Summary of the second IEEE Rebooting Computing Summit (RCS 2)

The second IEEE Rebooting Computing Summit (RCS 2), organized by the Future Directions Committee (FDC) Rebooting Computing Initiative, concluded successfully on May 16, 2014 at the Chaminade, Santa Cruz, CA. RCS 2 included 48 invited participants who are thought leaders from government agencies, academia and industry. RCS 2 built on the findings of the first Rebooting Computing Summit (RCS 1, Dec 11-13, 2013, Washington DC) and focused on four computing technologies: Augmentation of CMOS, Approximate Computing, Adiabatic and Reversible Computing and Neuromorphic Computing. RCS 2 also included a poster session.

On May 14 afternoon, Tom Conte and Elie Track, RCS 2 Co-Chairs, opened the Summit, welcomed participants and provided a recap of RCS 1 followed by an introduction to the RCS 2 agenda, goals, and expected outcomes. Next, Facilitator Scott Holmes led a group discussion to restate and adjust the goals of RCS 2. This was followed by two plenary talks.

- *"ITRS 2.0 and Its System Drivers: Focus on Systems Trends and 'MTM' [More Than Moore]"*– Representing ITRS, Andrew Kahng, UC San Diego.
  Prof. Kahng contrasted the traditional ITRS roadmap, based on enhancement of IC technology according to Moore's Law, with the new version, ITRS 2.0, which includes a focus on applications and system drivers, which he called "More Than Moore," or MTM. An example of system drivers for the next decade includes mobile applications, where power consumption and cost are essential criteria. This new vision will be reflected in the 2015 ITRS roadmap.

- "*Introduction to Neuromorphic Computing - Insight and Challenges,*" Todd Hylton, Brain Corporation.
  Dr. Hylton was formerly the DARPA program manager who initiated the SyNAPSE project on Neuromorphic Computing. He focused in his talk on the lessons learned during this project, including that building a computer from components that act as neurons is NOT the same thing as building a brain. We know how to do the former, but we don't really know how brains work, and we don't know how to develop the required software. The performance of brain structures on the largest scale may be only weakly dependent on the properties of neurons. Future R&D is necessary that combines algorithm development with network topology.

Yung-Hsiang Lu gave an overview of the "Competition for Low Power Image Recognition" sponsored by the Rebooting Computing Initiative. More details on the competition can be found on the RC Blog http://rebootingcomputing-ieee.blogspot.com/

The day concluded with a reception, dinner and Poster Presentations:

- Ken Segall, et al. (Colgate U) Josephson Neurons & Synapses in a Superconducting Digital Architecture
- Stan Williams (HP), Memristors for Neuromorphic Computing
- Dhireesha Kudithipudi (Rochester Inst. Technol), Intelligent Computing with Neuromemristive Circuits
- Maya Gokhale, et al. (Livermore Nat. Lab), Computing with Distributed Memory
- Adrian Sampson and Louis Ceze (U. Wash), Approximate Computing
- Liang Zhao, et al. (Stanford), Neuromorphic Computing

On May 15 morning, Elie Track, Tom Conte and Scott Holmes provided a recap of the May 14 activities. This was followed by two plenary talks.

- "*Reversible/Adiabatic Classical Computation – An Overview"*– David Frank, IBM
  Dr. Frank reviewed approaches to classical computing (not quantum computing) known as Adiabatic and Reversible Computing. Both of these are general approaches to reducing the switching power of computer circuits, trading off speed and complexity. Adiabatic computing reduces power dissipated in resistors, instead temporarily storing power in inductors and capacitors. Reversible computing can in principle go further, to completely eliminate power dissipation. While adiabatic computing can be applied to conventional CMOS technology, power reductions may be somewhat limited. Novel alternative technologies such as Quantum Dot Cellular Automata and superconducting circuits may be more amenable to power reduction, but are much less developed.

- "*Approximation- Beyond the Tyranny of Digital Computing,*" Hadi Esmaeilzadeh, Georgia Tech.
  Prof. Esmaeilzadeh addressed a set of approaches to reducing power based on obtaining acceptable answers from components that may themselves be inaccurate or unreliable. For many applications such as searching, image processing, and analog sensor processing, an approximate result may be quite sufficient, and can be obtained with reduced power on mobile devices. This requires innovation on both the software and the hardware levels, and involves a change from the traditional paradigm where maximum accuracy was assumed to be essential.

Mark Stalzer, Moore Foundation, talked about the concepts and requirements of a possible XPrize for Rebooting Computing.

The discussion portion of the Summit, moderated by Scott Holmes, began on May 15 afternoon. Participants divided themselves into four working groups

- Augmentation of CMOS, facilitated by Subu Iyer (IBM)
- Approximate Computing, facilitated by Hadi Esmaeilzadeh (Georgia Tech)
- Adiabatic and Reversible Computing, facilitated by Erik DeBenedictis (Sandia)
- Neuromorphic Computing, facilitated by David Mountain (Ctr. For Exceptional Computing)

On May 16, each of the four working groups provided an outbrief of their respective discussions. The Summit concluded with a plenary discussion where participants shared their insights and conclusions on the RCS 2 vision and discussed potential topics for the next Summit. An upcoming third Summit (RCS 3) is being planned for October 23-24, 2014, in San Jose, California to further refine the vision and recommend the next steps to promote implementation of the vision.

The general consensus of the participants was that although the computer industry will continue to advance in the near term, the end of Moore's Law on the chip level will require at least a partial Rebooting of Computing. Alternative computing technologies and approaches are not yet mature enough to supplant conventional technologies, but they are sufficiently promising to recommend further R&D to identify how they may provide opportunities for Rebooting Computing in the future. Throughout this 3-day Summit, the high energy level, interactive discussions of an engaging audience and the genuine and insightful contributions of all participants were key ingredients to the success of RCS 2.

The PDF slides and links to videos of the four plenary presentations will be posted on the Rebooting Computing Portal http://rebootingcomputing.ieee.org soon.

The RCS 2 Final Report will also be available on the Rebooting Computing Portal in the near future.