

IN MEMORIAM: DONALD L. SCHILLING

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The communications engineering community was saddened in late November, 2022 by the death of one of the great contributors to 20th century (and 21st century) communications technology. Don Schilling, a leading educator, ComSoc volunteer including serving as President, adviser to U.S. government, and entrepreneur as well as researcher, significantly advanced spread spectrum techniques and applications. He graduated many students who became important contributors themselves. In addition to his technical contributions, Don was a dedicated husband and father, and a warm and generous friend to his students and to many of us who were his colleagues.

Born and raised in Brooklyn, New York, Professor Schilling received his Bachelor's degree from the City College of New York in 1956, a Master's degree from Columbia University in 1958, and a Ph.D. degree from the Polytechnic Institute of Brooklyn, now the New York University Tandon School of Engineering, in 1962. His doctoral work was supervised by Mischa Schwartz, a distinguished Past President of ComSoc, and his dissertation was on the phase-locked loop and its role in demodulation of FM signals. He became an IEEE Fellow in 1975 "For contributions to the design of communication systems and to engineering education." He was also a member of Sigma Xi and Eta Kappa Nu, and in 1971 became a New York State Professional Engineer.



Donald L. Schilling

AN EDUCATOR AND RESEARCHER

Don Schilling became Professor of Electrical Engineering at Polytechnic Institute of Brooklyn from 1962 to 1969. In 1969 he moved to the City University of New York, where he was the Herbert G. Kayser Distinguished Professor of Electrical Engineering until his retirement in 1992 as Professor Emeritus. His influence as an educator went far beyond City University, embodied in his 12 textbooks including *Digital Integrated Electronics* (Taub and Schilling, 1977), *Principles of Communication Systems* (Taub and Schilling, 1971, 2nd edition 1996), and *Electronic Circuits, Discrete and Integrated* (Schilling and Belove, 1989). He had a talent for explaining concepts step by step and in the simplest terms, to readers, students attending lectures, and judges in patent litigation cases, rather than overwhelming his audience with heavy presentations.

As a professor, he closely followed his Ph.D. students' progress, making sure they were developing independent abilities to analyze and solve technical challenges and assisting them with personal living problems as well. As a result, the more than 85 Ph.D. engineers whom he graduated became close friends as they developed as successful colleagues in the field of Electrical Engineering. Professor Schilling tracked his students' success far beyond graduation, helped them when needed with careers, and attended prominent events and celebrations. A number of former students gathered for his 77th birthday, a surprise party arranged by his family. It was a thrill for all participants. Each of the attending students signed a golf ball, recognizing their mentor's love for the game.

As a researcher, Professor Schilling, who authored or co-authored more than 200 technical papers and has more than 125 patents in telecommunications and electronics, was one of the first to recognize the potential of wideband spread spectrum as a signaling technique. As early as August, 1990, the tutorial article "Spread spectrum goes commercial" (co-authored with Ray Pickholtz and Larry Milstein), describing the difference between CDMA and frequency-hopping spread spectrum systems, noted "The use

of CDMA for cellular radio, where it promises a capacity of over 1000 users per cell." A system overview appeared in a chapter of *Wireless Personal Communications*, Kluwer, 1993 titled "Broadband-CDMA: A PCS Wireless Technology to Achieve Wireline Quality and Maximize Spectral Efficiency," with Professor Schilling as the first among four authors.

Later papers elaborated on the application details. His paper "Broadband spread spectrum multiple access for personal and cellular communications," presented at the IEEE Vehicular Technology Conference in May, 1993, explained how the bandwidth of a code division multiple access (CDMA) system "is governed by the system chip rate and affects capacity, fade margin, data rate, voice quality, performance in indoor and outdoor environments, transition plan, frequency manage-

ment, overlay capability, and adaptive power control." Many other publications followed, such as "A matched filter based wideband CDMA implementation" in January, 1996 and "Comparison of W-CDMA and DSSS-TDMA systems" in November, 1998. This last paper, of which he was the lead author among nine co-authors, compared two-directional W-CDMA "with a novel system which employs spread-TDMA transmission from terminal-to-base and W-CDMA transmission from base to-terminal, thereby providing high quality performance in both directions."

