Elvino Silveira Sousa

CV - Research Contributions

Current Affiliation

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2. Education

PHD	1985	University of Southern California, Los Angeles, CA, USA
MASc	1982	University of Toronto, Toronto, Canada
BASc	1980	University of Toronto, Toronto, Canada

3. Professional History

2007 -	University of Toronto, Professor and Jeffrey Skoll Chair in Computer Networks and Innovation
2001 - 2011	University of Toronto, Professor and Bell University Labs Chair, in Computer Engineering
2000 - 2000	Sony CSL, Tokyo, Japan, Sony Sabbatical Chair
1999 - 1999	Qulacomm Inc, Principal Engineer
1997 - 1999	University of Toronto, Professor and Chair of Communications Group
1996 - 1997	University of Toronto, Associate Professor and Chair of Communications Group
1992 - 1996	University of Toronto, Associate Professor and NSERC University Research Fellow

4. Major Contributions to Research

Prof. Sousa is best known for his pioneering research in wireless cellular communication systems and networks, particularly in the framework of code division multiple access (CDMA). Cellular networks are highly complex structures due to the fact that they encompass very many components across physical, medium access control, and networking layers of the protocol stack within a single point of view. As a matter of fact, the cellular design goes well beyond the protocol stack; the radio access network architecture itself, as well as various systems issues, such as the interference management and randomization, play essential roles in cellular networks. Many concepts that are taken as granted today in cellular communications have not been properly understood in the early days. Since late-1980's and throughout 1990's, Prof. Sousa did pioneering research on cellular communications, especially on technologies related to spread spectrum CDMA. It will not be an exaggeration to state that Prof. Sousa is one of the leading CDMA experts in academia in the world. It should be stressed that many concepts developed by Prof. Sousa and his research team within the CDMA framework have relevance and impact in a much broader context. For instance, the subcarrier loading concept within the multi-carrier CDMA which was studied by Prof. Sousa can be used in OFDMA systems through adaptive modulation and coding across resource blocks.

Prof. Sousa's was the first to work on a number of CDMA technologies such as "differential coherent schemes for CDMA PN code acquisition" and "multi-carrier CDMA in the cellular context". Also, Prof. Sousa's group was among the first to perform "wideband channel impulse response measurements".

Prof. Sousa was also among the first researchers who articulated on the concept of "space division duplexing" in 1990s to address fundamental issues in the use of spectrum in an FDD system. This considerably generalized the classical system where the higher frequency band was allocated to base stations and the lower band to the mobile terminals. Elements of these ideas are now being incorporated in 4G cellular systems.

Prof. Sousa has made important contributions to antenna systems as well, especially to transmitter diversity and distributed antenna techniques. He was the first to introduce the idea of transmitter diversity that is a precursor to the current area of MIMO systems. This work preceded the work in the area known as space-time coding and is related to the well known as the Alamouti code. The scheme developed by Prof. Sousa and patented before the work by Alamouti is referred to as fading resistant modulation and is based on performing rotations of a signaling constellation where the components of the signals are signals transmitted on different antennas. Variants of this scheme are now included in OFDM standard for LTE. This form of transmitter diversity along with the traditional approach of multiple receiving antennas led the research community to the area of MIMO systems which is a popular area of research today. In this area Prof. Sousa has also obtained important results on the performance of transmit diversity based on spreading the signal over multiple antennas leading to a technique termed spread-space spectrum. Prof. Sousa was among the first to propose the concept of distributed antennas for CDMA in early 1990s. The systems proposed utilized a network of cables that fed discrete radiators in order to improve coverage over areas with poor propagation characteristics. This concept is now being considered for 4G systems as a way to enhance coverage.

He worked extensively on techniques involving the use of ***highly sectorized antenna systems*** (stressing beam switching) as appose to the traditional and more difficult to implement fully adaptive antennas. Another of his works was among the first to consider transmission bit rate adaptation instead of power control as a preferable method of interference management in CDMA cellular systems.

