中国科学院国家天文台
National Astronomical Observatories, CAS

千人計劃
RECRUITMENT
PROGRAM OF GLOBAL EXPERTS

UNIVERSITÄT
HEIDELBERG
Zukunft. Seit 1386.

Introduction to GPU Accelerated Computing: 1. History of Computer Architecture Many-Core, GPU, and other ideas...

University

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Astronomisches Rechen-Inst., ZAH, Univ. of Heidelberg, Germany
National Astronomical Observatories (NAOC), Chinese Academy of Sciences
Kavli Institute for Astronomy and Astrophysics (KIAA), Peking University

spurzem@ari.uni-heidelberg.de
http://silkroad.bao.ac.cn

the SILK ROAD PROJECT at NAOC/KIAA
丝绸之路 计划

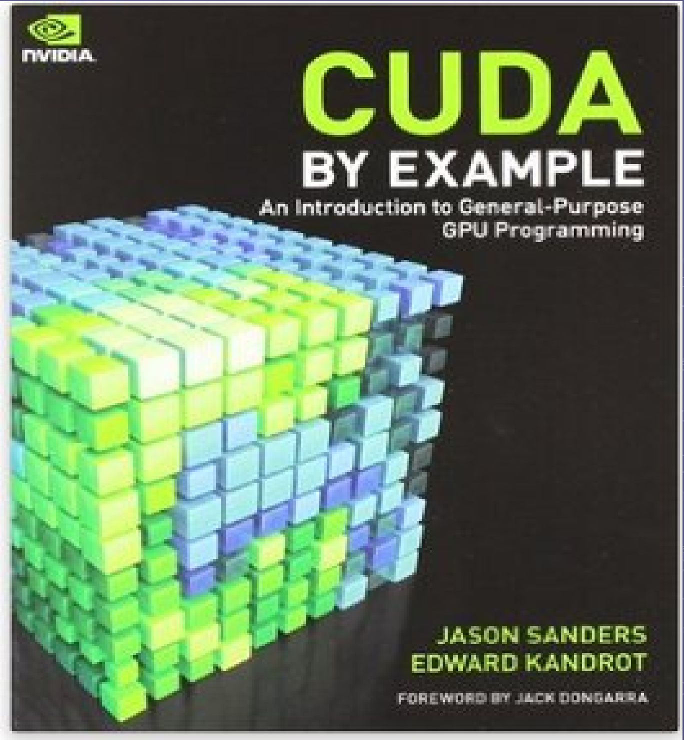
北京大学
PEKING UNIVERS

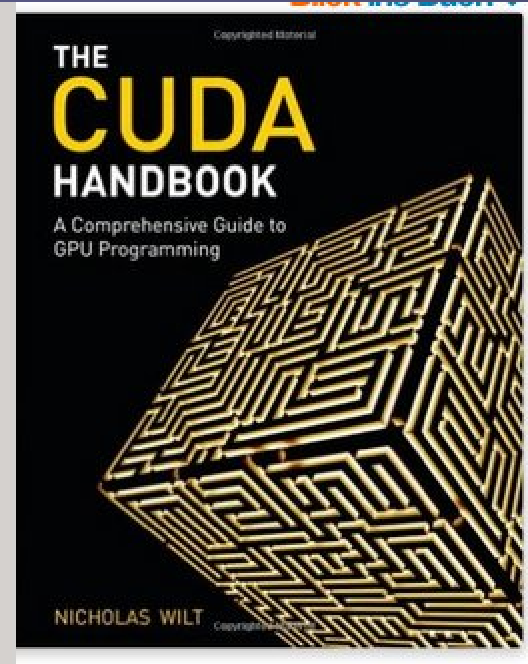
Introduction to GPU Accelerated Computing
February 10 – 13, 2020

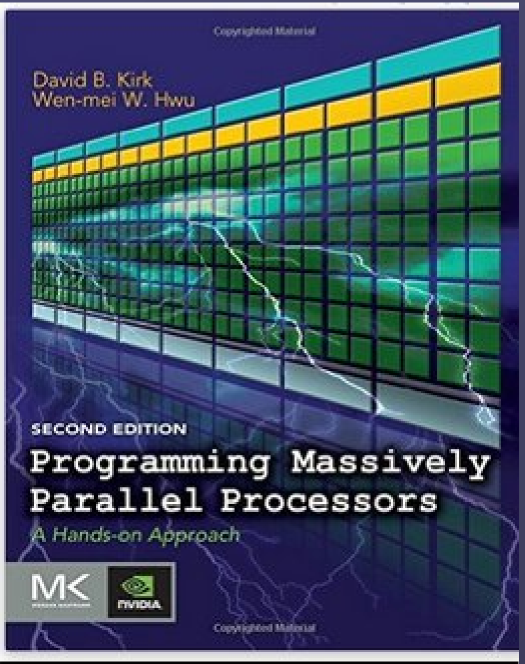
Table of Contents (subject to adjustment/change):

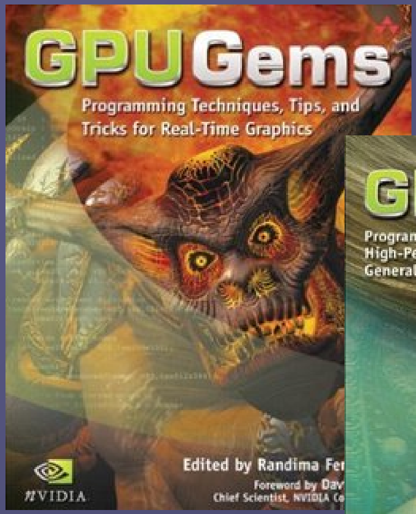
Send **id_rsa.pub** to **spurzem@ari.uni-heidelberg.de**

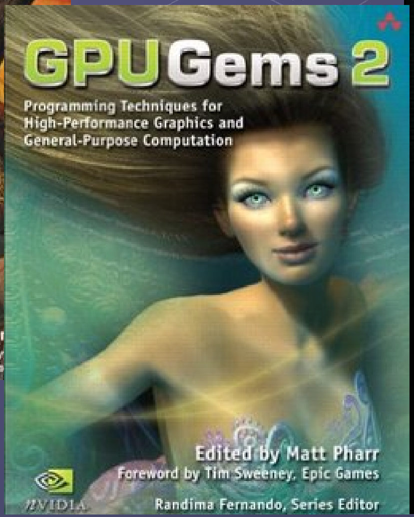
Literature

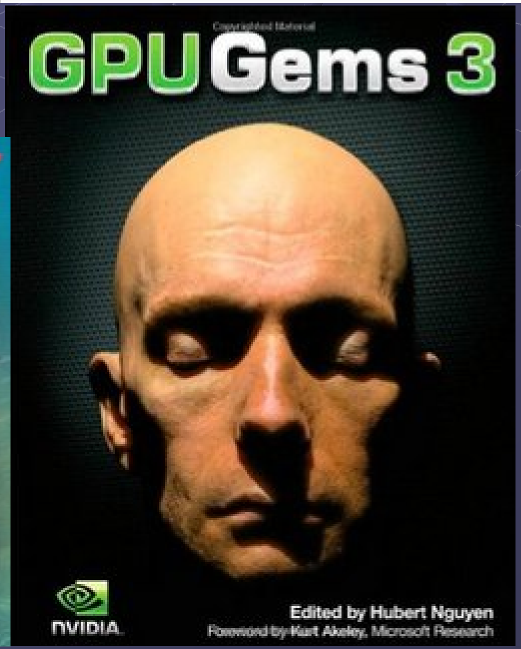

NVIDIA
CUDA
BY EXAMPLE
An Introduction to General-Purpose GPU Programming
JASON SANDERS
EDWARD KANDROT
FOREWORD BY JACK DONGARRA

