



Master Informatics Eng.

2024/25

A.J.Proen  a

Top HPC systems in TOP500 lists
(most images are from internet)

Why analyse results from the TOP500 list?...



- The **TOP500** lists the fastest HPC systems in the world based on top technology digital compute devices, measured according to strict scientific rules (HPL, HPGC, Green, HPL-MxP,...)
- The evolution along time of these systems shows what technologies are worth to pursue and what were rejected
- These current top systems will be shrunk to commodity chips in just a few years ahead, following past tech evolutions
 - for example, the top systems in the 1st list (in 1993) were based on vector computers (currently a normal extension to compute devices) and on massively parallel processors (trend today in electronic gadgets...)
- Helps us to understand strategic science & tech policies



WIKIPEDIA
The Free Encyclopedia

What is TOP500?



TOP500

From Wikipedia, the free encyclopedia

The **TOP500** project ranks and details the 500 most powerful non-distributed computer systems in the world. The project was started in 1993 and publishes an updated list of the **supercomputers** twice a year. The first of these updates always coincides with the International Supercomputing Conference in June, and the second is presented at the ACM/IEEE Supercomputing Conference in November. The project aims to provide a reliable basis for tracking and detecting trends in high-performance computing and bases rankings on HPL,^[1] a portable implementation of the high-performance **LINPACK benchmark** written in Fortran for distributed-memory computers.

The most recent edition of TOP500 was published in November 2024 as the 64th edition of TOP500, while the next edition of TOP500 will be published in June 2025 as the 65th edition of TOP500. Since November 2024, the United States' **El Capitan** is the most powerful supercomputer on TOP500, reaching 1742 **petaFlops** (1.742 exaFlops) on the LINPACK benchmarks.^[2] As of 2018, the United States has by far the highest share of total computing power on the list (nearly 50%).^[3] As of 2024, the United States has the highest number of systems with 173 supercomputers, China is in second place with 63, and Germany being third at 40.

The TOP500 list is compiled by **Jack Dongarra** of the **University of Tennessee, Knoxville**, Erich Strohmaier and Horst Simon of the **National Energy Research Scientific Computing Center (NERSC)** and **Lawrence Berkeley National Laboratory (LBNL)**, and, until his death in 2014, **Hans Meuer** of the **University of Mannheim, Germany**.

The TOP500 project lists also **Green500** and **HPCG** benchmark list.

TOP500	
	
Key people	The List.
Erich Strohmaier	Jack Dongarra
Jack Dongarra	Horst Simon
Horst Simon	Martin Meuer
Martin Meuer	
Established	24 June 1993
Website	www.top500.org



LINPACK benchmarks (HPL)

LINPACK benchmarks

From Wikipedia, the free encyclopedia

For the software library, see [LINPACK](#).

The **LINPACK Benchmarks** are a measure of a system's floating point computing power. Introduced by [Jack Dongarra](#), they measure how fast a computer solves a dense n by n system of linear equations $Ax = b$, which is a common task in engineering.

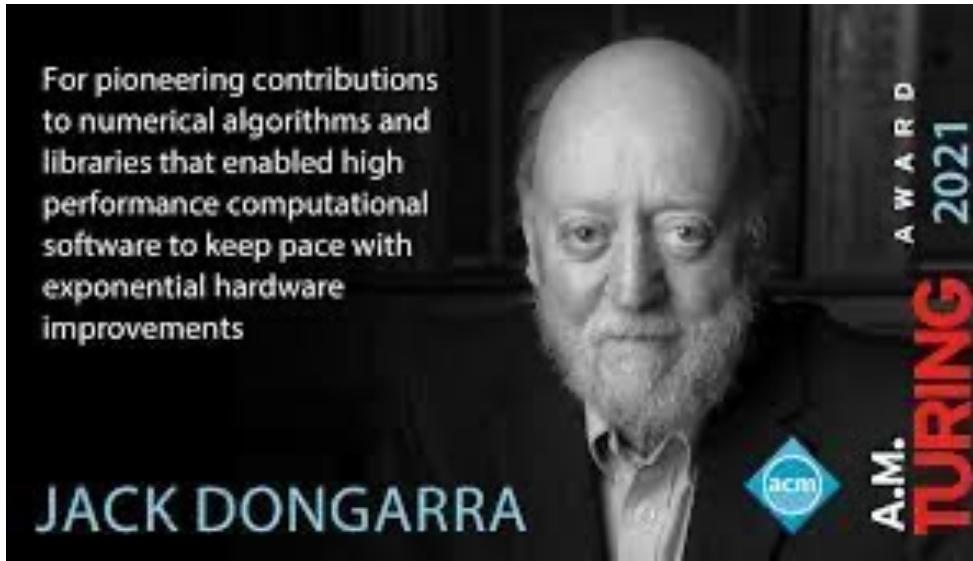
The latest version of these **benchmarks** is used to build the [TOP500](#) list, ranking the world's most powerful supercomputers.^[1]

The aim is to approximate how fast a computer will perform when solving real problems. It is a simplification, since no single computational task can reflect the overall performance of a computer system. Nevertheless, the LINPACK benchmark performance can provide a good correction over the peak performance provided by the manufacturer. The peak performance is the maximal theoretical performance a computer can achieve, calculated as the machine's frequency, in cycles per second, times the number of operations per cycle it can perform. The actual performance will always be lower than the peak performance.^[2] The **performance of a computer** is a complex

HPL, written in C, measures the sustained floating-point rate (GFLOPs/s) to solve a dense system of linear equations using double-precision floating-point arithmetic

LINPACK benchmarks

Original author(s)	Jack Dongarra , Jim Bunch, Cleve Moler, and Gilbert Stewart
Initial release	1979
Website	www.netlib.org/benchmark/hpl/



ACM Turing Award:
equivalent to
Nobel Price in
Computing

AJProen , Parallel Computing,

ACM Turing Award 2021: Jack Dongarra

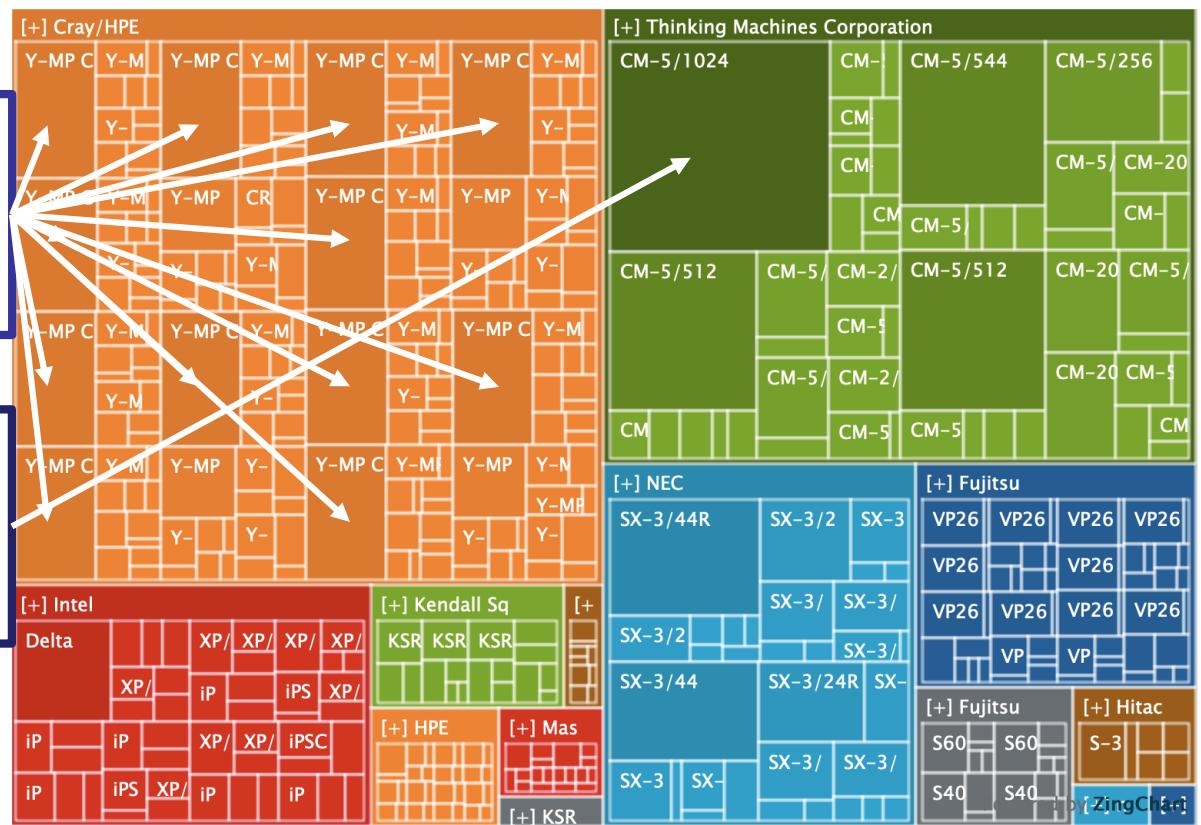
A screenshot of a YouTube video player. The video frame shows a portrait of Jack Dongarra with a play button overlaid. The player interface includes a search bar, a microphone icon, a magnifying glass icon, a settings gear icon, a bell icon, and a profile picture of Jack Dongarra. The video title at the bottom reads "ACM A.M. TURING AWARD LECTURE". Logos for SC22 and the event location "Dallas, hpc TX accelerates" are visible in the background of the video frame.

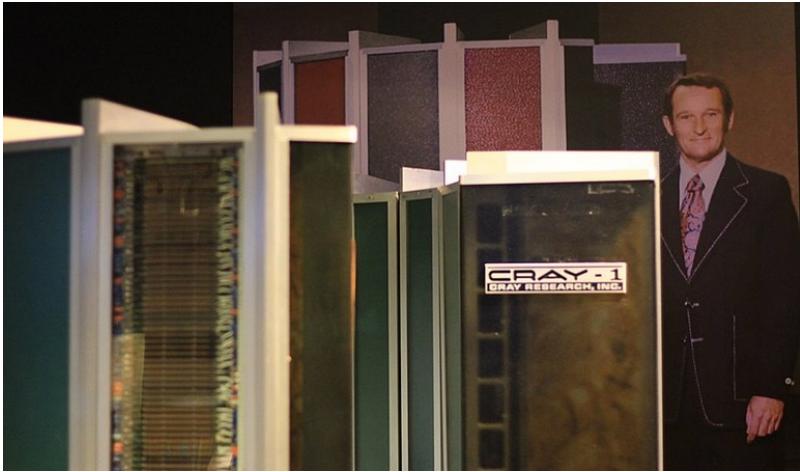
<https://www.youtube.com/watch?v=lsnRP9akCDk>



Cray Y-MP C916
a vector processor supercomputer
with 16 processors
launched by Cray Research in 1991

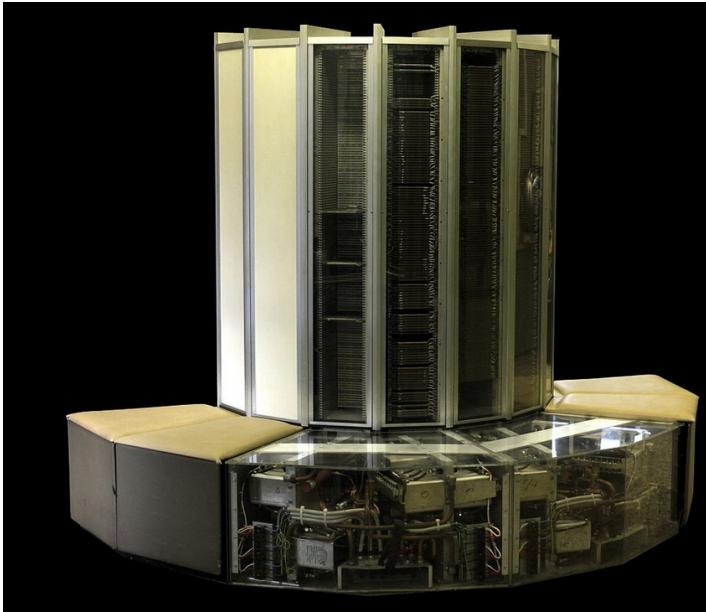
Connection Machine, CM-5/1024 a
massively parallel system based on
a fat tree network of 1024 SPARC
processors, announced in 1991





The Cray-1

The Cray-1, announced in 1975, was the first Cray design to use integrated circuits and the first supercomputer to implement the vector processor design, at \$10 million, with vector peak performance of 160 MFLOPS.





1. TOP500 (*LINPACK*)

- a) TOP10 lists from Nov'18 to Nov'24
- b) Analysis of TOP1 in Nov'24 & some past relevant systems in 2022
- c) Country distribution over the past 25 years
- d) Processor distribution (*system share & performance*) in the past 4 years
- e) Accelerator family distribution (*system share & performance*) in Jun'12 - Nov'24

2. GREEN500

- a) TOP10 in Nov'24

3. HPCG

- a) HPCG vs. HPL: an overview
- b) TOP7 in Jun'24

4. HPL-AI

- a) High-performance Linpack (HPL) and artificial intelligence (AI) workloads
- b) TOP7 in Nov'24

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	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	2,397,824	143,500.0	200,794.9	9,783
2	Sierra - IBM Power System S922LC, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100 , Dual-rail Mellanox EDR Infiniband , IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States	1,572,480	94,640.0	145,712.0	7,438
3	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
4	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 , Cray Inc. Swiss National Supercomputing Centre (CSCS) Switzerland	387,872	21,230.0	27,154.3	2,384
6	Trinity - Cray XC40, Xeon E5-2698v3 16C 2.3GHz, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect , Cray Inc. DOE/NNSA/LANL/SNL United States	979,			
7	AI Bridging Cloud Infrastructure (ABCi) - PRIMERGY CX2570 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2 , Infiniband EDR , Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan	391,			
8	SuperMUC-NG - ThinkSystem SD530, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path , Lenovo Leibniz Rechenzentrum Germany		305,856	19,476.6	26,873.9
9	Titan - Cray XK7, Opteron 6274 16C 2.200GHz, Cray Gemini interconnect, NVIDIA K20x , Cray Inc. DOE/SC/Oak Ridge National Laboratory United States		560,640	17,590.0	27,112.5
10	Sequoia - BlueGene/Q, Power BQC 16C 1.60 GHz, Custom , IBM DOE/NNSA/LLNL United States		1,572,864	17,173.2	20,132.7

Top 10 HPC systems Nov'18 TOP500

NVIDIA Volta GPU devices interconnected w/ POWER9 through NVLink

Compute accelerators: move from NVIDIA GPU to Xeon Phi to Chinese Matrix

Top 10 HPC systems Nov'19 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	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	2,414,592	148,600.0	200,794.9	10,096
2	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	1,572,480	94,640.0	125,712.0	7,438
3	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz , Sunway , NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
4	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz , TH Express-2, Matrix-2000 , NUDT National Super Computer Center in Guangzhou China	4,981,760	61,444.5	100,678.7	18,482
5	Frontera - Dell C6420, Xeon Platinum 8280 28C 2.7GHz , Mellanox InfiniBand HDR , Dell EMC Texas Advanced Computing Center/Univ. of Texas United States	448,448	23,516.4	38,745.9	
6	Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz , Aries interconnect , NVIDIA Tesla P100 , Cray/HPE Swiss National Supercomputing Centre (CSCS) Switzerland	387,872			
7	Trinity - Cray XC40, Xeon E5-2698v3 16C 2.3GHz , Intel Xeon Phi 7250 68C 1.4GHz , Aries interconnect , Cray/HPE DOE/NNSA/LANL/SNL United States	979,072			
8	AI Bridging Cloud Infrastructure (ABCi) - PRIMERGY CX2570 M4, Xeon Gold 6148 20C 2.4GHz , NVIDIA Tesla V100 SXM2 , Infiniband EDR , Fujitsu National Institute of Advanced Industrial Science and Technology (AIST) Japan		391,680	19,880.0	32,576.6 1,649
9	SuperMUC-NG - ThinkSystem SD650, Xeon Platinum 8174 24C 3.1GHz , Intel Omni-Path , Lenovo Leibniz Rechenzentrum Germany		305,856	19,476.6	26,873.9
10	Lassen - IBM Power System AC922, IBM POWER9 22C 3.1GHz , Dual-rail Mellanox EDR Infiniband, NVIDIA Tesla V100 , IBM / NVIDIA / Mellanox DOE/NNSA/LLNL United States		288,288	18,200.0	23,047.2

Frontera (TACC):
successor of Stampede2

Top 10 HPC systems Nov'20 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442,010.0	537,212.0	29,899
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	2,414,592	148,600.0	200,794.9	10,096
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	1,572,480	94,640.0	125,712.0	7,438
4	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway, NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014.6	125,435.9	15,371
5	Selene - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia NVIDIA Corporation United States	555,520	62,130.0	79,215.0	2,446
6	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000, NUDT National Super Computer Center in Guangzhou China	4,981,19	449, 10	448,448	23,516.4
7	JUWELS Booster Module - Bull Sequana XH2000 , AMD EPYC 7402 24C 2.8GHz, NVIDIA A100, Mellanox HDR InfiniBand/ParTec ParaStation ClusterSuite, Atos Forschungszentrum Juelich (FZJ) Germany	669,760	35,450.0	51,720.8	2,252
8	HPC5 - PowerEdge C410, Xeon Gold 6252 24C 2.1GHz, NVIDIA Tesla V100, Mellanox HDR Infiniband, Dell EMC Eni S.p.A. Italy	448,448	23,516.4	38,745.9	
9	Frontera - Dell C6420, Xeon Platinum 8280 28C 2.7GHz, Mellanox InfiniBand HDR, Dell EMC Texas Advanced Computing Center/Univ. of Texas United States	672,520	22,400.0	55,423.6	
10	Dammam-7 - Cray CS-Storm, Xeon Gold 6248 20C 2.5GHz, NVIDIA Tesla V100 SXM2, InfiniBand HDR 100, HPE Saudi Aramco Saudi Arabia	449, 10			

New #1: an ARM-based chip that overcomes IBM & NVIDIA GPUs

New in the TOP10 list:
NVIDIA Ampere GPUs

Top 10 HPC systems Nov'21 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)			
1	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442,010.0	537,212.0	29,899			
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	2,414,592	148,600.0	200,794.9	10,096			
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	1,572,480	94,640.0	125,712.0	7,438			
4	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway, NRCPC National Supercomputing Center in Wuxi China	10,649,600	93,014	125,435.9	15,371			
5	Perlmutter - HPE Cray EX235n, AMD EPYC 7763 64C 2.45GHz, NVIDIA A100 SXM4 40 GB, Slingshot-10, HPE DOE/SC/LBNL/NERSC United States	761,856	70,870.0	93,750.0	2,589			
6	Selene - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia NVIDIA Corporation United States	55	9	JUWELS Booster Module - Bull Sequana XH200, AMD EPYC 7402 24C 2.8GHz, NVIDIA A100, Mellanox HDR InfiniBand/ParTec ParaStation ClusterSuite, eos Forschungszentrum Juelich (FZJ) Germany	449,280	44,120.0	70,980.0	1,764
7	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000, NUDT National Super Computer Center in Guangzhou China	4,98	10	HPC5 - PowerEdge C4140, Xeon Gold 62 24C 2.1GHz, NVIDIA Tesla V100, Mellanox HDR Infiniband, DELL EMC Eni S.p.A. Italy	669,760	35,450.0	51,720.8	2,252
				Voyager-EUS2 - ND96amsr_A100_v4, AMD EPYC 7V12 48C 2.45GHz, NVIDIA A100 80GB, Mellanox HDR Infiniband, Microsoft Azure Azure East US 2 United States	253,440	30,050.0	39,531.2	

New in the TOP10 list since June'21, with AMD Milan (Zen3)

Microsoft Azure, pushed TACC Frontera to 13th...

Top 10 HPC systems Nov'22 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,730,112	1,102.00	1,685.65	21,100
2	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.61	537.21	29,899
3	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,220,288	309.10	428.70	6,016
4	Leonardo - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, Atos EuroHPC/CINECA Italy	1,463,616	174.70	255.75	5,610
5	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	2,414,592	148.60	200.79	10,096
8	Perlmutter - HPE Cray EX235n, AMD EPYC 7763 64C 2.45GHz, NVIDIA A100 SXM4 40 GB, Slingshot-10, HPE DOE/SC/LBNL/NERSC United States	761,856	70.87	93.75	2,589
6	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	555,520	63.46	79.22	2,646
7	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway, NRCPC National Supercomputing Center in Wuxi China	4,981,760	61.44	100.68	18,482
9	Selene - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia NVIDIA Corporation United States	4,981,760	61.44	100.68	18,482
10	Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000, NUDT National Super Computer Center in Guangzhou China	4,981,760	61.44	100.68	18,482

Exascale!

