INL/MIS-19-54938-Revision-0

Supercomputing For Everyone!

July 2019

Matthew William Anderson

Changing the World's Energy Future

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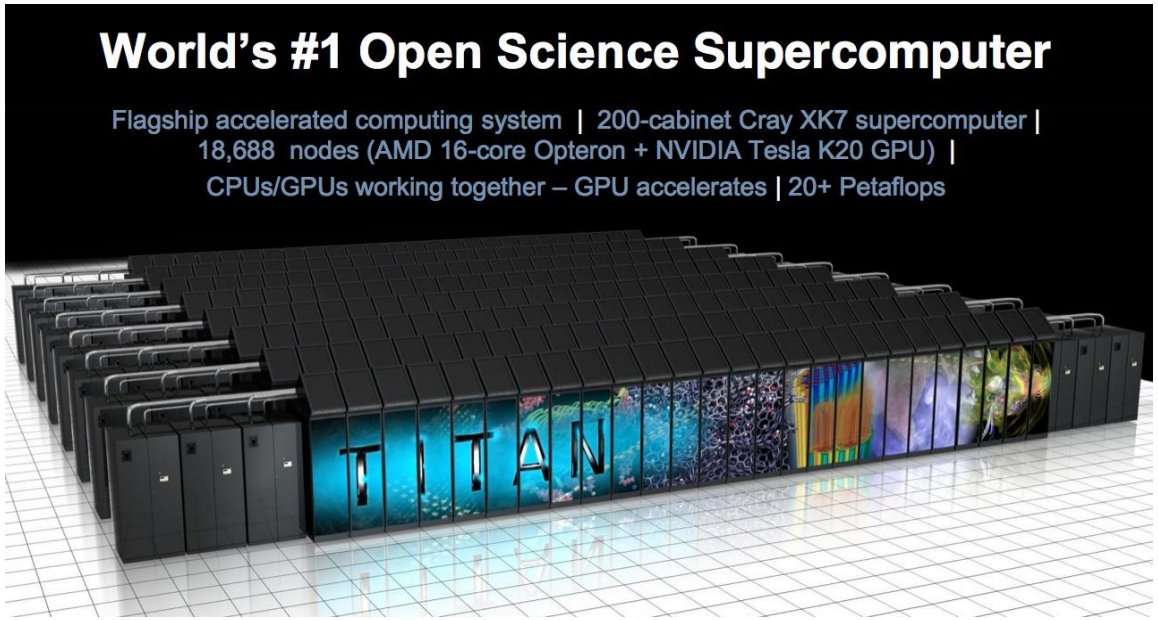
What is a Supercomputer?

A computer that operates at or near the peak performance achievable within the constraints of existing technology and available power and cooling.

What makes a supercomputer "super"?

- Cost:
  - A leadership scale supercomputer costs ~$1E8!
- Size:
  - Can require 6,000+ square feet of space!
- Power:
  - Can require $6-7 million/year to operate
- Speed:
  - INL's supercomputers can compute in one second what would take a human with a calculator 50 trillion years!
- Rate of innovation:
  - Today's smart phones are faster than supercomputers in the 1970's!



vs

Epochs in Supercomputing

- Automated Calculators: 2400 BCE to 1900's

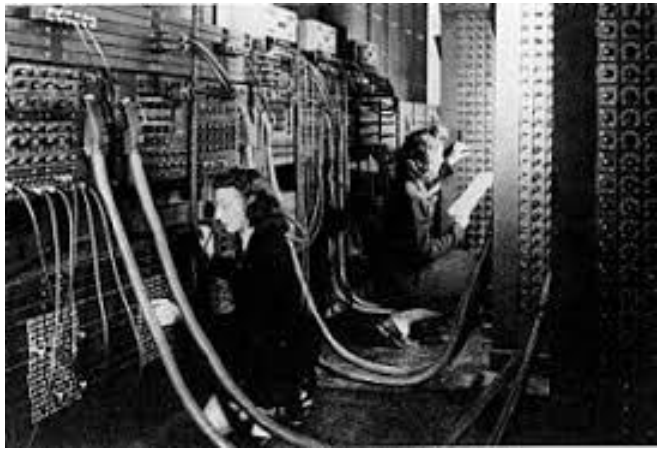
Charles Babbage "Analytical Engine" (1834)

