

TOP500.ORG

NOVEMBER 2021



Mundo

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	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	555,520	63,460.0	79,215.0	2,646
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	4,981,760	61,444.5	100,678.7	18,482

8	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	449,280	44,120.0	70,980.0	1,764
9	HPC5 - PowerEdge C4140, Xeon Gold 6252 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
10	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	

Japão usa supercomputador mais potente do mundo para buscar cura para Covid

O supercomputador japonês Fugaku está sendo utilizado por pesquisadores em uma tentativa de identificar novos tratamentos para a covid-19. O projeto é liderado por uma equipe da Universidade de Tóquio, que vai usar a máquina para simular interações moleculares em massa.

Em comunicado, a Fujitsu, empresa que construiu o supercomputador juntamente com o instituto de pesquisa Reiken, afirmou que o objetivo é identificar compostos que possam ser usados no combate à infecção pelo coronavírus.

A Supercomputer Analyzed Covid-19 — and an Interesting New Theory Has Emerged

Earlier this summer, the Summit supercomputer at Oak Ridge National Lab in Tennessee set about crunching data on more than 40,000 genes from 17,000 genetic samples in an effort to better understand Covid-19. Summit is the second-fastest computer in the world, but the process — which involved analyzing 2.5 billion genetic combinations — still took more than a week.



RIKEN Center for Computational Science

Fugaku Supercomputer



Number of Nodes

Number of Nodes

158,976 nodes
 $384 \text{ nodes} \times 396 \text{ racks} = 152,064$
 $192 \text{ nodes} \times 36 \text{ racks} = 6,912$

Peak Performance

Peak Performance

Normal Mode:
2.0 GHz

- Double Precision (64 bit) 488 Petaflops
- Single Precision (32 bit) 977 Petaflops
- Half Precision (16 bit) 1.95 Exaflops
- Integer (8 bit) 3.90 Exa Exaops

Boost Mode:
2.2 GHz

- Double Precision (64 bit) 537 Petaflops
- Single Precision (32 bit) 1.07 Exaflops
- Half Precision (16 bit) 2.15 Exaflops
- Integer (8 bit) 4.30 Exaops

Total Memory

4.85 PIB

Total Memory Bandwidth

163 PB/s

Node

Architecture		Armv8.2-A SVE 512bit With the following Fujitsu's extensions: Hardware barrier, Sector cache, and Prefetch
Core		48 cores for compute and 2 or 4 cores for OS activities 4 CMGs (NUMA nodes)
Performance	Normal Mode: 2.0 GHz	DP: 3.072 TF, SP: 6.144 TF, HP: 12.288 TF
	Boost Mode: 2.2 GHz	DP: 3.3792 TF, SP: 6.7584 TF, HP: 13.5168 TF
Cache ^{*1 *2}		L1D/core: 64 KiB, 4way, 256 GB/s (load), 128 GB/s (store)
		L2/CMG: 8 MiB, 16way L2/node: 4 TB/s (load), 2 TB/s (store) L2/core: 128 GB/s (load), 64 GB/s (store)
Memory		HBM2 32 GiB, 1024 GB/s
Interconnect		Tofu Interconnect D (28 Gbps x 2 lane x 10 port)
I/O		PCIe Gen3 x16
Technology		7nm FinFET

*1 Performance at 2 GHz

*2 For more information, please refer to <https://github.com/fujitsu/A64FX> .

Programming Language and Library

Compiler	Fortran2008 & Fortran2018 subset
	C11 & GNU and Clang extensions
	C++14 & C++17 subset and GNU and Clang extensions
	OpenMP 4.5 & OpenMP 5.0 subset
	Java
Parallel Programming	XcalableMP
	FDPS
Script Language	Python + Numpy + Scipy, Ruby
Math Library	BLAS, LAPACK, ScaLAPACK
	SSL II (Fujitsu)
	EigenExa, Kevd, Batched BLAS, 2.5D-PDGEMM