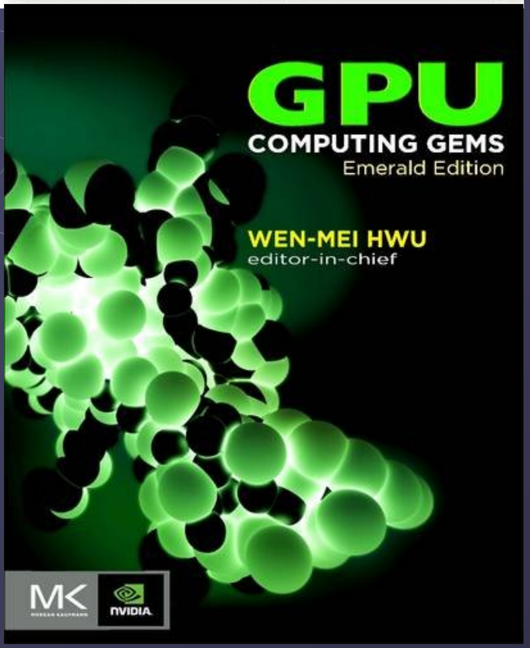

THE CUDA HANDBOOK
A Comprehensive Guide to GPU Programming
NICHOLAS WILT


David B. Kirk
Wen-mei W. Hwu
SECOND EDITION
Programming Massively Parallel Processors
A Hands-on Approach
MK
NVIDIA


GPU Gems
Programming Techniques, Tips, and Tricks for Real-Time Graphics
NVIDIA


GPU Gems 2
Programming Techniques for High-Performance Graphics and General-Purpose Computation
Edited by Matt Pharr
Foreword by Tim Sweeney, Epic Games
NVIDIA
Randima Fernando, Series Editor


GPU Gems 3
NVIDIA
Edited by Hubert Nguyen
Foreword by Kurt Akeley, Microsoft Research


GPU
COMPUTING GEMS
Emerald Edition
WEN-MEI HWU
editor-in-chief
MK
NVIDIA

Observations (Experiment)

Theory

Computational Physics

GPU Computing

History

History

Erik Holmberg (1908-2000)

Dissertation Univ. Lund (Schweden) (1937):

``A study of double and multiple galaxies´´

Galaxies often in Groups and Pairs

Irregular Distribution of Satellite Galaxies
(Holmberg-Effect)

Father of numerical astrophysics?

» **...with 200 light bulbs**

History

http://cdsads.u-strasbg.fr/abs/1941ApJ....94..385H

The Astrophysical Journal, Nov. 1941

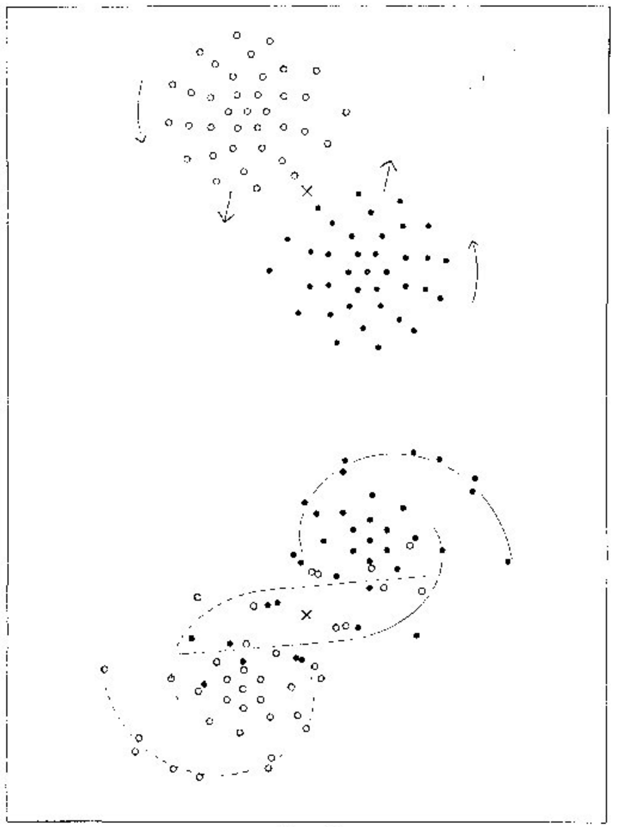


FIG. 4b

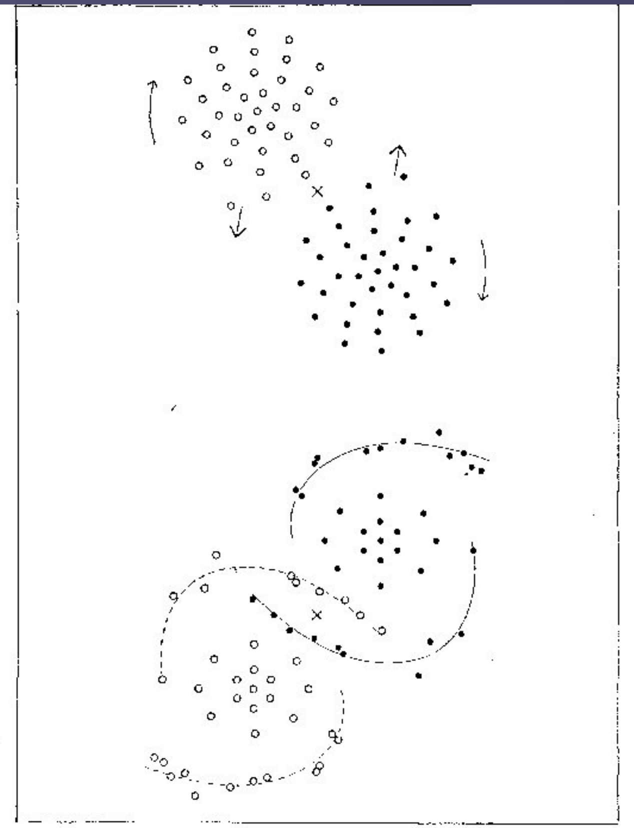


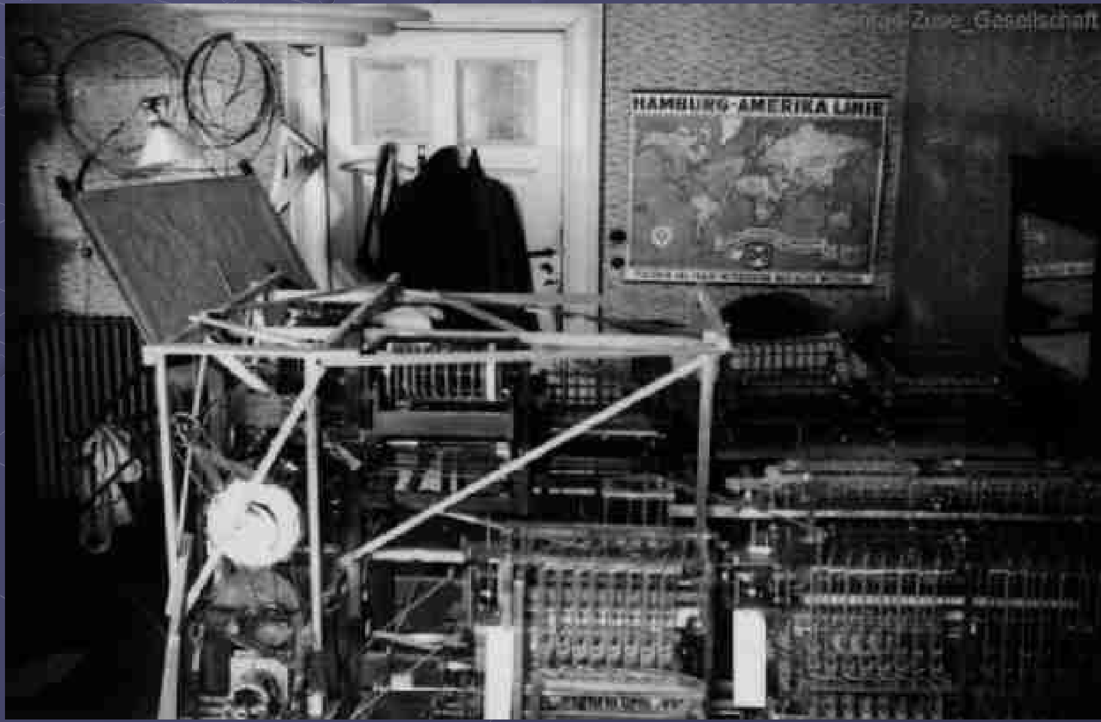
FIG. 4a

HARDWARE

...before von Neumann...