New in the TOP10 list
since June'22,
with AMD Milan “Trento” &
GPU AMD Instinct MI250X

New in the TOP10 list,
with 3rd Gen Xeon & A100

Top 10 HPC systems Nov'23 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE DOE/SC/Oak Ridge National Laboratory United States	8,699,904	1,194.00	1,679.82	22,703
2	Aurora - HPE Cray EX - Intel Exascale Compute Blade, Xeon CPU Max 9470 52C 2.4GHz, Intel Data Center GPU Max, Slingshot-11, Intel DOE/SC/Argonne National Laboratory United States	4,742,808	585.34	1,059.33	24,687
3	Eagle - Microsoft NDv5, Xeon Platinum 8480C 48C 2GHz, NVIDIA H100, NVIDIA Infiniband NDR, Microsoft Microsoft Azure United States	1,123,200	561.20	846.84	
4	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848	442.01	537.21	29,899
5	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland	2,752,704	379.70	531.51	7,107
6	Leonardo - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, EVIDEN EuroHPC/CINECA Italy	1,824,768	238.70	304.47	1,404
7	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	2,414,592	148.60		
8	MareNostrum 5 ACC - BullSequana XH3000, Xeon Platinum 8460Y+ 40C 2.3GHz, NVIDIA H100 64GB, Infiniband NDR200, EVIDEN EuroHPC/BSC Spain	680,960	138.20		
9	Eos NVIDIA DGX SuperPOD - NVIDIA DGX H100, Xeon Platinum 8480C 56C 3.8GHz, NVIDIA H100, Infiniband NDR400, Nvidia NVIDIA Corporation United States	485,888		121.40	188.65
10	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	1,572,480		94.64	125.71

Since June 22

New in the TOP10 list,
with 4th Gen Xeon & Intel GPU

New in the TOP10 list,
with 4th Gen Xeon & H100

3 EuroHPC systems in
the TOP10 list!

14

Top 10 HPC systems

Nov'24 TOP500

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
1	El Capitan - HPE Cray EX255a, AMD 4th Gen EPYC 24C 1.8GHz, AMD Instinct MI300A, Slingshot-11, TOSS, HPE DOE/NNSA/LLNL United States	11,039,616	1,742.00	2,746.38	29,581
2	Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE Cray OS, HPE DOE/SC/Oak Ridge National Laboratory United States	9,066,176	1,357.00	2,055.72	24,607
3	Aurora - HPE Cray EX - Intel Exascale Compute Blade, Xeon CPU Max 9470 52C 2.4GHz, Intel Data Center GPU Max, Slingshot-11, Intel DOE/SC/Argonne National Laboratory United States	9,264,128	1,012.00	1,980.01	38,698
4	Eagle - Microsoft NDv5, Xeon Platinum 8480C 48C 2GHz, NVIDIA H100, NVIDIA Infiniband NDR, Microsoft Azure Microsoft Azure United States	2,073,600	561.20	846.84	
5	HPC6 - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, RHEL 8.9, HPE Eni S.p.A. Italy	3,142,320	8		
6	Supercomputer Fugaku - Supercomputer Fugaku, A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu RIKEN Center for Computational Science Japan	7,630,848			
7	Alps - HPE Cray EX254n, NVIDIA Grace 72C 3.1GHz, NVIDIA GH200 Superchip, Slingshot-11, HPE Cray OS, HPE Swiss National Supercomputing Centre (CSCS) Switzerland	2,121,600	10		
8	LUMI - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE EuroHPC/CSC Finland				
9	Leonardo - BullSequana XH2000, Xeon Platinum 8358 32C 2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA HDR100 Infiniband, EVIDEN EuroHPC/CINECA Italy				
10	Tuolumne - HPE Cray EX255a, AMD 4th Gen EPYC 24C 1.8GHz, AMD Instinct MI300A, Slingshot-11, TOSS, HPE DOE/NNSA/LLNL United States	1,161,216	208.10	288.88	3,387



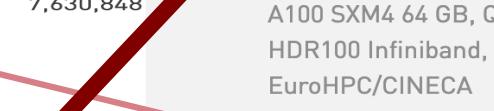
New in the TOP10 list,
with 1st AMD APU Instinct (MI300A)



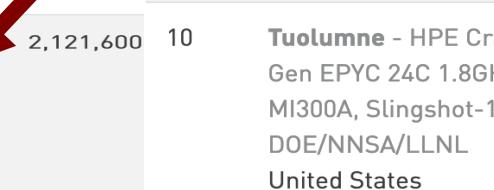
New in the TOP10 list,
fastest European system



New in the TOP10 list, since June
w/ Nvidia GH Superchip



Barcelona MareNostrum down to 11th



2nd AMD APU Instinct (MI300A)
Sister of El Capitan...



1. TOP500 (*LINPACK*)

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-  b) Analysis of TOP1 in Nov'24 & some past relevant systems in 2022
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- a) TOP10 in Nov'24

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- a) HPCG vs. HPL: an overview
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4. HPL-AI

- a) High-performance Linpack (HPL) and artificial intelligence (AI) workloads
- b) TOP7 in Nov'24



El Capitan at LLNL

#1 in TOP500 Nov'24

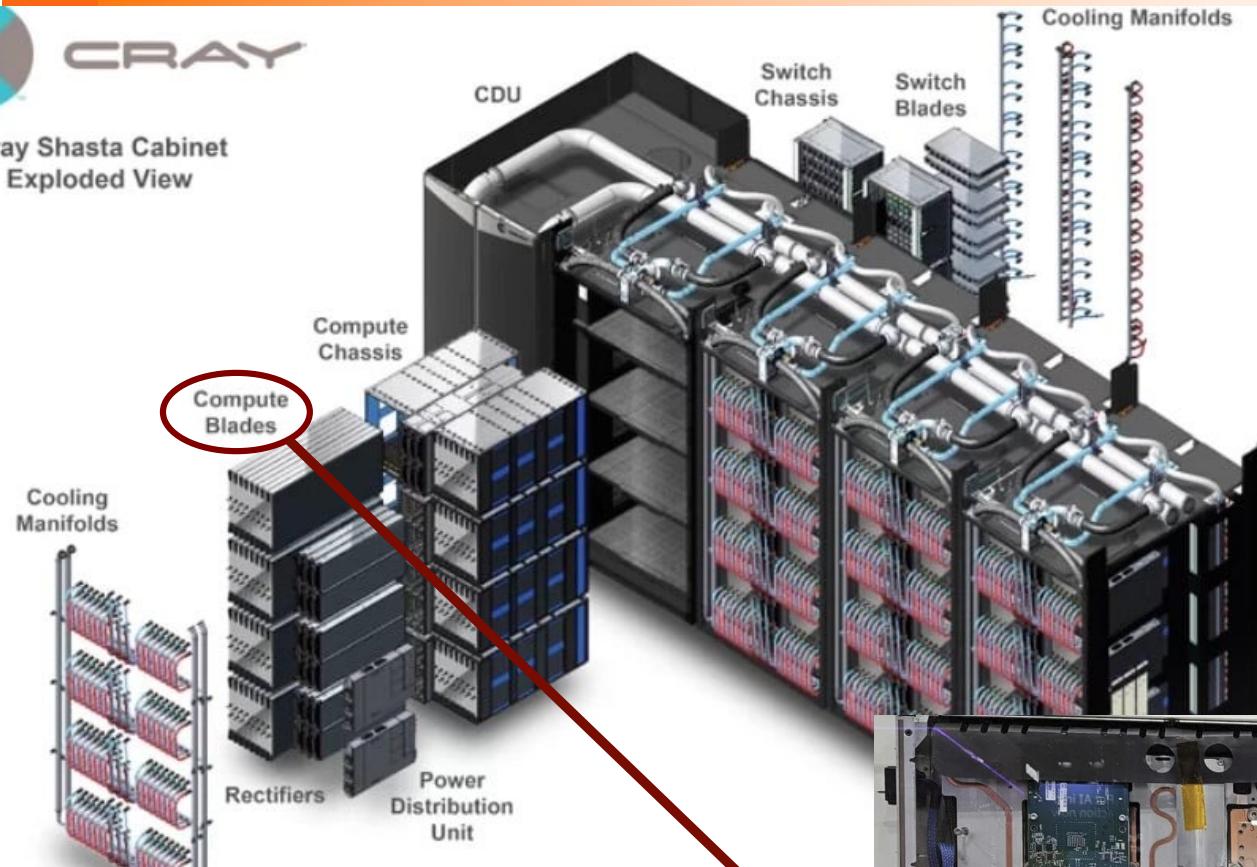




El Capitan architecture based on AMD APUs MI300A



Cray Shasta Cabinet
Exploded View



1 blade:
2 nodes/blade
2x4 AMD APU/blade

**43,808 APUs
in 11,136 nodes
in 5,568 blades
in 87 cabinets**





New architecture in TOP10:
ALPS in Switzerland
#7 in Nov'24



ALPS with 10,752 NVIDIA Grace Hopper Superchips

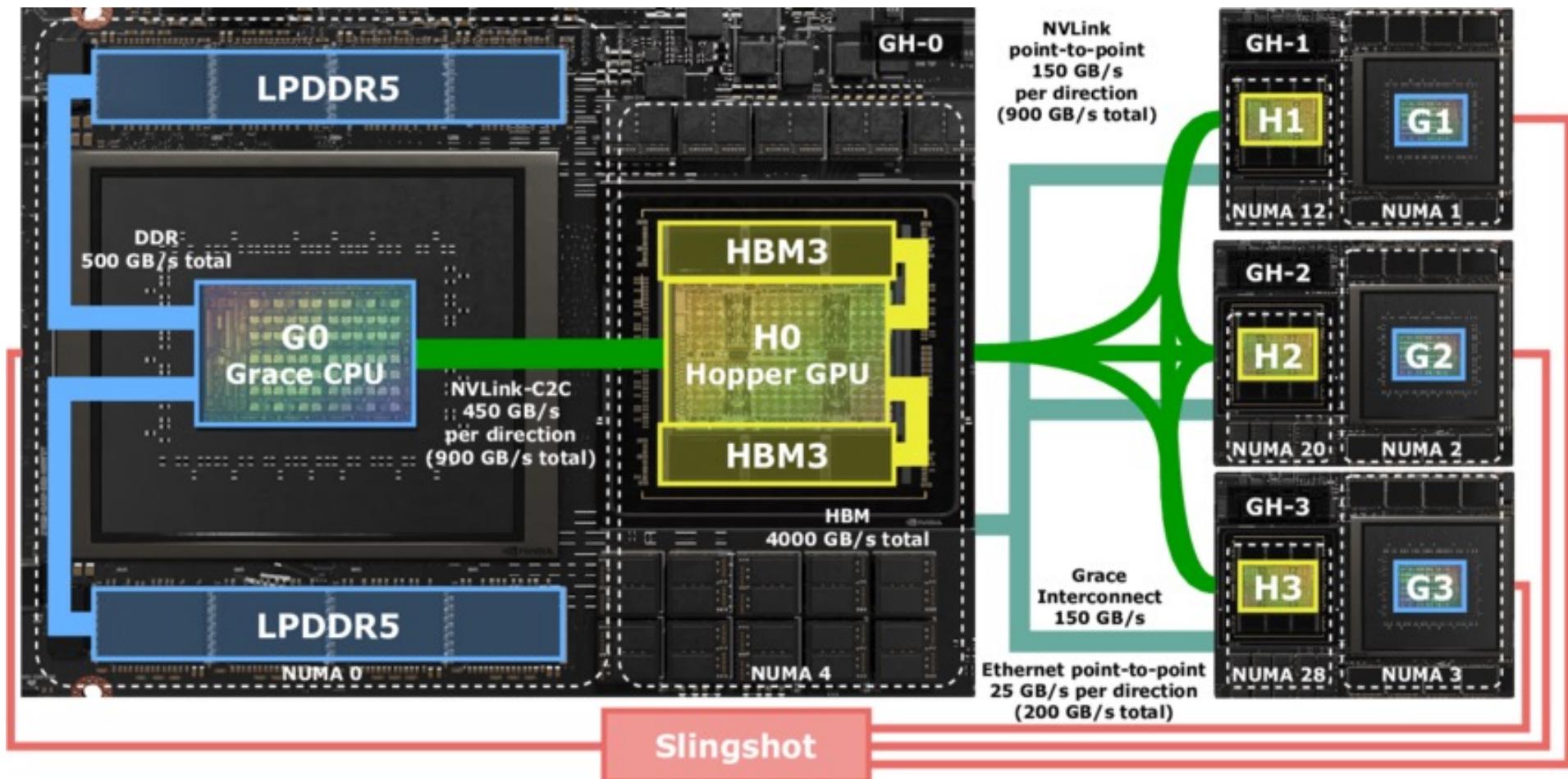




New architecture in TOP10: the Quad GH200 node in ALPS

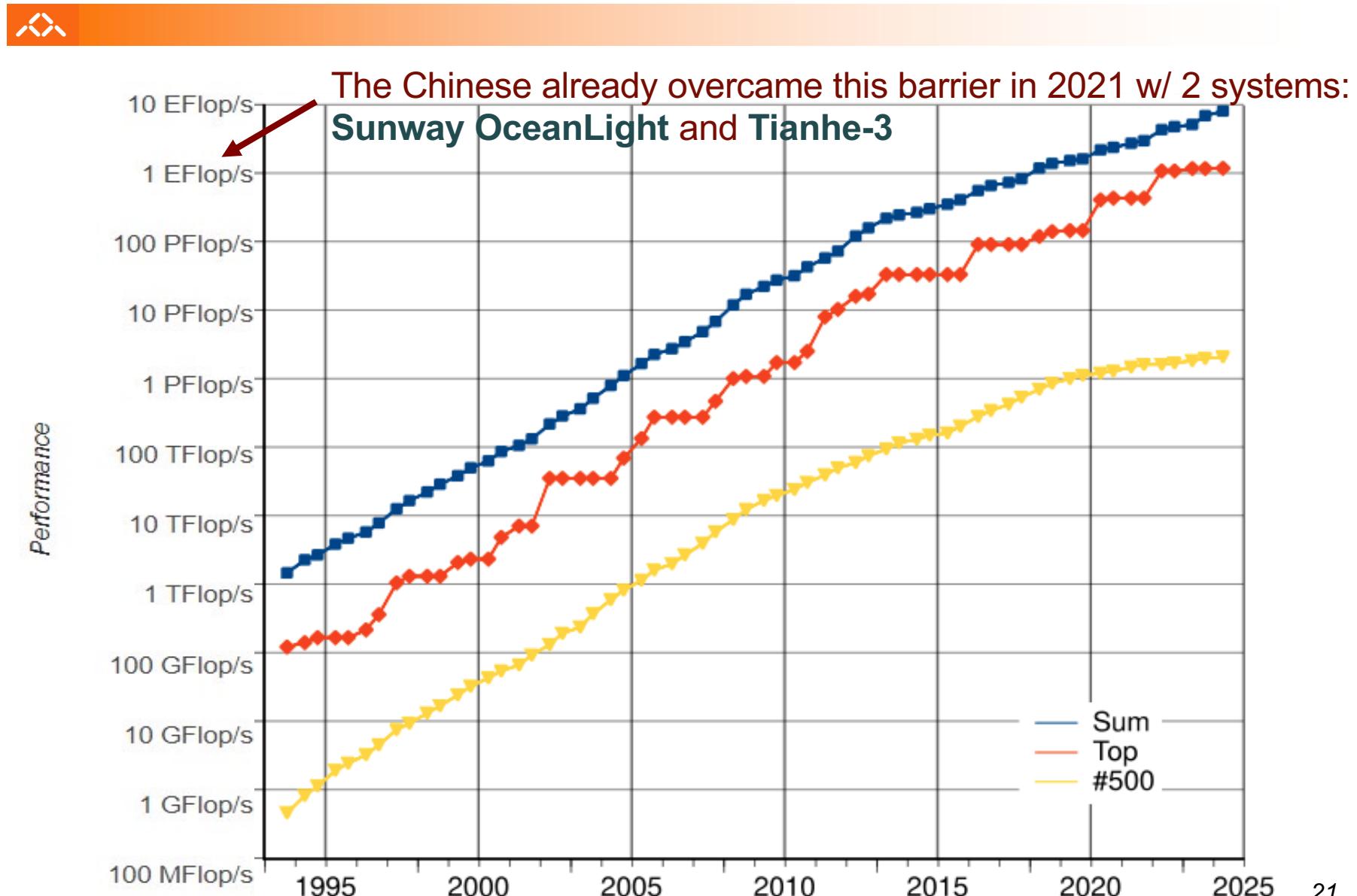


Architecture of the Quad GH200 node of the Alps supercomputer

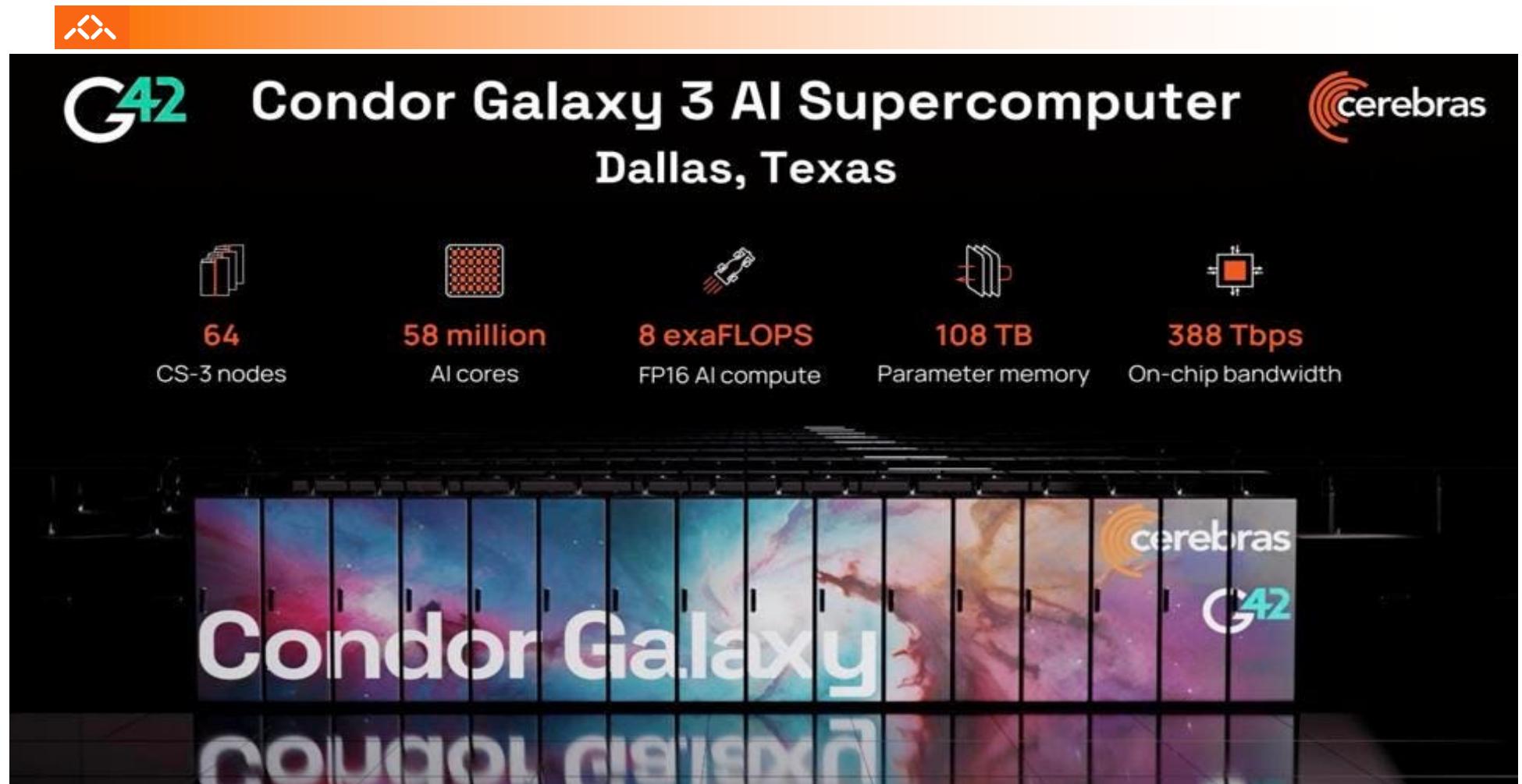


Grace & Hopper do not share the same RAM

Peak performance 1993 to 2024



A data-centre with CEREBRAS: why not in TOP500 list?



The banner for the Condor Galaxy 3 AI Supercomputer features the G42 logo and the cerebras logo. It highlights the following specifications:

- 64 CS-3 nodes
- 58 million AI cores
- 8 exaFLOPS FP16 AI compute
- 108 TB Parameter memory
- 388 Tbps On-chip bandwidth

The banner also shows a large server rack with the "Condor Galaxy" logo and the cerebras and G42 logos.

Systems based on CEREBRAS are focused on "training" of neural networks, and CEREBRAS only supports FP16 (16-bit).