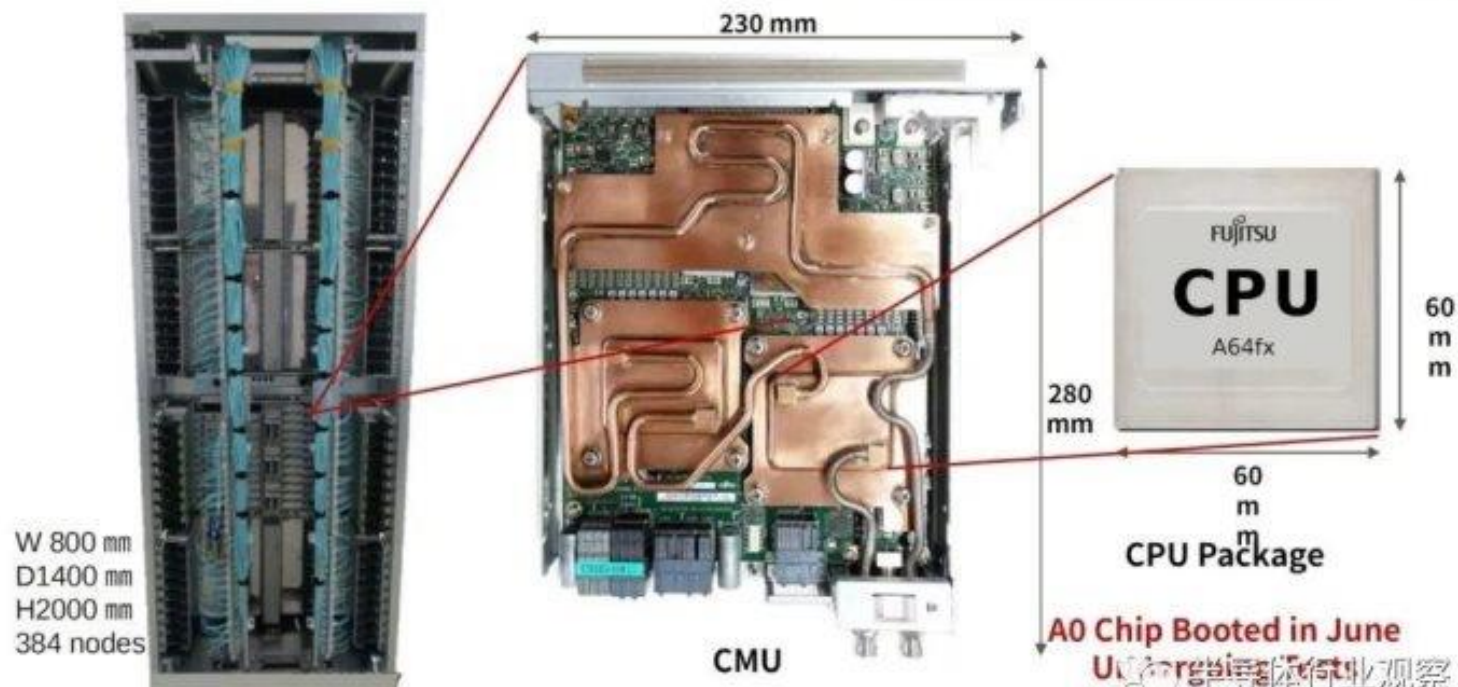
System Software

OS	Red Hat Enterprise Linux 8
	McKernel
MPI	Fujitsu MPI (Based on OpenMPI), RIKEN-MPICH (Based on MPICH)
File IO	LLIO
	<i>Application-oriented file IO libraries</i>



