Rebooting Computing Week 2017 Impressions

By D. Scott Holmes, SNF Co-editor Electronics

January 28, 2018 (HE114, STH625). Rebooting Computing Week (November 6-10, 2017) included three related meetings focusing on the next era of computing. This year superconductor electronics, while still far from central, was noticeably present and actively discussed. Links to videos from the meetings are available here.

Nov. 6-7 International Roadmap for Devices and Systems (IRDS) Fall Conference

The International Technology Roadmap for Semiconductors (ITRS) projected technology requirements and potential solutions for semiconductors from 2001 to 2014. The ITRS used transistor feature sizes, density, clock rate, and other metrics to roadmap the future of integrated circuits. In 2015, the ITRS committee presented a new roadmap, called ITRS 2.0, for key systems that contain integrated circuits and drive process, design, and integration technologies. Subsequent partnering of ITRS 2.0 with the IEEE Rebooting Computing (IEEE RC) Initiative resulted in the International Roadmap for Devices and Systems (IRDS).

The IRDS mission is to “Identify the roadmap of electronic industry from devices to systems and from systems to devices”, which represents a broadening of the scope. For an overview, see Paolo Gargini's presentation given at the November 10 Industry Summit and described below.

“Beyond CMOS” is one of the IRDS focus topics and includes technologies other than Complementary Metal-Oxide Semiconductor (CMOS) electronics such as memristors, spintronics, straintronics, and superconductor electronics. As participants in the Beyond CMOS International Focus Team, D. Scott Holmes and Erik DeBenedictis started a Cryogenic Electronics group, thus initiating superconductor electronics as an activity within the IRDS.

The IRDS outbrief on November 7 included a slide summarizing the Cryogenic Electronics group's progress. The Cryogenic Electronics team included 18 people and technology areas: superconductor electronics (SCE), cryogenic semiconductor electronics, and cryogenic quantum computing (QC).

The IRDS report for 2017 is expected to be available in March. Whereas ITRS reports in off (even) years were minor revisions, the IRDS 2018 effort is expected to be substantial as this was the first for the IRDS and the first to include cryogenic (and superconductor!) electronics.

Nov. 7-9 IEEE International Conference on Rebooting Computing (ICRC)

Robert Schoelkopf of Yale gave a plenary talk "The Prospects for Quantum Computing with Superconducting Circuits". While the talk is not yet available online, a presentation given earlier in the year with the same title is available here. Schoelkopf's conclusion is that significant progress has been made with superconducting circuits. While most steps towards fault-tolerant quantum computation have been demonstrated, much work remains to make a quantum computer.

Superconducting quantum computing was also the subject of "Building a Quantum Computing Community and Ecosystem" presented by Jerry Chow of IBM Watson Research Center. Included was information about IBM's online quantum experience (IBM Q) and quantum information software kit (QISK).

Quantum annealing using D-Wave machines based on superconductor circuits was the subject of 3 talks. Nga Nguyen of Los Alamos National Laboratory presented "Solving Sparse Representation for Image Classification using Quantum D-Wave 2X Machine". Georg Hahn of Imperial College London presented "Reducing Binary Quadratic Forms for More Scalable Quantum Annealing". Zachary Baker of Los Alamos National Laboratory presented "An FPGA-Quantum Annealer Hybrid System for Wide-Band RF Detection".

Michael Schneider of NIST presented a vision for how to achieve neuromorphic (brain-like) computing using superconductor electronics in "Energy-Efficient Single-Flux-Quantum Based Neuromorphic Computing". Key to the concept are neural cells based on magnetic Josephson junctions (MJJs) in which the magnetic order parameter, and thus the critical current, depends on the past history of currents through the device. Spiking networks built from such cells should have a promising combination of energy efficiency and high speed. The paper is available (doi:10.1109/ICRC.2017.8123634). For an IEEE reporter's take on the presentation, see "4 Strange New Ways to Compute" by Samuel K. Moore.

"Hybrid Cryogenic Memory Cells for Superconducting Computing Applications" by Jeng-Bang Yau, Yat-Kiu-Kent Fung, and Gerald W. Gibson, Jr. of IBM Watson Research Center proposed a hybrid cryogenic memory architecture made with Josephson junctions and Toggle MRAM. Toggle field magnetic tunnel junction (MTJ) devices have been operated successfully at 4.2 K with encouraging results. Memories based on Josephson MRAM appear to have significant density advantages over vortex-transitional (VT) memories and power advantages over both VT and Josephson-CMOS SRAM. The paper is available (doi:10.1109/ICRC.2017.8123684).

Nov. 10 Industry Summit on The Future of Computing

Dario Gil, IBM Research VP for AI and IBM Q, gave the lead presentation "The Future of Computing: AI and Quantum". In the talk he announced that for the first time that IBM’s scientists have successfully built and measured a quantum processor prototype with 50 superconducting qubits — a major milestone. Gil argues that we are now in a "quantum ready" era projected to run from 2016 to ~2020 and to be followed by an era of "quantum advantage".

Paolo Gargini, IRDS Chair, presented "A Roadmap for Devices and Systems" telling the story of the International Roadmap for Devices and Systems (IRDS) and how it evolved from the ITRS.