Some relevant systems in 2022



1. #1 since Nov'22: **Frontier** (*AMD Epyc Trento 64c + Instinct MI250x*)
2. #2 in Nov'22 (#1 in Jun'20): **Fugaku** (*Fujitsu A64FX, 48 cores*)
3. #4 in Nov'22: **Leonardo**, (*3rd Gen Xeon, 32c + NVidia Ampere A100*)
4. #5 in Nov'22 (#1 in Nov'18): **Summit** (*IBM POWER9, 22 cores + NVidia Volta GV100*) + **Sierra (#6)**, follow-up of
#1 in Jun'12, **Sequoia** (*IBM POWER BGQ, 16 cores*)
5. #7 in Nov'22 (#1 in Nov'17): **TaihuLight** (*Sunway SW26010, 260 c*)
6. #9 in Nov'22: **Selene** (*AMD Epyc Rome 64 c + NVidia A100*)
7. #10 in Nov'22: **Tianhe-2A** (*MilkyWay-2A*) (*Xeon, 12c + Matrix-2000*),
follow-up of
#1 in Jun'13, **Tianhe-2** (*MilkyWay-2*) (*Xeon, 6 c + Xeon Phi 31S1P*)
#1 in Nov'10, **Tianhe-1A** (*MilkyWay-1A*) (*Xeon, 6 c + NVidia Fermi*)

1



Competitive procurement asking for:

50–100× application performance of Titan

Support for traditional modeling and simulation, high-performance data analysis, and artificial intelligence applications

Peak performance >1000 PF

Smooth transition for existing and future applications



Jaguar: 2.3 PF
World's Fastest

2008



Titan: 27 PF
Accelerated Computing
World's Fastest

2012



Summit: 200 PF
Accelerated Computing
5–10× Titan Performance

2017



Frontier: >1000 PF
Competitive Procurement
5–10× Summit Performance

2021



JAGUAR

No. 1 in 2009, 2010



TITAN

No. 1 in 2012



SUMMIT

No. 1 in 2018



FRONTIER

No. 1 in 2022

Frontier at ORNL



Frontier - HPE Cray EX235a, AMD Optimized 3rd Generation EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot-11, HPE
DOE/SC/Oak Ridge National Laboratory
United States
Nov'24



Frontier architecture

Frontier Overview

Extraordinary Engineering



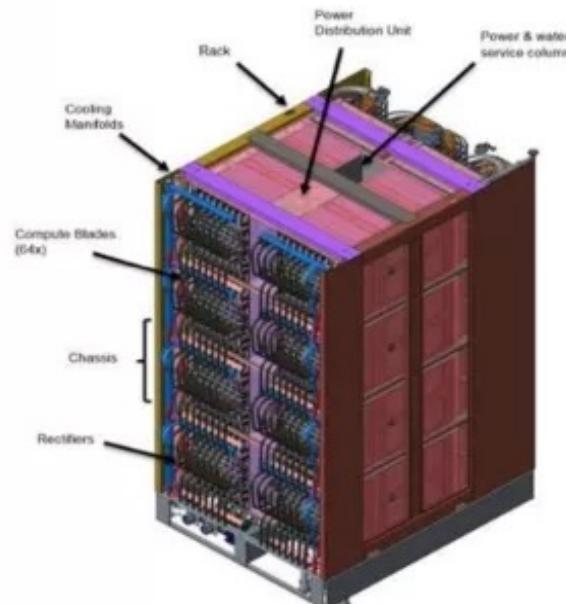
System

- 2 EF Peak DP FLOPS
- 74 compute racks
- 29 MW Power Consumption
- 9,408 nodes
- 9.2 PB memory
(4.6 PB HBM, 4.6 PB DDR4)
- Cray Slingshot network with dragonfly topology
- 37 PB Node Local Storage
- 716 PB Center-wide storage
- 4000 ft² foot print

Built by HPE

Olympus rack

- 128 AMD nodes
- 8,000 lbs
- Supports 400 KW



Powered by AMD

AMD node

- 1 AMD “Trento” CPU
- 4 AMD MI250X GPUs
- 512 GiB DDR4 memory on CPU
- 512 GiB HBM2e total per node
(128 GiB HBM per GPU)
- Coherent memory across the node
- 4 TB NVM
- GPUs & CPU fully connected with AMD Infinity Fabric
- 4 Cassini NICs, 100 GB/s network BW

Trento:
an optimized
version of Milan

Compute blade

- 2 AMD nodes



All water cooled, even DIMMs and NICs

2



Fugaku



6

Supercomputer Fugaku - Supercomputer Fugaku,
A64FX 48C 2.2GHz, Tofu interconnect D, Fujitsu
RIKEN Center for Computational Science
Japan

Nov'24

TOP 500

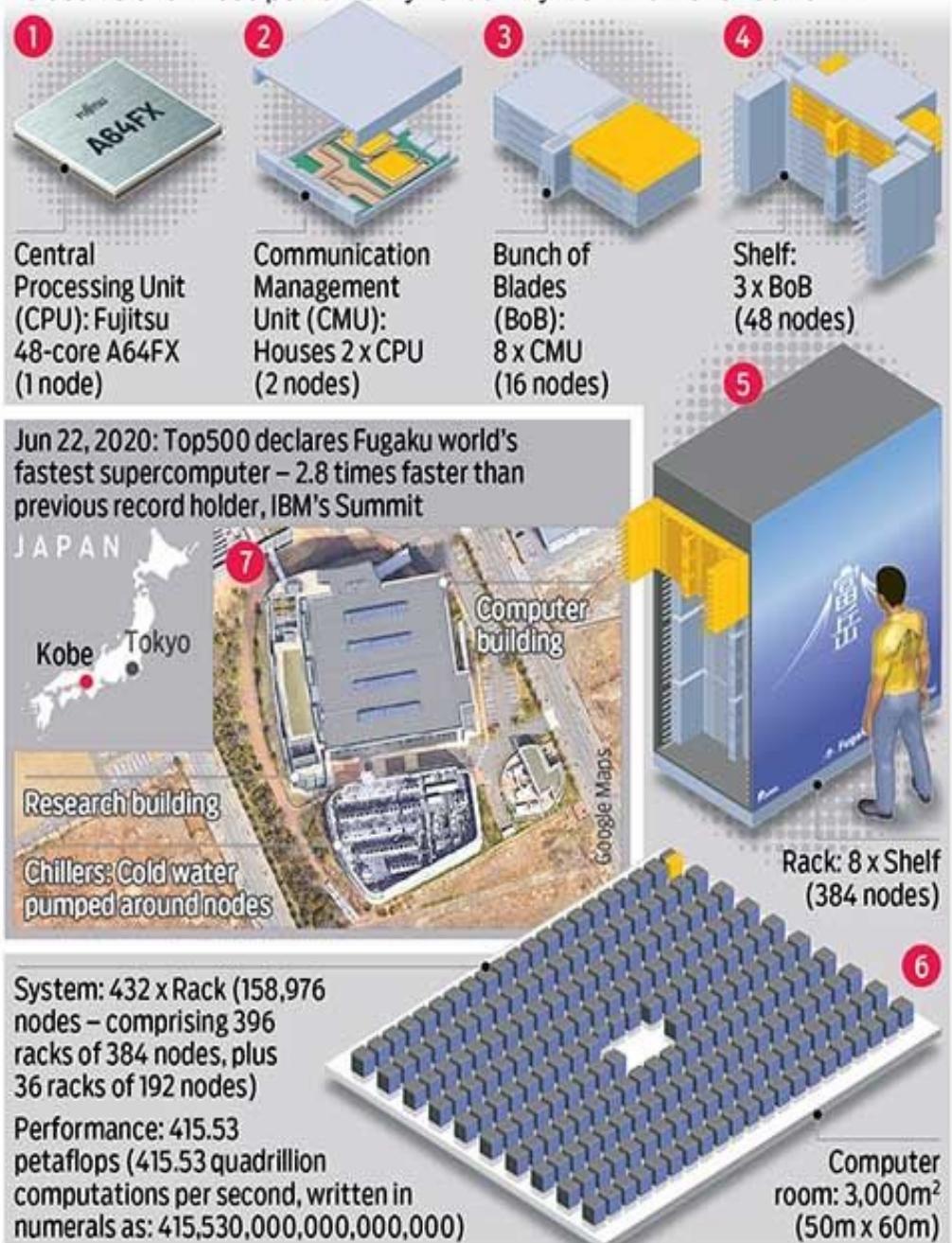
The List.



AJProenca, Parallel Computing, MEI, UMinho, 2024/25

Supercomputer to seek Covid-19 cure

The world's fastest supercomputer, Japan's \$1.2 billion Fugaku, is to use its enormous power to try to identify treatments for Covid-19



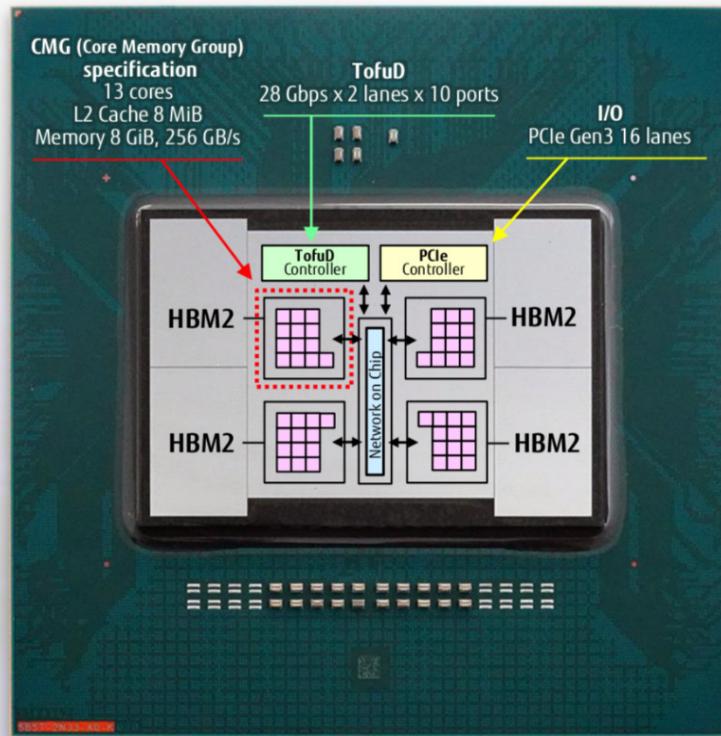


Fujitsu A64FX in Fugaku

1. High-Performance Arm CPU A64FX in HPC and AI Areas

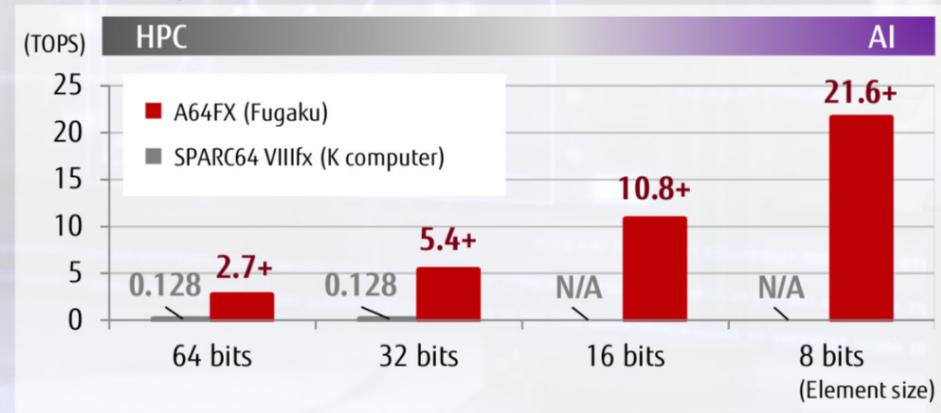
FUJITSU

■ Architecture features



ISA	Armv8.2-A (AArch64 only) SVE (Scalable Vector Extension)	arm
SIMD width	512-bit	
Precision	FP64/32/16, INT64/32/16/8	
Cores	48 computing cores + 4 assistant cores (4 CMGs)	
Memory	HBM2: Peak B/W 1,024 GB/s	
Interconnect	TofuD: 28 Gbps x 2 lanes x 10 ports	

■ Peak performance (Chip level)



3

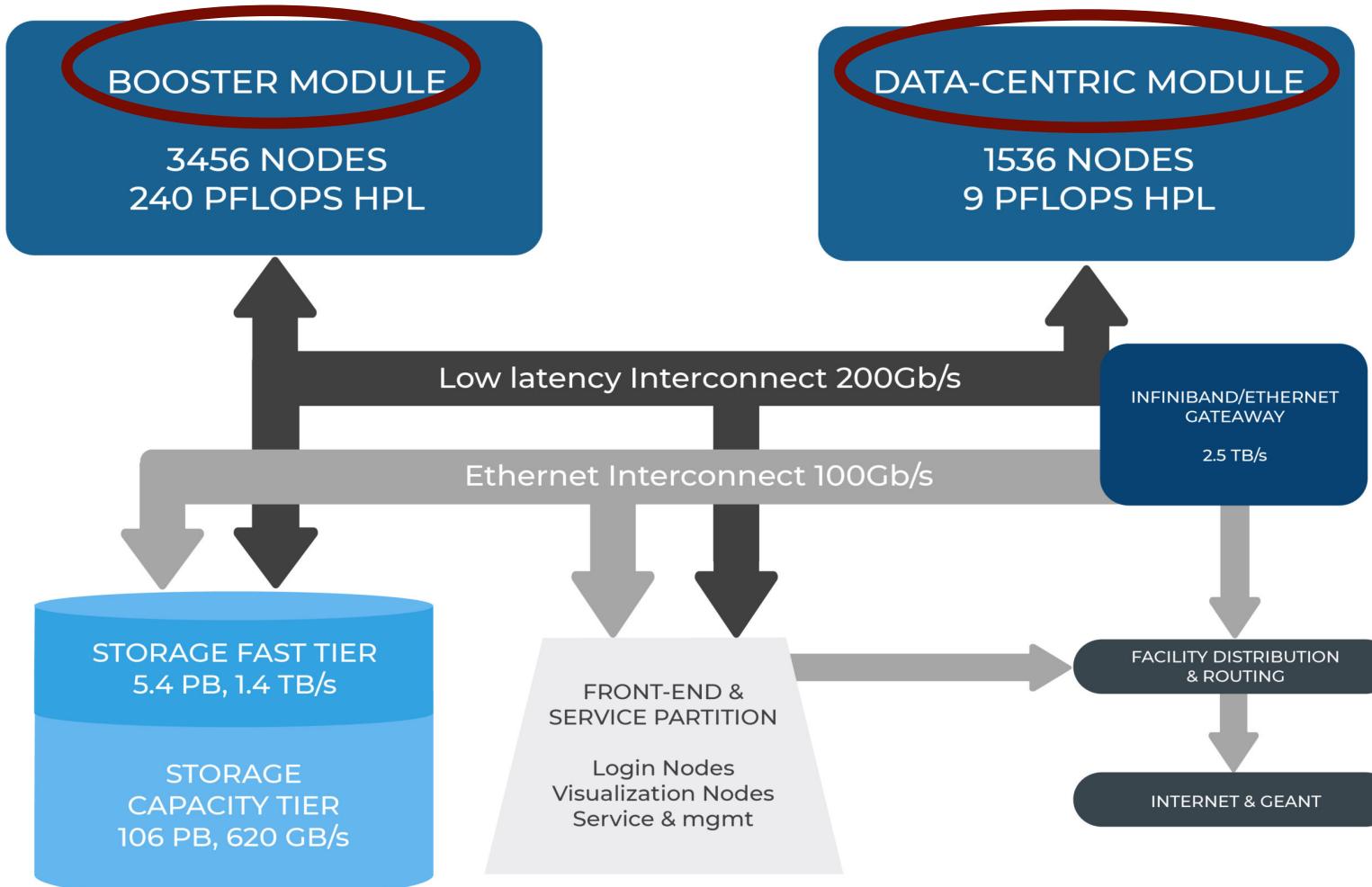


Leonardo at CINECA, Italy

9

Leonardo - BullSequana XH2000, Xeon Platinum 8358 32C
2.6GHz, NVIDIA A100 SXM4 64 GB, Quad-rail NVIDIA
HDR100 Infiniband, Atos
EuroHPC/CINECA
Italy

Nov'24



<https://leonardo-supercomputer.cineca.eu/hpc-system/>



Leonardo at CINECA, Italy

BOOSTER MODULE

3456 nodes

Features a **custom BullSequana X2135 "Da Vinci" blade**, composed of:
Ice Lake

- 1 x CPU Intel Xeon 8358 32 cores, 2,6 GHz
- 512 (8 x 64) GB RAM DDR4 3200 MHz
- 4 x NVidia custom Ampere GPU 64GB HBM2
- 2 x NVidia HDR 2×100 Gb/s cards



Performance per node: 89,4 TFLOPs
peak

DATA CENTRIC MODULE

1536 nodes

Features a **BullSequana X2610 compute blade**.

Each computing node is composed of:

- 2x Intel Sapphire Rapids, 56 cores, TDP 350 W
- 512 (16 x 32) GB RAM DDR5 4800 MHz
- 1 x NVidia HDR100 100 Gb/s card
- 8 TB NVM





EuroHPC Supercomputers at the TOP11 & Green500

Nov'24

2 EuroHPC SUPERCOMPUTERS RANKED AMONG THE WORLD'S TOP 10 SUPERCOMPUTERS

LUMI #8

LUMI

LEONARDO #9

LEONARDO

JUPITER: EUROPE FIRST EXASCALE SUPERCOMPUTER

JEDI MODULE #1 GREEN500

JETI MODULE #18

and

MARENOSTRUM 5 #11

4



IBM POWER9 Summit

(Nov'19 #1 TOP500)



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

Nov'22

Summit Overview



Compute Node

- 2 x POWER9
- 6 x NVIDIA GV100

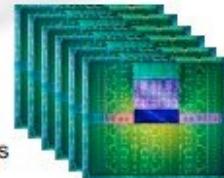
NVMe-compatible PCIe 1600 GB SSD



- 25 GB/s EDR IB- (2 ports)
- 512 GB DRAM- (DDR4)
- 96 GB HBM- (3D Stacked)
- Coherent Shared Memory



- NVIDIA GV100**
- 7 TF
 - 16 GB @ 0.9 TB/s
 - NVLink



Compute Rack

- 18 Compute Servers

Warm water (70°F direct-cooled components)

RDHX for air-cooled components



Compute System

10.2 PB Total Memory

256 compute racks

4,608 compute nodes

Mellanox EDR IB fabric

200 PFLOPS

~13 MW

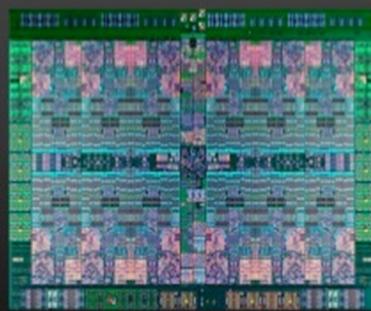




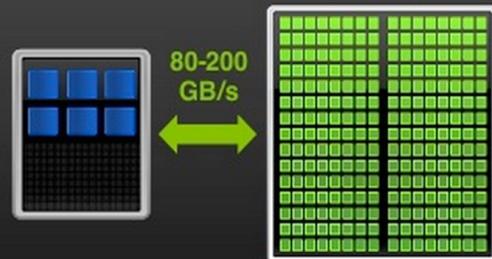
IBM POWER9 + NVidia V100



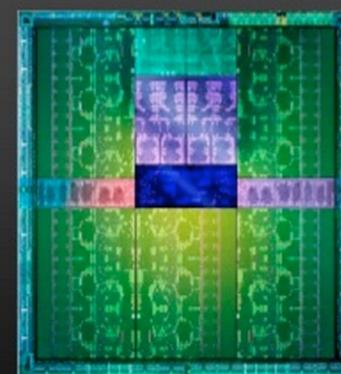
Accelerated Computing 5x Higher Energy Efficiency



IBM POWER CPU
Most Powerful Serial Processor



NVIDIA NVLink
Fastest CPU-GPU Interconnect

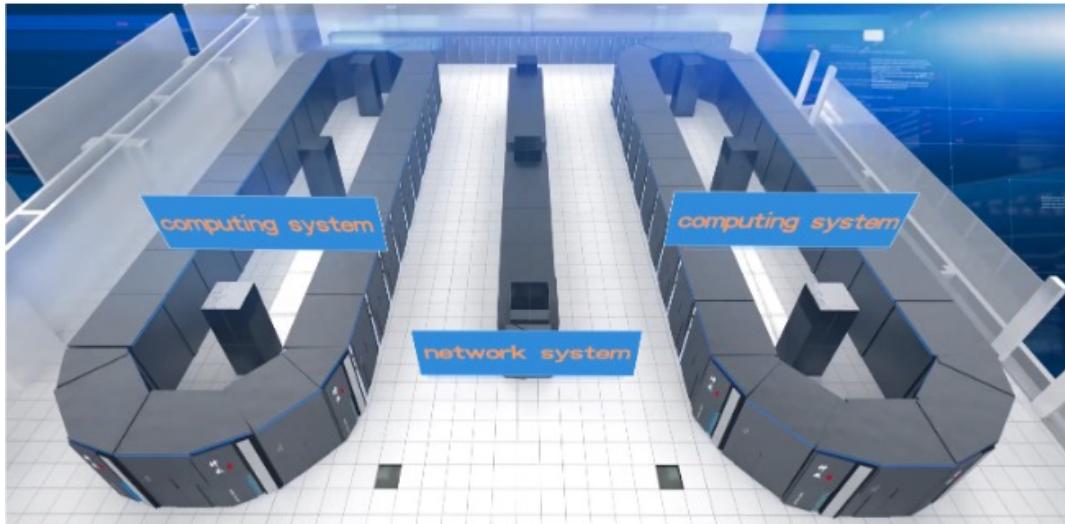


NVIDIA Volta GPU
Most Powerful Parallel Processor

5



Overview of the Sunway TaihuLight System



Sunway TaihuLight

(#1 in June '16 TOP500)

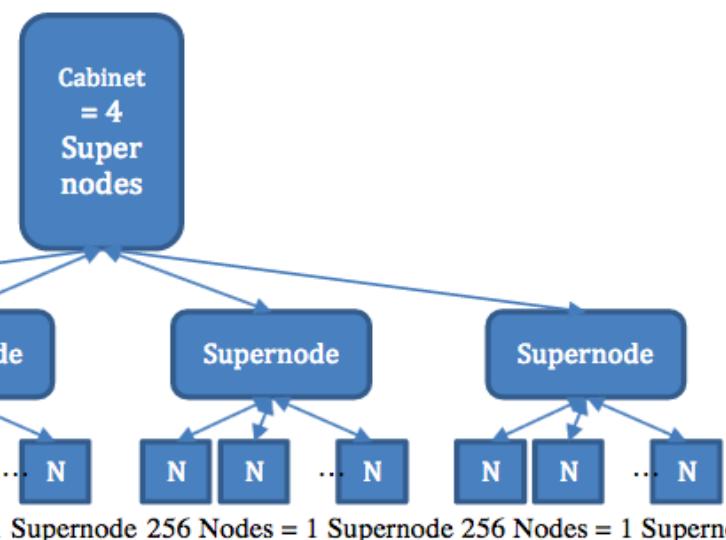
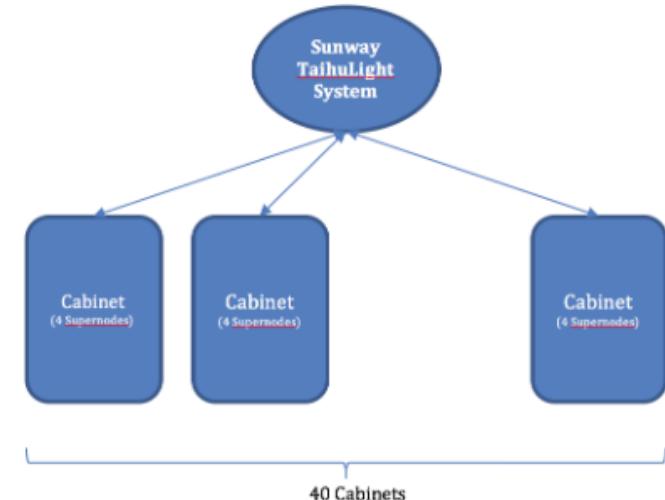
7



Sunway TaihuLight - Sunway MPP, Sunway SW26010
260C 1.45GHz, Sunway, NRCPC

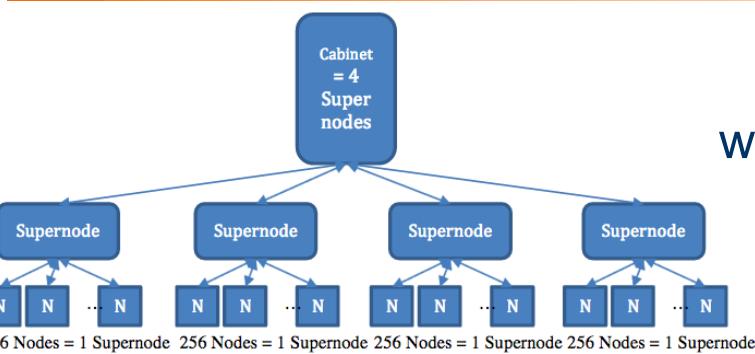
National Supercomputing Center in Wuxi
China

Nov'22





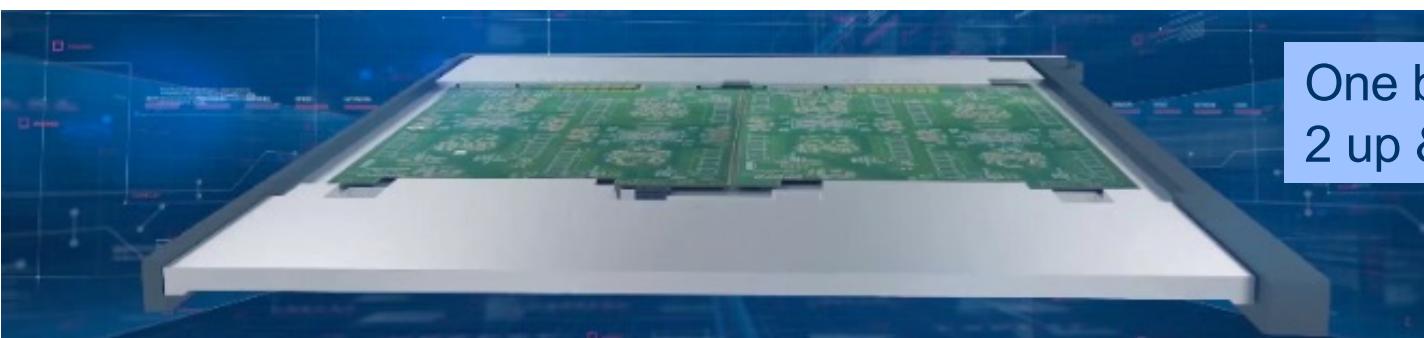
Sunway TaihuLight



One cabinet
with 4 Supernodes



One Supernode
with 32 boards



One board with 4 cards,
2 up & 2 down



Sunway TaihuLight

SW26010 chip with
4x NUMA Core Groups (CG).