Fugaku Chassis, PCB (w/DLC), and CPU Package

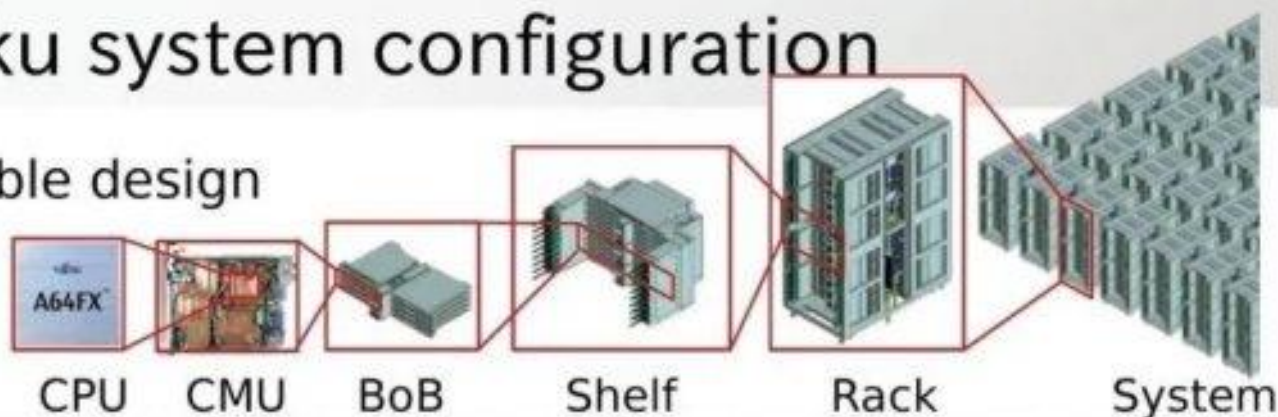
FUJITSU



Fugaku system configuration

FUJITSU

■ Scalable design



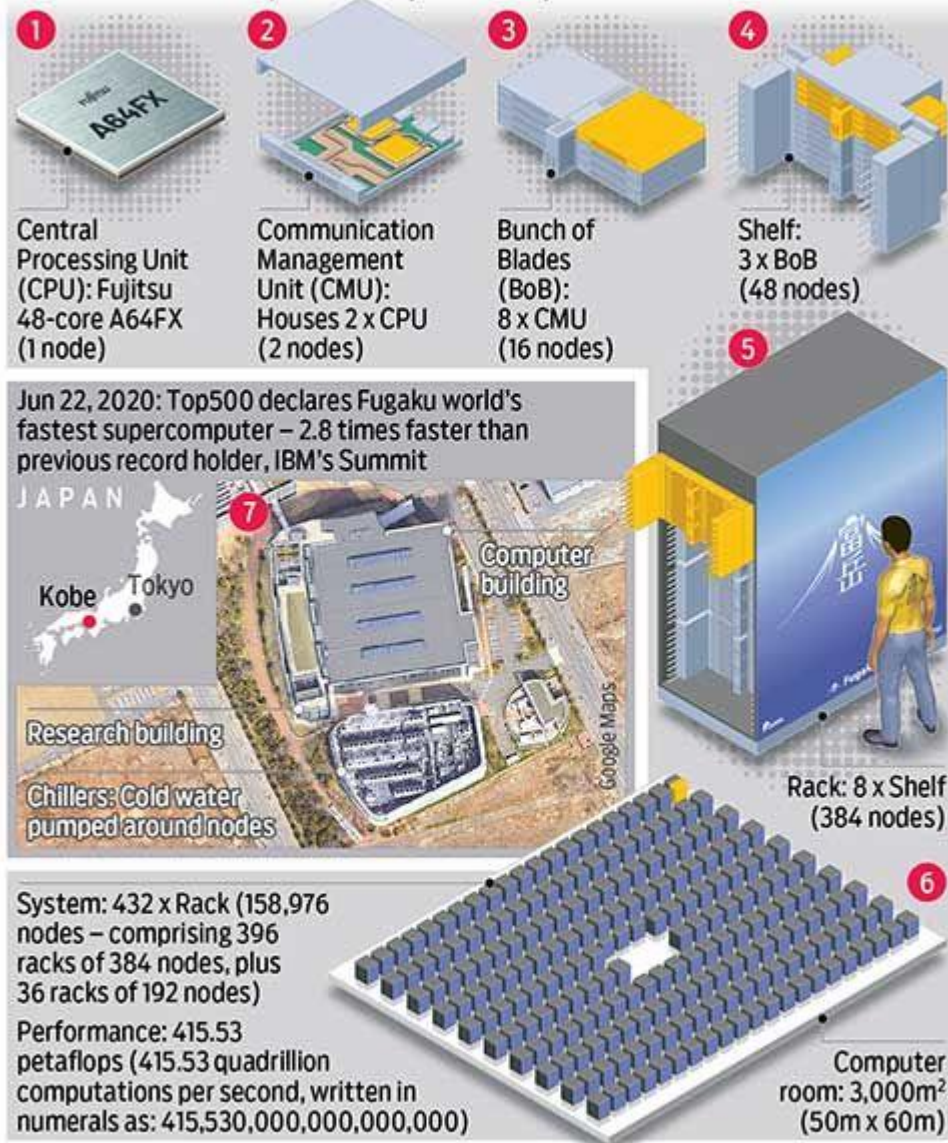
Unit	# of nodes	Description
CPU	1	Single socket node with HBM2 & Tofu interconnect D
CMU	2	CPU Memory Unit: 2x CPU
BoB	16	Bunch of Blades: 8x CMU
Shelf	48	3x BoB
Rack	384	8x Shelf
System	150k+	As a Fugaku system

半导体行业观察

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Supercomputer to seek Covid-19 cure

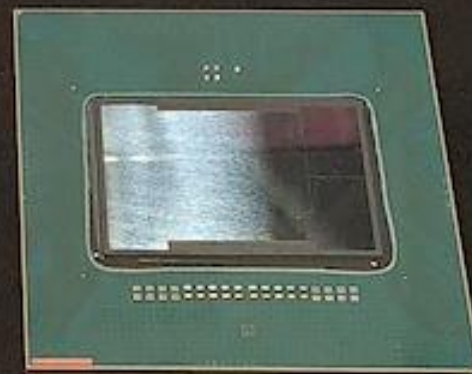
The world's fastest supercomputer, Japan's \$1.2 billion Fugaku, is to use its enormous power to try to identify treatments for Covid-19



Despite being unfinished, Fugaku is already studying how respiratory droplets travel inside trains with open carriage windows. When completed in 2021, it will try to identify potential drug treatments for Covid-19

Sources: Top500, BBC, The Guardian, RIKEN Center for Computational Science

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A64FX Chip Overview

■ Architecture Features

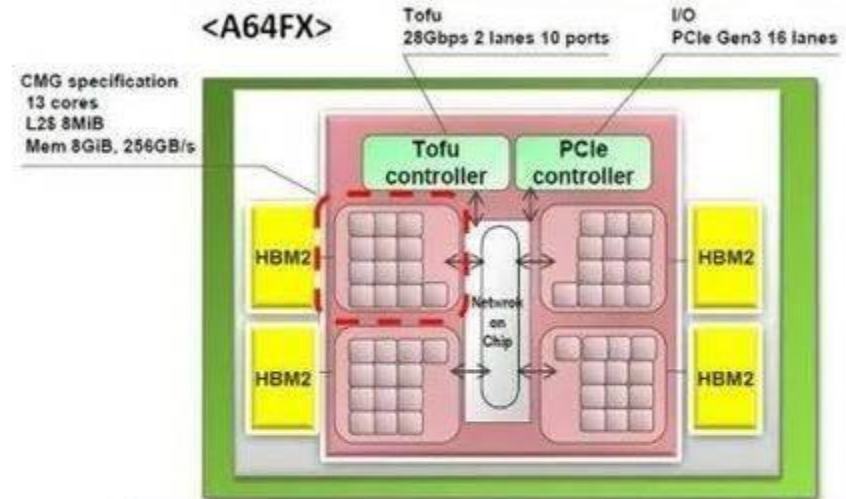
- Armv8.2-A (AArch64 only)
- SVE 512-bit wide SIMD
- 48 computing cores + 4 assistant cores*
*All the cores are identical
- HBM2 32GiB
- Tofu 6D Mesh/Torus 28Gbps x 2 lanes x 10 ports
- PCIe Gen3 16 lanes

■ 7nm FinFET

- 8,786M transistors
- 594 package signal pins

■ Peak Performance (Efficiency)

- >2.7TFLOPS (>90%@DGEMM)
- Memory B/W 1024GB/s (>80%@Stream Triad)