The Harvard Mark 1 (1944)
Peak performance: 1 instruction/sec

Von Neumann architecture in Vacuum Tubes

The vacuum tube invented by Thomas Edison by accident in 1880 gave rise a new epoch in computing capability:

The Electronic Delayed Storage Automatic Calculator (1949).
Peak performance: 600 instructions/sec



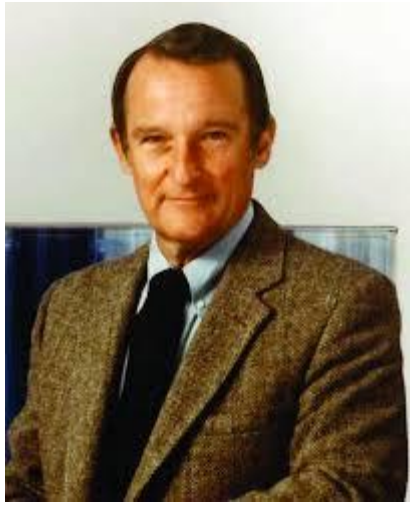
The ENIAC (1945).

The IBM 701 (1952). Peak performance: 4000 instructions/sec

The Transistor

- The transistor was invented at Bell labs in 1947 as an alternative to the vacuum tube; it uses semiconducting materials to act as an electronic switch

The CDC 6600: The "First" Supercomputer (1964)
Peak performance: 1 Megaflops



Seymour Cray: "father of supercomputing"

Vector Processing

- The Integrated Circuit (Jack Kilby 1959, Nobel prize 2000) and shrinking transistor sizes enabled small scale integration.

The Cray X-1, peak performance 136 Megaflops

Attack of the Killer Micro

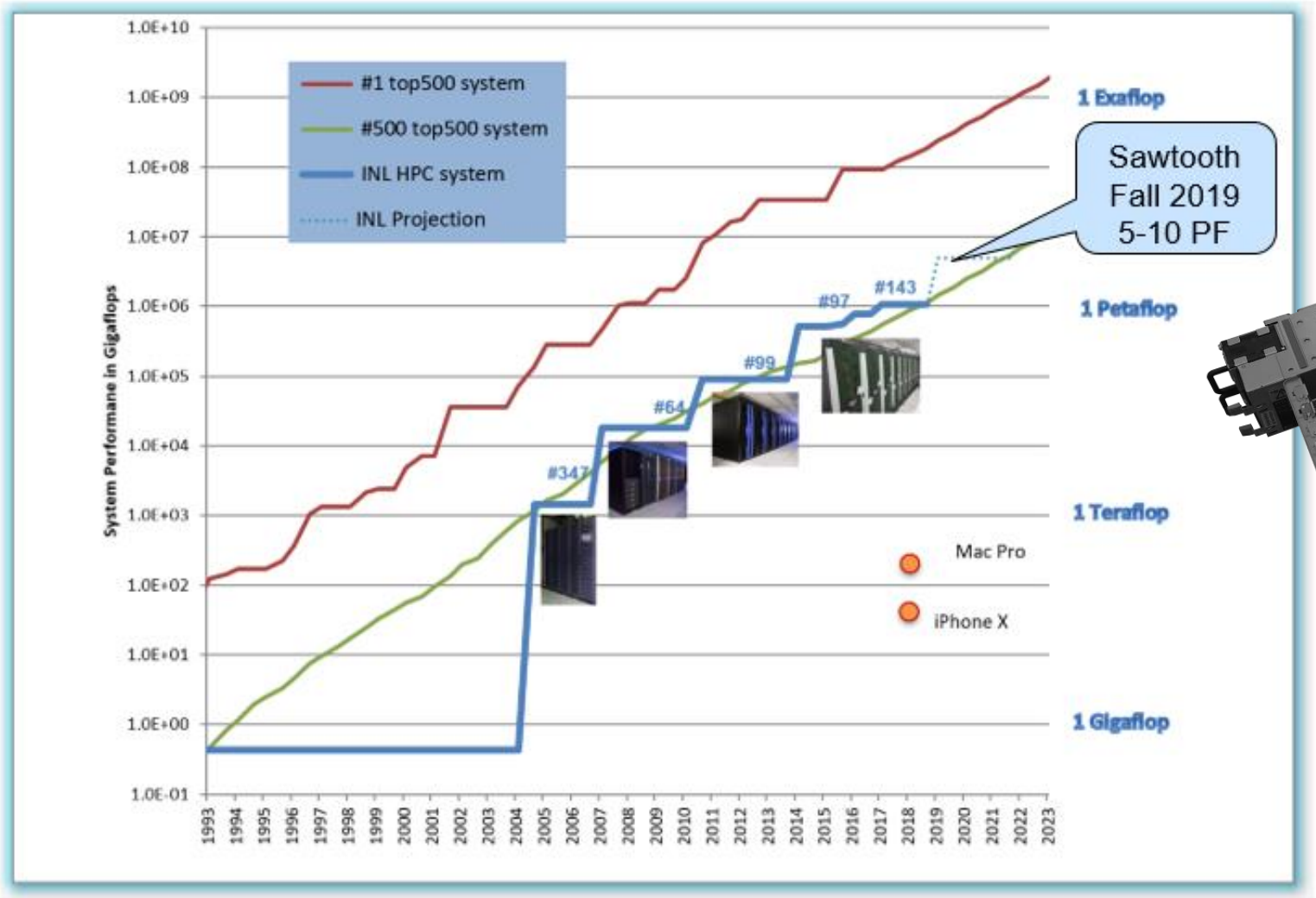
- Billions of transistors on a single semiconductor die. Concentrated functional capability on the microprocessor. Message-passing capability between devices

