

Nanocomputing with Delays

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Abstract

The push to obtain smaller and denser circuits solely based on lithography and silicon technology is quickly reaching limits imposed by device physics and processing technology. It is anticipated that these limits will invalidate Moore's law and lead to unacceptable manufacturing costs, unreliable devices, and hard-to-manage power dissipation and interconnect problems. Nanotechnologies that rely on self-assembly, biomolecular components, and nanoelectronics are promising alternatives to silicon-based microelectronics. They will eventually enable levels of integration that exceed that of today's silicon-based microelectronics by three orders of magnitude.

These nascent technologies present intriguing challenges and exciting opportunities to use biologically inspired solutions to address system architecture questions. Biological computation is capable of sensing and reacting to a time-varying redundant environment without the benefit of logic gates and formal systems. It does so by using coupled nonlinear dynamic systems which, while consisting of simple distributed components, have emergent complex and rich behavior. Applying models of the nonlinear dynamics of biological (neuro) computing to the design of nanocomputers and nanocomponents will make nanosystems ideal for applications for which von-Neumann architectures and microelectronic circuits are ill suited. These applications include pattern recognition, image processing, olfactory sensing, information filtering, and other forms of processing of sensorial information. They will be critical in bringing about extremely small, highly integrated intelligent sensors and actuators that combine micro-electrical-mechanical, chemical, and other forms of sensing with signal processing for purposes of perception, motion, and autonomous navigation.

This talk discusses recent results of an ongoing collaborative research effort by nanotechnologists, neurocomputing experts, and computer and circuit designers to explore novel architectures for nanoscale neuromorphic systems. The focus will be on implementations whose behavior depends on how propagation delays affect communication among system components. The components under considerations are reminiscent of spiking neurons and, unlike in classical systems, interconnect is used for computation as well as communication purposes. Hybrid systems will also be briefly discussed.

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José A.B. Fortes received an M.S. degree in Electrical Engineering from the Colorado State University, Fort Collins, in 1981 and a Ph.D. in Electrical Engineering from the University of Southern California, Los Angeles, in 1984. From 1984 until 2001, he was on the faculty of the School of Electrical Engineering of Purdue University at West Lafayette, Indiana. In 2001, he joined both the Department of Electrical and Computer Engineering and the Department of Computer and Information Science and Engineering of the University of Florida as Professor and BellSouth Eminent Scholar. From July 1989 through July 1990, he served at the National Science Foundation as director of the Microelectronics Systems Architecture program. From June 1993 till January 1994, he was a Visiting Professor at the Computer Architecture Department of the Universitat Politècnica de Catalunya in Spain.

Fortes' research interests are in the areas of network computing, biologically inspired nanocomputing, advanced computing architecture, and distributed information processing systems. He has authored or coauthored over 130 technical papers. His research has been funded by the Office of Naval Research, AT&T Foundation, IBM, General Electric, and the National Science Foundation.

José Fortes is a Fellow of the Institute of Electrical and Electronics Engineers (IEEE) professional society. He was a Distinguished Visitor of the IEEE Computer Society from 1991 till 1995. José Fortes is on the Editorial Boards of Cluster Computing: The Journal of Networks, Software Tools and Applications, the International Journal on Parallel Programming, and the Journal of VLSI Signal Processing. He is also a past member of the Editorial Boards of IEEE Transactions on Parallel and Distributed Systems and the Journal of Parallel and Distributed Computing.