- Konrad Zuse (1910-1995) Berlin

Invented freely programmable Computer



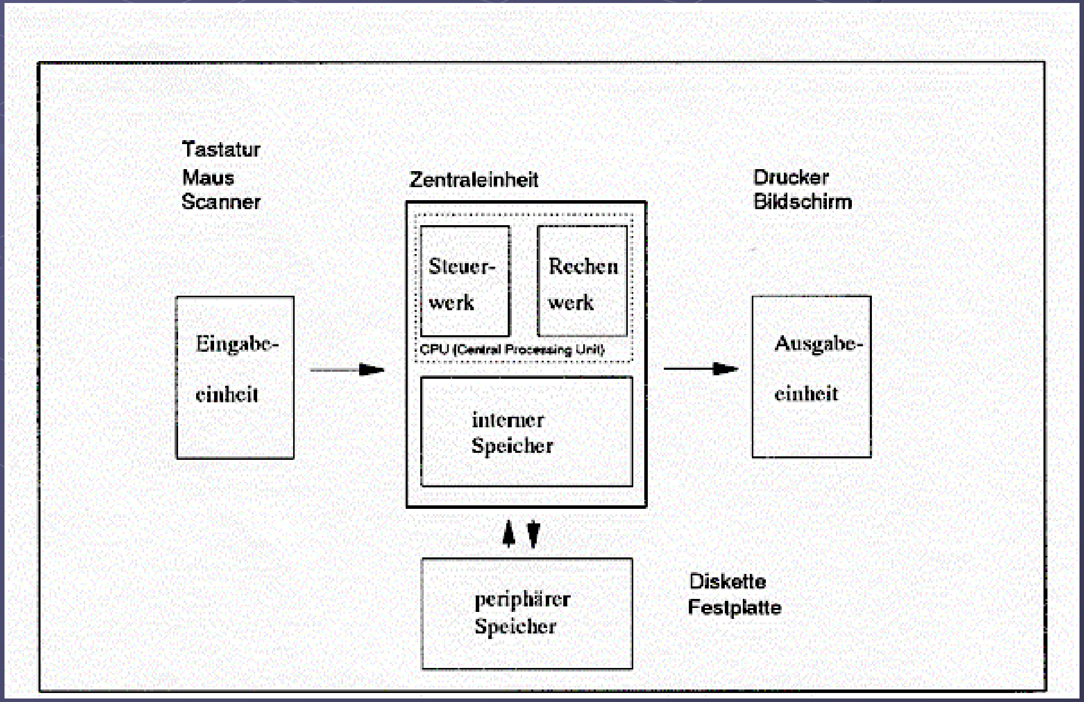
Z1 in parental flat 1936

HARDWARE

- John von Neumann (1903-1957)

Born Budapest, Lecturer Berlin, since 1930 Princeton Univ.

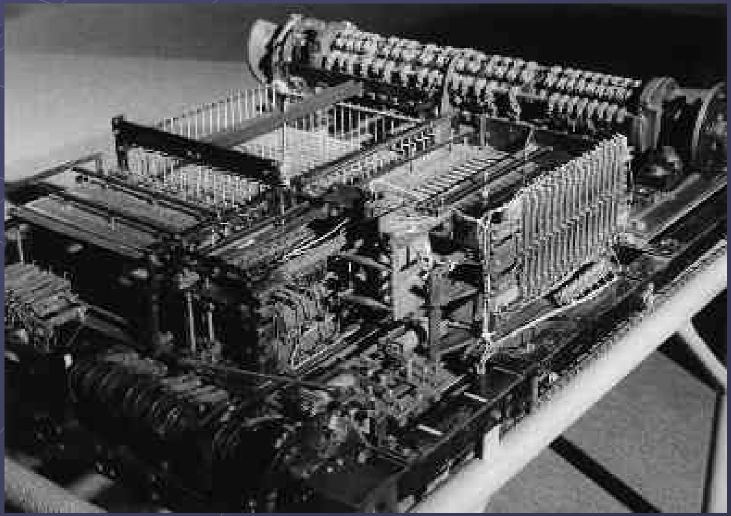
Requirements for the Construction of an electronic computing device(1946)



History

Zuse Z4: 1944 Berlin, 1950 Zürich, 1954 Frankreich

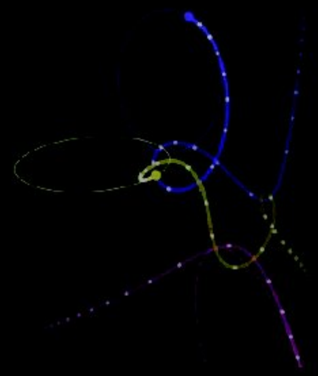
1959 Deutsches Museum München



Computing Speed 0.03 MHz

Memory 256 byte

Astronomisches Rechen-Institut (ARI) at Univ. of Heidelberg, Germany



Siemens 2002 Computer in 1964 At ARI

History

http://cdsads.u-strasbg.fr/abs/1960ZA.....50..184V

Astronomisches Rechen-Institut in Heidelberg
Mitteilungen Serie A Nr. 14

Die numerische Integration des *n*-Körper-Problemes für Sternhaufen I

Von

SEBASTIAN VON HOERNER

Mit 3 Textabbildungen

(Eingegangen am 10. Mai 1960)

Tabelle 5. *Zahl der gegenseitigen Umläufe, Häufigkeit des Auftretens und kleinster gegenseitiger Abstand D_m der engsten Paare.* (Alle engsten Paare mit mehr als zwei vollen Umläufen wurden notiert)

Umläufe	Häufigkeit	D_m
2—3	11	0.0102
3—5	9	0.0177
5—10	5	0.0070
10—20	2	0,0141
20—50	1	0.0007
50—100	1	0.0035
100—200	1	0.0039

Astronomisches Rechen-Institut in Heidelberg
Mitteilungen Serie A Nr. 19

Die numerische Integration des *n*-Körper-Problems für Sternhaufen, II.

Von

SEBASTIAN VON HOERNER

Mit 10 Textabbildungen

(Eingegangen am 19. November 1962)

http://cdsads.u-strasbg.fr/abs/1963ZA.....57...47V

S.v. Hoerner,
Z.f.Astroph. 1960, 63

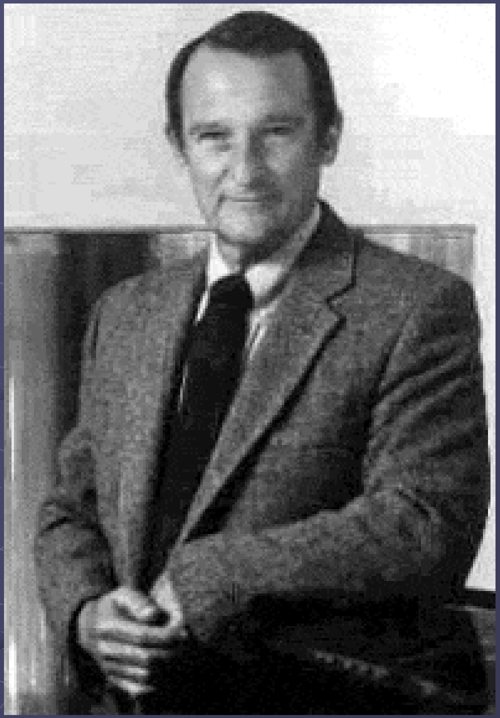
Siemens 2002
N=4,8,12,16 (4 Trx)

N=16,25 (40 Trx)

History

- Seymour Cray (1925-1996)

“father of supercomputing”



CRAY1: Vectorregisters (1976)

160 Mflop, 80 MHz, 8 MByte RAM

CRAY2: (1984)

1Gflop, 120MHz, 2GByte RAM

History

Supercomputer JUGENE IBM Blue Gene At FZ Jülich, Germany

Opening Ceremony June 2008

Computational Science...