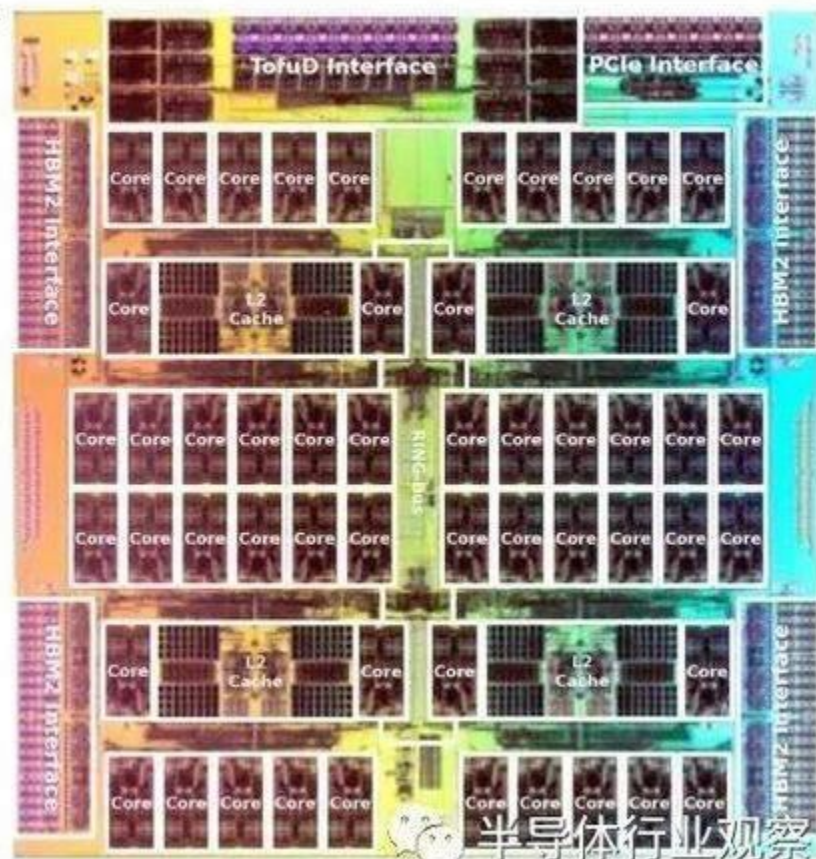
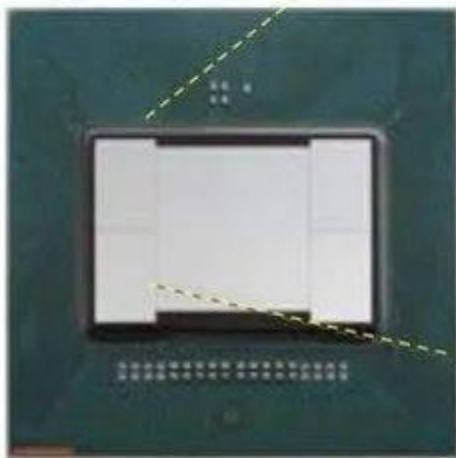


	A64FX (Post-K)	SPARC64 Xlfx (PRIMEHPC FX100)
ISA (Base)	Armv8.2-A	SPARC-V9
ISA (Extension)	SVE	HPC-ACE2
Process Node	7nm	20nm
Peak Performance	>2.7TFLOPS	1.1TFLOPS
SIMD	512-bit	256-bit
# of Cores	48+4	32+2
Memory	HBM2	240GB/s x2 (in/out)
Memory Peak B/W	1024GB/s	240GB/s x2 (in/out)

A64FX Leading-edge Si-technology

■ TSMC 7nm FinFET & CoWoS

- Broadcom SerDes, HBM I/O, and S RAMs
- 8.786 billion transistors
- 594 signal pins



半导体行业观察

FUJITSU Supercomputer PRIMEHPC FX700 Specifications



	CPU	Name	A64FX™
		Instruction set architecture	Armv8.2-A SVE
		Number of cores	48 cores
		Clock	1.8 GHz or 2.0 GHz
		Theoretical peak performance	2.7648 TFLOPS or 3.072 TFLOPS (double precision)
	Node	Architecture	1 CPU/node
		Memory capacity	32 GiB (HBM2, 4 stacks)
		Memory bandwidth	1,024 GB/s
		Interconnect	InfiniBand EDR
	Main unit	Form factor	2U rack-mount chassis
		Maximum number of nodes	8 nodes/chassis
		Cooling method	Air cooling
	Software	OS	Red Hat Enterprise Linux 8
		HPC middleware	FUJITSU Software Compiler Package (Fujitsu) OpenHPC (open source software) Bright Cluster Manager (Bright Computing)



Oak Ridge National Laboratory

The birthplace of the Manhattan Project — is also home to Titan, another supercomputer that was once the fastest in the world and now holds the title for fifth fastest (soon to be sixth after Summit is officially recognized as the fastest in the world by Top500) supercomputer in the world