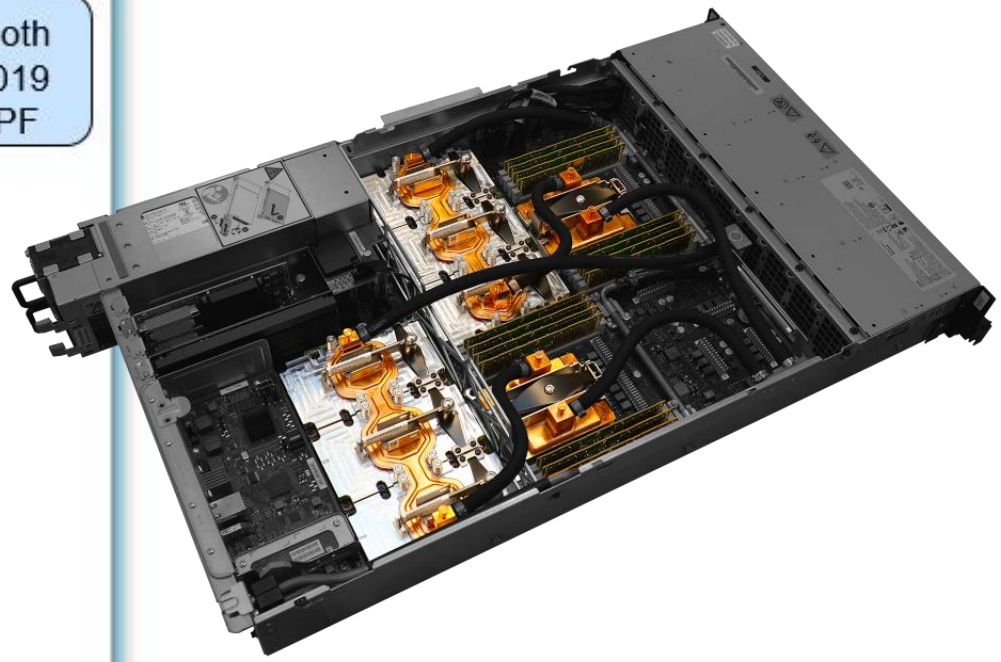
Touchstone Delta (1990s). 500 cores connected by mesh topology. 10-20 Gigaflops.

Beowulf cluster (1994). Today >80% of supercomputers are of this class.

We often use the term "cluster" to refer to Beowulf class supercomputers. The term originates from the DEC M31 Andromeda project.

