Top 3 Supercomputers

Rank	System
1	**Supercomputer Fugaku** - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan
2	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM DOE/SC/Oak Ridge National Laboratory United States
3	**Sierra** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband, IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States

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1. SUPERCOMPUTER FUGAKU

The Fugaku computer system was designed and built by Fujitsu and RIKEN. The system is installed at the RIKEN Center for Computational Science (R-CCS) in Kobe, Japan. RIKEN is a large scientific research institute in Japan with about 3,000 scientists in seven campuses across Japan. Development for Fugaku hardware started in 2014 as the successor to the K computer. The K Computer mainly focused on basic science and simulations and modernized the Japanese supercomputer to be massively parallel. The Fugaku system is designed to have a continuum of applications ranging from basic science to Society 5.0, an initiative to create a new social scheme and economic model by fully incorporating the technological innovations of the fourth industrial revolution. The relation to the Mount Fuji image is to have a broad base of applications and capacity for simulation, data science, and AI— with academic, industry, and cloud startups—along with a high peak performance on large-scale applications.

The Fugaku system is built on the A64FX ARM v8.2-A, which uses Scalable Vector Extension (SVE) instructions and a 512-bit implementation.

The Fugaku system adds the following Fujitsu extensions:

- hardware barrier
- sector cache: In sector mapping, the main memory and the cache are both divided into sectors; each sector is composed of a number of blocks. Any sector in the main memory can map into any sector in the cache and a tag is stored with each sector in the cache to identify the main memory sector address.
- prefetch: Windows creates a prefetch file when an application is run from a particular location for the very first time. This is used to help speed up the loading of applications.
- 48/52 core CPU.

It is optimized for high-performance computing (HPC) with

- an extremely high bandwidth 3D stacked memory
- 4x 8 GB High Bandwidth Memory (HBM) with 1024 GB/s
- on-die Tofu-D network BW (~400 Gbps)
- high SVE FLOP/s (3.072 TFLOP/s): In computing, floating point operations per second is a measure of computer performance, useful in fields of scientific computations that require floating-point calculations. For such cases it is a more accurate measure than measuring instructions per second.
- various AI support (FP16, INT8, etc.)

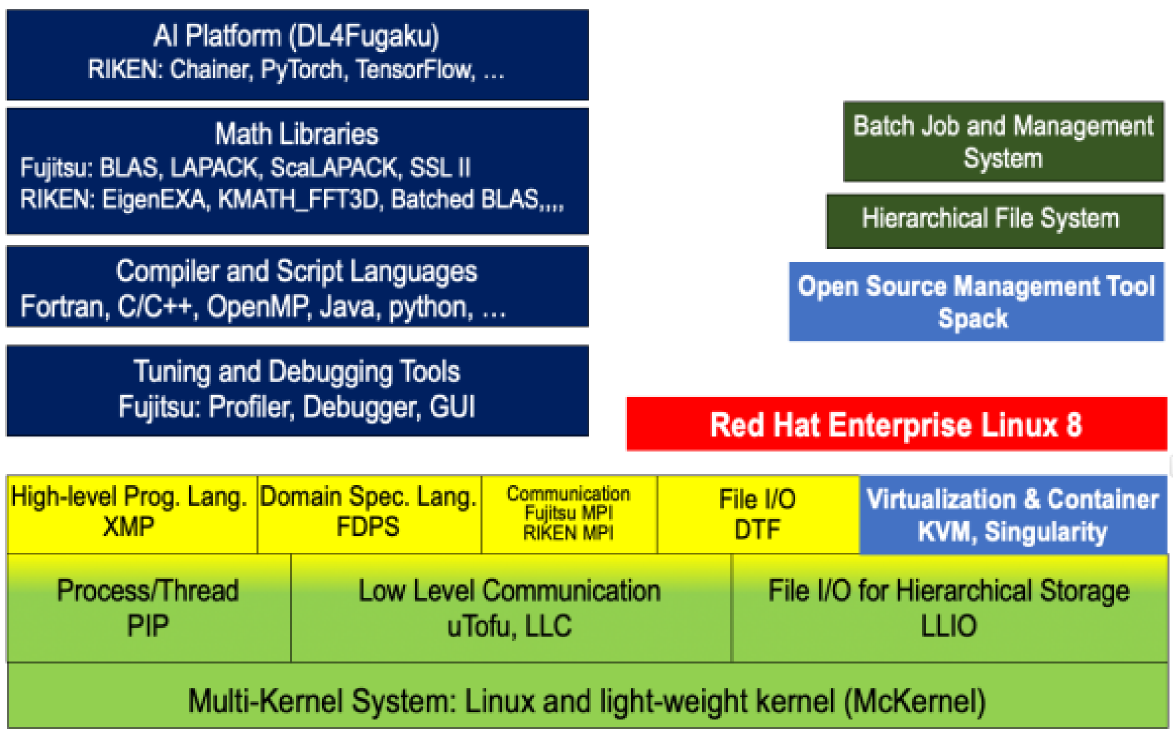
The A64FX processor provides for general purpose Linux, Windows, and other cloud systems. Simply put, Fugaku is the largest and fastest supercomputer built to date.

Below is further breakdown of the hardware.

