

AI DAYS 2022: Novinky v superpočítačích a AI

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Na úvod: krátký pohled do fyziky

SI prefixes^[3]V·T·E

Prefix		Base 10	Decimal	English word		Adoption ^[nb 1] ^[4]
Name	Symbol			Short scale	Long scale	
quetta	Q	10 ³⁰	1 000 000 000 000 000 000 000 000 000 000	nonillion	quintillion	2022
ronna	R	10 ²⁷	1 000 000 000 000 000 000 000 000 000 000	octillion	quadrilliard	2022
yotta	Y	10 ²⁴	1 000 000 000 000 000 000 000 000 000 000	septillion	quadrillion	1991
zetta	Z	10 ²¹	1 000 000 000 000 000 000 000 000 000 000	sextillion	trilliard	1991
exa	E	10 ¹⁸	1 000 000 000 000 000 000 000 000 000 000	quintillion	trillion	1975
peta	P	10 ¹⁵	1 000 000 000 000 000 000 000 000 000 000	quadrillion	billiard	1975
tera	T	10 ¹²	1 000 000 000 000 000 000 000 000 000 000	trillion	billion	1960
giga	G	10 ⁹	1 000 000 000 000 000 000 000 000 000 000	billion	milliard	1960
mega	M	10 ⁶	1 000 000 000 000 000 000 000 000 000 000	million		1873
kilo	k	10 ³	1 000 000 000 000 000 000 000 000 000 000	thousand		1795
hecto	h	10 ²	100 000 000 000 000 000 000 000 000 000	hundred		1795
deca	da	10 ¹	10 000 000 000 000 000 000 000 000 000	ten		1795
		10 ⁰	1	one		—

Konference SC22



Fotoreportáž: <https://mcomputers.cz/2022/11/20/konference-sc22-dallas/>

Konference SC22



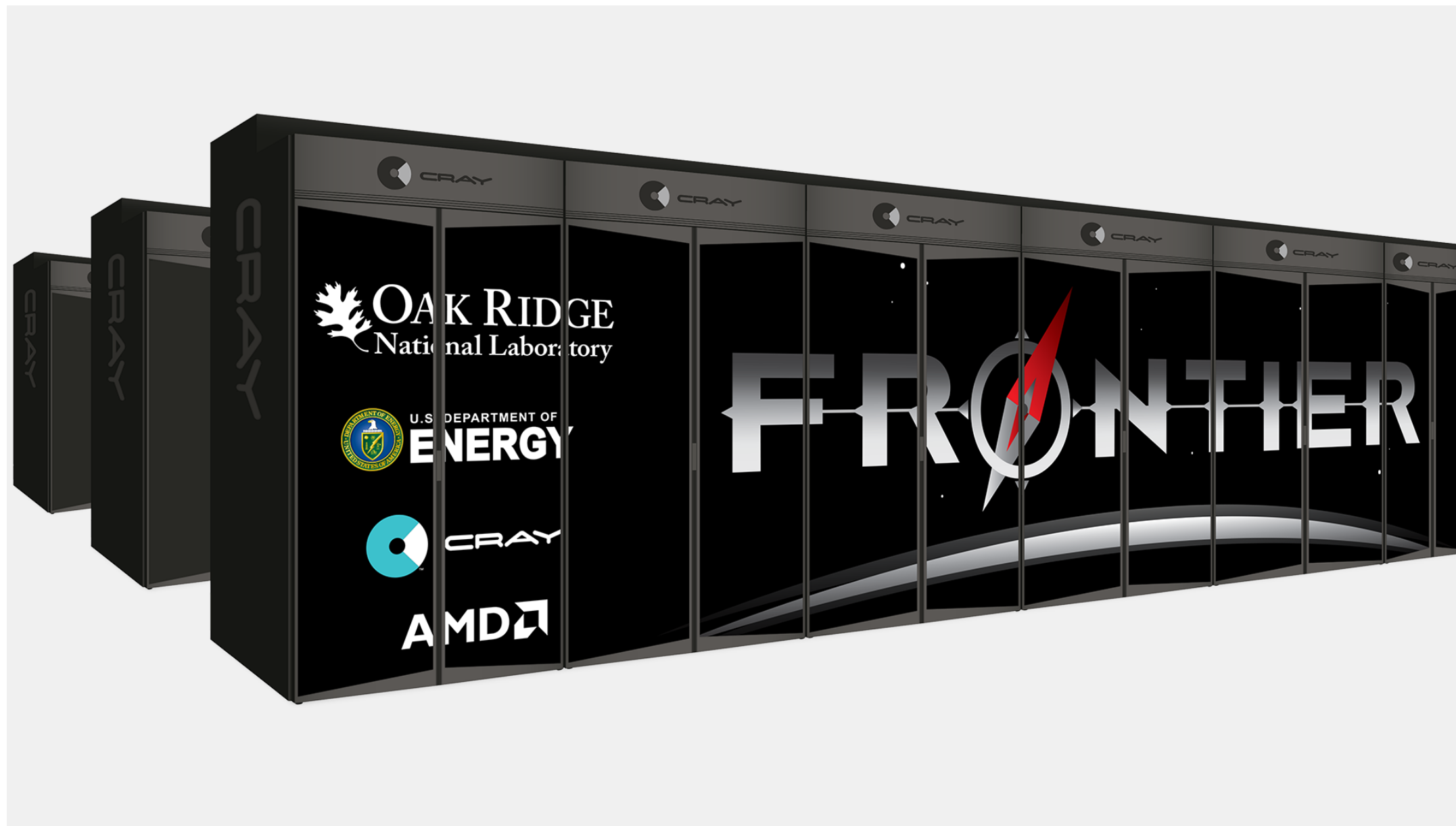
Jack Dongarra: Keynote speech – <https://youtu.be/cS00Tc2w5Dg>