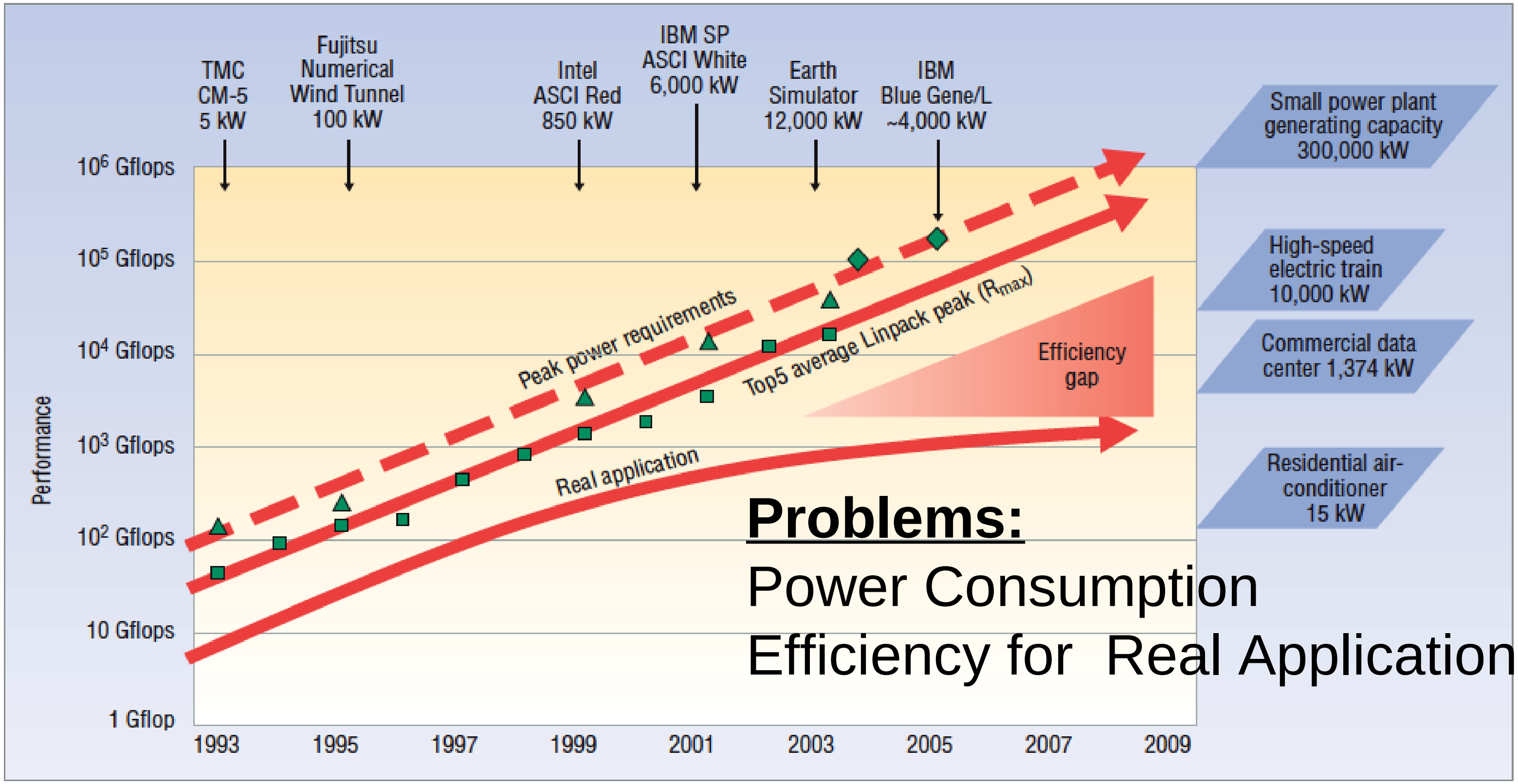
...after von Neumann...

Exaflop/s?

Petaflop/s

Teraflop/s

Gigaflop/s



Problems:

Power Consumption

Efficiency for Real Applications

Figure 1. Rising power requirements. Peak power consumption of the top supercomputers has steadily increased over the past 15 years.

Thanks to Horst Simon, LBNL/NERSC for this diagram.

GPU Computing

Special Hardware Accelerators

SPECIAL HARDWARE

CPUs
Central Processing Units

- General Purpose oriented
- 1-12 Cores
- Up to 4 pipes per core using Vector Units
- Fully Programmable, many languages available
- Very well studied
- Max. 125W per processor

GPUs
Graphic Processing Units

- Graphics oriented
- 16-512 Cores
- Massively Parallel Architecture, specialized instructions for parallel processing
- Fully programmable, but limited languages
- Algorithms not fully explored
- Max. 400W per card

FPGAs
Field Programmable Gate Arrays

- Custom designs, best for processing streaming data
- Programmable Logic, Architecture is custom-built for the required application
- Requires extensive knowledge to program, development time is longer than CPUs and GPUs
- Application interface is custom built on each case
- Max. 60W per FPGA

ASICs
Application Specific Integrated Circuits

- Fully custom designs, built for a specific application
- Not flexible, cannot be changed once it is built
- Development is even more specialized than FPGAs
- Power consumption varies with the application, usually best performance per Watt

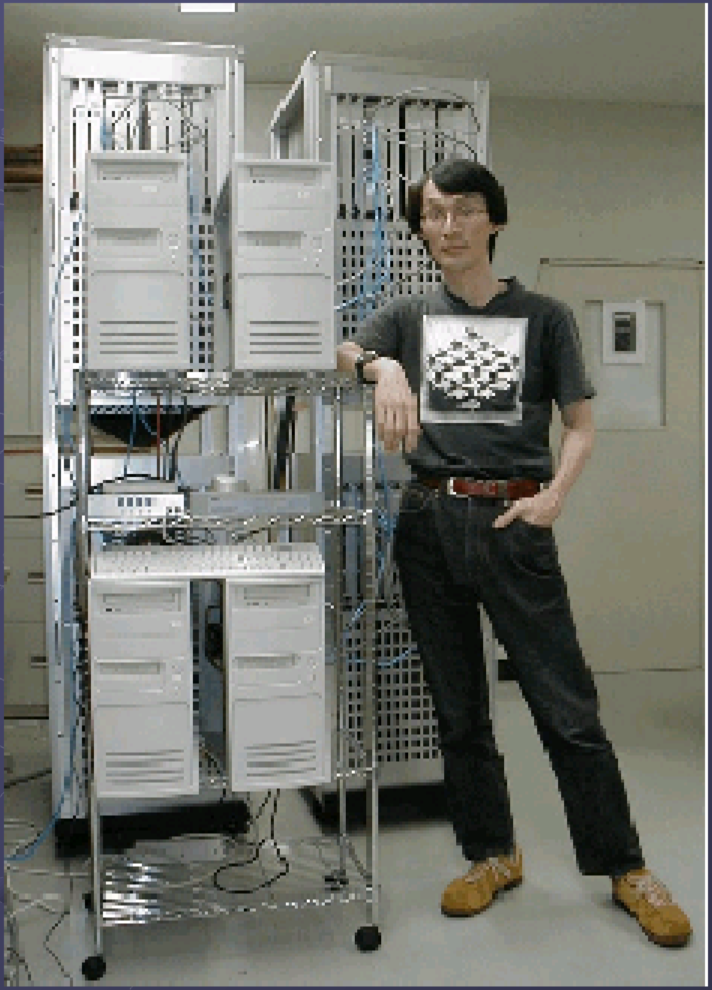
Slide: Guillermo Marcus

HITS

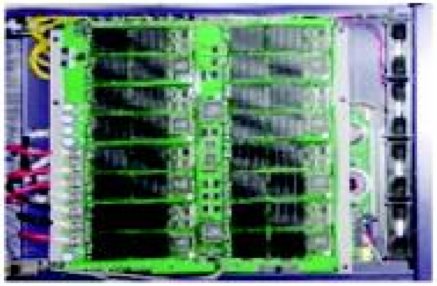
HARDWARE

GRAPE-6 Gravity/Coulomb Part

- G6 Chip: 0.25μ 2MGate ASIC, 6 Pipelines
- at 90MHz, 31Gflops/chip
- 48Tflops full system (March 2002)
- Plan up to 72Tflops full system (in 2002)
- Installed in Cambridge, Marseille, Drexel, Amsterdam, New York (AMNH), Mitaka (NAO), Tokyo, etc..
  New Jersey, Indiana, Heidelberg



GRAPE-6



1998, 120 Gflops

Developers: Junichiro Makino, Toshiyuki Fukushige, Hiroshi Daisaka, Eiichiro Kokubo, Masaki Koga, Makoto Taiji, Ken Namura

GRAPE-6: Massively-Parallel Special-Purpose Computer for Astrophysical Particle Simulations

Sales information

The Green500 List - November 2010

Listed below are the November 2010 The Green500's energy-efficient supercomputers ranked from 1 to 100.

