- REFLECTIONS WITH VICTOR – with Roy Want (Google) @ MobiSys 2019; with Teresa Meng (Stanford) @ MobiCom 2018; with Randy Katz (UCB**)**, Len Kleinrock, (UCLA), David Goodman (Rutgers) @MobiCom 2014

- GENERAL CHAIR, IEEE DySPAN 2012, ACM SIGCOMM 2008, IEEE IWCS 2007, IEEE COMSWARE/COMSNET 2005, IEEE ISWC 2001, and ACM MobiCom 1999

- STEERING COMMITTEE CHAIR, MobiCom (2002-); MobiSys (2002-); MCS (2009-14)

- STEERING COMMITTEE MEMBER**,** IEEE/ACM Symposium on Edge Computing (2015 – present); Artificial Intelligence of Things (AIoT) Workshop (2017 – present); IEEE DySPAN (2004-16); IEEE Wearable Information Systems (2002-12); IEEE Communications Systems Software and Middleware (2005-10); IEEE Symposium on Wireless Com. Systems (2006 – present); ACM SenSys (2002-05)

- SEARCH COMMITTEES: IEEE Pervasive Computing EiC 2009, ACM MC2R EiC 2010, IEEE ISWC 2001-present

- PROGRAM COMMITTEE CHAIR, ACM/IEEE Symposium on Edge Computing (2018): ACM Vehicular Ad hoc Networking Workshop (2006), IEEE Symposium on Wearable Computers (2001), IEEE Conference on Wireless Mobile Multimedia (2001)

- ACM SIGMOBILE CHAIR (2001-05); Vice Chair (1996– 2001), Executive Committee (2005-09)

- PROGRAM COMMITTEE MEMBER of over <u>six dozen</u> technical conferences, symposiums, and workshops

- EDITOR-IN-CHIEF, Mobile Computing and Communications Review (1996 - 2001), SENIOR ADVISOR (2001-)

- EDITORIAL BOARD MEMBER**,** Kluwer's Telecommunications Systems Journal (2001-06), Elsevier's Adhoc Networks Journal (since inception in 2002-05), IEEE Journal on Selected Areas in Communications (1997-1999), ACM Journal on Wireless Networks (1997-2003)

- GUEST EDITOR, IEEE Journal on Selected Topics in Communications, (Sept. 2009), IEEE Journal on Selected Topics in Communications, (May 1999), ACM Mobile Networks and Applications Journal (June 1998), IEEE Communications Magazine (June 1998)

- WORKING GROUP CHAIR, Bluetooth WG on Location determination & management (1999-2000)

- PANELIST ACM/IEEE SEC '19, SEC'17, MobiCom'14**,** DySPAN'10, MobiSys'09, MobiCom'07, ISWCS'07, DySPAN'06, MobiHoc'05, MobiCom'04, NOSSDAV'04, WMASH'03, WoWMoM 2003, Hot Interconnects'02, ISSCC'00, MobiCom'97, IC3N'95 (incomplete list)

- DIVERSITY SPEAKER: Grace Hopper Conference 18; N2Women workshops (4 times); ACM Women Workshop 2017

Mind Swaps / Brainstorming Events

I have organized over a dozen internal brainstorming events, which led to successful cross-organizational projects. I have also organized several **external** events (here's a sample):

- MSR Workshop on *The Bleeding Edge of Intelligent Edge*, Redmond, WA (July 27, 2018)
- UW/MSR Summer Institute on *Unfolding the Future of IoT*, Snoqualmie, WA (July-Aug. 2017)
- Microsoft 17th Annual *Faculty Summit*, Redmond, WA (July 2016) (Chief guest: Bill Gates)
- Microsoft Research **25th Anniversary Celebrations**, Redmond, WA (July 2016)
- Microsoft Research *Graduate Student Summit* on *Networked Systems,* California (Feb. 2016)
- Annual (NSF style) Networking Summits (general 2.5 days each) on

  - *Data analytics & networking, Woodinville, WA (2012)*
  - *Mobile + Cloud, Bellevue, WA (2010)*
  - *Edge networking* (2006);
  - *Self-managing networks* (2005)
  - *Networking dreams*, Redmond, WA (2011)
  - *Cognitive networking, Redmond, WA (2008)*
  - *Wireless networking*, Goa, India (2005)
  - *Mesh networking*, Redmond, WA (2004)

Government Policy & Study Group Contributions

- Briefing to the National Defense Science Board Panel on *New Dimensions of Conflict* with respect to the cloudification of the telecommunications infrastructure (Sept. 22, 2020)