As a result of work in software radio (at Sony) and in the context of CDMA and direct conversion receivers, Dr. Sousa realized that there are gains to be made in going back to ***analog despreading*** in the sense that much larger chip rates can be achieved. The result was a spread spectrum receiver based on a ***5-port RF front-end*** that combines ***direct-conversion*** and despreading. A Ph.D. thesis followed in the area and it has since then been published as a book. This work went against the grain in the software radio research community where the motto of the day was to put the D/A converter as close to the antenna as possible. We said that it should be put as ***far from the antenna as possible*** and that modern digital processing techniques with feedback should be used to cure the usual ills of analogue circuits such as drifts and offsets.

The most significant recent contribution is a concept for 4G cellular systems. Dr. Sousa was the first to introduce the concept of ***autonomous infrastructure wireless networks*** (white paper in 2003). This vision for 4G was introduced at a time where the industry was focusing in a different direction for the evolution of cellular systems – that of integration of cellular and WiFi, and also WiMax in the form of IEEE 802.16e,m. In the last three years the industry has come around to this vision and is currently referring to a limited version of this area as ***femtocells***. The general development of this area beyond the limited scope of femto-cells (customer deployed in-home access points) is the subject of the current application.

Prof. Sousa gave numerous tutorials and short courses at various major international conferences such as (ICC and Globecom), and at various universities and industries, on various aspects of CDMA and wireless communications (ranging from a half-day tutorial to a full-week short course). He also gave numerous special presentations at various industries and universities in various countries. His presentations on CDMA technology has been extremely well received by industry and are generally regarded as among the best in the world from the point of view of a good balance of theoretical and implementation issues.

Over the years, Dr. Sousa has had extensive interaction with industry. He was the first wireless researcher in Canada to have research projects sponsored by cellular operating companies. His extensive collaboration with Bell Mobility was a major catalyst in the initiation of the endowed chairs program at the University of Toronto. The collaboration eventually led to the creation of the Bell University labs at the University of Toronto.

5. Specific Technical Contributions

A. CDMA -- Foundational Principles and Enabling Technologies

The following two highly-cited papers are among the earliest foundational theoretical work in direct-sequence spread-spectrum systems (almost 500 citations in total):

[1] E.S. Sousa, J.A. Silvester, "Optimum transmission ranges in a direct-sequence spread-spectrum multihop packet radio network", IEEE JSAC, vol. 8-5, pp. 762-771, June 1990 [243 citations].

[2] E.S. Sousa, J.A. Silvester, "Spreading code protocols for distributed spread-spectrum packet radio networks", IEEE TCOM, vol. 36-3, pp. 272-281, Mar 1988 [224 citations].***The following two papers are among the very first (and also the most cited) in the area of multi-carrier CDMA. Subsequently, multicarrier CDMA became part of the 3G cellular standards.

[3] V.M. DaSilva, E.S. Sousa, "Multicarrier orthogonal CDMA signals for quasi-synchronous communication systems", IEEE JSAC, vol. 12-5, pp. 842-852, June 1994 [169 citations].

[4] V.M. DaSilva, E.S. Sousa, "Performance of orthogonal CDMA codes for quasi-synchronous communication systems", IEEE ICUPC 1993 [167 citations].

Prof. Sousa's group was among the first to perform wideband channel impulse response measurements (100 ns multi-path resolution), which were of fundamental importance in the investigation of many aspects of cellular systems:

[5] E.S. Sousa, V.M. Jovanovic, C. Daigneault, "Delay spread measurements for the digital cellular channel in Toronto", IEEE TVT, vol. 43-4, pp. 837-847, Nov. 1994 [89 citations].

B. Interference, Spectrum Sharing, and Cognitive Radio

Prof. Sousa was arguably the first researcher who investigated interference using Stochastic Geometry. The below two papers were well ahead of their time. In the last five years or so there is great interest in this area mainly in the context of spectrum sharing and cognitive radio. These papers demonstrate that the interference can be modeled through a stable distribution (such as Gaussian) in most wireless networks.

[6] E.S. Sousa "Performance of a spread spectrum packet radio network link in a Poisson field of interferers", IEEE Trans. Information Theory, vol. 38-6, pp. 1743-1754, Nov. 1992 [103 citations].

[7] E.S. Sousa, "Interference modeling in a direct sequence spread spectrum packet radio network", IEEE TCOM, vol. 38, pp. 1475-1482, Sept. 1990 [45 citations].