http://www.green500.org

Green500 Rank	MFLOPS/W	Site*	Computer*	Total Power (kW)
1	1684.20	IBM Thomas J. Watson Research Center	NNSA/SC Blue Gene/Q Prototype	38.80
2+	1448.03	National Astronomical Observatory of Japan	GRAPE-DR accelerator Cluster, Infiniband	24.59
2	958.35	GSIC Center, Tokyo Institute of Technology	HP ProLiant SL390s G7 Xeon 6C X5670, Nvidia GPU, Linux/Windows	1243.80
3	933.06	NCSA	Hybrid Cluster Core i3 2.93Ghz Dual Core, NVIDIA C2050, Infiniband	36.00

GPU: NAOC laohu cluster Beijing, China

Heidelberg

Kepler GPU cluster

VolkswagenStiftung

Kepler GPU cluster

12 nodes = 12 x 16 = 192 CPU cores (@ 2 GHz)

12 x 64 GB = 768 GB RAM CPU memory

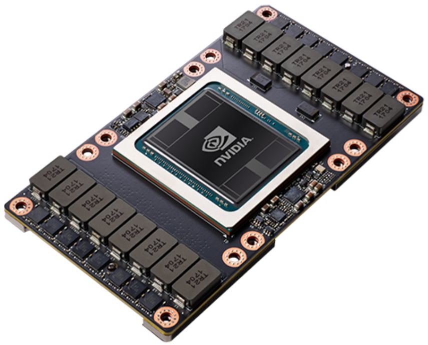
12 GPUs K20m = 12 x 2496 ~ 30k GPU threads

12 x 4.8 GB ~ 57 GB GPU device memory

4 x Xilinx Virtex-6 FPGA (ML 605)

since beg. 2013 operated.

NVIDIA Volta V100 GPU, 21 billion transistors, 5120 cores



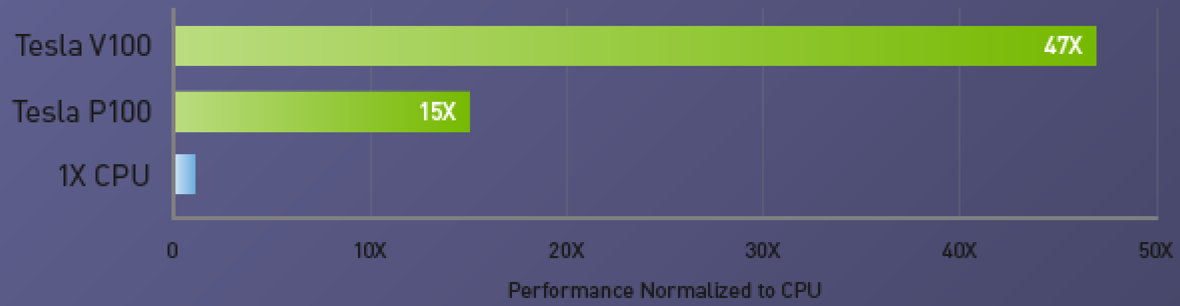
With NVLINK

Without NVLINK

PERFORMANCE with NVIDIA GPU Boost™	DOUBLE-PRECISION 7.8 teraFLOPS	DOUBLE-PRECISION 7 teraFLOPS
	SINGLE-PRECISION 15.7 teraFLOPS	SINGLE-PRECISION 14 teraFLOPS
	DEEP LEARNING 125 teraFLOPS	DEEP LEARNING 112 teraFLOPS
INTERCONNECT BANDWIDTH Bi-Directional	NVLINK 300 GB/s	PCIE 32 GB/s
MEMORY CoWoS Stacked HBM2	CAPACITY 32/16 GB HBM2	
	BANDWIDTH 900 GB/s	
POWER Max Consumption	300 WATTS	250 WATTS

NVIDIA Volta V100 GPU, 21 billion transistors, 5120 cores

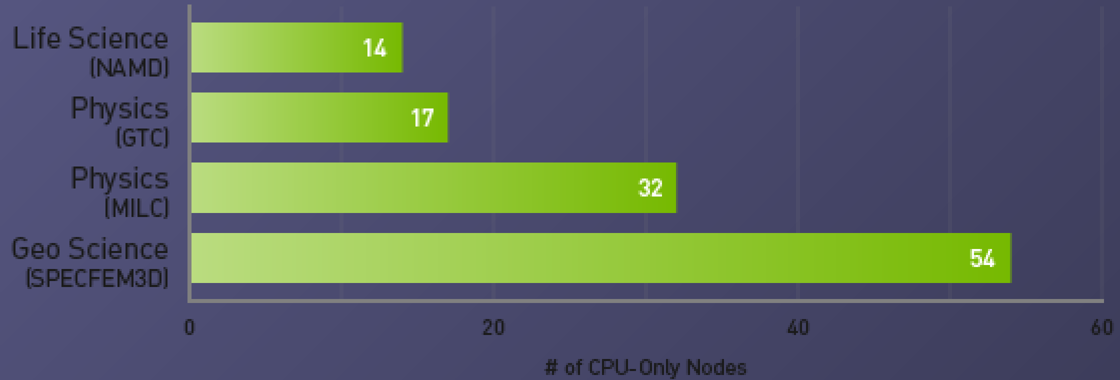
47X Higher Throughput Than CPU Server on Deep Learning Inference



Workload: ResNet-50 | CPU: 1X Xeon E5-2690v4 @ 2.6 GHz | GPU: Add 1X Tesla P100 or V100

1 GPU Node Replaces Up To 54 CPU Nodes

Node Replacement: HPC Mixed Workload



CPU Server: Dual Xeon Gold 6140@2.30GHz, GPU Servers: same CPU server w/ 4x V100 PCIe | CUDA Version: CUDA 9.x| Dataset: NAMD (STMV), GTC (mpi#proc.in), MILC (APEX Medium), SPECFEM3D (four_material_simple_model) | To arrive at CPU node equivalence, we use measured benchmark with up to 8 CPU nodes. Then we use linear scaling to scale beyond 8 nodes.

Top 10 List November 2010

From www.top500.org - list of fastest supercomputers in the world... ... last year Nov. 2010:

1	National Supercomputing Center in Tianjin China	**Tianhe-1A** - NUDT TH MPP, X5670 2.93Ghz 6C, NVIDIA GPU, FT-1000 8C NUDT	***GPU***
2	DOE/SC/Oak Ridge National Laboratory United States	**Jaguar** - Cray XT5-HE Opteron 6-core 2.6 GHz Cray Inc.	
3	National Supercomputing Centre in Shenzhen (NSCS) China	**Nebulae** - Dawning TC3600 Blade, Intel X5650, NVidia Tesla C2050 GPU Dawning	***GPU***
4	GSIC Center, Tokyo Institute of Technology Japan	**TSUBAME 2.0** - HP ProLiant SL390s G7 Xeon 6C X5670, Nvidia GPU, Linux/Windows NEC/HP	***GPU***
5	DOE/SC/LBNL/NERSC United States	**Hopper** - Cray XE6 12-core 2.1 GHz Cray Inc.	
6	Commissariat a l'Energie Atomique (CEA) France FR	**Tera-100** - Bull bullx super-node S6010/S6030 Bull SA	
7	DOE/NNSA/LANL United States	**Roadrunner** - BladeCenter QS22/LS21 Cluster, PowerXCell 8i 3.2 Ghz / Opteron DC 1.8 GHz, Voltaire Infiniband IBM	
8	National Institute for Computational Sciences/University of Tennessee United States	**Kraken XT5** - Cray XT5-HE Opteron 6-core 2.6 GHz Cray Inc.	
9	Forschungszentrum Juelich (FZJ) Germany	**JUGENE** - Blue Gene/P Solution IBM	
10	DOE/NNSA/LANL/SNL United States	**Cielo** - Cray XE6 8-core 2.4 GHz Cray Inc.	

China Grabs Supercomputing Leadership Spot in Latest Ranking of World's Top 500 Supercomputers

Thu, 2010-11-11 22:42

MANNHEIM, Germany; BERKELEY, Calif.; and KNOXVILLE, Tenn.—The 36th edition of the closely watched TOP500 list of the world's most powerful supercomputers confirms the rumored takeover of the top spot by the Chinese Tianhe-1A system at the National Supercomputer Center in Tianjin, achieving a performance level of 2.57 petaflop/s (quadrillions of calculations per second).

NCSA director: GPU is future of supercomputing

by Brooke Crothers

A A Font size   Print   E-mail   Share   6 comments

The director of the National Center for Supercomputing Applications has seen the future of supercomputing and it can be summed up in three letters: GPU.