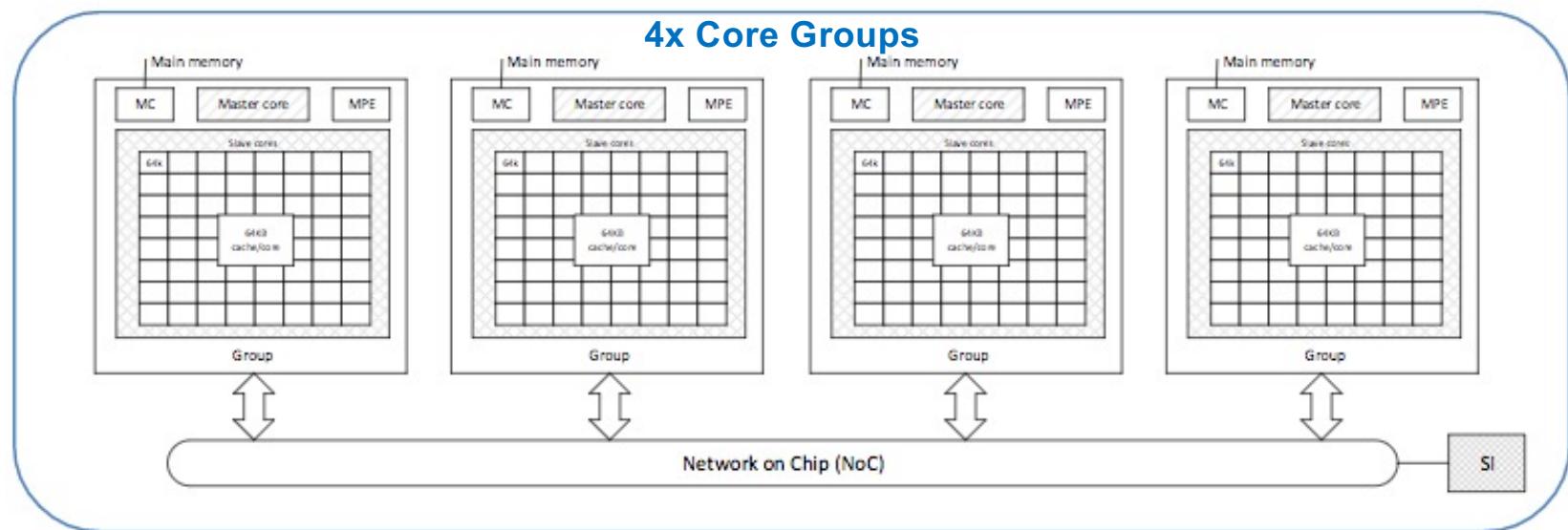
Each CG follows a hybrid approach:

- 1 fat-core (MPE) for serial work, OoO execution, superscalar, L1 & L2
- 8x8 grid of skinny-cores (CPE), L1 private & L2 shared by the grid
- all cores are 64-bit RISC PU and all support 256-bit vector instructions

One card w/ two PU devices (*two SW26010 chips*)



SW26010
chip



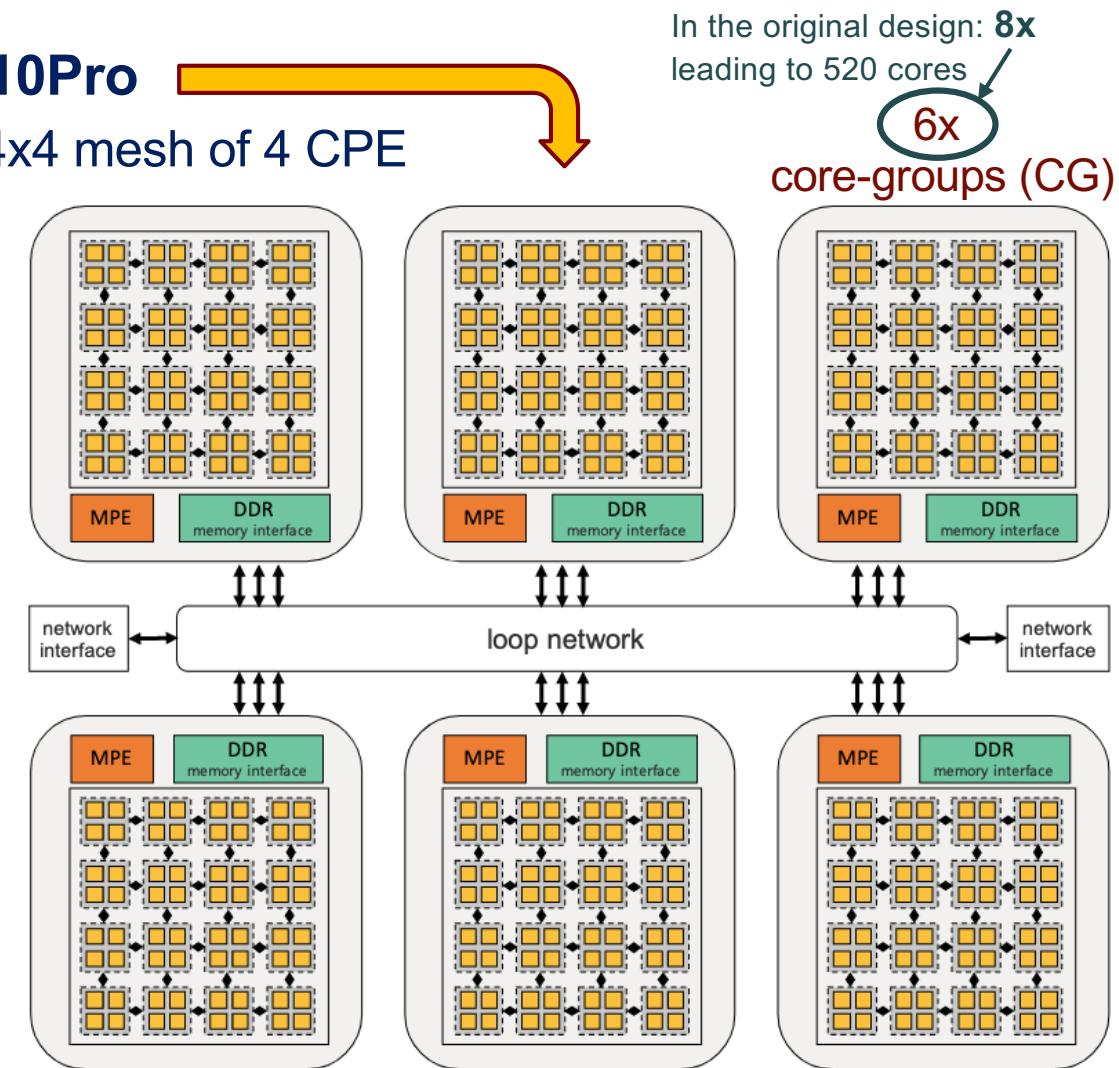
AJProen a,

The new Sunway OceanLight supercomputer

(April'21)



- Based on the chip **SW26010Pro**
 - 6x CG, each 1x fat-core & 4x4 mesh of 4 CPE
 - overall **390 cores**
 $(= 6 \times (1 + 64))$
 - mem controller at each CG accesses 16 GiB DDR4 with 51.2 GiB/s bandwidth
 - each chip: accesses 96 GiB DDR4 with 307.2 GiB/s bandwidth
- Single-socket nodes
- More nodes, more cores:
from 7.6 millions cores to over **41.9 millions cores!**



6



NVidia Selene: 280 DGX A100 nodes



Selene - NVIDIA DGX A100, AMD EPYC 7742 64C
2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia
NVIDIA Corporation
United States

Nov'22



DGX A100 node



Dual 64-core AMD Rome
1 TB RAM
8x NVidia A100 GPUs

NVIDIA DGX H200

The gold standard for AI infrastructure.



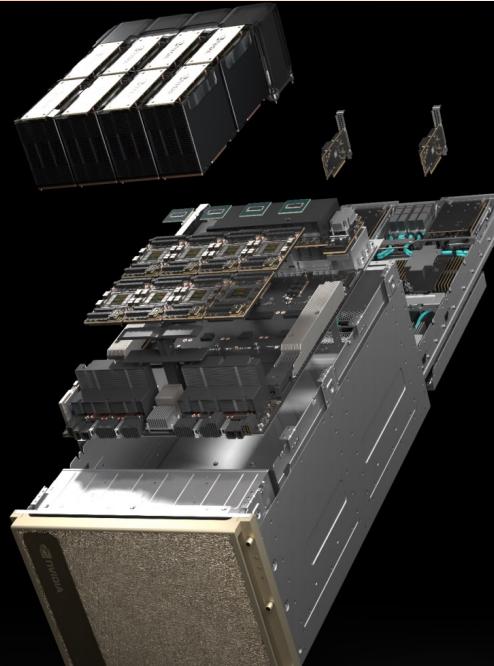
Next NVidia DGX nodes: H200, GB200



Explore NVIDIA DGX H200

> 8x NVIDIA H200 GPUs with 1,128GBs of Total GPU Memory

18x NVIDIA NVLink® connections per GPU,
900GB/s of bidirectional GPU-to-GPU bandwidth



> 4x NVIDIA NVSwitches™

7.2TB/s of bidirectional GPU-to-GPU bandwidth, 1.5X more than
previous generation

> 10x NVIDIA ConnectX®-7 400Gb/s Network Interface

1TB/s of peak bidirectional network bandwidth

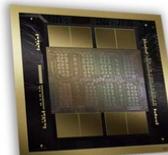
> Dual Intel Xeon Platinum 8480C processors, 112 cores total, and 2TB System Memory

Powerful CPUs for the most intensive AI jobs

> 30TB NVMe SSD

High-speed storage for maximum performance

NVIDIA B200 Blackwell Superchip



NVIDIA Grace Superchip

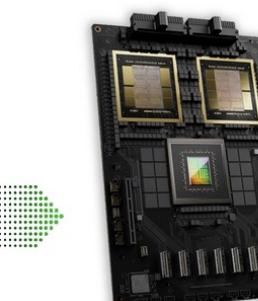


GB200 Compute Tray

(besteht aus 2x GB200 Blackwell Superchip)

DGX GB200 NVL72

(besteht aus 18x GB200 Compute Trays (72x GPUs))



GB200 Grace Blackwell Superchip

(besteht aus 2x B200 Blackwell Superchip und 1x Grace Superchip)





Overview of Tianhe-2A

(Tianhe-2 #1 in June'13 TOP500)



Tianhe-2A - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2
12C 2.2GHz, TH Express-2, Matrix-2000, NUDT
National Super Computer Center in Guangzhou
China Nov'22



Overview of Tianhe-2A

Comparison

Items	Milkyway-2	Milkyway-2A
Nodes & Performance	16000 nodes with Intel CPU + KNC 54.9Pflops	17792 nodes with Intel CPU + Matrix-2000 94.97Pflops
Interconnection	10Gbps, 1.57us	14Gbps, 1us
Memory	1.4PB	3.4PB
Storage	12.4PB, 512GB/s	20PB, 1TB/s
Energy Efficiency	17.8MW, 1.9Gflops/W	About 18MW, >5Gflops/W
Heterogeneous software	MPSS for Intel KNC	OpenMP/OpenCL for Matrix-2000



Overview of Tianhe-2A

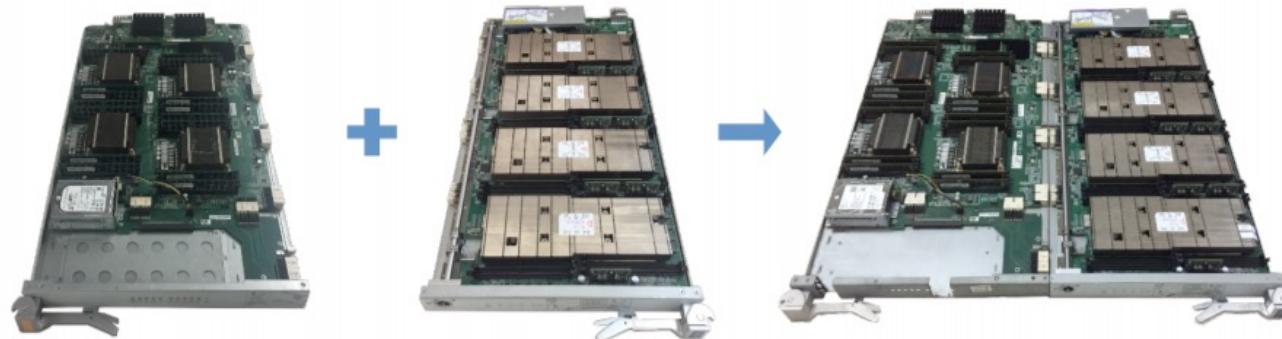


Compute nodes

● Heterogeneous Compute Blades

- Compute blade = Xeon part + Matrix-2000 part

4 Intel Xeon CPUs 4 FT Matrix-2000 2 Compute Nodes



- Use the Matrix-2000 part to replace the KNC part



Replacing the KNC in Tianhe-2A: the Matrix-2000 accelerator

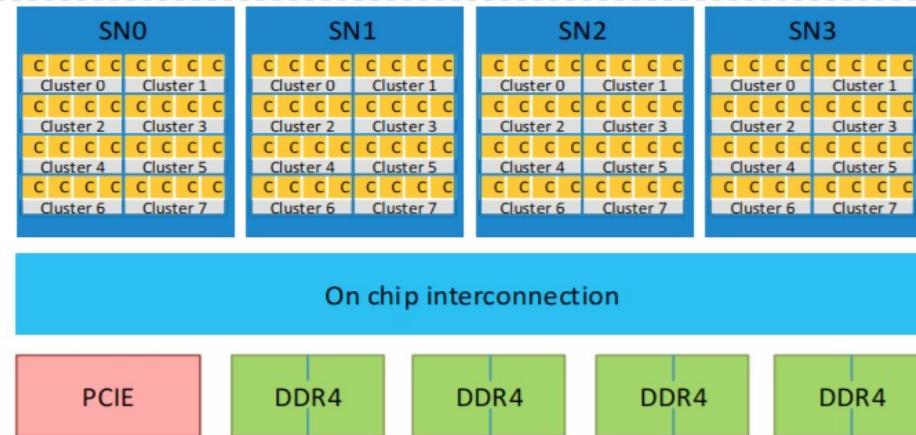


Matrix-2000 accelerator



Chip specification

- 128cores
 - 4 super-nodes (SN)
 - 8 clusters per SN
 - 4 cores per cluster
 - Core
 - Self-defined 256-bit vector ISA
 - 16 DP flops/cycle per core
- Peak performance: 2.4576Tflops@1.2GHz
 - 4 SNs x 8 clusters x 4cores x 16 flops x 1.2 GHz = 2.4576 Tflops



- Peak power dissipation: ~240W
- Interface
 - 8 DDR4-2400 channels
 - X16 PCIE 3.0 EP Port



1. TOP500 (*LINPACK*)

- a) TOP10 lists from Nov'18 to Nov'24
- b) Analysis of TOP1 in Nov'24 & some past relevant systems in 2022
- c) Country distribution over the past 25 years
- d) Processor distribution (*system share & performance*) in the past 4 years
- e) Accelerator family distribution (*system share & performance*) in Jun'12 - Nov'24



2. GREEN500

- a) TOP10 in Nov'24

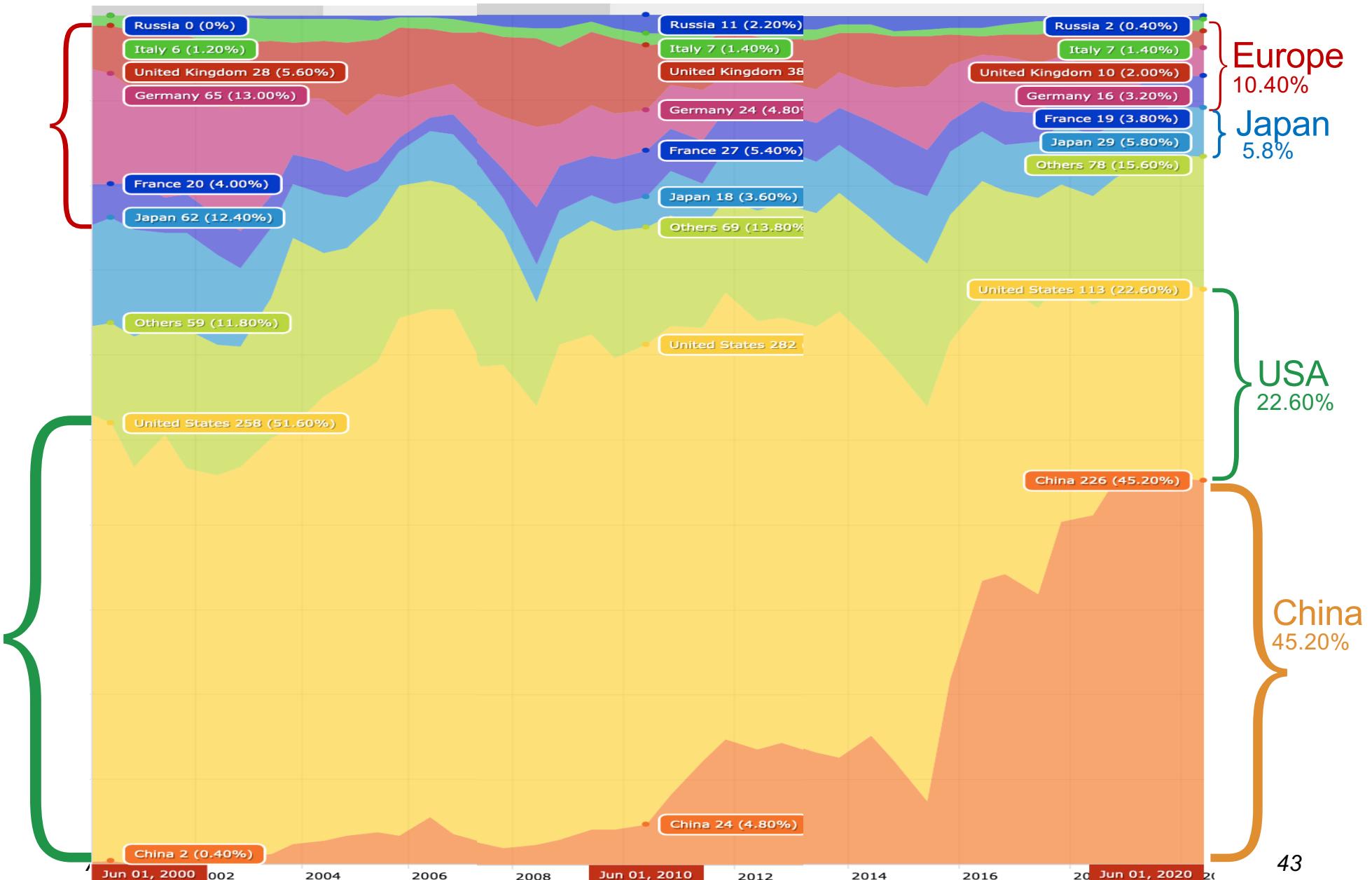
3. HPCG

- a) HPCG vs. HPL: an overview
- b) TOP7 in Jun'24

4. HPL-AI

- a) High-performance Linpack (HPL) and artificial intelligence (AI) workloads
- b) TOP7 in Nov'24