- Federal Communications Commission

  - Best Application and People's Choice Award in FCC Open Internet App. Challenge Award 2011
  - *White Space Networking,* Presentation to the FCC Chairman Genachowski, Redmond, WA (Aug. 14, 2010)

- *White-Fi Network using TV white spaces spectrum*, FCC. Ex Parte (Apr. 29, 2010)
- *Research Recommendation for National Broadband Task Force,* Washington, DC (Nov. 23, 2009)
- *Broadband Spectrum: A Looming Crisis?* National Broadband Plan Field Hearing on Mobile Broadband, San Diego, CA (Oct. 8, 2009)

- National Science Foundation
    - Advisor & organizing committee, Workshop on *Edge Computing*, Washington DC (Oct. 26, 2016)
    - Critic, Workshop on *Future Directions in Wireless Networking, Arlington*, VA (Nov 4-5, 2013)
    - *Reactions & Perspectives on Future Wireless Communication Networks*, Arlington, VA (Nov. 2-3, 2009)
    - *Site Visitor*, $25M Renew Funding for Center for Embedded Network Sensing, UCLA, (June 7, 2006)
    - *NeTs Program PI Research Review,* UCLA August 5, 2010
    - *Study Group on Perspectives on Peer-to-Peer Networks,* Dagstuhl, Germany, April 20, 2005
    - *Study Group on Residential Broadband Revisited: Research Challenges in Residential Networks, Broadband Access and Applications*, Chicago, Illinois, USA (October 23-24, 2003)
    - *Network Research Testbed*, Chicago, IL, USA (October 17-18, 2002)
    - *Wireless Information Technology and Networking Initiative*, Study conducted by the Division of Advanced Networking Infrastructure and Research (CISE/ANIR) (July 1999)
    - *Networking Research Program*, Div. of Advanced Networking Infrastructure & Research, (Jan. 1999)

- Computing Community Consortium, Wide-Area Data Analytics, Washington DC. (Oct. 3-4, 2019)

- COST (European Union*), Exchanges and Trends in Networking*, Chania, Greece (June 23, 2003)

- National Research Council, *The Intersection of Geospatial Information and Information Technology,* Study conducted by the CS and Telecommunications Board (CSTB), sponsored by NASA & NSF (Sept. 2001)

Blogs, Podcasts & Reflections

My recent blogs are about developing an infrastructure that can support both the telecommunications and cloud industries. You can find these blogs here: https://www.microsoft.com/en-us/research/people/bahl/blogs-podcasts/

Additional blogs:
- THE GENESIS OF EDGE COMPUTING (Podcast, October 1, 2020)
- REFLECTING WITH VICTOR – GUEST ROY WANT (Fireside chat, June 19, 2019)
- High performance container networking (February 26, 2019)
- ON THE PAST AND FUTURE OF THE INTERNET (Podcast, Illinois Public Radio, February 6, 2019)
- Working on the Edge (Q/A with Nature Electronics, January 15. 2019)
- REFLECTING WITH VICTOR – GUEST TERESA MENG (Fireside chat, November 15, 2018)
- 10 YEARS, BUT WE ARE JUST GETTING STARTED (Edge Computing, October 19, 2018)
- RELIABLE NETWORKING IN THE CLOUD (Live video interview, August 15, 2018)
- A BRIEF HISTORY OF NETWORKING (AND A BIT ABOUT THE FUTURE TOO) (Podcast, August 15, 2018)
- DIAGNOSING PACKET LOSS IN CLOUD-SCALE NETWORKS (April 6, 2018)
- IMPROVING THE EFFICIENCY & CAPACITY OF CLOUD-SCALE OPTICAL NETWORKS (December 1, 2017)
- A GIANT STEP TOWARDS ELIMINATING NETWORK DOWNTIME (October 31, 2017)

Employment

MICROSOFT CORPORATION, Redmond, WA

TECHNICAL FELLOW – RESEARCH, Microsoft Corporation	09/2019 – Present
CHIEF TECHNOLOGY OFFICER, Azure for Operators, Strategic Missions & Technologies	10/2020 – 07/2024
DISTINGUISHED SCIENTIST, REDMOND LAB. LEADERSHIP TEAM, Microsoft Research	03/2015 - 08/2019
SENIOR CORP. PARTNER & Founding DIRECTOR Mobility & Networking Research	12/2010 - 02/2015
CORP. PARTNER & RESEARCH MANAGER Networking Research	01/2006 - 11/2010
PRINCIPAL RESEARCHER & Founding MANAGER Networking Research	01/2002 - 12/2006
SENIOR RESEARCHER, Systems & Networking Research	06/1997 - 12/2002