Summit

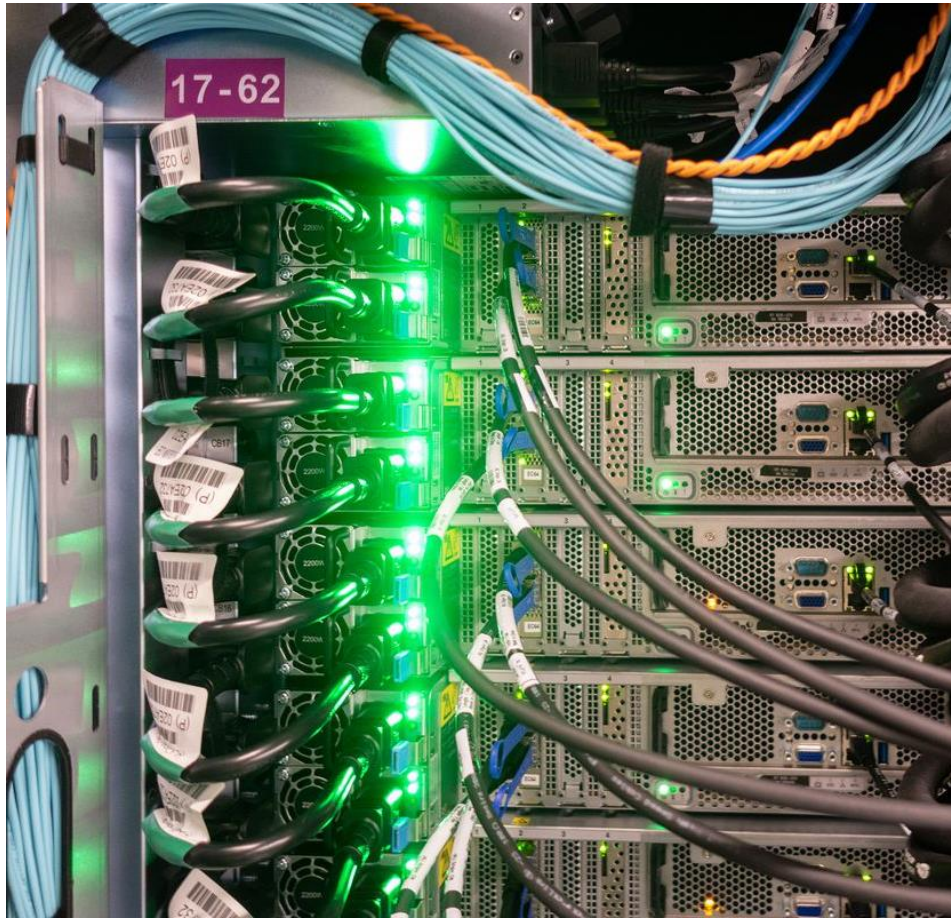


Summit



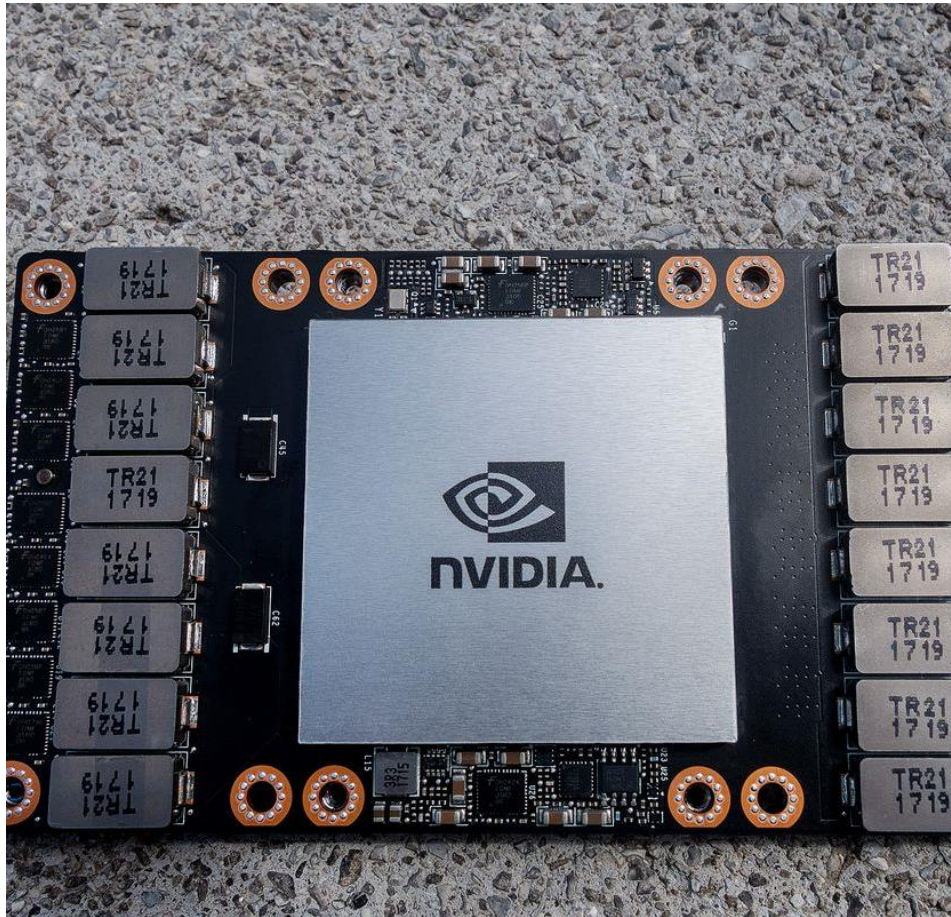
- The system is connected by 185 miles of fiber-optic cables and can store 250 petabytes of data, which is equal to 74 years of HD video.

Summit



- To keep Summit from overheating, more than 4,000 gallons of water are pumped through the system every minute, carrying away nearly 13 megawatts of heat from the system.