More recently, Prof. Sousa with Amir Ghasemi (a PhD student at the time) was among the first to work in the area of cognitive radio in Canada. 15 years after Prof. Sousa's original work, they revisited the concept of interference in the contemporary context of cognitive radio. The below three papers are among the most cited ones in this area (with 900+ citations), in addition to many other well cited papers of the same authors:

[8] A. Ghasemi, E.S. Sousa, "Collaborative spectrum sensing for opportunistic access in fading environments", IEEE DySPAN 2005 [617 citations].

[9] A. Ghasemi, E.S. Sousa, “Fundamental limits of spectrum-sharing in fading environments”, IEEE TWC, vol. 6-2, pp. 649-658, Feb. 2007 [153 citations].

[10] A. Ghasemi, E.S. Sousa, “Spectrum sensing in cognitive radio networks: requirements, challenges and design trade-offs”, IEEE Communications Magazine, vol. 46-4, pp. 32-39, April 2008 [146 citations].

C. Transmit Diversity

The following paper and the granted patent were among the first research on transmitter diversity (without increase in redundancy); these works arguably constitute the first space-coding schemes (before the works of Alamouti and Tarokh):

[11] V.M. DaSilva, E.S. Sousa “Fading-resistant modulation using several transmitter antennas”, IEEE TCOM, vol. 45-10 10, pp. 1236-1244, Oct. 1997 [106 citations].

[12] E.S. Sousa, V.M. DaSilva, "Transmitter diversity and fading-resistant modulation for wireless communication systems", U.S. patent #US05832044, Nov. 1998 [51 citations].

D. Multicarrier CDMA

Prof. Sousa, with his PhD student Q. Zhen (now with Qualcomm), was one of the first to consider multi-carrier CDMA in the cellular context (orthogonalize the reverse link as an alternative to multi-user detection, unequal loading of the sub-carriers to adapt to channel fading). The ideas became standard incorporations into CDMA cellular system design.

[13] Q. Chen, E.S. Sousa, S. Pasupathy, “Multicarrier CDMA with adaptive frequency hopping for mobile radio systems”, IEEE JSAC, vol. 14-9, pp. 1852-1858, Dec. 1996 [75 citations].

[14] Q. Chen, E.S. Sousa, and S. Pasupathy, “Performance of a coded multi-carrier DS-CDMA system in multi-path fading channels”, Wireless Personal Communications, vol. 2-1, pp. 167-183, 1995 [31 citations].

E. PN Code Acquisition

Prof. Sousa was the first to develop differential coherent schemes for CDMA PN code acquisition. These schemes somewhat surprisingly outperform the classical non-coherent PN code acquisition schemes. This work is the main reference in US patents 6275519 and 6788708:

[15] M.H. Zarrabizadeh, E.S. Sousa, “A differentially coherent PN code acquisition receiver for CDMA systems”, IEEE TCOM, vol. 45-11, pp. 1456-1465, Nov. 1997 [71 citations].

F. Radio Resource Management

The below two papers are samples from the high volume of RRM papers produced by Prof. Sousa’s research group:

[16] S. Lal, E.S. Sousa, “Distributed resource allocation for DS-CDMA-based multimedia ad hoc wireless LANs”, IEEE JSAC, vol. 17-5, pp. 947-967, May 1999 [63 citations].

[17] B. Hashem, E.S. Sousa, “Reverse link capacity and interference statistics of a fixed-step power-controlled DS/CDMA system under slow multipath fading”, IEEE TCOM, vol. 47-12, pp. 1905-1912, Dec. 1999 [55 citations].

G. Distributed Antennas

The work of Prof. Sousa along with H. Yanikomeroglu on distributed antennas was a precursor for the coordinated multipoint (CoMP) transmission and reception technologies which are part of the 4th generation LTE-Advanced cellular networks. The below ICUPC 1993 paper was arguably the first paper on distributed antennas with a mathematical framework:

[18] H. Yanikomeroglu, E.S. Sousa, "Antenna gain against interference in CDMA macrodiversity systems", IEEE TCOM, vol. 50-8, pp. 1356-1371, Aug. 2002.

