NERSC
National Energy Research Scientific Computing Center

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NERSC: the Mission HPC Facility for DOE Office of Science Research

Largest funder of physical science research in the U.S.

Bio Energy, Environment

Computing

Materials, Chemistry, Geophysics

Particle Physics, Astrophysics

Nuclear Physics

Fusion Energy, Plasma Physics

6,000 users, 700 projects, 700 codes, 48 states, 40 countries, universities & national labs
Focus on Science

NERSC supports the broad mission needs of the six DOE Office of Science program offices.

7,000 users and 850 projects.

Supercomputing and data users.

NERSC science engagement team provides outreach and POCs.

2,000 refereed publications per year.
High Performance Computing is …

… the application of "supercomputers" to scientific computational problems that are too large for standard computers, would take them too long, would be too dangerous, or probe inaccessible realms.

- Understanding The Universe
- Extreme Climate Events
- Biofuels
- Designing Better Batteries
- Understanding How Proteins Work

Cheap & Efficient Solar
Science Highlights June 2017

Astrophysics
First 2D models of rare superluminous supernova reveal insight into their origin.
NERSC PI: Woosley, UC Santa Cruz. Astrophysical Journal

Materials Science
Researchers develop a process that promises to speed the discovery of commercially viable materials to produce solar fuels. PI: Neaton, Berkeley Lab. Proc. Nat. Acad. Sci.

Materials Science
Scientists have discovered a way to use diamondoids to make electrical wires just 3 atoms wide. NERSC PI: Devereaux, Stanford, Nature Materials

Fusion Energy
Researchers find multiscale electron energy transport in tokamak fusion reactors. NERSC PI: Holland, UC San Diego. Nuclear Fusion

Atmospheric Science
3D models lead to an improved statistical representation of clouds. NERSC PI: Ovchinnikov, Pacific NW Labs, J. of Geophys. Resrch: Atmospheres

Environment
Simulations reveal that less dust leads to worse air pollution in China. NERSC PI: Ghan, Pacific NW Labs. Nature Communications
Production High Performance Computing Systems

**Cori**

- 9,600 Intel Xeon Phi “KNL” manycore nodes
- 2,000 Intel Xeon “Haswell” nodes
- 700,000 processor cores, 1.2 PB memory
- Cray XC40 / Aries Dragonfly interconnect
- 30 PB Lustre Cray Sonexion scratch FS
- 1.5 PB Burst Buffer

#6 on list of Top 500 supercomputers in the world

**Edison**

- 5,560 Ivy Bridge Nodes / 24 cores/node
- 133 K cores, 64 GB memory/node
- Cray XC30 / Aries Dragonfly interconnect
- 6 PB Lustre Cray Sonexion scratch FS
A Supercomputer is …

… not so different from a super high-end desktop computer.

Or rather, a lot of super high-end desktop computers.

Cori has 11,000 “nodes” (each ~a powerful high-end desktop)

700,000 compute cores
~$30 \times 10^{15}$ calculations/second
7 billion people on 4 million Earths doing 1 calculation each second = 1 Cori
In parallel computing, scientists divide a big task into smaller ones

“Divide and conquer”

For example, to simulate the behavior of Earth’s atmosphere, you can divide it into zones and let each processor calculate what happens in each.

From time to time each processor has to send the results of its calculation to its neighbors. Without the high-speed custom network available on supercomputers, this communication step would make the calculations take much too long.
The nodes are all connected to each other with a high speed, low latency network.

This is what allows the nodes to “talk” to each other and work together to solve problems you could never solve on your laptop or even 150,000 laptops.

**Typical point-to-point bandwidth**
Supercomputer: 10 GBytes/sec
Your home: 0.02* GBytes/sec

**Latency**
Supercomputer: 1 µs
Your home computer: 20,000* µs

* If you’re really lucky
PBs of fast storage for files and data
Cori: 26 PB
Your laptop: 0.0005 PB
Your iPhone: 0.00005 PB

Write data to permanent storage
Edison: 140 GB/sec
My iMac: 0.01 GB/sec

How big is 26 PBs?
338 years of HD video
½ the entire written works of mankind ever, in all languages

Cloud systems have slower I/O and less permanent storage

HPSS tape library: 75 PB
• ~20 NERSC projects have “EERE” in their project description.
• 100s are working on the basic science of energy technologies

- Materials for photovoltaics, H₂O catalysis and hydrogen storage, full-spectrum & high-power LEDs, battery storage, artificial photosynthesis, biofuels, …
- Earthquake safety for nuclear power plants
- All-liquid thermal storage materials
- City building energy saver
- Historical climate effects on California wind power resources
- Understanding and Mitigating Barriers to Wind Energy Expansion in California
- Turbulence over complex terrain: a wind-energy perspective
- Exascale Predictive Wind Plant Flow Physics Modeling
- Effect of offshore wind farms on storm surges
- Nuclear waste disposal
- CRUD formation and boron disposition on fuel rods
Research questions are focused on the energy impacts and efficacy of our changing transportation system through the lens of user behavior and decision-making in both the short and long run time frames.

Along with analysis of changing modes of mobility, the project is conducting detailed work on vehicle-grid integration to analyze the potential for EVs to support the grid through management of uni-directional or bi-directional vehicle charging.

This effort requires an analytical approach that captures the expected behaviors of EV drivers in how they choose to charge their vehicles and whether they will elect to participate in vehicle to grid exchanges or managed charging sessions.
Matthew Barone, Stefan Domino
Sandia (NM) National Laboratories
Michael Sprague, Matthew Churchfield
National Renewable Energy Laboratory
ALCC Project 2017
10.7 Million NERSC Hours

• DOE’s Wind Power Program targeting significant reductions in the cost of wind energy through its Atmosphere to Electrons (A2e) program
• DOE EERE Wind and Power Technologies Office committed to developing technologies to enable 35% of U.S. electric supply by 2050
• Aimed at improving fundamental understanding of the complex physics governing wind flow into and through wind plant.
• Accurate predictive simulations reduce uncertainty for project planning and financing.

Complex terrain can lower efficiency by 30%
Turbines in farms experience fail more often
1% improvement in performance = $100 M in U.S. savings
2% improvement saves $1B annually by 2030
NERSC at a Glance

A U.S. Department of Energy Office of Science User Facility
Provides High Performance Computing and Data Systems and Services
Unclassified Basic and Applied Research in Energy-Related Fields
6,000 users, 750 different scientific projects
Located at Lawrence Berkeley National Lab, Berkeley, CA
Permanent Staff of about 70