Even more important than these groundbreaking papers were his critical very early patents which laid out implementations. Among these are:

- Spread spectrum multipath receiver apparatus and method, US5081643A, Priority Nov. 16, 1990, granted Jan. 14, 1992.
- Adaptive power control for a spread spectrum transmitter, US5093840A, Priority Nov. 16, 1990, granted Mar. 3, 1992.
- Overlaying spread spectrum CDMA personal communications system, US5351269A, Priority Dec. 5, 1990, granted Sept. 27, 1994.
- Synchronous spread-spectrum communications system and method, US5228056A, Priority Dec. 14, 1990, granted July 13, 1993.
- High capacity spread spectrum channel, US5166951A, Priority May 15, 1991, granted Nov. 24, 1992.

His patents were challenged but he won most if not all of these contests and he is widely recognized now as a leading inventor of CDMA technologies. He contributed in other wireless areas as well; his patents in MESH (network), HSPA (high speed packet access) and MIMO technology are used in today's 3G, 4G, and 5G systems.

Professor Schilling received many recognitions for his distinguished contributions. In 1990, he was awarded the IEEE Alexander Graham Bell Medal for his contributions to the development of spread spectrum communications and its applications in military and commercial communication systems. In 1992 it was the IEEE Medal of Honor, one of the highest honors in electrical engineering, recognizing his pioneering work on spread spectrum and its impact on modern communication systems. In 2000 he received the Marconi International Fellowship Award for his contributions to the development of wireless communication technologies. The Institute of Navigation presented him its Tycho Brahe Award in 2001 for his contributions to the development of GPS and other navigation systems. And in 2003, President George W. Bush awarded him the National Medal of Technology and Innovation for his contributions in electrical engineering and wireless communication. These major awards reflect the significant impact that his work had on the field of electrical engineering and modern communication systems.

AN ENTREPRENEUR

Professor Schilling initiated or joined several important entrepreneurial businesses to exploit and extend his patents. Beginning in 1973 and continuing until 1992, he was President and chief executive officer of SCS Mobilecom and SCS Telecom, the latter a consulting business which he and his wife, Annette, started. A substantial portion of the early work in broadband CDMA described above was done at these companies. In 1990, SCS Mobilecom, in a joint venture with Millicom, Inc., had begun the field of PCS (personal communication systems) in the USA by developing broadband CDMA. SCS Telecom was involved in military communications and electronic warfare, and developed popular short courses that were offered to government agencies and to industry.

From 1992 to 1994 he served as Vice-Chairman of the Board, Executive VP, and then CEO of InterDigital Communications Corporation (IDCC – NASDAQ), where he led the further development of broadband CDMA. InterDigital licensed numerous companies for their use of his patents. In 2002 InterDigital inducted him into its Inventors Hall of Fame and established the Dr. Donald L. Schilling Scholarship Fund at Drexel University.

As Chairman of Golden Bridge Technologies from 1996 to 1998, he initiated the WIMS (Wideband Information Management Standardization) program with AT&T, and formed the T1A (Telecommunications Industry Association) 46.1 Committee for 3G Standardization. The work of this Committee was reflected in the later 3GPP broadband wireless standard.

From 1998 until 2019, he was Chairman and Chief Executive Officer of Linex Technologies, a company that patented MIMO-centered technologies exploiting spread spectrum, HSPA and Mesh Network systems. Professor Schilling concluded his career as an expert consultant in wireless communication, offering his expertise in 5G and IoT to a few companies and law firms. He also, shortly before he passed away, published a novel, *The Enterprise*, reflecting on his career and offering his observations on how the world of enterprises works.