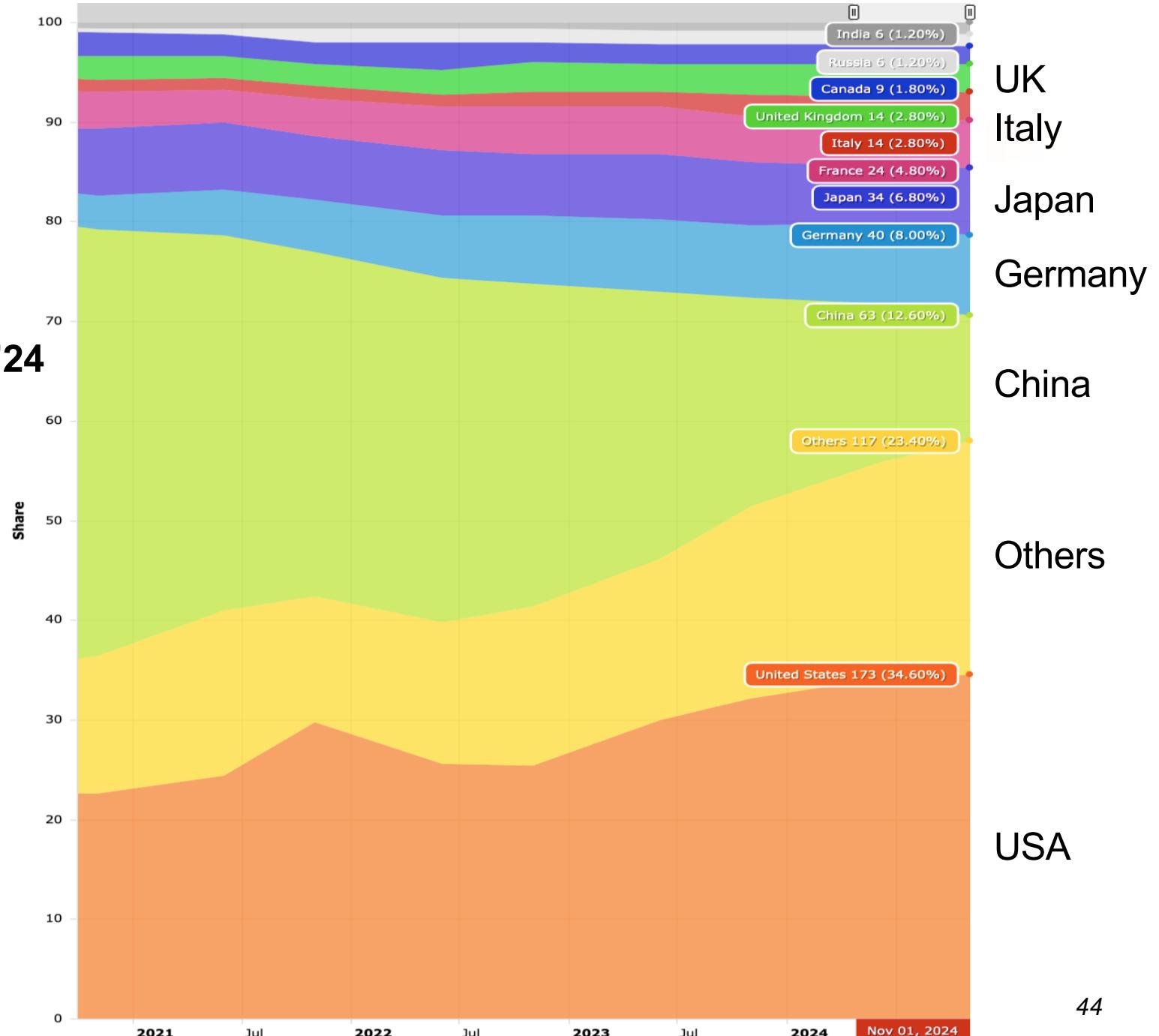
Country distribution over 20 years: from 2000 to 2020, #systems



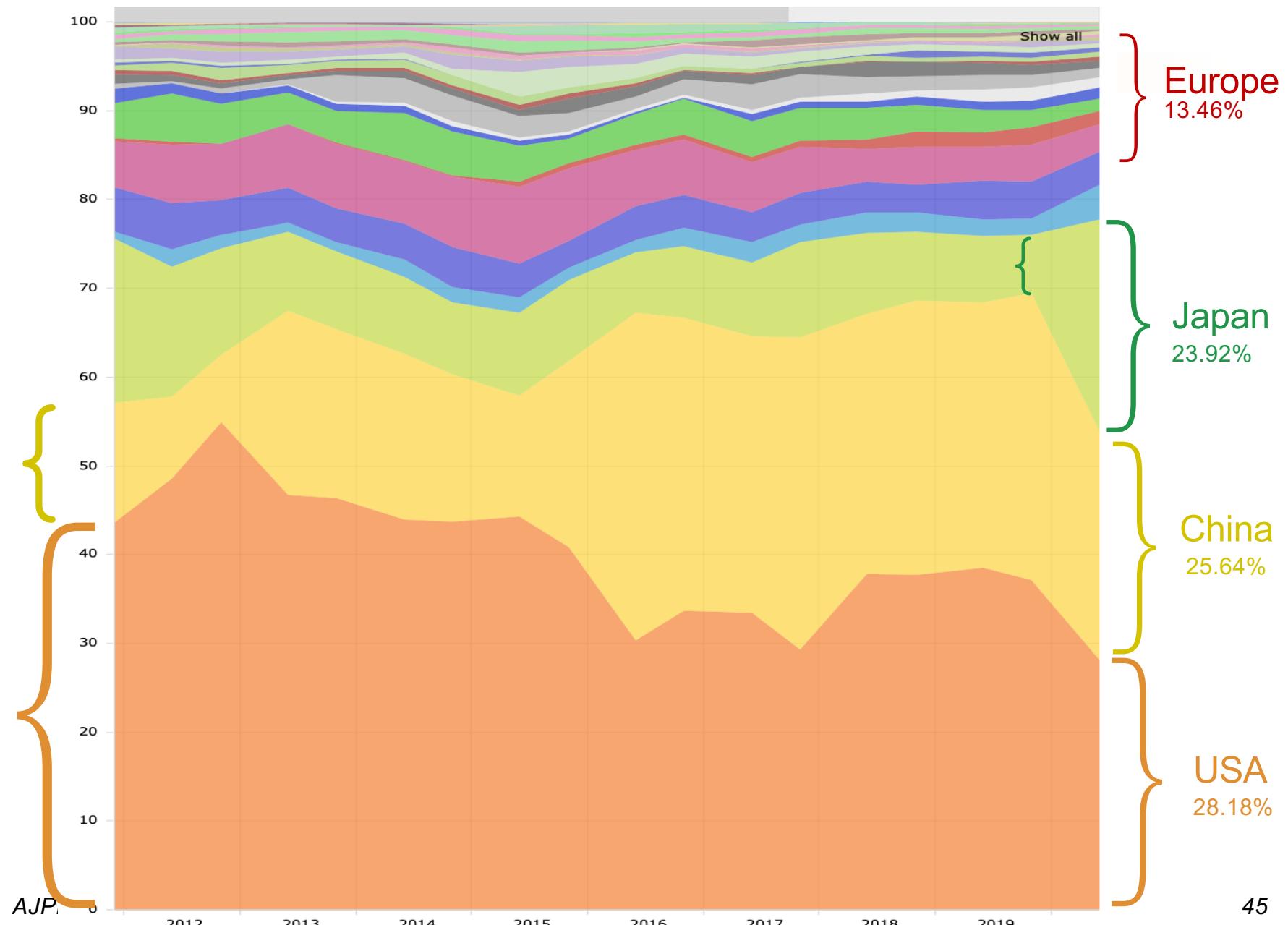


Nov'20 to Nov'24
#systems

Country distribution in the past 4 years



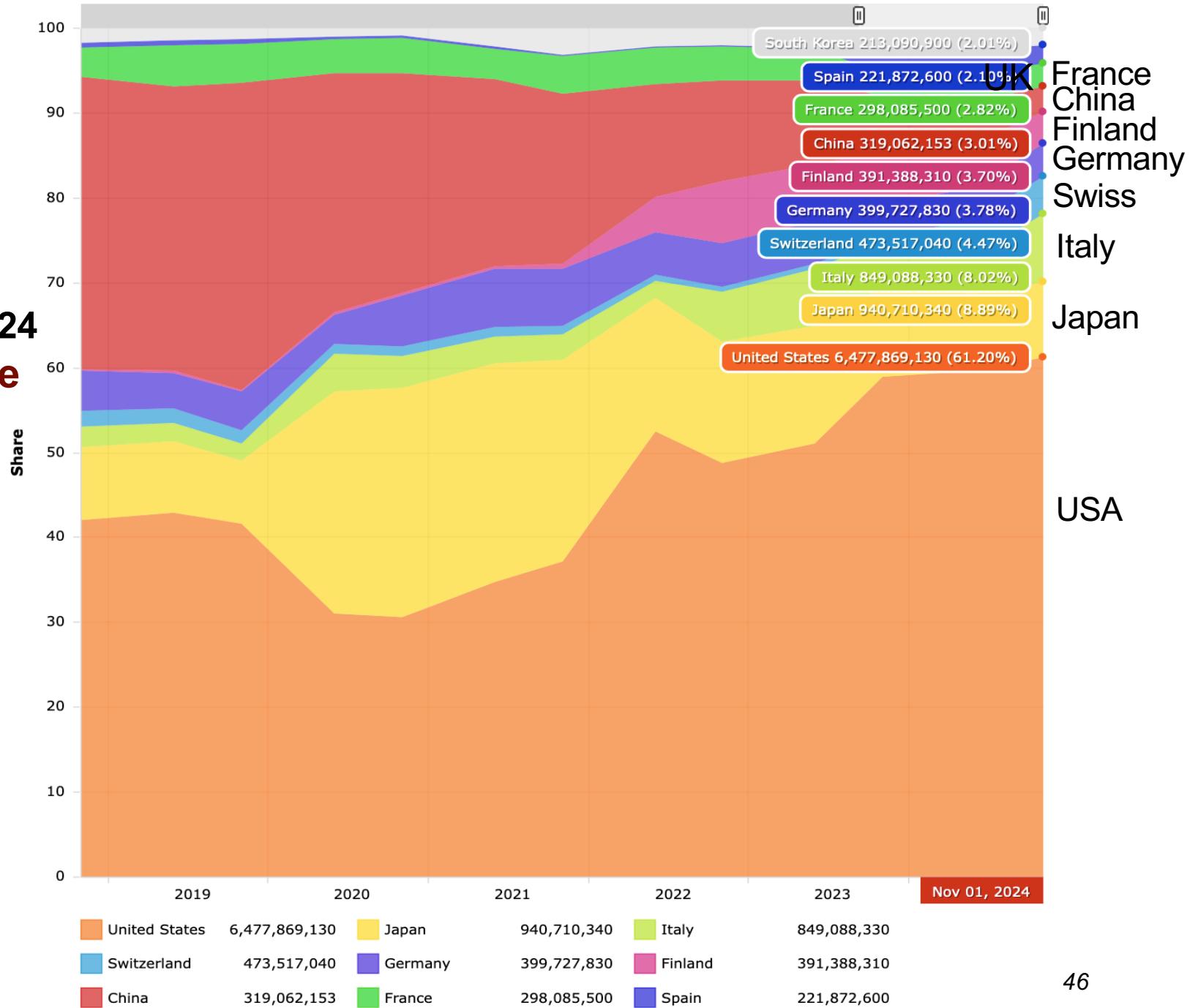
Country distribution over 20 years: from 2000 to 2020, aggregate performance



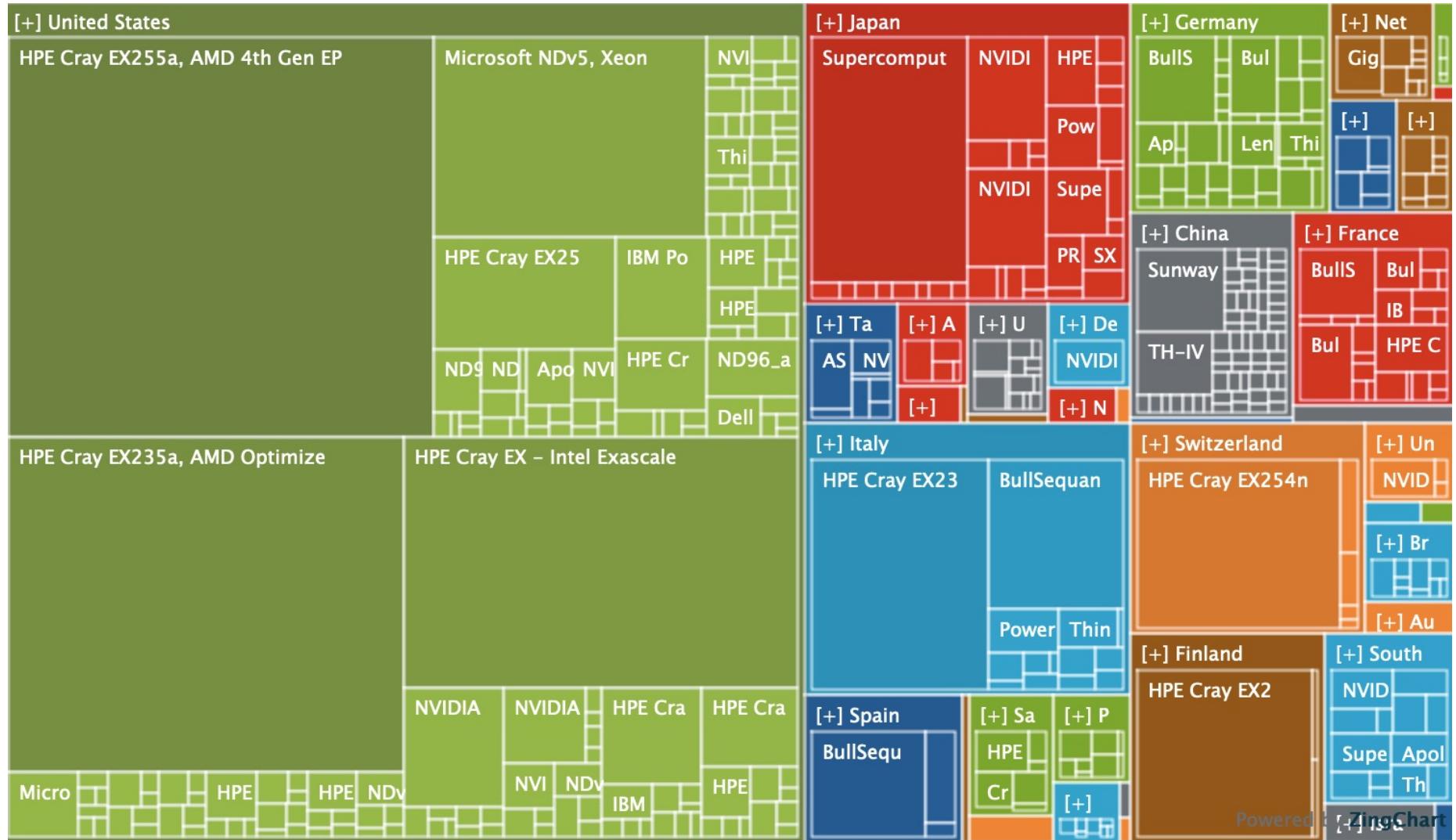


Nov'20 to Nov'24
performance

Country distribution in the past 4 years



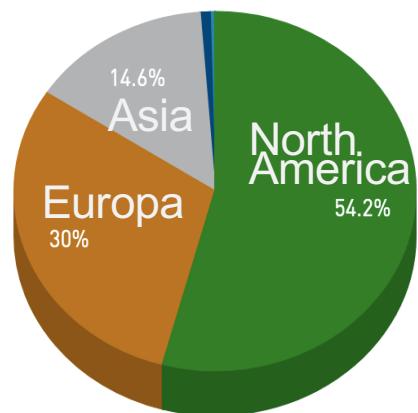
Country distribution: #systems & performance (Nov'24)



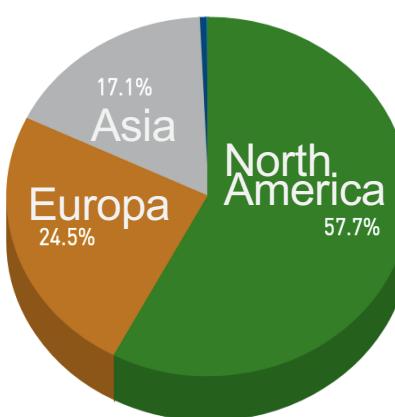
<https://www.top500.org/statistics/treemaps/>

Continent distribution in this century: from 2000 to 2024, systems & performance share