[19] H. Yanikomeroglu, E.S. Sousa, "Antenna interconnection strategies for personal communication systems", IEEE JSAC, vol. 15-7, pp. 1327-1336, Sep. 1997.

[20] H. Yanikomeroglu, E.S. Sousa, "CDMA distributed antenna system for indoor wireless communications", IEEE ICUPC 1993.

General Packet Networks

[21] M. Lotfinezhad, B. Liang, E. S. Sousa, “On stability region and delay performance of linear-memory randomized scheduling for time-varying networks, IEEE/ACM Trans. on Networking vol. 17-6, pp. 1860-1873, 2009.

[22] M. Lotfinezhad, B. Liang, E. S. Sousa, “Adaptive cluster-based data collection in sensor networks with direct sink access”, IEEE TMC, vol. 7, pp. 884-897, July 2008.

6. Activities - Awards, Offices Held, Committee Memberships

A. Conference Organization

• TP Committee Co-Chair, IEEE PIMRC 2011, Toronto, Canada.

• TP Committee Co-Chair, WPMC (Int'l Symp. Wireless Personal Multimedia Communications) 2010, Recife, Brazil.

• TP Committee Chair, IEEE Globecom 1999 General Symposium, Rio de Janeiro, Brazil.

• TP Committee Chair, IEEE PIMRC 1995, Toronto, Canada.

• Chair, IEEE ComSoc Technical Committee on Personal Communications (TCPC), 1998-2000. Under Prof. Sousa’s leadership, TCPC (now called Wireless Communications TC) became one of the most influential TCs in ComSoc.

• Member of the Executive Committees and Technical Program Committees for a very high number of Comsoc conferences over many years: ICC, Globecom, Infocom, Milcom, ICUPC, WCNC, PIMRC, …

• Organizer and chair of numerous technical sessions in the above conferences.

• Reviewer for IEEE Transactions on Communications, IEEE Journal on Selected Areas in Communications, IEEE Proceedings, IEEE Network, IEEE Transactions on Computers, IEEE Transactions on Education, and IEEE sponsored conferences (ICC, GLOBECOM, MILCOM, INFOCOM, PIMRC, ICUPC, WCNC, VTC).

B. Participation in Panels.

• Member, National Science Foundation (NSF) Panel, 2011.

• Member, IMT-Advanced Canadian Evaluation Group, 2009-2010.

• Chair and Member, Portuguese Government Foundation Grant Selection Committee (the main Portuguese university research program), 2007-2011 (Chair, Telecommunications), 2003 (Member), 2000 (Member), 1998 (Member), 1996 (Member).

• Chair, URSI Commission C, Canada, 1996–1999.

• Member, EPSRC (UK) Project Evaluation Panel, Mobile VCE Proposal Assessment, 1999.

• Examiner for Professional Engineers, Ontario PEO (1988-2004).

• Science Monitor, Government of Ontario Technology Fund, 1996–1999 (Ontario Government Advisor for the Technology Fund).

• International Telecommunications Union (ITU) Consultant, CPqD Telebras, Brazil, 1995-1996.

C. Editorial Boards

• Co-Editor in Chief, IEEE ComSoc/SBrT Journal of Communication and Information Systems.

• Former Associate Editor (CDMA systems), IEEE Transactions on Communications.

• Member of the Editorial Board, International Journal of Wireless Information Networks, Springer.

• Member of the Editorial Board, Wireless Personal Communications, Springer.

• Guest Editor, Journal for Communications and Networks (Korea), Cognitive Radio: A path in the Evolution of Public Wireless Networks, April 2009, Innovations in Ad Hoc Mobile Pervasive Networks, March 2002.

• Guest Editor, European Transactions on Telecommunications and Related Technologies, Special Issue on Spread Spectrum Techniques, 1994.

• Guest Editor, Wireless Personal Communications, Special Issue on CDMA for Universal Personal Communication Systems, 1998.

D. Awards

• Queen Elizabeth II Golden Jubilee Medal (awarded by the Government of Canada for significant contributions to Canada).

• Recipient, 2003 New Pioneers Science and Technology Award, Canada.

• Comsoc TCPC Recognition Award for “outstanding technical contributions in the field of wireless and mobile communications theory, systems, and networks”, 2002.