Federal Vision for Future Computing

-A Nanotechnology-Inspired Grand Challenge-

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www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

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A Nanotechnology-Inspired Grand Challenge for Future Computing

OCTOBER 20, 2015 AT 6:00 AM ET BY LLOYD WHITMAN, RANDY BRYANT, AND TOM KALIL

Summary: Today, the White House is announcing a grand challenge to develop transformational computing capabilities by combining innovations in multiple scientific disciplines.

In June, the Office of Science and Technology Policy issued a Request for Information seeking suggestions for *Nanotechnology-Inspired Grand Challenges for the Next Decade*. After considering over 100 responses, OSTP is excited to announce the following grand challenge that addresses three Administration priorities—the National Nanotechnology Initiative, the National Strategic Computing Initiative (NSCI), and the BRAIN initiative:

Create a new type of computer that can proactively interpret and learn from data, solve unfamiliar problems using what it has learned, and operate with the energy efficiency of the human brain.

https://www.whitehouse.gov/blog/2015/10/15/nanotechnology-inspired-grand-challenge-future-computing

Grand Challenge Committee - Collaborating Agencies

DOE - *Robinson Pino (co-lead)*
NSF - *Sankar Basu (co-lead)*
IC - *David Mountain*
DARPA - *Kerry Bernstein*
NIST - *Curt Richter*
ARO - *Joe Qiu*

Members sought out participation, ideas, input, feedback, and contributions from home institutions and sister agencies

Objective:

- **Highlight potential areas of Federal *R&D* focus and investment**
  - Pursue emerging and innovative solutions that will address the Nanotechnology-Inspired Grand Challenge for Future Computing.
- **Describe technical challenges, opportunities, and potential applications**
  - Of interest to the collaborating agencies
  - Serve as a guide for future Federal investments

https://www.nano.gov/sites/default/files/pub_resource/federal-vision-for-nanotech-inspired-future-computing-grand-challenge.pdf

Success = Game-Changing Capabilities

- **Emerging computing architecture platforms, neuromorphic, quantum, …**
  - Significantly accelerate algorithm performance and concurrency while reducing energy consumption by over six orders of magnitude (from megawatts to watts)
- **Intelligent big data sensors: Autonomous and Reprogrammable**
  - Increased flexibility and communication with other networked nodes while maintaining security and avoiding interference with the things being sensed
- **Machine intelligence for scientific discovery**
  - Enable rapid extreme-scale data analysis and be able to deal with unlabeled data sets
  - Capable of understanding and making sense of results, thereby accelerating innovation
- **Cybersecurity**
  - Prevent/minimize unauthorized access, identify anomalous behavior, ensure data and software code integrity
  - Provide contextual analysis for adversary intent or situational awareness; i.e., deter, detect, protect, and adapt

Research and Development Focus Areas

Goals	Materials	Devices and Interconnects	Computing Architectures	Brain-Inspired Approaches	Fabrication	Software, Modeling, Simulation	Applications
5 Years	Identify new emerging material systems for devices and CMOS integration	Model and characterize emerging scalable devices and circuits	Digital and analog design, modeling and characterization	Translate knowledge - biology, neuroscience and materials	Tools and fabrication capabilities able to integrate new material systems	Software that do not require deep knowledge to use effectively	Understand attack scenarios, human-machine augmented interactions
10 Years	Modeling and simulation for characterization, simulation and prediction	Nonlinear models and standard libraries for large-scale	Predict performance using new material systems	Reverse engineer biology-inspired computing architectures	Prototyping of new architectures using new materials	Nonlinear phenomena and ensure modeling scalability	Space exploration with energy-efficient resources
15 Years	Understanding of systems properties, scaling, and prediction	Minimize knowledge required in materials or device physics	Application focused design and characterization	Large-scale emulation, and hardware prototyping	Accessible and cost-effective foundry process and design	Automated discovery and complex space exploration tools at scale	Autonomous complex space and scenario exploration at scale