• Caches:
  - L1D/core: 64 KB, 4way, 256 GB/s (load), 128 GB/s (store)
  - L2/CMG: 8 MB, 16 way
  - L2/node: 4 TB/s (load), 2 TB/s (store)
  - L2/core: 128 GB/s (load), 64 GB/s (store)

- 158,976 nodes
    - 384 nodes × 396 racks = 152,064
    - 192 nodes × 36 racks = 6,912
- 4.85 PB of total memory
- 163 PB/s memory bandwidth
- Tofu-D 6D Torus network, 6.49 PB/s injection bandwidth
    - (28 Gbps × 2 lanes × 10 ports)
- 15.9 PB of NVMe L1 storage
- PCIe Gen3 ×16
- Many-endpoint 100 Gbps I/O network into Lustre
- The first “exascale” machine (not for 64-bit floating point but in application performance).

Fugaku Software Stack:



2. SUMMIT

Summit (OLCF-4) is Titan's successor, a 200-petaFLOP supercomputer operating by the DoE Oak Ridge National Laboratory. Summit was officially unveiled on June 8, 2018 as the fastest supercomputer in the world, overtaking the Sunway TaihuLight.

	Components				System		
Processor	CPU	GPU		**Rack**	Compute Racks	Storage Racks	Switch Racks
Type	POWER9	V100		**Type**	AC922	SSC (4 ESS GL4)	Mellanox IB EDR
Count	9,216 2 × 18 x 256	27,648 6 × 18 x 256		**Count**	256 Racks × 18 Nodes	40 Racks × 8 Servers	18 Racks
Peak FLOPS	9.96 PF	215.7 PF		**Power**	59 kW	38 kW	
Peak AI FLOPS		3.456 EF			13 MW (Total System)		

Summit has over 10 petabytes of memory.

Summit Total Memory			
Type	DDR4	HBM2	NVMe
Node	512 GiB	96 GiB	1.6 GB
Summit	2.53 PiB	475 TiB	7.37 PB

- Summit combines HPC and AI techniques to automate, accelerate, and drive advancements in health, energy, and engineering. In fact, new breakthroughs are already underway in the Summit Early Science projects.
- Using deep learning and Summit’s advanced supercomputing, researchers are mapping patterns in human proteins and cellular systems, seeking to understand the genetic factors that contribute to diseases such as Alzheimer’s and conditions such as opioid addiction.
- Using scalable deep neural networks, scientists are making strides in the fight against cancer. By pairing unstructured data with deep learning on Summit, researchers can uncover hidden relationships between genes, biological markers, and the environment.
- Exploding stars reveal clues about how heavy elements seeded the universe. With AI supercomputing on Summit, physicists can simulate these phenomena at unprecedented scale, thousands of times longer and tracking 12X more elements than previously possible.
- Fusion energy—the source of the sun's energy and a potential source of clean electricity—requires reliable reactors. With deep learning on Summit, scientists at the world’s largest experimental fusion reactor can explore performance criteria and optimize operations before it comes online in 2025.

FACTS:

- Summit can perform 200 quadrillion floating-point operations per second (FLOPS). If every person on Earth completed 1 calculation per second, it would take 1 year to do what Summit can do in 1 second.
- Summit's file system can store 250 petabytes of data, or the equivalent of 74 years of high-definition video.
- At over 340 tons, Summit's cabinets, file system, and overhead infrastructure weigh more than a large commercial aircraft.

PERFORMANCE SPECIFICATIONS:

- APPLICATION PERFORMANCE: 200 petaFLOPS (Double Precision), 3.3 exaOPS (Tensor operations)
- PROCESSORS (per node: total system) 6 NVIDIA Volta: 27,648 GPUs 2 IBM POWER9: 9,216 CPUs
- POWER CONSUMPTION 13 megawatts
- NODE INTERCONNECT 300 GBps NVIDIA NVLink
- OPERATING SYSTEM Red Hat Enterprise Linux (RHEL) version 7.4
- NUMBERS OF NODES 4,608
- NODE PERFORMANCE 49 teraFLOPS
- TOTAL SYSTEM MEMORY: >10 PB DDR4 + HBM2 + Non-volatile

3. SIERRA

Sierra or ATS-2 is a supercomputer built for the Lawrence Livermore National Laboratory for use by the National Nuclear Security Administration as the second Advanced Technology System. It is primarily used for predictive applications in stockpile stewardship, helping to assure the safety, reliability and effectiveness of the United States' nuclear weapons.

Sierra is very similar in architecture to the Summit supercomputer built for the Oak Ridge National Laboratory. The Sierra system uses IBM POWER9 CPUs in conjunction with Nvidia Tesla V100 GPUs. The nodes in Sierra are Witherspoon S922LC OpenPOWER servers with two GPUs per CPU and four GPUs per node. These nodes are connected with EDR InfiniBand.

SIERRA SYSTEM ARCHITECTURE DETAILS:

	Sierra
Nodes	4,320
POWER9 processors per node	2
GV100 (Volta) GPUs per node	4
Node Peak (TFLOP/s)	29.1
System Peak (PFLOP/s)	125
Node Memory (GiB)	320(256+64)
System Memory (PiB)	1.29
Interconnect	2x IB EDR
Off-Node Aggregate b/w (GB/s)	45.5
Compute racks	240
Network and Infrastructure racks	13
Storage Racks	24
Total racks	277
Peak Power (MW)	~12

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