Summit



- contains 9,216 IBM Power9 CPUs and 27,648 Nvidia Volta GPUs

Summit

Brasil

Rank	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)
55	Dragão - Supermicro SYS-4029GP-TVRT, Xeon Gold 6230R 26C 2.1GHz, NVIDIA Tesla V100, Infiniband EDR, Atos Petróleo Brasileiro S.A Brazil	188,224	8,983.0	14,006.5	943
107	Atlas - Bull 4029GP-TVRT, Xeon Gold 6240 18C 2.6GHz, NVIDIA Tesla V100, Infiniband EDR, Atos Petróleo Brasileiro S.A Brazil	91,936	4,376.0	8,848.5	547
125	IARA - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100 SXM4 40 GB, Infiniband, Nvidia SiDi Brazil	24,800	3,657.0	4,130.4	
146	Fênix - Bull 4029GP-TVRT, Xeon Gold 5122 4C 3.6GHz, NVIDIA Tesla V100, Infiniband EDR, Atos Petróleo Brasileiro S.A Brazil	60,480	3,161.0	5,371.8	390
388	Santos Dumont (SDumont) - Bull Sequana X1000, Xeon Gold 6252 24C 2.1GHz, Mellanox InfiniBand EDR, NVIDIA Tesla V100 SXM2, Atos Laboratório Nacional de Computação Científica Brazil	33,856	1,849.0	2,727.0	



Atlas

- Número de servidores: 136
- Acelerador Matemático (GPU): Nvidia V100/32GB/SXM2
- Aceleradores por servidor: 8
- Processador: Intel Xeon Gold 6240
- Processadores por servidor: 2
- Núcleos por processador: 18
- Velocidade: 2.6GHz
- Memória por servidor: 768GB
- Rede interna: InfiniBand EDR 100gbps
- Sistema operacional: CentOS 7.7
- Desempenho teórico: 8,0 PFLOPS Rpeak DP
- Desempenho medido: 4,4 PFLOPS Rmax (ou 4.376 TFLOPS Rmax)
- Consumo (na capacidade máxima): 546KW

Fênix

- Número de servidores: 360
- Acelerador Matemático (GPU): Nvidia V100/32GB
- Aceleradores por servidor: 2
- Processador: Intel Xeon Gold 5122
- Processadores por servidor: 2
- Núcleos por processador: 4
- Velocidade: 3.6GHz
- Memória por servidor: 192GB
- Rede interna: InfiniBand EDR 100gbps
- Sistema operacional: CentOS 7.6
- Desempenho teórico: 5.372 TFLOPS Rpeak DP (ou 5,4 PFLOPS Rpeak DP)
- Desempenho medido: 3.161 TFLOPS Rmax (ou 3,2 PFLOPS Rmax)
- Consumo (na capacidade máxima): 390KW

Supercomputador Santos Dumont, do Laboratório Nacional de Computação Científica (LNCC), em Petrópolis





Supercomputador
Santos Dumont

MINISTÉRIO DA
CIÊNCIA, TECNOLOGIA,
INOVAÇÕES E COMUNICAÇÕES



PÁTRIA AMADA
BRASIL
GOVERNAR É SERVIR

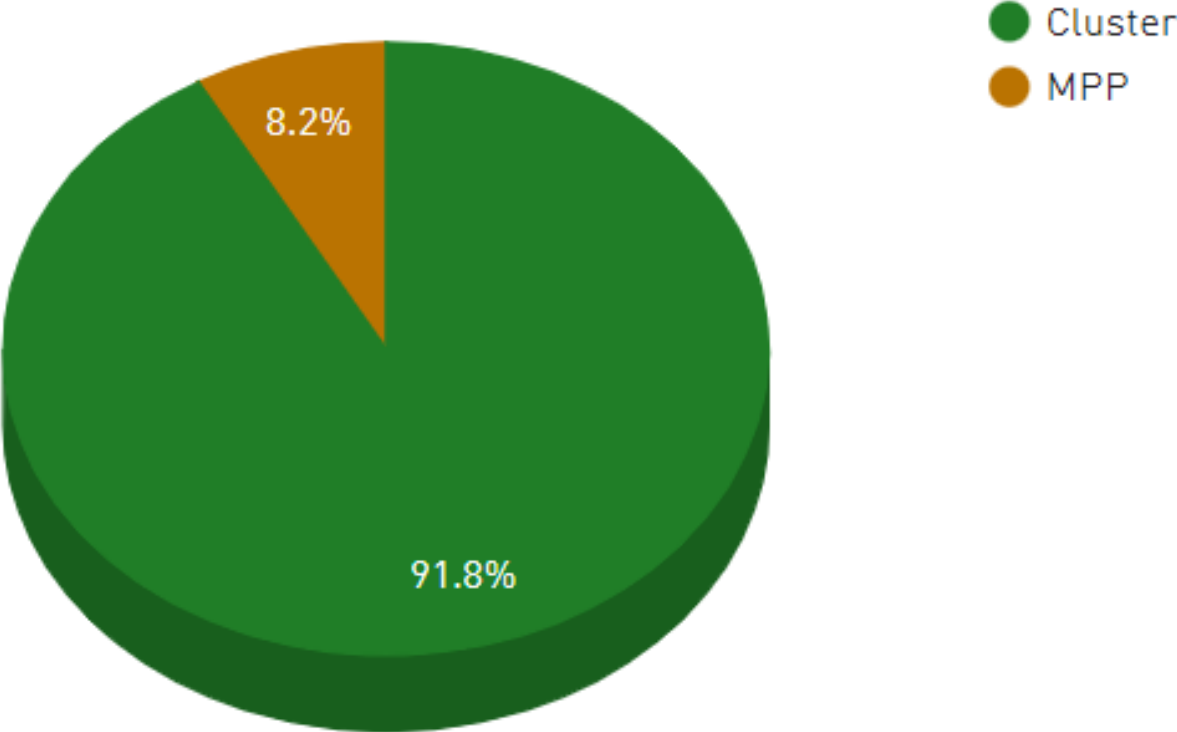
Atos

Supercomputador Santos Dumont

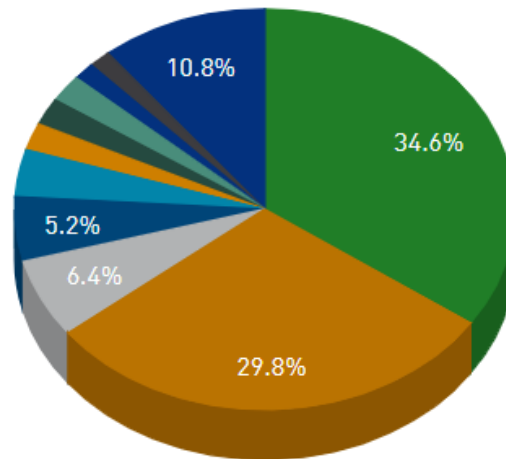
- O investimento foi de R\$ 60 milhões.
- O custo mensal de energia para o funcionamento da máquina é de aproximadamente R\$ 500 mil, cerca de R\$ 6 milhões / ano.
- Os equipamentos de apoio consomem mais R\$ 2 milhões / ano.