Grand Challenge Activities and Events

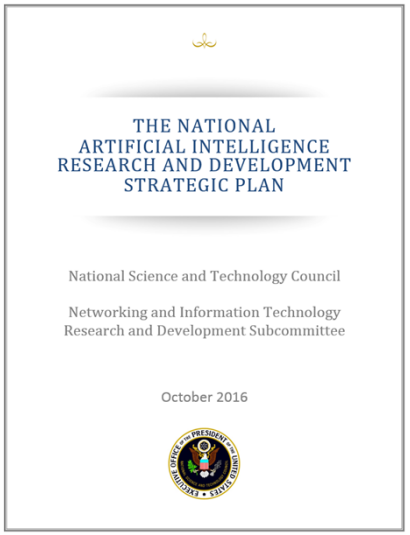
- **2015 DOE** Neuromorphic Computing – From Materials Research to Systems Architecture Roundtable
- **2015 IEDM** (note Focus Session – Beyond von Neumann Computing), Washington, DC, December 7–9, 2015
- **2015 IEEE** Rebooting Computing Summit 4 (RCS 4), Washington, DC, December 9–11, 2015
- **2015 OSA** Optical Computing Incubator, Washington, DC, December 9–11, 2015
- **2016 DOE** Neuromorphic Computing – Architectures, Models, and Applications Workshop
- **2016 LPIRC** Low-Power Image Recognition Challenge (LPIRC) 2016, Austin, TX, June 5–9, 2016
- **2016 Frontiers in Neuromorphics** Workshop, Los Angeles, CA, April 14-15, 2016
- **2016 Nanotechnology-Inspired** Information Processing Systems of the Future, Washington, D.C., August 31-September 1, 2016
- **2016 IEEE** Rebooting Computing conference, San Diego, CA, Oct. 17-19, 2016
- **2017 AAAS** The Human Brain and Computing Machines of the Future Symposium, 2017 AAAS Annual Meeting, February 19, 2017, Boston, MA
- **2017 AFRL-DOE** Energy Consequences of Information (ECI) Workshop, February 23-25, 2017, Santa Fe, NM
- **2017 NICE** Neuro Inspired Computational Elements Workshop, March 6-8, 2017, IBM, Almaden, CA

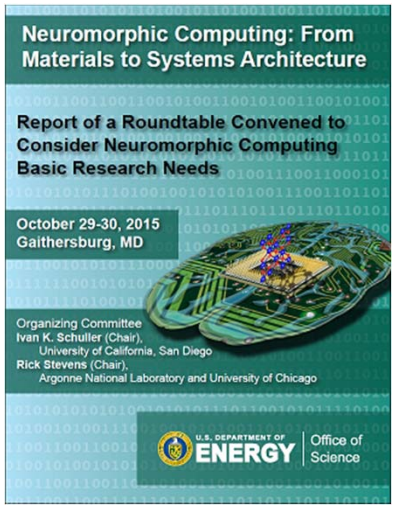
http://www.nano.gov/node/1523#reportsandwhitepapers
https://community.apan.org/wg/afosr/w/researchareas/18305.2017-energy-consequences-of-information-eci/
https://www.src.org/calendar/e006125/
https://aaas.confex.com/aaas/2017/webprogram/Session15145.html