Thom Dunning directs the Institute for Advanced Computing Applications and Technologies and the NCSA.

Thom Dunning, who directs the NCSA and the Institute for Advanced Computing Applications and Technologies at the famed supercomputing facilities on the campus of University of Illinois at Urbana-Champaign, says high-performance computing will begin to move toward graphics processing units or GPUs. Not coincidentally, **this is exactly what China has done to achieve the world's fastest speeds with its "Tianhe-1A"** supercomputer. That computer combines about 7,000 Nvidia GPUs with 14,000 Intel CPUs: the only hybrid CPU-GPU system in the world of that scale.

"What we're really seeing in the efforts in China as well as the ones we have in the U.S. is that GPUs are what the future will look like," said Dunning in a phone interview Thursday. "What we're seeing is the beginning of something that's going to be happening all over the world."

NCSA already has a small CPU-GPU hybrid system. "It's something we have been working on for a number of years. We have a CPU-GPU cluster for the NCSA academic community. Made up of Intel CPUs and Nvidia GPUs. A 50 teraflop machine," he said. (Note that **Oak Ridge National Laboratories is also installing a hybrid system now**.)

Intel MIC Hardware

INSPUR, NAOC - 2013.XI.26

icpc … "-mmic" … 61 x 4 = 244 x 1.1 GHz omp cores !!!

Full fp64 !!!

Intel MIC Hardware

Intel® Xeon Phi™ Coprocessor Family Reference Table

SKU #	Form Factor, Thermal	Peak Double Precision	Max # of Cores	Clock Speed (GHz)	GDDR5 Memory Speeds (GT/s)	Peak Memory BW	Memory Capacity (GB)	Total Cache (MB)	Board TDP (Watts)	Process
SE10P (special edition)	PCIe Card, Passively Cooled	1073 GF	61	1.1	5.5	352	8	30.5	300	
SE10X (special edition)	PCIe Card, No Thermal Solution	1073 GF	61	1.1	5.5	352	8	30.5	300	
5110P	PCIe Card, Passively Cooled	1011 GF	60	1.053	5.0	320	8	30	225	22nm
3100 Series	PCIe Card, Actively Cooled	>1 TF	Disclosed at 3100 series launch (H1'13)		5.0	240	6	28.5	300	
	PCIe Card, Passively Cooled	> 1 TF			5.0	240	6	28.5	300	

PCIe Card, Actively Cooled

PCIe Card, Passively Cooled

Current Generation:
Knights Landing
14nm

Intel MIC hardware / Recent Processors

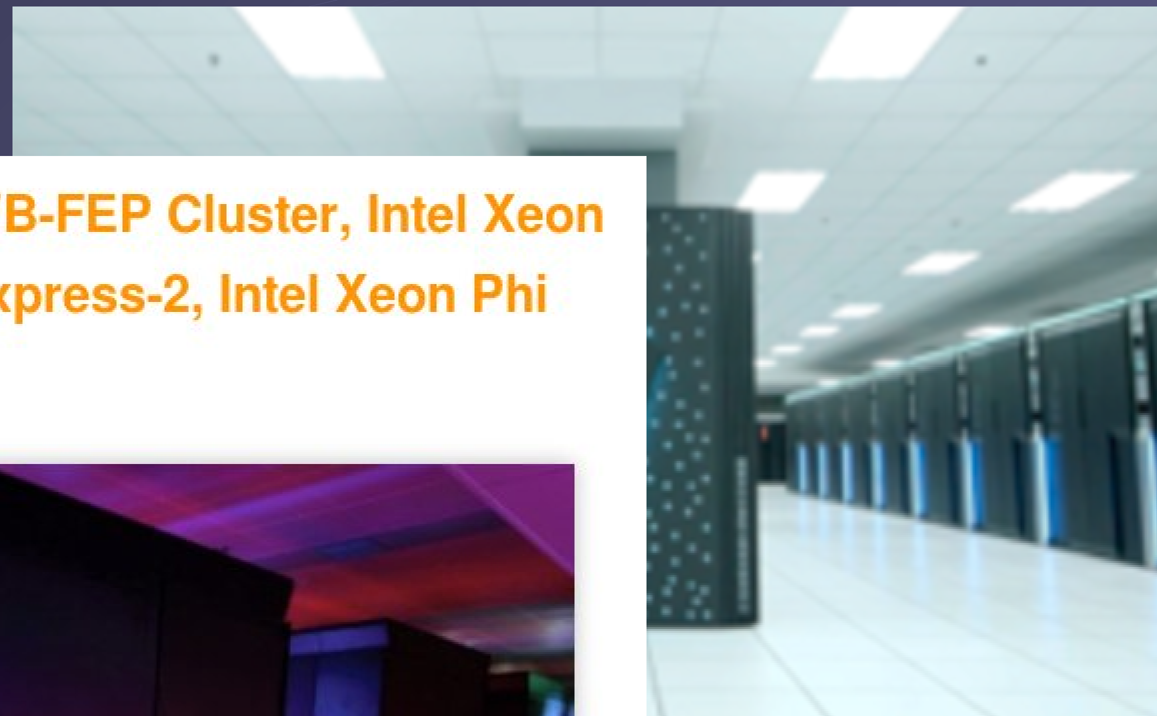
Intel® Xeon Phi™ Processor 7290

- 36 MB L2 Cache
- 72 Cores
- 72 Threads
- 1.70 GHz Max Turbo Frequency

Intel® Xeon Phi™ Processor 7290F

- 36 MB L2 Cache
- 72 Cores
- 72 Threads
- 1.70 GHz Max Turbo Frequency

Supercomputer from China: 96/33 Pflop/s Linpack
Wuxi/Guangzhou/Tianjin National Supercomputing Center
Taihu 10 mill. cores

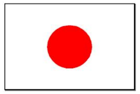


Tianhe-2 (MilkyWay-2) - TH-IVB-FEP Cluster, Intel Xeon E5-2692 12C 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P

32000 Intel Xeon 12 core,
48000 Intel Phi Accelerators 57 Core,
now Chinese processor

Test of Taihu planned;
But:
Local cluster with new GPUs at NAOC gives much more resources.

Rank	Site	System	Cores	Rmax (TFlop/s)	Rpeak (TFlop/s)	Power (kW)	
1	DOE/SC/Oak Ridge National Laboratory United States **USA**	**Summit** - IBM Power System AC922, IBM POWER9 22C 3.07GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband IBM	2,414,592	148,600.0	200,794.9	10,096	***GPU Volta***
2	DOE/NNSA/LLNL United States **USA**	**Sierra** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, NVIDIA Volta GV100, Dual-rail Mellanox EDR Infiniband IBM / NVIDIA / Mellanox	1,572,480	94,640.0	125,712.0	7,438	***GPU Volta***
3	National Supercomputing Center in Wuxi China 	**Sunway TaihuLight** - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway NRCPC	10,649,600	93,014.6	125,435.9	15,371	*Chinese Processor*
4	National Super Computer Center in Guangzhou China 	**Tianhe-2A** - TH-IVB-FEP Cluster, Intel Xeon E5-2692v2 12C 2.2GHz, TH Express-2, Matrix-2000 NUDT	4,981,760	61,444.5	100,678.7	18,482	***Xeon ϕ***
5	Texas Advanced Computing Center/Univ. of Texas United States **USA**	**Frontera** - Dell C6420, Xeon Platinum 8280 28C 2.7GHz, Mellanox InfiniBand HDR Dell EMC	448,448	23,516.4	38,745.9		***Xeon Platinum***

6	Swiss National Supercomputing Centre (CSCS) Switzerland **Swiss**	**Piz Daint** - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interconnect , NVIDIA Tesla P100 Cray/HPE	387,872	21,230.0	27,154.3	2,384	***GPU Pascal***
7	DOE/NNSA/LANL/SNL United States **USA**	**Trinity** - Cray XC40, Xeon E5-2698v3 16C 2.3GHz, Intel Xeon Phi 7250 68C 1.4GHz, Aries interconnect Cray/HPE	979,072	20,158.7	41,461.2	7,578	***Xeonϕ***
8	National Institute of Advanced Industrial Science and Technology (AIST) Japan 	**AI Bridging Cloud Infrastructure (ABCI)** - PRIMERGY CX2570 M4, Xeon Gold 6148 20C 2.4GHz, NVIDIA Tesla V100 SXM2, Infiniband EDR Fujitsu	391,680	19,880.0	32,576.6	1,649	***GPU Volta***
9	Leibniz Rechenzentrum Germany 	**SuperMUC-NG** - ThinkSystem SD650, Xeon Platinum 8174 24C 3.1GHz, Intel Omni-Path Lenovo	305,856	19,476.6	26,873.9		***Xeon Platinum***
10	DOE/NNSA/LLNL United States **USA**	**Lassen** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, Dual-rail Mellanox EDR Infiniband, NVIDIA Tesla V100 IBM / NVIDIA / Mellanox	288,288	18,200.0	23,047.2		***GPU Volta***

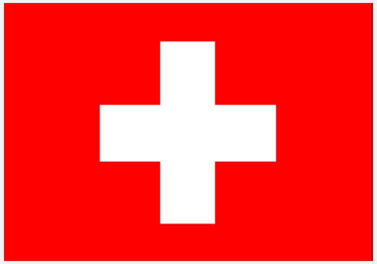
TOP500 List Refreshed, US Edged Out of Third Place ....