Continents System Share

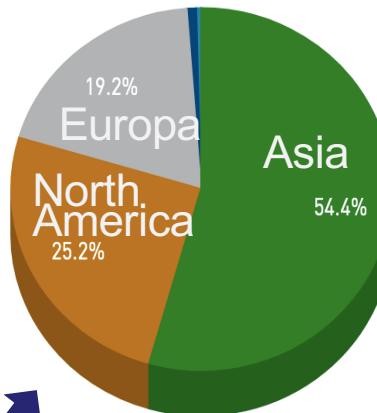


Continents Performance Share



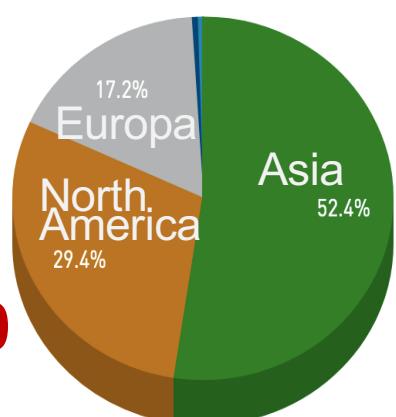
2000

Continents System Share

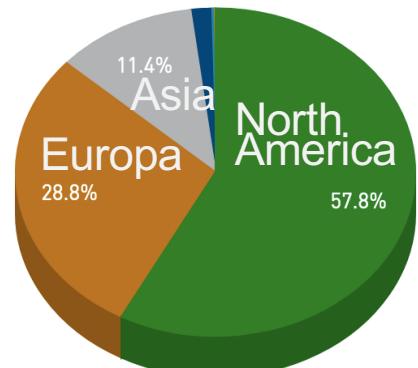


2020

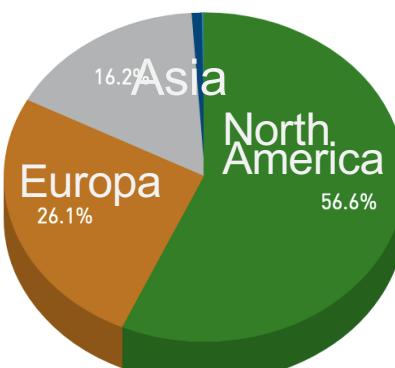
Continents Performance Share



Continents System Share

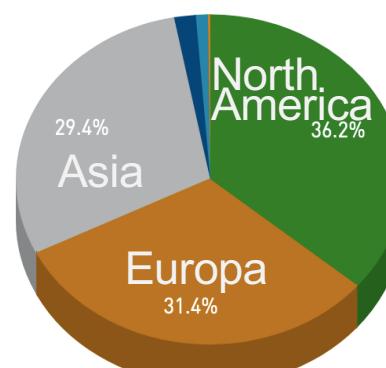


Continents Performance Share



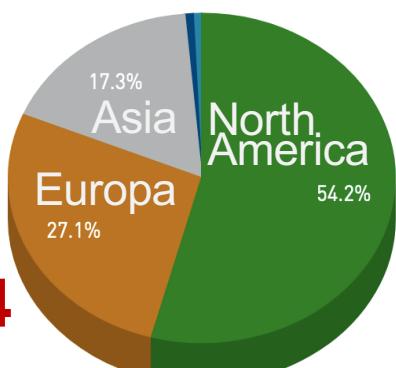
2010

Continents System Share



2024

Continents Performance Share





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2. GREEN500

- a) TOP10 in Nov'24

3. HPCG

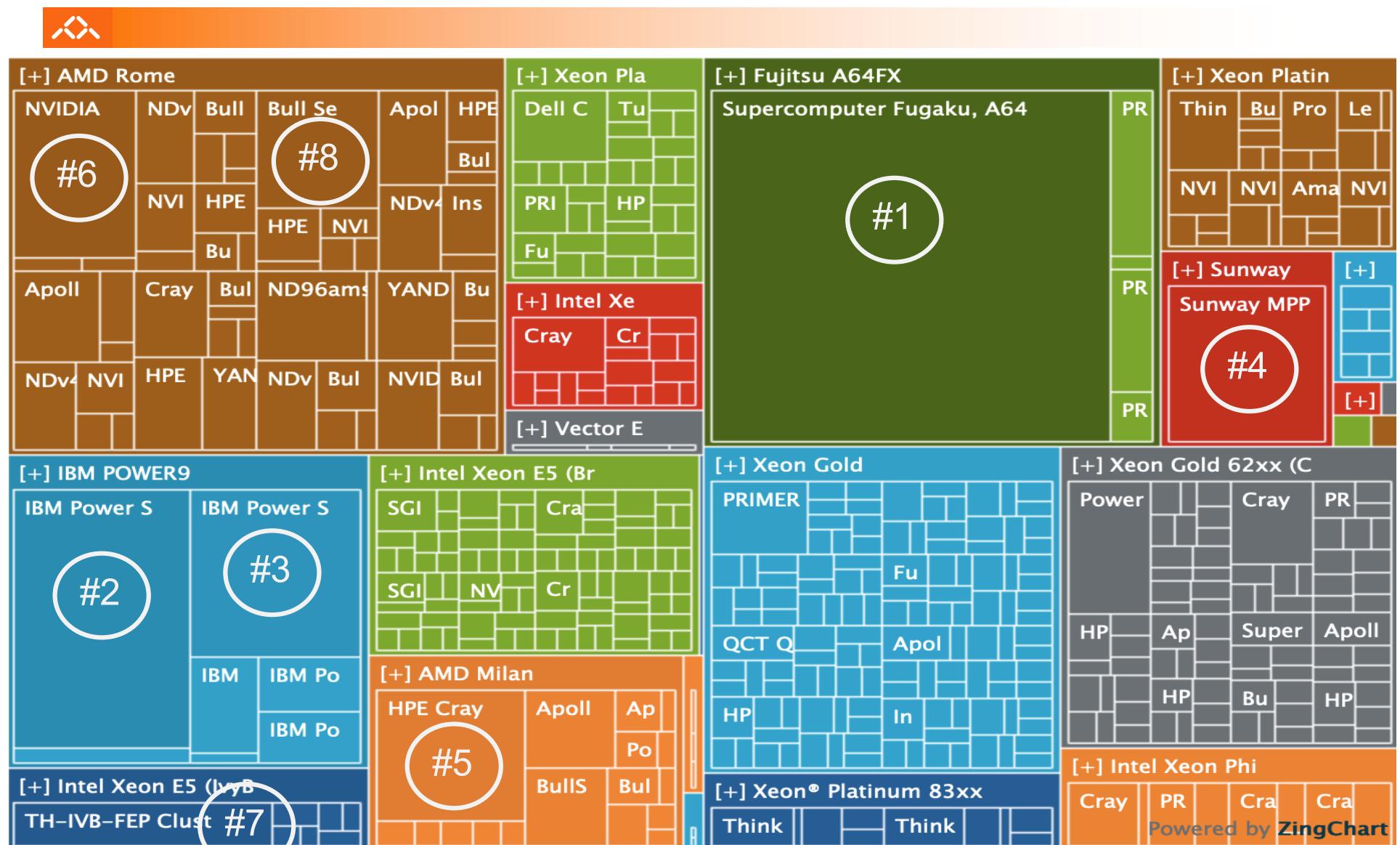
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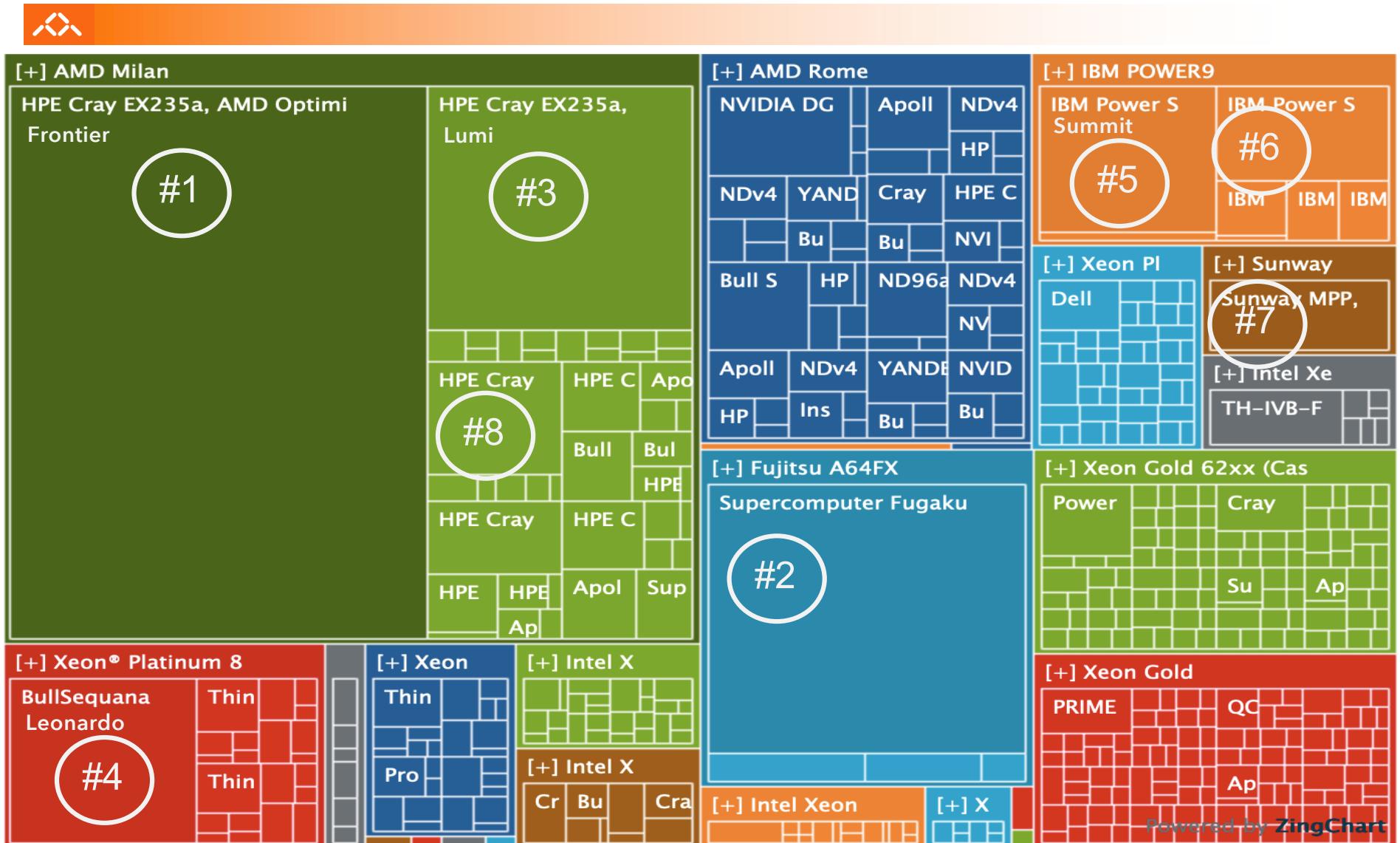
Processor distribution

Nov'21



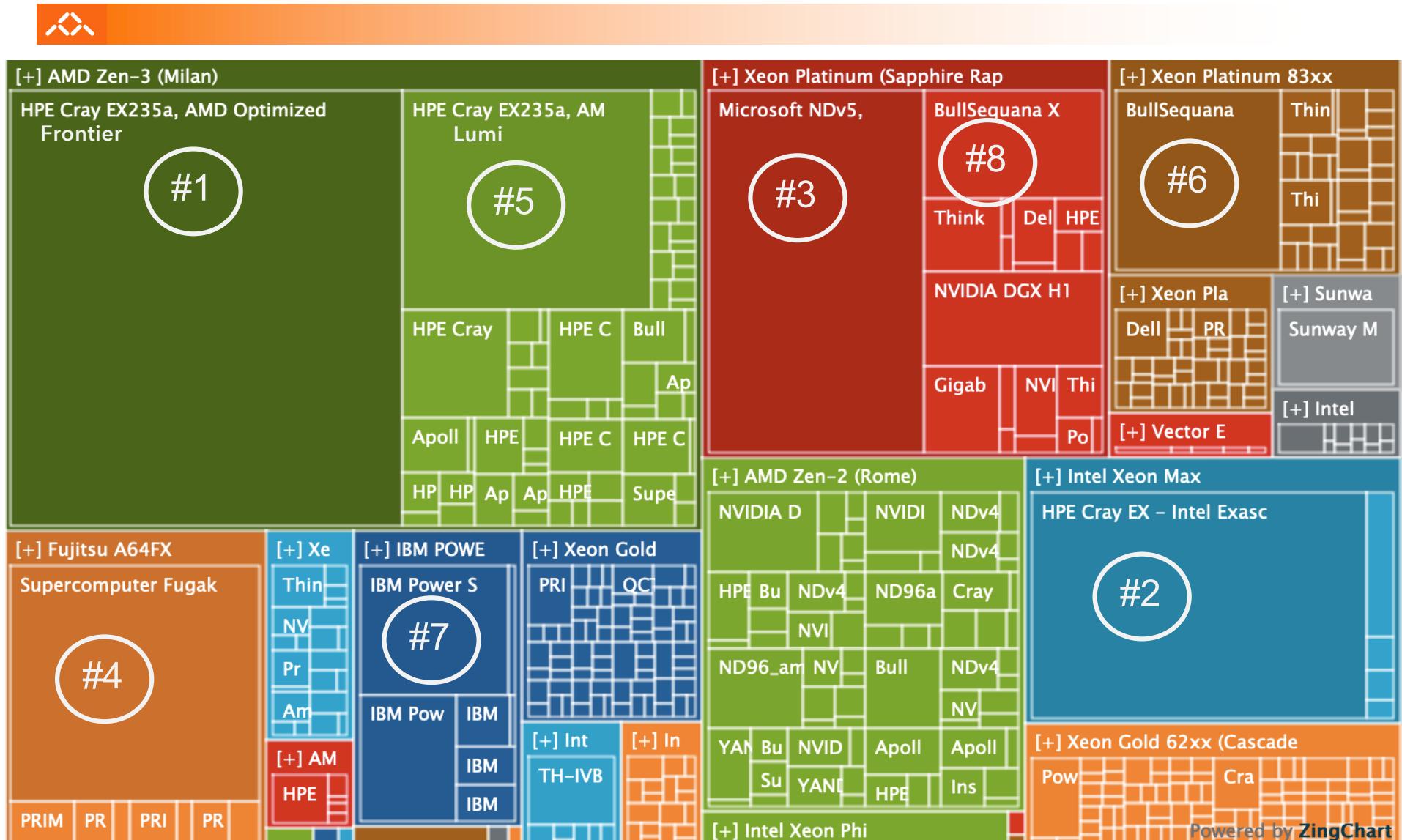
Processor distribution

Nov'22



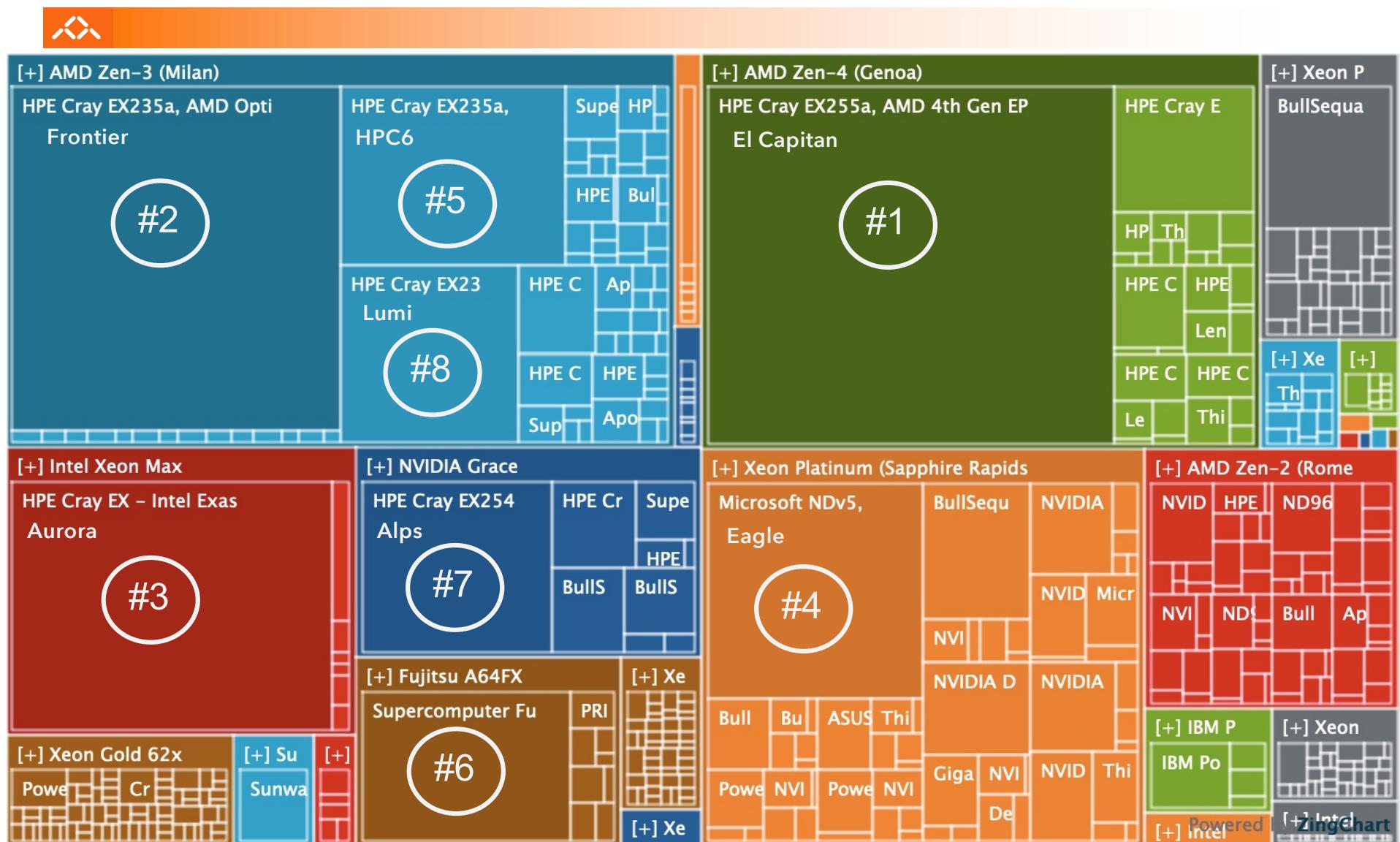
Processor distribution

Nov'23



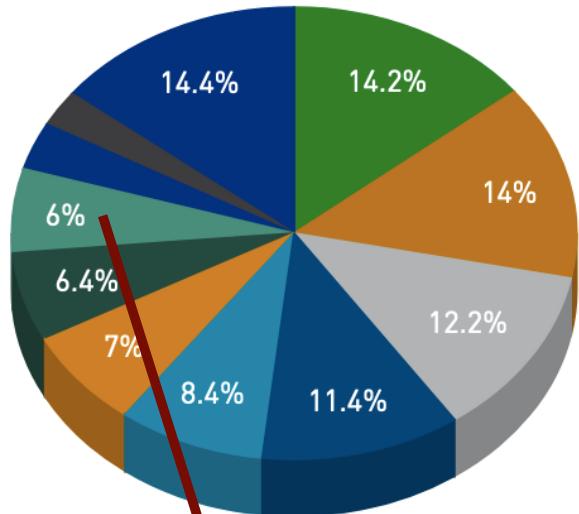
Processor distribution

Nov'24

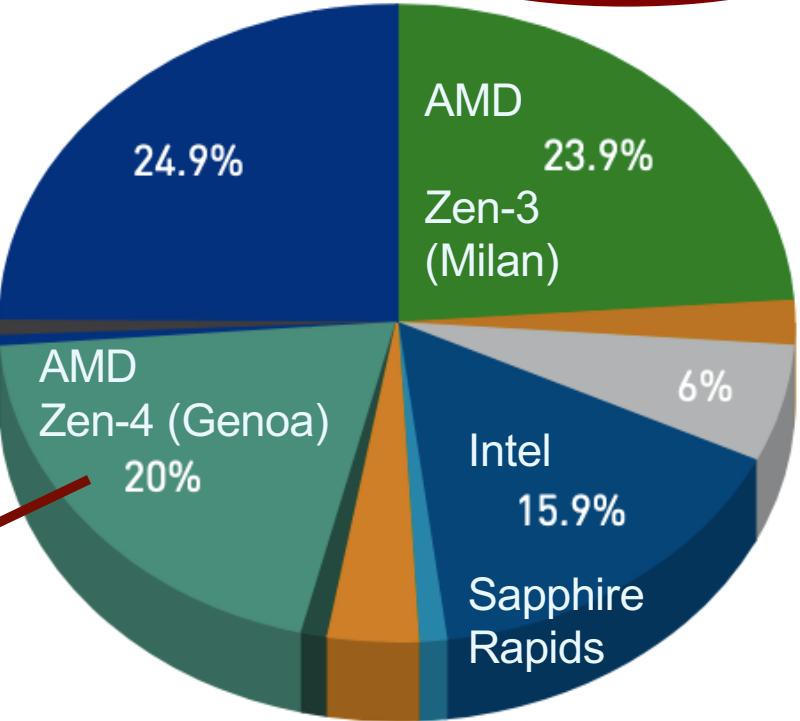


Processor generation share Nov'24

Processor Generation System Share



Processor Generation Performance Share



- AMD Zen-3 (Milan)
- Xeon Gold 62xx (Cascade Lake)
- AMD Zen-2 (Rome)
- Xeon Platinum (Sapphire Ra...)
- Xeon Gold (Skylake)
- Xeon Platinum 83xx (Ice Lake)
- Xeon Platinum 82xx (Cascad...)
- AMD Zen-4 (Genoa)
- Intel Xeon E5 (Broadwell)
- Xeon Platinum (Skylake)
- Others

AMD Genoa:

- only on 6% of #systems
- but with 20% of overall performance!

Performance share:

- **AMD: 50%**
- **Intel: 25%**



1. TOP500 (*LINPACK*)

- a) TOP10 lists from Nov'18 to Nov'24
- b) Analysis of TOP1 in Nov'24 & some past relevant systems in 2022
- c) Country distribution over the past 25 years
- d) Processor distribution (*system share & performance*) in the past 4 years
- e) Accelerator family distribution (*system share & performance*) in Jun'12 - Nov'24



2. GREEN500

- a) TOP10 in Nov'24

3. HPCG

- a) HPCG vs. HPL: an overview
- b) TOP7 in Jun'24

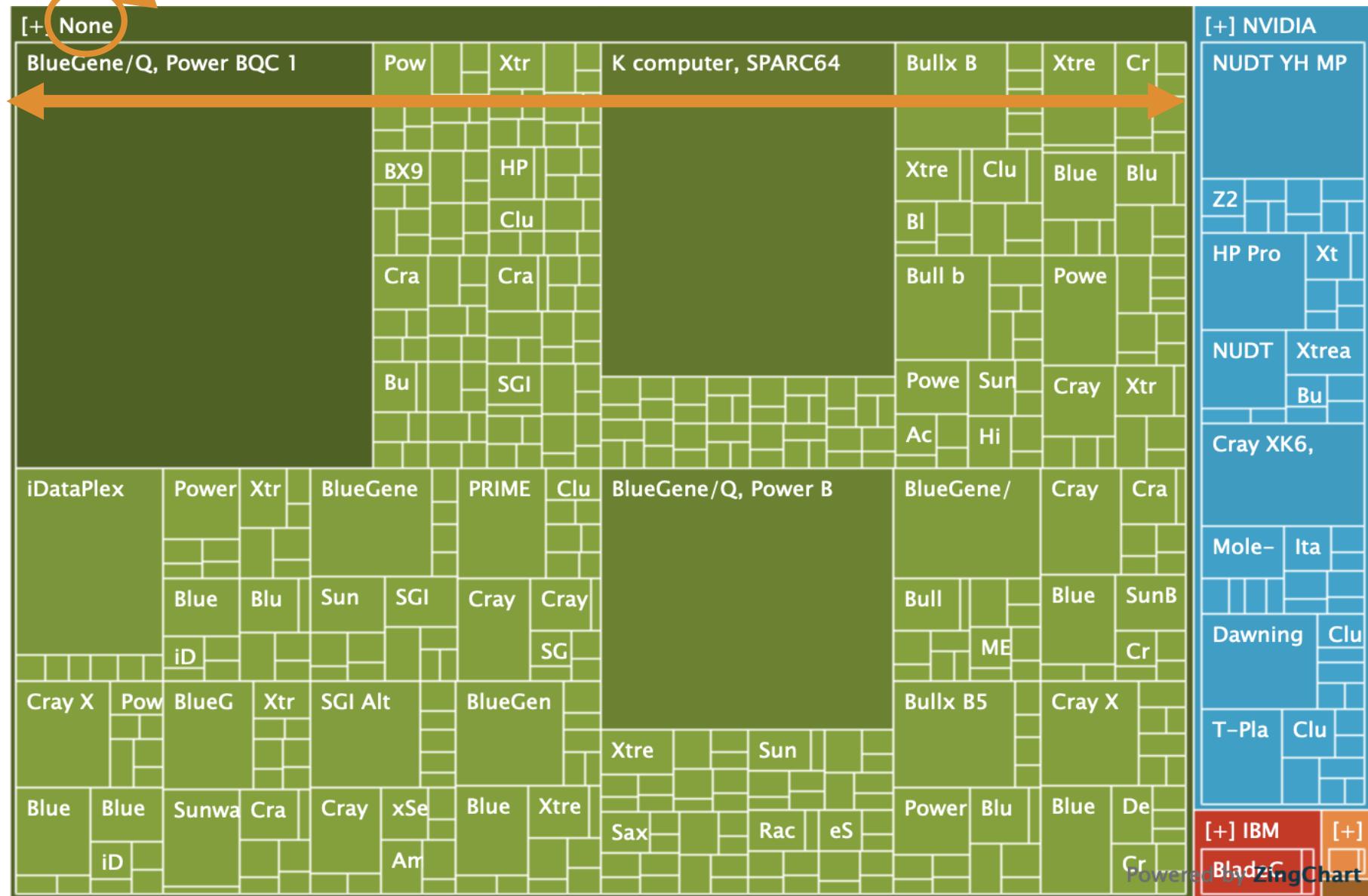
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- a) High-performance Linpack (HPL) and artificial intelligence (AI) workloads
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Accelerator family distribution

