Why Reliability Is Such a Nemesis – Rebooting Computing Reliability

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Offering high quality services/products has been from the early beginnings of paramount importance both for *communications* and for *computations*, which have started in dire need of designs which could enhance their reliability. That is why John von Neumann proposed the first *gate-level method* (using redundancy to build reliable systems from unreliable components), while Edward F. Moore and Claude E. Shannon followed suit with the first *device-level scheme* (where the nodes of the network were considered to be perfectly reliable, while the edges could fail independently with a certain probability). Moore and Shannon fundamental problem was that of estimating the probability that two (or more) nodes are connected, the solution being represented by the well-known reliability polynomial (a problem later proven to be #P-complete). Such concepts have been used heavily for *communications*, where big strides were made and applied for networks of: roads, railways, power lines, telegraph and telephone lines, optical fibers (Internet), as well as wireless phones and sensors (Internet of Things). Unfortunately, the story is quite different for *computations* where the research community converged on the gate-level method proposed by von Neumann, and the device-level scheme crafted by Moore and Shannon—although very practical and detailed—did not inspire circuit designers and went under the radar for the last half-century. Moore and Shannon scheme was built on a thought-provoking network called *hammock*, exhibiting regular brick-wall near-neighbor connections. With the steadfast progress of advanced CMOS nodes (currently in the realm of single digit nanometer), as well as the mind-blowing progress achieved by various quantum chips, networks for computing are being reassessed, and hammocks are somehow being revenged. That is why this talk aims to present the latest developments of a reasonably old field (network reliability) which is regaining traction as a very hot topic. The focus will be on ranking networks with respect to their computing reliability, an aspect which has never been properly analyzed before. The main conclusion is that a rebooting/rethinking/reassessing of how we should design and implement our future computing systems is both timely as well as immediately applicable to: arrays of devices (like, e.g., FinFET, MBCFET, GAA), qubits and (last but not least) topological quantum computing.

Short Bio: Valeriu Beiu(S'92–M'95–SM'96) received the MSc in Computer Engineering from the University "Politehnica" Bucharest in 1980, and the PhD summa cum laude in Electrical Engineering from the Katholieke Universiteit Leuven in 1994. Since graduating in 1980 he has been with the Research Institute for Computer Techniques, "Politehnica" University of Bucharest, Katholieke Universiteit Leuven, King's College London, Los Alamos National Laboratory, Rose Research, Washington State University, United Arab Emirates University, and currently is with "Aurel Vlaicu" University of Arad. His research interests have constantly been on biological-/neural-inspired circuits and brain-inspired architectures (low-power, highly reliable, massively parallel), being funded at over US$ 51M, and publishing over 270 papers (over 50 invited and more

than 10 patents) as well as giving over 200 invited talks, organizing over 100 conferences, and working (unfortunately very slowly) on two books: Emerging Brain-Inspired Nano-Architectures and VLSI Complexity of Discrete Neural Networks. Dr. Beiu has received five fellowships and eight best paper awards and is a Senior Member of the IEEE as well as a member of: ACM, INNS, ENNS, and MCFA. He was a member of the SRC-NNI Working Group on Novel Nano-architectures, the IEEE CS Task Force on Nano-architectures, and the IEEE Emerging Technologies Group on Nanoscale Communications, and has been an Associate Editor of the IEEE Transactions on Neural Networks(2005–2008), the IEEE Transactions for Very Large Scale Integration Systems(2011–2015), and the Nano Communication Networks(2010–2016).