Architecture System Share

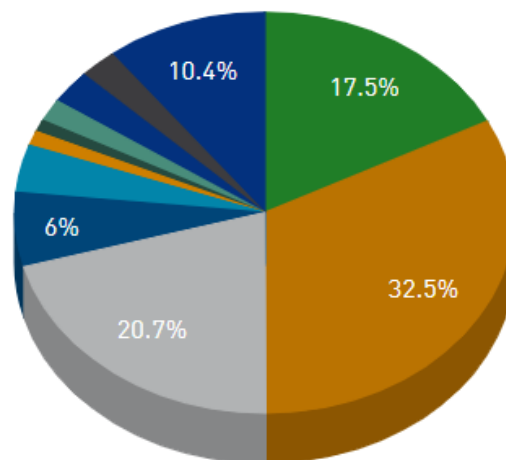


Countries System Share



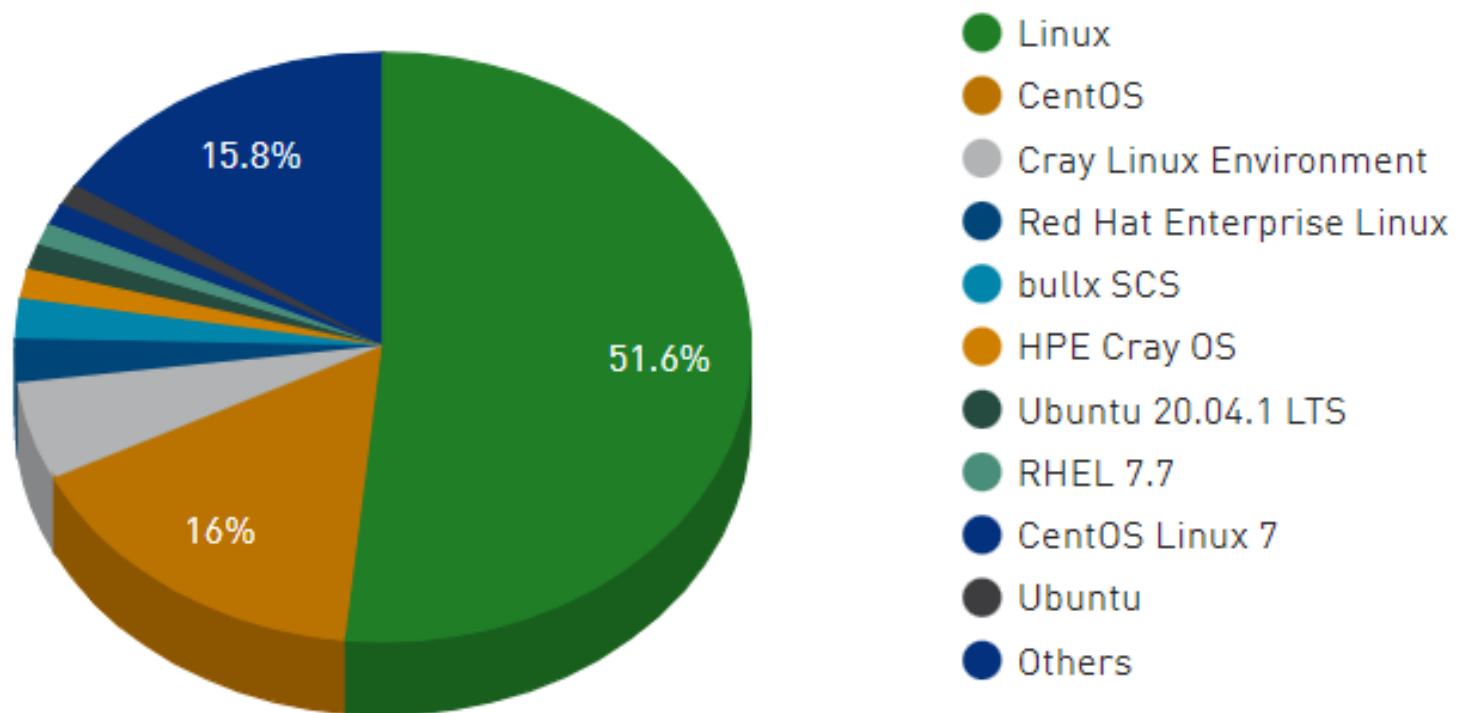
- China
- United States
- Japan
- Germany
- France
- Netherlands
- Canada
- United Kingdom
- South Korea
- Russia
- Others

Countries Performance Share



- China
- United States
- Japan
- Germany
- France
- Netherlands
- Canada
- United Kingdom
- South Korea
- Russia
- Others