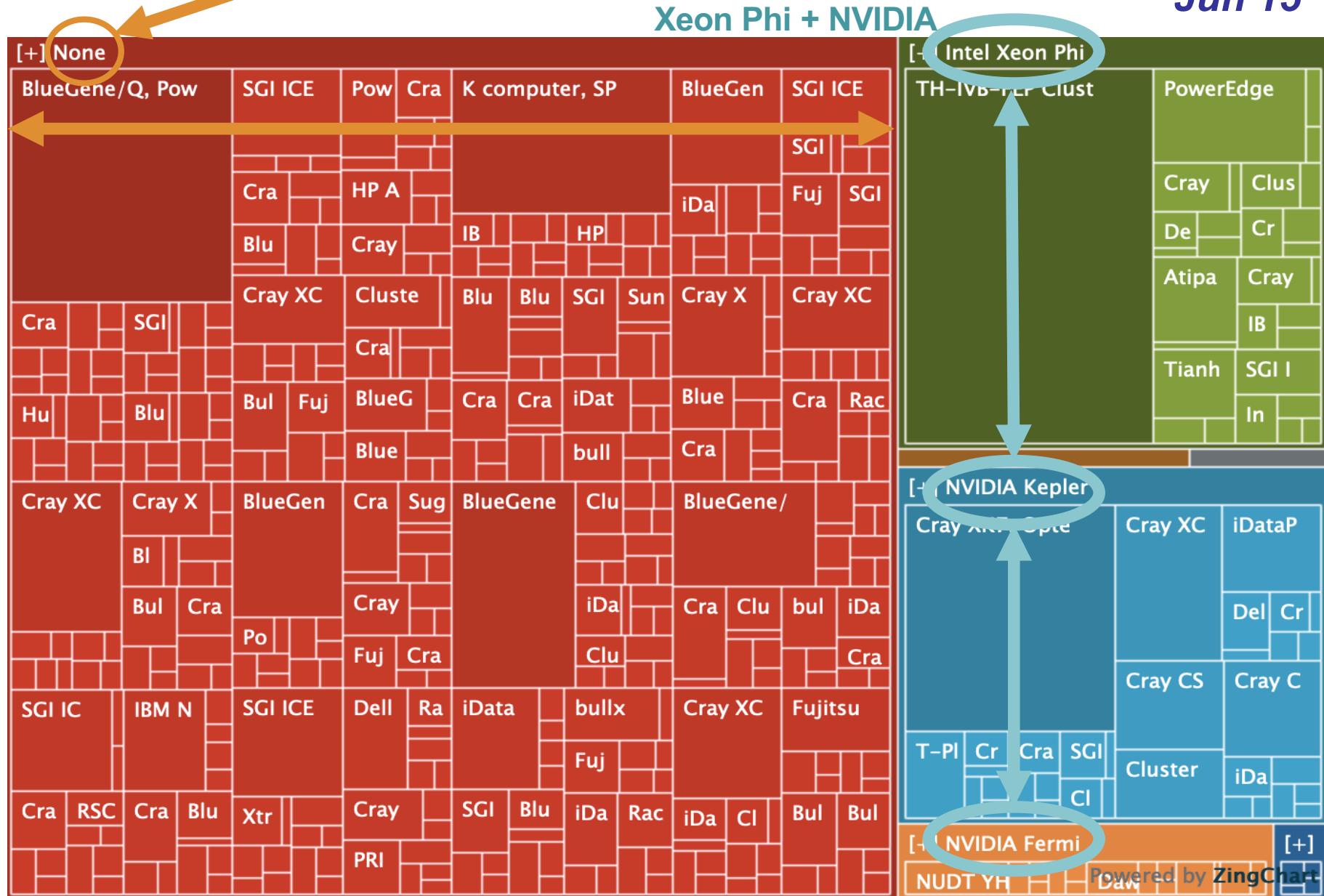
Jun'12





Accelerator family distribution

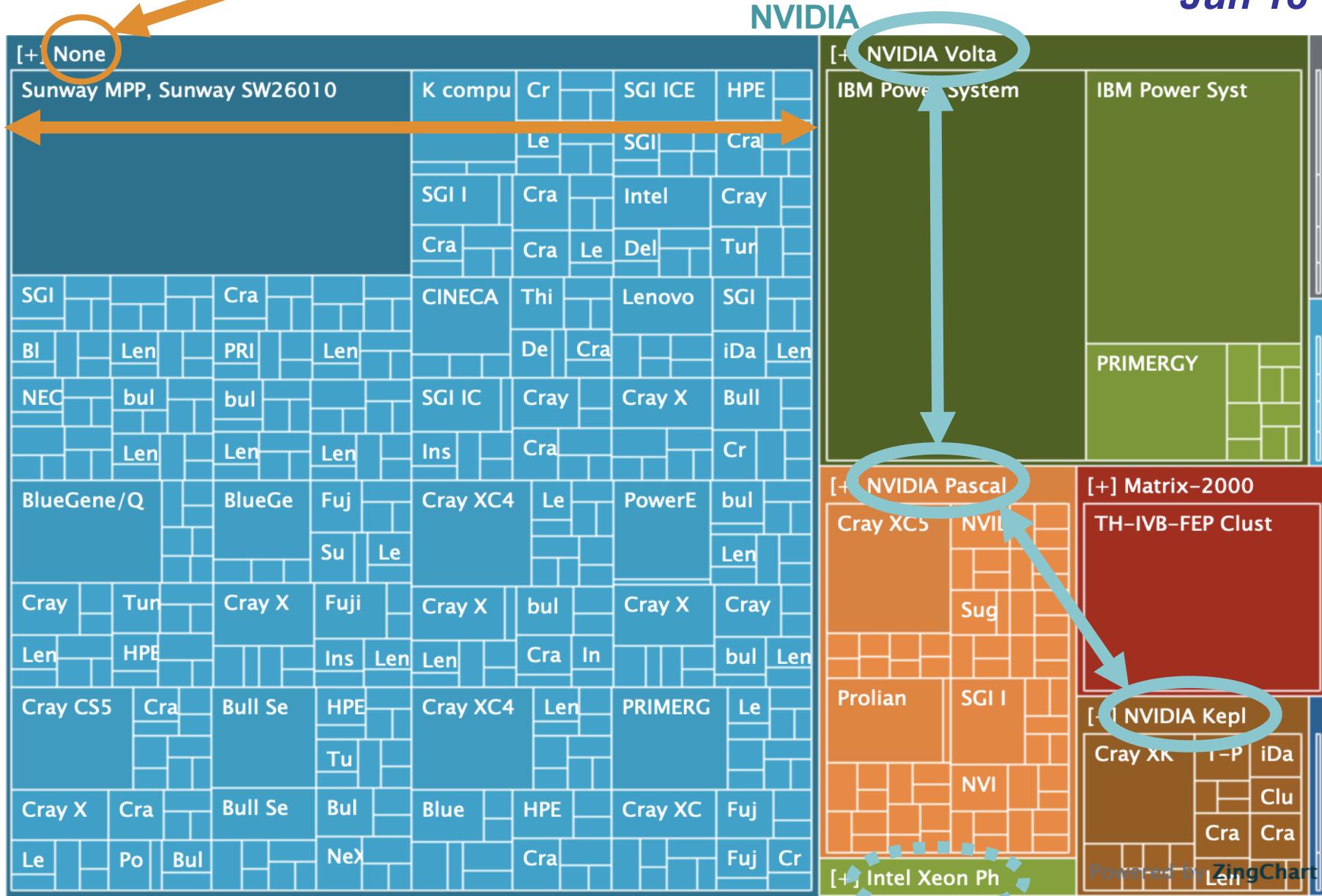
Jun'15





Accelerator family distribution

Jun'18





Accelerator family distribution

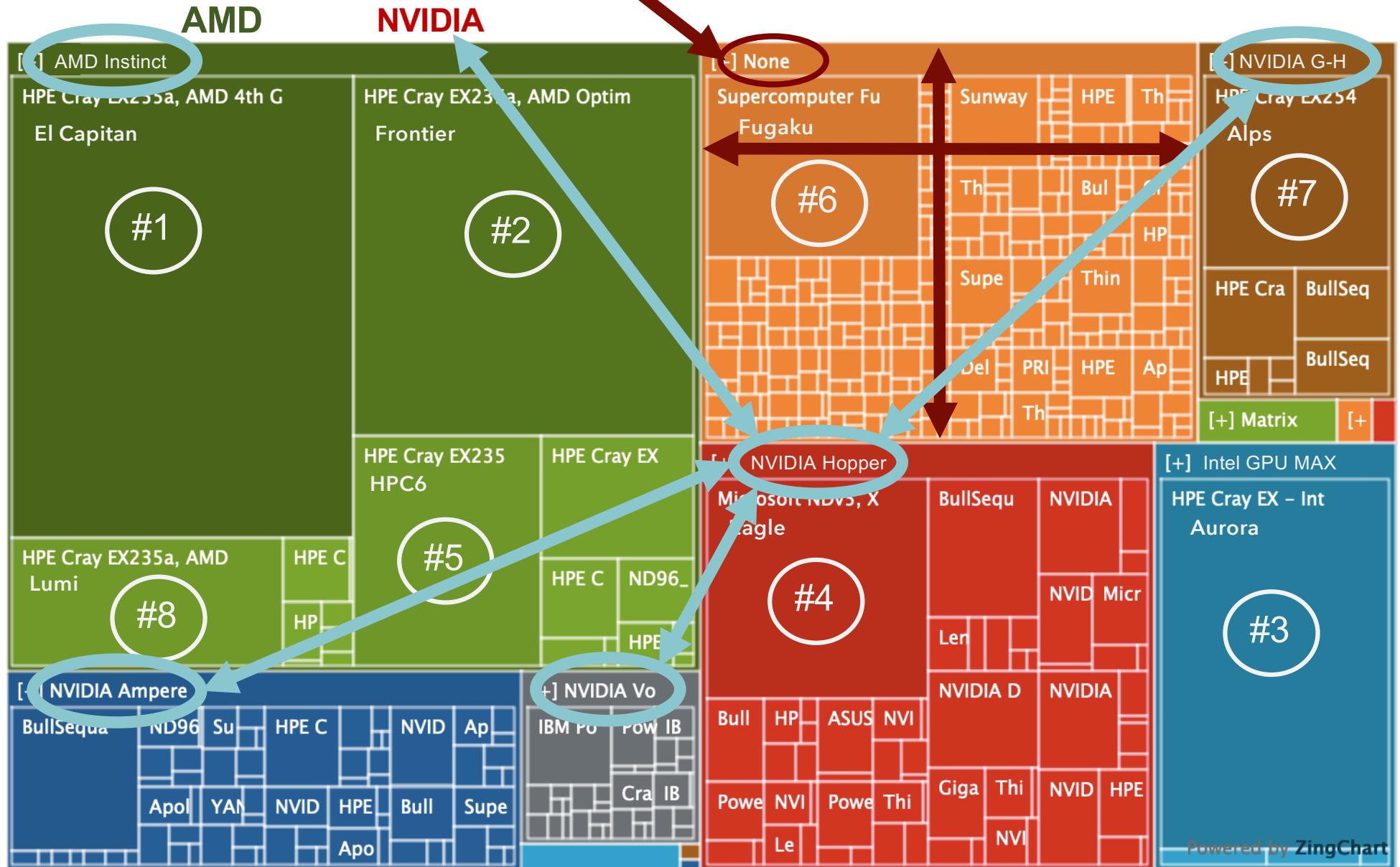
Nov'21





Accelerator family distribution

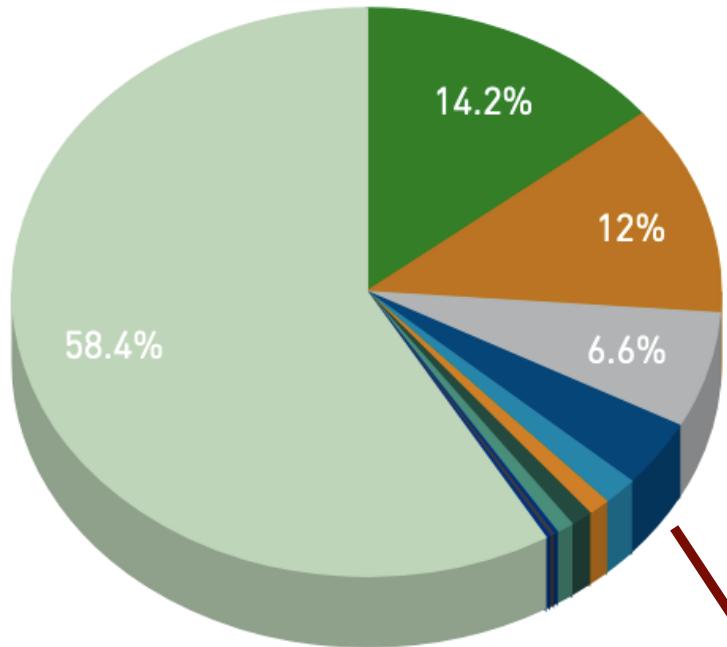
Nov'24



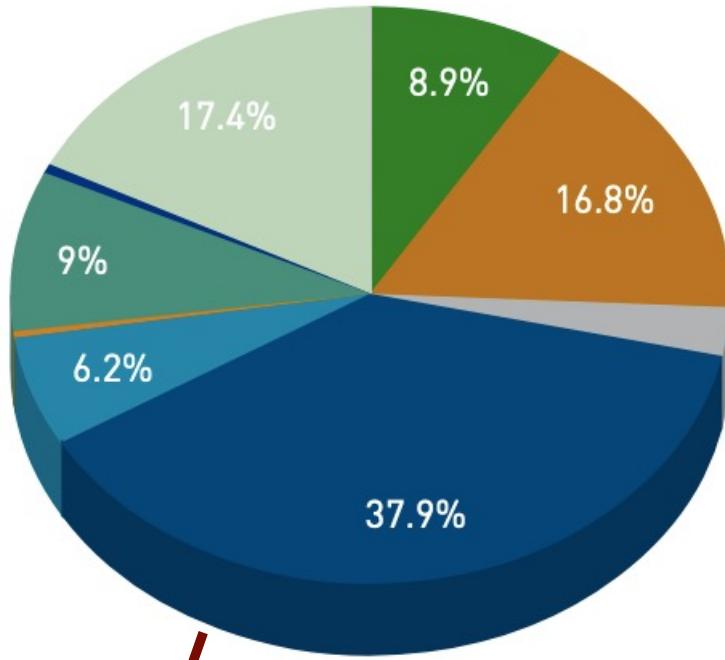
Accelerator family distribution

Nov'24

Accelerator/CP Family **System Share**



Accelerator/CP Family **Performance Share**



Intel GPU MAX

- NVIDIA Ampere
- NVIDIA Hopper
- NVIDIA Volta
- AMD Instinct
- NVIDIA GH200
- NVIDIA Pascal
- NVIDIA Kepler
- Intel GPU MAX
- Matrix-2000
- Intel Xeon Phi
- Hybrid
- Others

AMD Instinct MI300A & MI250X

Highlights from the Nov'24 List



211 systems on the list use compute accelerator devices, up from 194 in Jun'24, which include:

- 72 with NVIDIA Ampere chips
- 61 with NVIDIA Hopper chips
- 33 with NVIDIA Volta chips
- 12 with AMD Instinct MI250X chips
- 4 with Intel Data Centre GPU Max chips
- 13 with integrated APU chips:
 - 8 with NVIDIA GH200 Superchips
 - 5 with AMD APU Instinct MI300A chips

Outline



1. TOP500

- a) TOP10 lists from Nov'18 to Nov'24
- b) Analysis of TOP1 in Nov'24 & some past relevant systems in 2022
- c) PU chip technology evolution in the past 25 years and since last year
- d) Processor distribution (*system share & performance*) in the past 4 years
- e) Accelerator family distribution (*system share & performance*) in Jun'12 - Nov'24

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The Green500 list

The list ranks computers in terms of energy efficiency, typically measured as LINPACK FLOPS per watt.

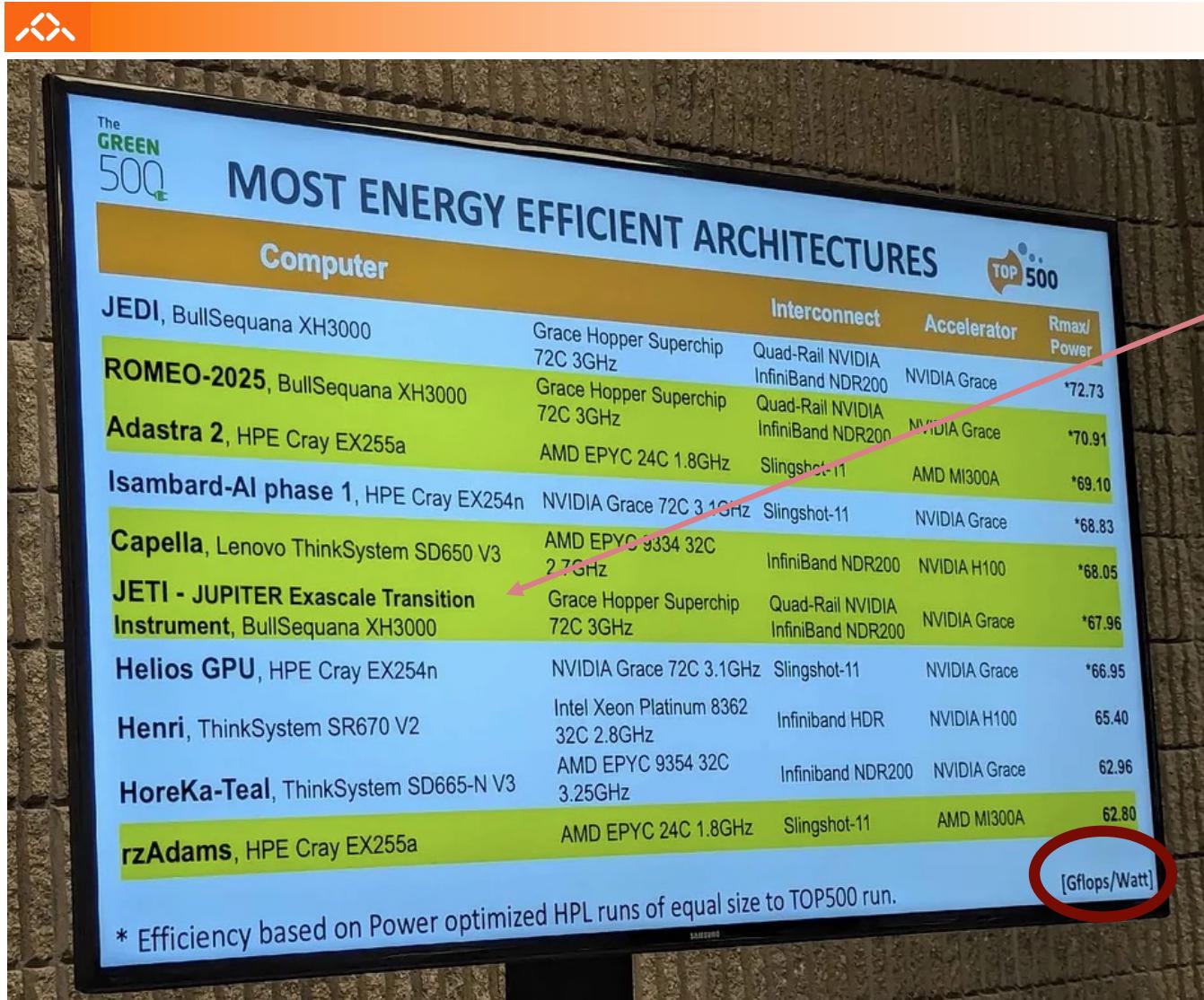
About the Green500 List

The Green500 list ranks the top 500 supercomputers in the world by energy efficiency. The focus of performance-at-any-cost computer operations has led to the emergence of supercomputers that consume vast amounts of electrical power and produce so much heat that large cooling facilities must be constructed to ensure proper performance. To address this trend, the Green500 list puts a premium on energy-efficient performance for sustainable supercomputing.

The inaugural Green500 list was announced on November 15, 2007 at SC|07. As a complement to the TOP500, the unveiling of the Green500 ushered in a new era where supercomputers can be compared by performance-per-watt.

While the selection of any power-performance metric will be controversial, we currently opt for "FLOPS-per-Watt" given that it has already become a widely used metric in the community and for

Top Green500 systems Nov'24



Best placed in HPL list:
JETI-JUPITER (#18)

- 5 systems with Grace Hopper Superchip
- 2 systems with AMD APU MI300A
- 2 systems with AMD Epyc & H100
- 1 system with Intel Xeon & H100

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HPCG benchmark



HPCG is a self-contained C++ program with MPI and OpenMP support that measures the performance of basic operations in a unified code:

- Sparse matrix-vector multiplication
- Vector updates
- Global dot products
- Local symmetric Gauss-Seidel smoother
- Sparse triangular solve (part of Gauss-Seidel smoother)

HPCG benchmark

From Wikipedia, the free encyclopedia

The **HPCG** (high performance conjugate gradient) **benchmark** is a [supercomputing](#) [benchmark](#) test proposed by Michael Heroux from [Sandia National Laboratories](#), and [Jack Dongarra](#) and Piotr Luszczek from the [University of Tennessee](#).^{[1][2]} It is intended to model the [data access](#) patterns of real-world [applications](#) such as [sparse matrix](#) calculations, thus testing the effect of limitations of the [memory](#) subsystem and internal [interconnect](#) of the supercomputer on its computing performance.^[3] Because it is internally [I/O bound](#), HPCG testing generally achieves only a tiny fraction of the peak [FLOPS](#) of the computer.^[4]

HPCG is intended to complement benchmarks such as the [LINPACK](#) [benchmarks](#) that put relatively little stress on the internal interconnect.^[5] The source of the HPCG benchmark is available on [GitHub](#).^[6]



TOP500: HPCG vs. HPL



HPCG Benchmark

The High Performance Conjugate Gradients (HPCG) Benchmark project is an effort to create a new metric for ranking HPC systems. HPCG is intended as a complement to the High Performance LINPACK (HPL) benchmark, currently used to rank the TOP500 computing systems. The computational and data access patterns of HPL are still representative of some important scalable applications, but not all. HPCG is designed to exercise computational and data access patterns that more closely match a different and broad set of important applications, and to give incentive to computer system designers to invest in capabilities that will have impact on the collective performance of these applications.

HPCG is a complete, stand-alone code that measures the performance of basic operations in a unified code:

- Sparse matrix-vector multiplication.
- Vector updates.
- Global dot products.
- Local symmetric Gauss-Seidel smoother.
- Sparse triangular solve (as part of the Gauss-Seidel smoother).
- Driven by multigrid preconditioned conjugate gradient algorithm that exercises the key kernels on a nested set of coarse grids.
- Reference implementation is written in C++ with MPI and OpenMP support.