TOP500 Team | June 19, 2017 00:22 CEST

FRANKFURT, Germany; BERKELEY, Calif.; and KNOXVILLE, Tenn.— The 49th edition of the TOP500 list was released today in conjunction with the opening session of the ISC High Performance conference, which is taking place this week in Frankfurt, Germany. The list ranks the world's most powerful supercomputers based on the Linpack benchmark and is released twice per year.

Read more

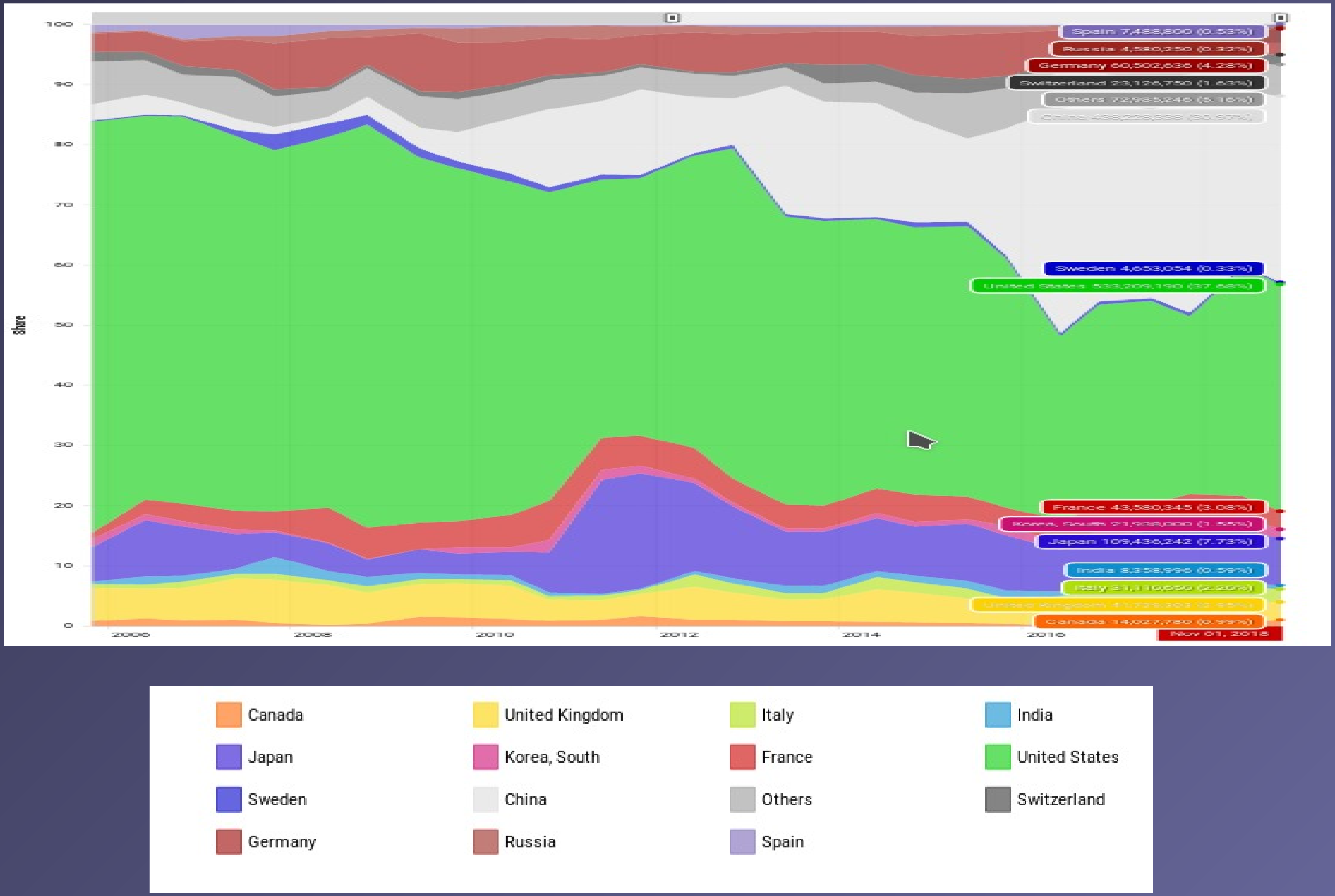
System
Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45G Sunway , **NRCPC** National Supercomputing Center in Wuxi **China**
Tianhe-2 (MilkyWay-2) - TH-IVB-FEP Cluster, Intel Xeon E5-269 2.200GHz, TH Express-2, Intel Xeon Phi 31S1P , **NUDT** National Super Computer Center in Guangzhou **China**
Piz Daint - Cray XC50, Xeon E5-2690v3 12C 2.6GHz, Aries interc NVIDIA Tesla P100 , **Cray Inc.** Swiss National Supercomputing Centre (CSCS) **Switzerland**



....

By Switzerland

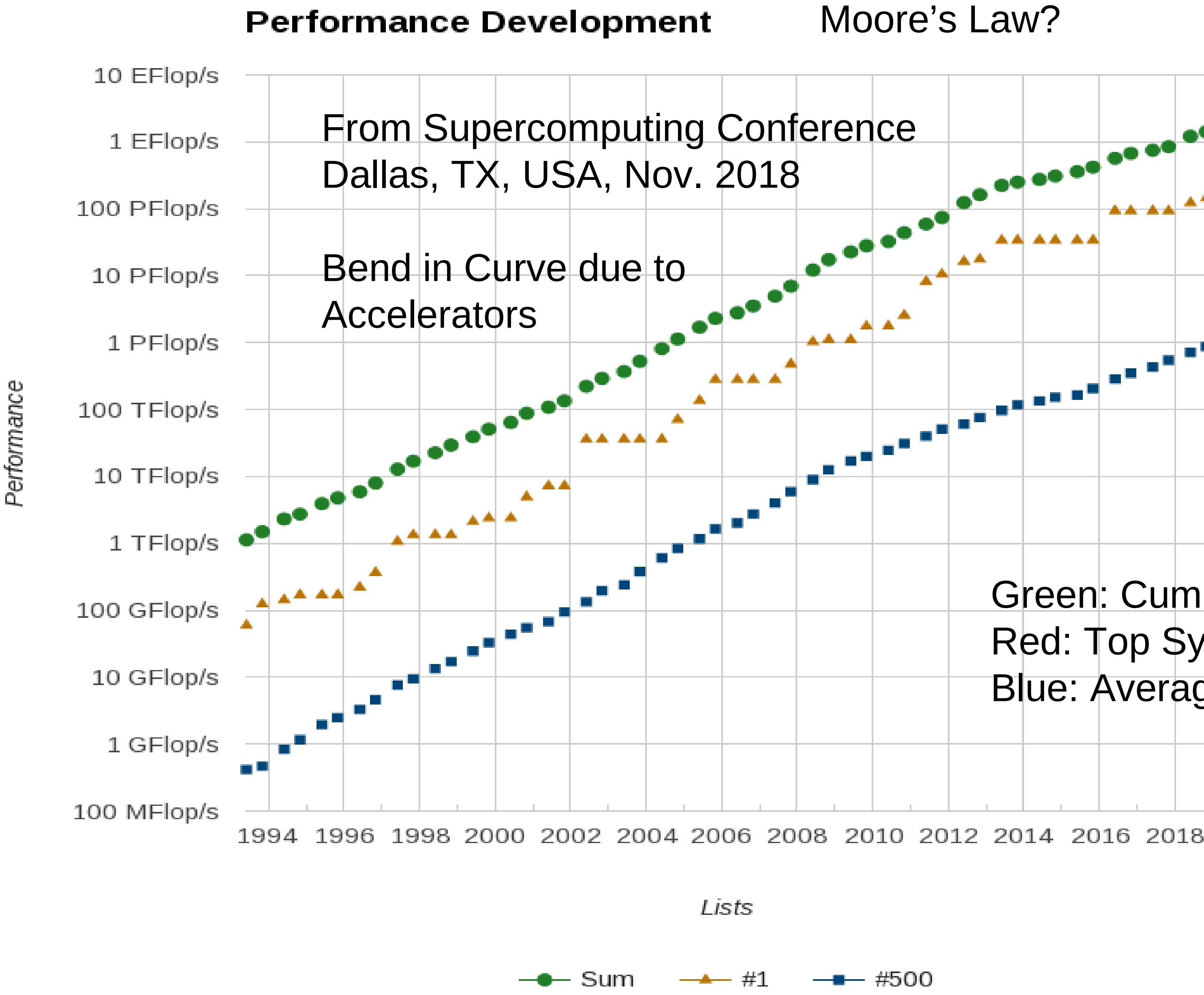
Top 500 List November 2018 – Performance Share of Countries