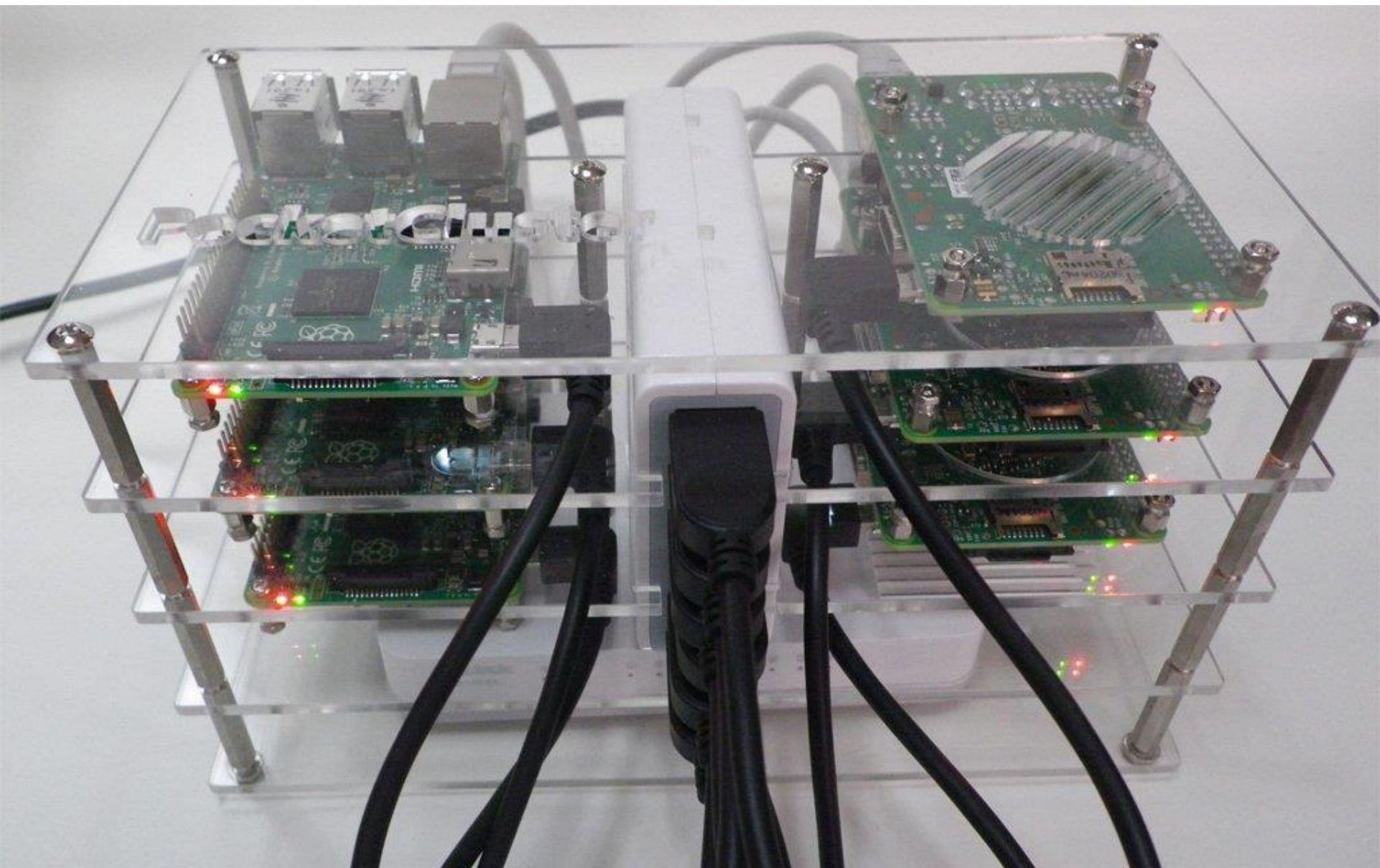
Operating System System Share













Cluster Playstation



Playstation 2



Playstation 2

- National Center for Supercomputing Applications - NCSA (Estados Unidos)
- 70 PlayStation
- custo total de US\$50.000,00
- capaz de executar meio trilhão de operações por segundo



Playstation 3



POR DENTRO DO PLAYSTATION 3



processamento

Chip: Cell 3.2 GHz, projetado por Sony, IBM e Toshiba. Tem um núcleo e oito processadores. Pode realizar até 2 trilhões de cálculos por segundo.

Memória RAM: 512 MB (256 MB dedicados)

Poder de processamento: 2 TFLOPS* (o computador mais rápido do mundo atinge 280,6 TFLOPS. Uma calculadora comum consegue 10 FLOPS).

armazenamento

Discos rígidos de 20, 60 e 80 GB, dependendo da versão. Conexão via SATA.

Mídia: Blu-ray 25GB (50GB em dupla camada), capaz de rodar jogos e filmes. Também aceita CD e DVD. O disco rígido pode ser preparado para a instalação de sistemas operacionais, como o Linux.

conexões de vídeo

Entradas para HDMI, portas analógicas e digitais

Resoluções: 480i, 480p, 720p, 1080i, 1080p

entradas

Bluetooth, Wireless, USB, Ethernet

*FLOPS: "Operações de ponto flutuante por segundo", medida usada para determinar o desempenho de computadores em cálculos científicos.



US Defense Department Condor Cluster

- 1.760 consoles foram unidos sob o comando de 168 unidades de processamento gráfico e 84 servidores coordenadores
- 33.º maior computador do mundo, em 2010
- custo total foi de US\$ 2 milhões



Unicamp

- 12 PlayStation 3 ligados em rede
- Sistema Operacional Linux
- cluster de processamento, ajudando a pesquisadora argentina Monica Pickholz nos cálculos de bioinformática desde junho de 2007