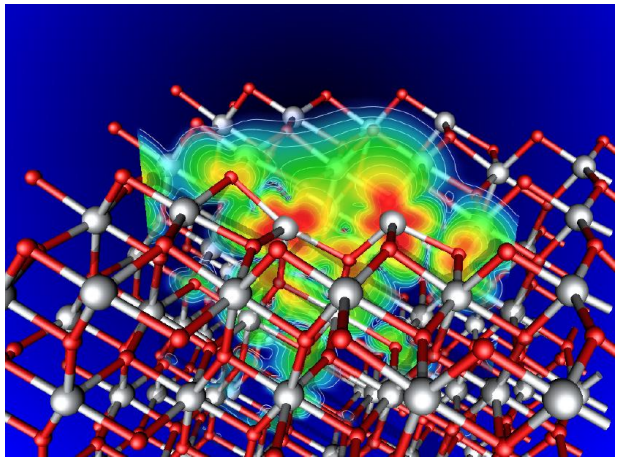
Multicore Petaflops



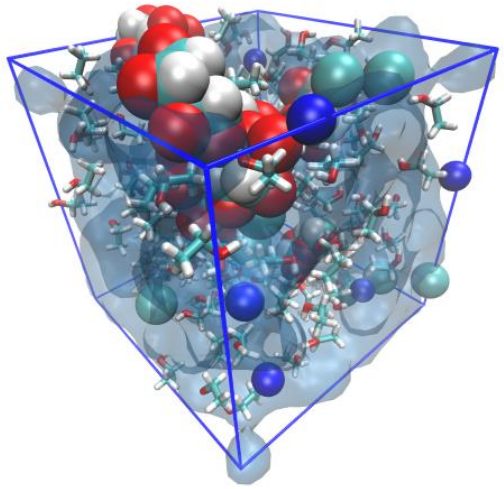


Node of Summit with 6 GPUs/node. Power for Summit: 13 MW

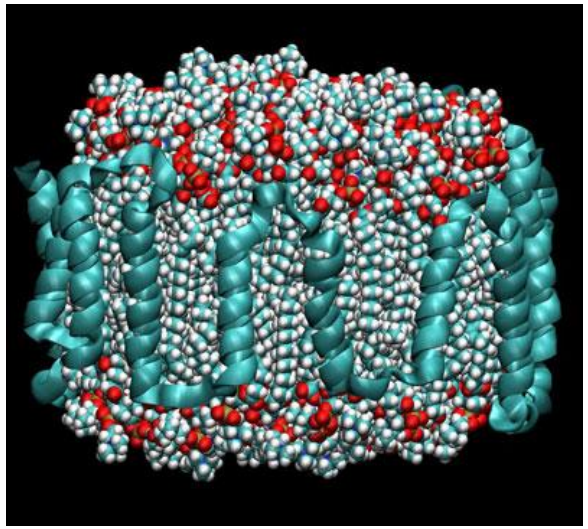
Applications for Supercomputers



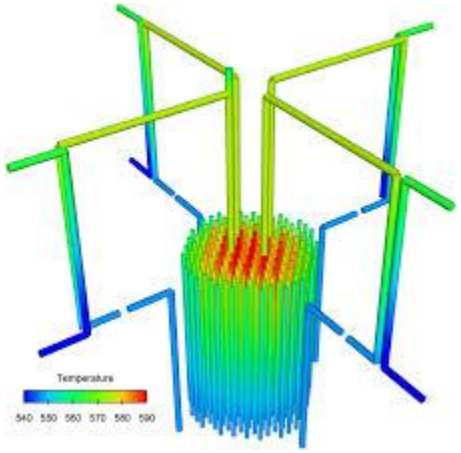
Supersteel design



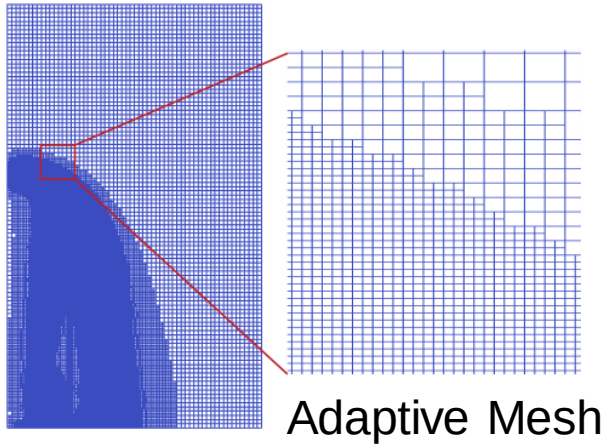
Molecular dynamics materials simulations



Protein modeling for in-vivo simulation



Full core nuclear reactor simulation



Adaptive Mesh Refinement simulations