Top systems

Jun'24



June 2024 HPCG Results

Rank	Site	Computer	Cores	HPL Rmax (Pflop/s)	TOP500 Rank	HPCG (Pflop/s)	Fraction of Peak
1	RIKEN Center for Computational Science Japan	Supercomputer Fugaku — A64FX 48C 2.2GHz, Tofu interconnect D	7,630,848	442.01	4	16.00	3.0%
2	DOE/SC/Oak Ridge National Laboratory United States	Frontier — AMD Optimized 3rd Generation EPYC 64C 2GHz, Slingshot-11, AMD Instinct MI250X	8,699,904	1206.00	1	14.05	0.8%
3	DOE/SC/Argonne National Laboratory United States	Aurora — Xeon CPU Max 9470 52C 2.4GHz, Slingshot-11, Intel Data Center GPU Max	9,264,128	1012.00	2	5.613	0.3%
4	EuroHPC/CSC Finland	LUMI — AMD Optimized 3rd Generation EPYC 64C 2GHz, Slingshot-11, AMD Instinct MI250X	2,752,704	379.70	5	4.587	0.9%
5	Swiss National Supercomputing Centre (CSCS) Switzerland	Alps — NVIDIA Grace 72C 3.1GHz, Slingshot-11, NVIDIA GH200 Superchip	1,305,600	270.00	6	3.671	1.0%
6	EuroHPC/CINECA Italy	Leonardo — Xeon Platinum 8358 32C 2.6GHz, Quad-rail NVIDIA HDR100 Infiniband, NVIDIA A100 SXM4 64 GB	1,824,768	241.20	7	3.114	1.0%
7	DOE/SC/Oak Ridge National Laboratory United States	Summit — IBM POWER9 22C 3.07GHz, Dual-rail Mellanox EDR Infiniband, NVIDIA Volta GV100	2,414,592	148.60	9	2.926	1.5%



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HPL-MXP MIXED-PRECISION BENCHMARK

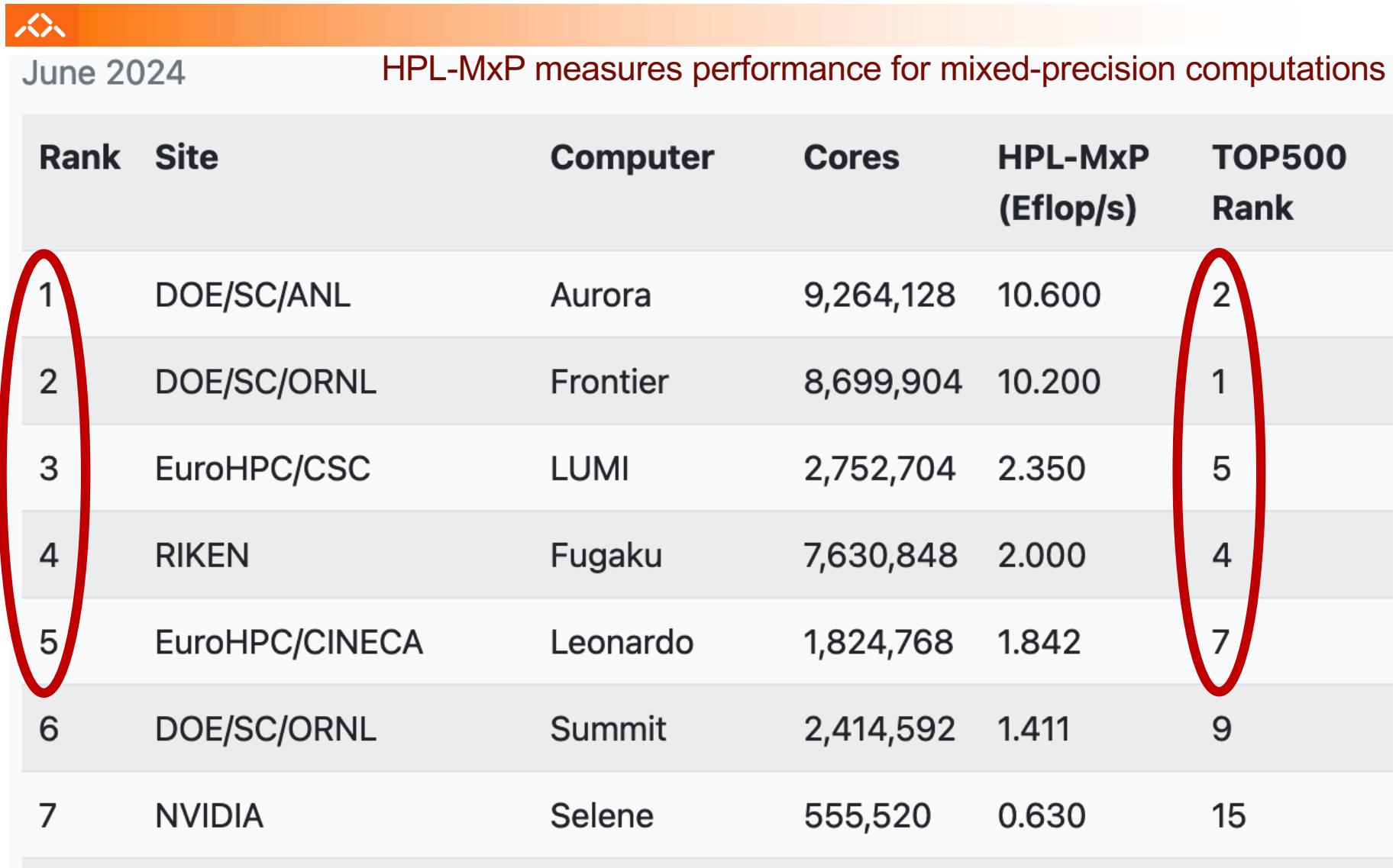
<https://hpl-mxp.org/>

The HPL-MxP benchmark seeks to highlight the emerging convergence of high-performance computing (HPC) and artificial intelligence (AI) workloads. While traditional HPC focused on simulation runs for modeling phenomena in physics, chemistry, biology, and so on, the mathematical models that drive these computations require, for the most part, 64-bit accuracy. On the other hand, the machine learning methods that fuel advances in AI achieve desired results at 32-bit and even lower floating-point precision formats. This lesser demand for accuracy fueled a resurgence of interest in new hardware platforms that deliver a mix of unprecedented performance levels and energy savings to achieve the classification and recognition fidelity afforded by higher-accuracy formats.

HPL-MxP strives to unite these two realms by delivering a blend of modern algorithms and contemporary hardware while simultaneously connecting to the solver formulation of the decades-old HPL framework of benchmarking the largest supercomputing installations in the world. The solver method of choice is a combination of LU factorization and iterative refinement performed afterwards to bring the solution back to 64-bit accuracy. The innovation of HPL-MxP lies in dropping the requirement of 64-bit computation throughout the entire solution process and instead opting for low-precision (likely 16-bit) accuracy for LU, and a sophisticated iteration to recover the accuracy lost in factorization. The iterative method guaranteed to be numerically stable is the generalized minimal residual method (GMRES), which uses application of the L and U factors to serve as a preconditioner. The combination of these algorithms is demonstrably sufficient for high accuracy and may be implemented in a way that takes advantage of the current and upcoming devices for accelerating AI workloads.

HPL-MxP

HPL-AI List
Jun'24



The screenshot shows a table of HPL-MxP results from June 2024. The table has columns for Rank, Site, Computer, Cores, HPL-MxP (Eflop/s), and TOP500 Rank. The data is as follows:

Rank	Site	Computer	Cores	HPL-MxP (Eflop/s)	TOP500 Rank
1	DOE/SC/ANL	Aurora	9,264,128	10.600	2
2	DOE/SC/ORNL	Frontier	8,699,904	10.200	1
3	EuroHPC/CSC	LUMI	2,752,704	2.350	5
4	RIKEN	Fugaku	7,630,848	2.000	4
5	EuroHPC/CINECA	Leonardo	1,824,768	1.842	7
6	DOE/SC/ORNL	Summit	2,414,592	1.411	9
7	NVIDIA	Selene	555,520	0.630	15

<https://hpl-mxp.org/results.md>

TOP500 Overview... and next?



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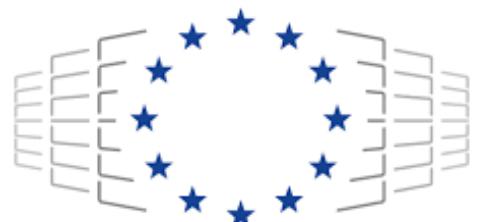
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European Supercomputing



EuroHPC
Joint Undertaking

European Supercomputing



EuroHPC
Joint Undertaking

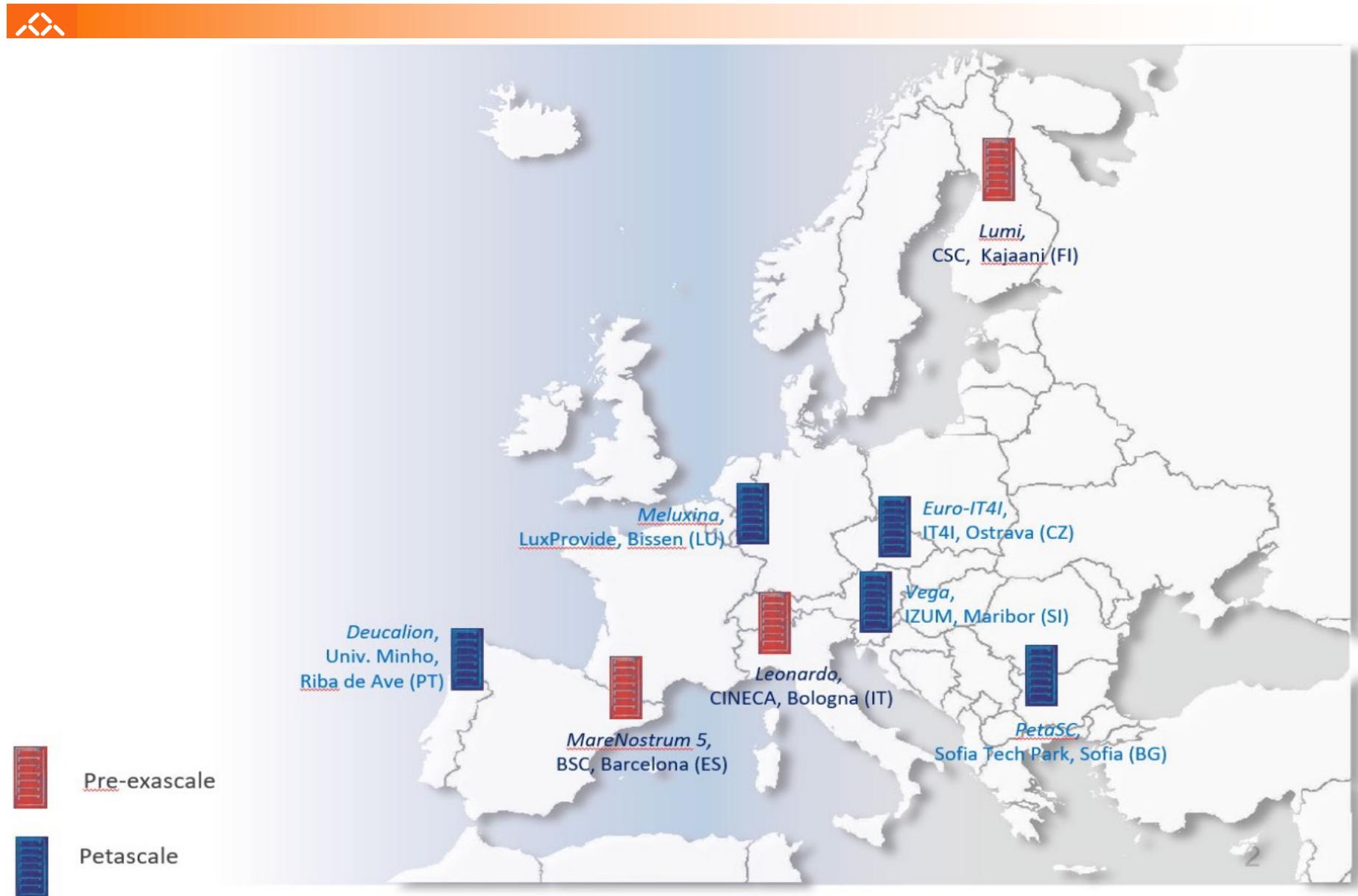


NOV 2024	TOP500	Green500
LUMI	#8	#25
LEONARDO	#9	#52
MARENOSTRUM 5	#11	#30
MELUXINA	#112	#60
KAROLINA	#165	#57
DISCOVERER	#223	#307
DEUCALION Pt	#259	#99
VEGA	#266	#332
JEDI (Jupiter's first module)	#224	#1
JETI (Jupiter's second module)	#18	#6



EuroHPC
Joint Undertaking

EuroHPC supercomputers: their locations





EuroHPC supercomputers: in Portugal

 PAGE CONTENTS

in TOP10

LUMI

LEONARDO

MARENOSTRUM 5

MELUXINA

KAROLINA

DISCOVERER

VEGA

DEUCALION

JUPITER

7.22 petaflops

10.00 petaflops

Sustained performance

Peak performance

Compute partitions:

ARM Partition: 1632 nodes, 3.8 PFLops ; x86 Partition: 500 nodes, 1,62 PFLops ; Accelerated: 33 nodes, 1,72 PFLops

Central Processing Unit (CPU):

A64FX (ARM partition), AMD EPYC (x86 partitions)

Graphics Processing Unit (GPU):

NVidia Ampere

Storage capacity:

430 TB High-speed NVMe partition, 10.6 PB high-speed based Parallel File System partition.

Applications:

Traditional Computational, AI, Big Data

DEUCALION

Deucalion is a petascale EuroHPC supercomputer located in Guimarães, Portugal. It is supplied by Fujitsu Technology Solutions combining a Fujitsu PRIMEHPC (ARM partition) and Atos Bull Sequana (x86 partitions). Deucalion is hosted by MACC [2].



FCT

AJProenca,
https://eurohpc-ju.europa.eu/supercomputers/our-supercomputers_en#deucalion



EuroHPC supercomputers: 1st exascale supercomputer

PAGE CONTENTS

- LUMI
- LEONARDO
- MARENOSTRUM 5
- MELUXINA
- KAROLINA
- DISCOVERER
- VEGA
- DEUCALION
- JUPITER

in TOP11

JUPITER

JUPITER [\[2\]](#) will be the first EuroHPC exascale supercomputer. The system will be located at the Forschungszentrum Jülich [\[2\]](#) campus in Germany and operated by the Jülich Supercomputing Centre [\[2\]](#). It will be based on Eviden's BullSequana XH3000 direct liquid cooled architecture.



JSC

1 Exaflop*

Sustained performance

Expected in May'25

Compute partitions:	Booster Module (highly-scalable GPU accelerated) ~6000 nodes Cluster Module (general-purpose, high memory bandwidth) ~1300 nodes
Central Processing Unit (CPU):	The Cluster Module will utilise the SiPearl Rhea1 processor (ARM, HBM), integrated into the BullSequana XH3000 platform.
Graphics Processing Unit (GPU):	The Booster Module will utilise NVIDIA technology, integrated into the BullSequana XH3000 platform.

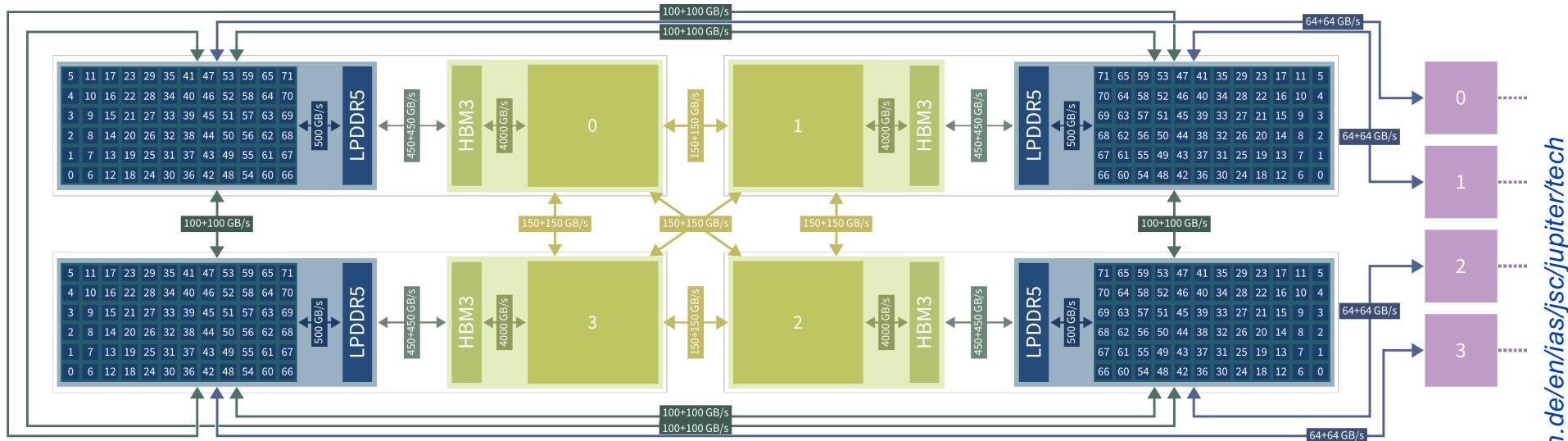
AJProenca,



EuroHPC supercomputers: JUPITER Technical Overview

Booster node w/ 4 NVIDIA Grace-Hopper superchips (GH200)

- Grace CPU w/ 72 Neoverse V2 cores, each SVE2-enabled with four 128 bit functional units
- Grace accesses 120 GB of LPDDR5X memory, with a bandwidth of 500 GB/s
- Hopper H100 GPU has 96 GB of HBM3 memory, accessible with 4 TB/s bandwidth



Cluster node w/ 2 European HPC processor Rhea, developed by SiPearl

- Rhea1 processors based on ARM Neoverse Zeus ISA, with SVE and HBM2e
- additional 512 GB or 1 TB of DDR5 main memory



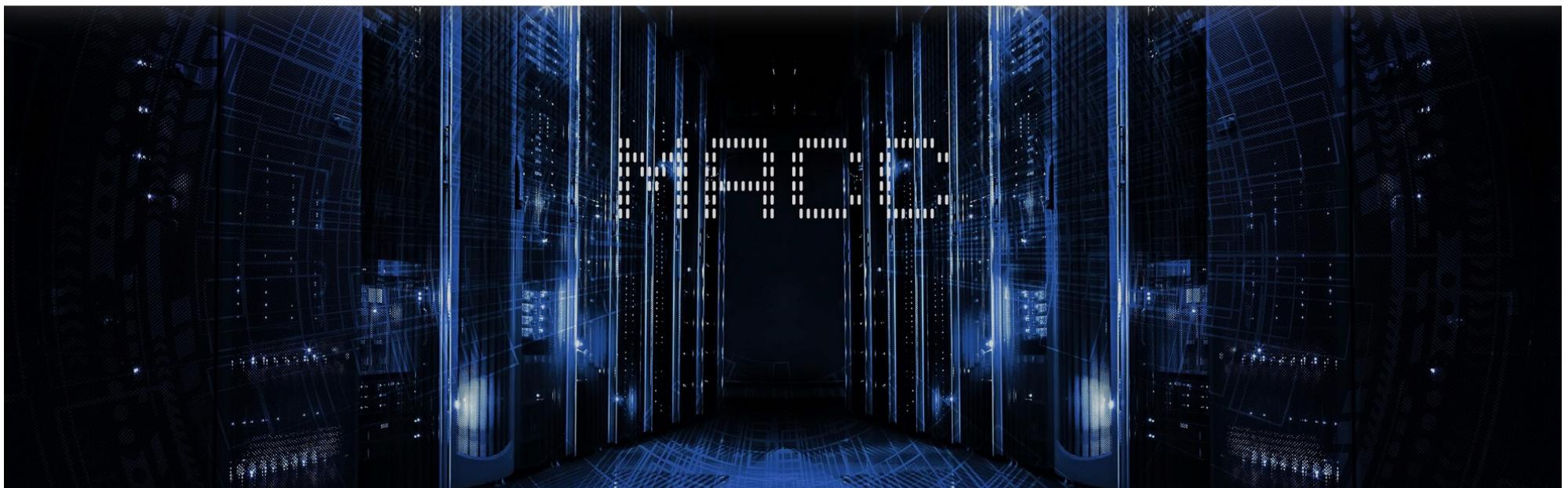
MACC

<https://macc.fccn.pt/>

MACC

Minho
Advanced
Computing
Center

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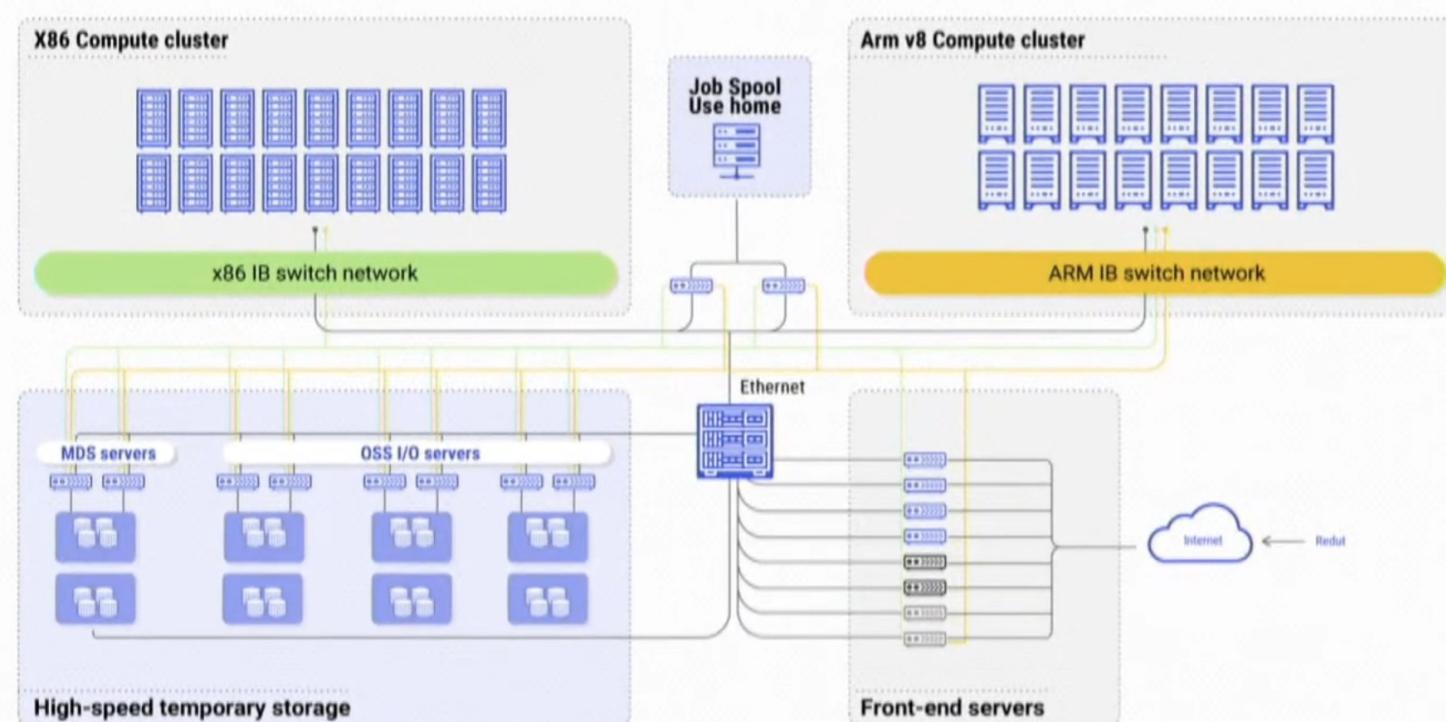
**Advancing knowledge
discovery for**

Minho Advanced
Computing Center is
empowering all partners to
discover, innovate, and

The Deucalion in MACC



DEUCALION OVERALL ARCHITECTURE



AMD X86 CLUSTER
EPYC Rome 7742 2.25GHz
500 DUAL NODES

64000 CORES

128TB RAM

NVIDIA A100 CLUSTER

33 DUAL + QUAD NODES

16 TB RAM + 5TB HBM

FUJITSU ARM CLUSTER
Fujitsu A64FX 2.0GHz
1632 NODES

78336 CORES

52TB HBM RAM

DDN HSS

10 PB SSD+HDD