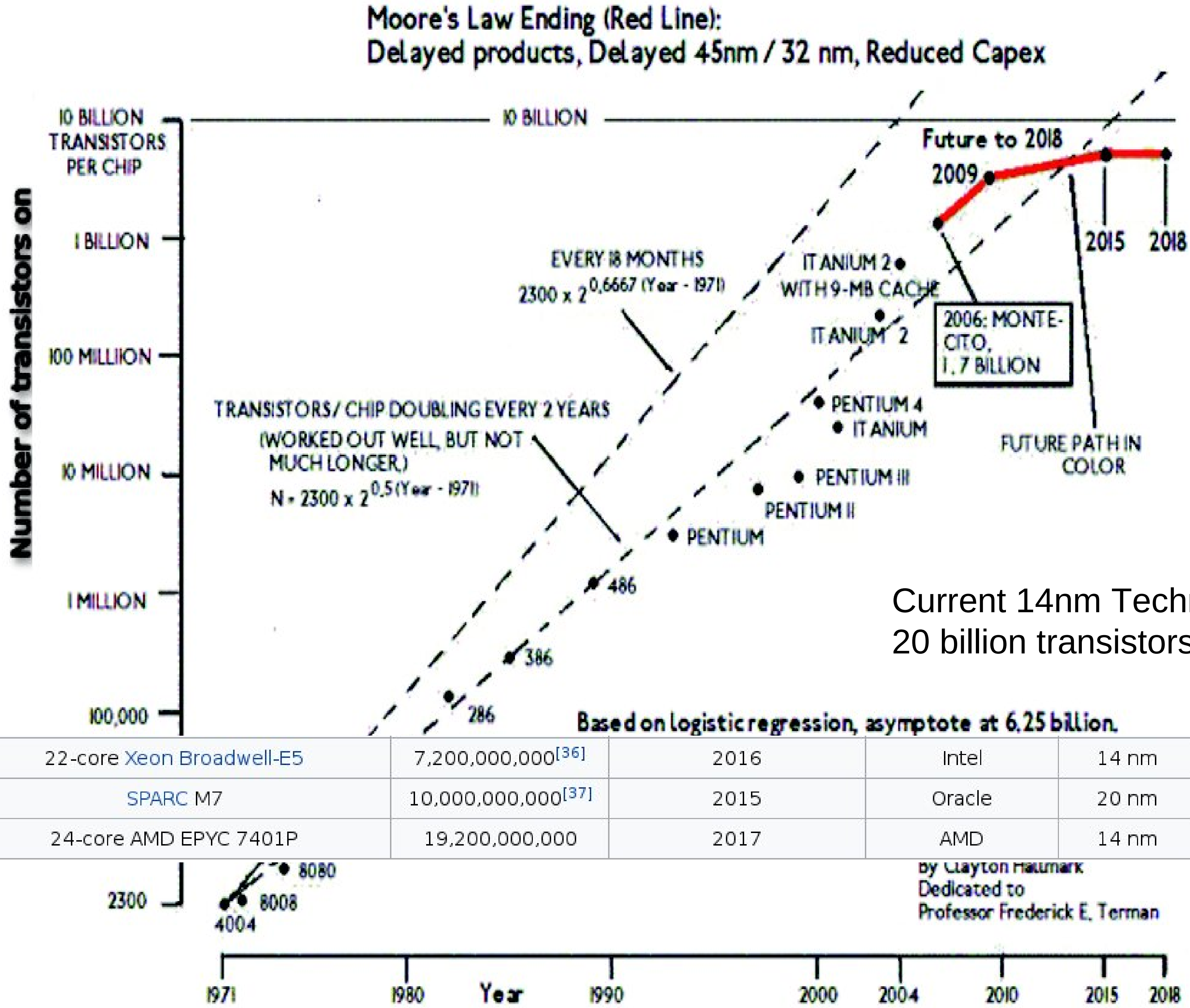
Moore’s Law?

From Supercomputing Conference
Dallas, TX, USA, Nov. 2018

Bend in Curve due to
Accelerators



Green: Cumulative
Red: Top System
Blue: Average of 500



Current 14nm Technology
20 billion transistors

22-core Xeon Broadwell-E5	7,200,000,000[36]	2016	Intel	14 nm	456 mm²
SPARC M7	10,000,000,000[37]	2015	Oracle	20 nm	
24-core AMD EPYC 7401P	19,200,000,000	2017	AMD	14 nm	195 mm²

GREEN 500 list 2018 Power Efficiency (Gflops/Watts), see also http://www.top500.org/green500   - 2019 similar.

Rank	TOP500 Rank	System	Cores	Rmax (TFlop/s)	Power (kW)	Power Efficiency (GFlops/watts)
1	375	**Shoubu system B** - ZettaScaler-2.2, Xeon D-1571 16C 1.3GHz, Infiniband EDR, PEZY-SC2 , PEZY Computing / Exascaler Inc. Advanced Center for Computing and Communication, RIKEN Japan	953,280	1,063.3	60	17.604
2	374	**DGX SaturnV Volta** - NVIDIA DGX-1 Volta36, Xeon E5-2698v4 20C 2.2GHz, Infiniband EDR, NVIDIA Tesla V100 , Nvidia NVIDIA Corporation United States	22,440	1,070.0	97	15.113
3	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	9,783	14.668
4	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	391,680	19,880.0	1,649	14.423
5	22	**TSUBAME3.0** - SGI ICE XA, IP139-SXM2, Xeon E5-2680v4 14C 2.4GHz, Intel Omni-Path, NVIDIA Tesla P100 SXM2 , HPE GSIC Center, Tokyo Institute of Technology Japan	135,828	8,125.0	792	13.704
6	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	7,438	12.723
7	446	**AIST AI Cloud** - NEC 4U-8GPU Server, Xeon E5-2630Lv4 10C 1.8GHz, Infiniband EDR, NVIDIA Tesla P100 SXM2 , NEC National Institute of Advanced Industrial Science and Technology Japan	23,400	961.0	76	12.681
8	411	**MareNostrum P9 CTE** - IBM Power System AC922, IBM POWER9 22C 3.1GHz, Dual-rail Mellanox EDR Infiniband, NVIDIA Tesla V100 , IBM Barcelona Supercomputing Center Spain	19,440	1,018.0	86	11.865
9	38	**Advanced Computing System(PreE)** - Sugon TC8600, Hygon Dhyana 32C 2GHz, Deep Computing Processor, 200Gb 6D-Torus , Sugon Sugon China	163,840	4,325.0	380	11.382
10	20	**Taiwania 2** - QCT QuantaGrid D52G-4U/LC, Xeon Gold 6154 18C 3GHz, Mellanox InfiniBand EDR, NVIDIA Tesla V100 SXM2 , Quanta Computer / Taiwan Fixed Network / ASUS Cloud National Center for High Performance Computing Taiwan	170,352	9,000.0	798	11.285

Japan

GPU Volta

GPU Volta

GPU Volta

GPU Pascal

GPU Volta

GPU Pascal

GPU Volta

China

GPU Volta