A LEADING COMSOC VOLUNTEER

Professor Schilling was a prominent ComSoc volunteer and one of our most influential Presidents. He had a deep interest in developing ComSoc publications to be the unquestioned best in the communications field. He was, from 1969 to 1979, Director of Publications and Editor in Chief of what was initially named the *Transactions on Communications Technology*, published by the IEEE Group on Communications Technology. The Group transitioned into the IEEE Communications Society in 1972. Professor Schilling insisted on the highest quality in acceptance and peer review of papers, and also increased the frequency of publication from three issues per year in 1968 to six issues per year by 1971. In 1972 the journal's name changed to the *Transactions on Communications*, reflecting ComSoc's name change as well as Professor Schilling's desire to broaden its scope and impact. During those 10 years he also stimulated the transition of the ComSoc newsletter into *Communications Magazine*, relying on several innovative editors beginning with Martin Nesenbergs.

Professor Schilling was a co-founder, along with Robert Lucky and Jack Salz, of the legendary Communication Theory workshops that began in the 1970s. These workshops, always held at attractive locations and drawing many of the leading names in the field, became known for both their intensive and influential discussions (for example, "is coding dead?") and their enthusiastic socializing, particularly the famous poker games. The Workshops continue, perhaps a bit more restrained these days.

Professor Schilling became ComSoc President in 1980-1981. He and Richard Merwin, president of the IEEE Computer Society, encouraged Harvey Freeman to start "a conference on networks" which resulted in the launching of IEEE INFOCOM, the most prestigious conference among networking and computer communications researchers and developers. He also stimulated the founding of MILCOM, providing a venue for the large military communications community. His foresight and appreciation of these fields significantly advanced ComSoc's prominence.

As President, Professor Schilling pressed toward a more global presence of the Communications Society. The highlight was the visit of a ComSoc delegation, which he headed, to China in June, 1981, at the invitation of the Chinese Institute of Electronics (CIE). The delegation visited universities and research institutions in Beijing, Shanghai and Hangzhou, getting a feeling for the status of communications R&D in the newly opening China and inviting the professors and researchers there to participate in ComSoc publications and conferences. China was just beginning its spectacular economic development and the visit by our ComSoc delegation was one of several IEEE initiatives around that time or soon after to develop mutually beneficial relationships with comparable professional organizations in China.

Professor Schilling received many recognitions from ComSoc, notably the Donald W. McLellan Meritorious Service Award in 1978 and the Edwin Howard Armstrong Achievement Award in 1998.

A FAMILY MAN AND FRIEND

Don Schilling understood that family, friends, and relaxation were as important as technical ability to professional and personal achievement. He was the grandson of Jewish immigrants from Ukraine and his life represents a notable but not unusual success story of immigrant families. He and Annette were both family and business partners. Their children and grandchildren carry on the family traditions.



Don and family members celebrating Annette's birthday.

Don loved being with other people. He was happy when fishing, playing golf or tennis, traveling, and taking part in the Jewish community. As a friend, he was congenial and sympathetic. Always encouraging and supportive, he was also a fun-loving companion who enjoyed life and wanted his friends to enjoy it with him. He organized a gourmet dining group, which made roughly bimonthly visits to some of the better restaurants in Manhattan. One of his former students was co-owner of a restaurant where his group would sometimes go for a sumptuous dinner, organized by a grateful protégé. Don also enjoyed the great Russian food in the Brighton Beach area of Brooklyn.

His friends occasionally had the pleasure of joining Don and Annette on visits to nice places, particularly when they were venues for the memorable series of Communication Theory Workshops mentioned earlier. In addition to his natural kindness, he understood the importance of building personal relationships and sharing pleasures to the success of the communications engineering community.

HIS LEGACY

Don's life and work contributed greatly to the advances made in communication theory and technology during the golden age of communications in the second half of the twentieth century. In equal measure, his actions as a leading ComSoc volunteer helped advance ComSoc and its publications and conferences into the world leaders they are today. His friends and colleagues feel privileged to honor his memory.