DOE Office of Science Programmatic Activities

Joint activities by ASCR and BES since launch of Grand Challenge

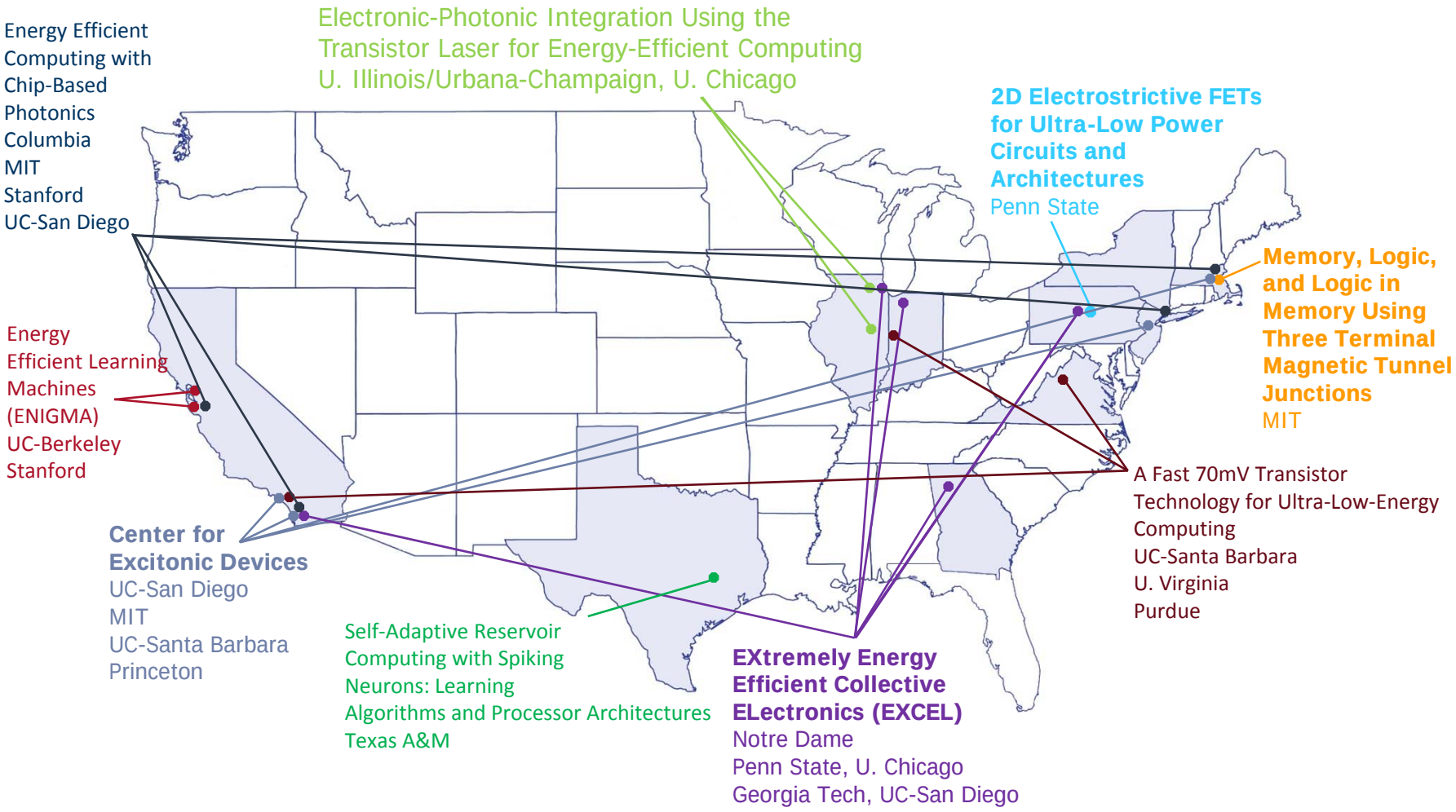
- Goal and Objectives
  - Evaluate both advanced materials and scientific computing research opportunities to support development of a new paradigm for extreme and self-reconfigurable computing architectures that go beyond Moore's Law and mimic neuro- biological computing architectures
- Why Neuromorphic Computing?
  - Conventional computing fails in some of the most basic tasks that biological systems have mastered such as language and vision *understanding*
  - Cues from biology might lead to fundamental improvements in computational capabilities





Energy Efficient Computing: Devices to Architectures (E2CDA) – jointly between NSF and SRC

- **Focus: Non-silicon, non-von Neumann**
- **FY 2016: Total $21.6M, Award amounts $600k -$1.6M/yr for 3 years**



Related Other Joint Activities at NSF

Intelligent Cognitive Assistants NSF-sponsored workshop (May 2016):

Robotics, computational neuroscience, AI, machine learning, and computer science and engineering to identify critical research gaps and recommended 'next steps'. Report
https://www.nsf.gov/crssprgm/nano/2016-1001_IntelligentCognitiveAssistants_Workshop_2016_Final_Report.pdf

Smart Autonomous Systems (SAS), part of NRI Inititative/SRC:

SAS focused on intelligent autonomy, NRI 2.0 focused on 'co-robots' (robot-human collaboration)

NSF/Intel Partnership:

Computer Assisted Programming for Heterogeneous Architectures (CAPA). PROGRAM SOLICITATION NSF 16-606

https://www.nsf.gov/pubs/2016/nsf16606/nsf16606.htm