(Served on the Redmond LT and world-wide SLT of Microsoft Research and the LT of Azure for Operators each with a annual budget of over $600 million)

DIGITAL EQUIPMENT CORPORATION, Maynard, MA
- ▪ DIRECTOR, Multimedia Engineering & Systems Division   12/1996 - 05/1997
- ▪ PRINCIPAL ENGINEER, Audio, Video and Image Processing Advanced Development   06/1992 - 05/1997
- ▪ SENIOR ENGINEER, Image Processing Research   06/1988 - 05/1992

PIERRE ET MARIE CURIE, SORBONNE UNIVERSITE, VISITING PROFESSOR Paris, France (sabbatical) Spring 2015
UNIVERSITY COLLEGE LONDON, London U.K, VISITING PROFESSOR (sabbatical)   Fall 2014

Education

DOCTOR OF PHILOSOPHY, Electrical & Computer Engineering   June 1997
   Thesis: *Real-Time Visual Communications Over Narrowband Wireless Radio Frequency Networks*
   University of Massachusetts, Amherst, MA
- **Digital Equipment Corporation PhD Fellowship** – 1995-97
- **University Distinguished Alumni Award** – 2012
- **ECE Distinguished Alumni Award** – 2021

MASTER OF SCIENCE & BACHELOR OF SCIENCE, Electrical & Computer Engineering   Jun. 1988 / Jun. 1986
   MSEE Thesis: *Recognition of Handwritten Script: A Hidden Markov Model Approach*
   BSEE Thesis: *Conic Shape Detection Using a Non-Linearized Iterative Approach*
   University at Buffalo, State University of New York, New York
- **Deans Award for Achievement** – 2024
- **Commencement Speaker,** School of Engineering & Applied Sciences **–** 2024
- **Distinguished Alumni Award** on the 50th anniversary the EE/CSE Dept**.** – 2017
- **Commencement Speaker,** School of Engineering & Applied Sciences **–** 2018

Executive Leadership Training (sample)

Personal Executive Coach (Increasing Influence) • Leadership Principles • Business & Organizational Leadership • Leading Across Enterprise • Advanced Technology Pitch • Media/PR Training • Coached as a High Potential Employees • Senior Corporate Bench Program • The Leaders Voice: Values in Action • Dialog across Differences • Standards of Business Conduct • Data Privacy • Inclusive Hiring • Objective Interviewing • Caring through Allyship • Unconscious Bias • Insider Threats for Managers …

Diversity, Inclusion & Belonging

I strongly believe that a diverse & inclusive workforce is necessary for organizations and societies to thrive. I have tried to help, for example, I supported the creation of Networking-networking Women through sustained financial support (via Microsoft), encouragement (4-time speaker) & professional support (as SIGMOBILE founder). I have participated & contributed to GHC, CRA-W Grad Cohorts and ACM Women workshop. I have nominated and endorsed many women researchers for awards & recognition (e.g., Athena Lecturers, ACM & IEEE Fellows, tenure, promotions, jobs etc.). The SIG I founded and the MobiCom & MobiSys conferences I steer, have strong records of women serving in leadership positions. In addition, I routinely take courses on diversity & inclusion to acquire knowledge and learn the latest in social sciences, examples include Introduction to Covering, Allyship & Privilege. I also co-founded Computing For All, a non-profit which is dedicated to opening up IT pathways and careers for minorities and those who face socio-economic barriers.

Personal Information

I am a US citizen, married with two children. My son graduated from Washington University in St. Louis; he completed his residency in internal medicine from the University of Washington Seattle Medical School. He is now serving the community as an M.D. in Renton, Washington. My daughter graduated from Cornell University and is a 4th year student at Rutgers Robert Wood Johnsson Medical School; She also has a degree in Master of Public Health. My wife has two graduate degrees, an M.S. in computer engineering and an MBA from the University of Washington Seattle. She is the founder & CEO of Computing Kids (CK) whose mission is to empower every student in every school by teaching them computer science and its applications. In 2015 my wife & I **co-founded** a 501(c)(3)

non-profit organization Computing For All (CFA), whose mission is to **break down cultural and systemic social barriers** that prevent young adults of all races, genders, and abilities from exploring computer science as a potential career.

Residence: 1311 108th Ave, NE, Bellevue, Washington 98004-3620, United States

Victor Bahl   June 1, 2024