Historie superpočítačů, aktuální exa scale systémy, TOP500, Linpack + HPCG, future of supercomputing

Frontier: První exa scale systém (červen 2022)

1 flop = operace (sčítání nebo násobení) 64-bitového desetinného čísla

1 exaflop/s = 10^{18} flop/s = 1 000 000 000 000 000 000 flop/s (miliarda miliard operací za sekundu)



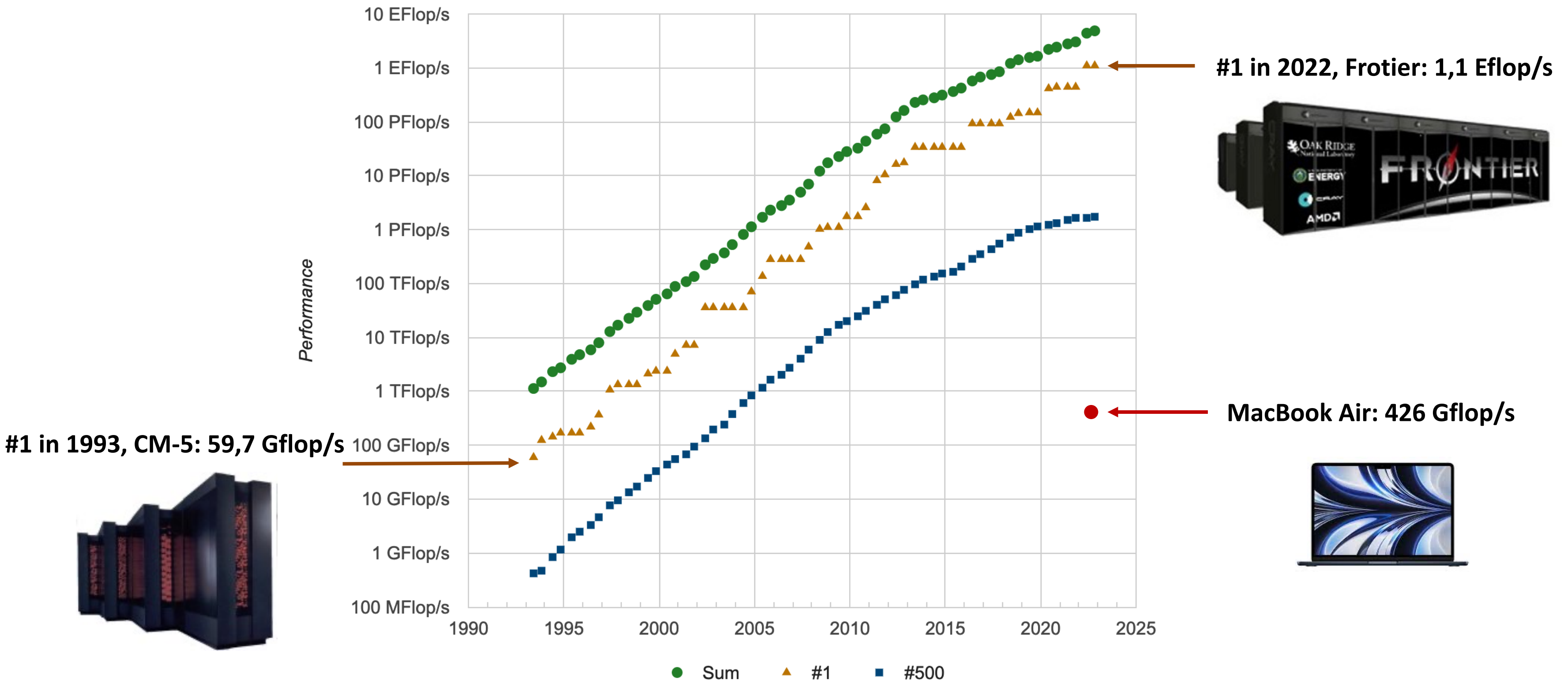
Pokud by každý člověk na planetě vykonal jeden výpočet každou sekundu, trvalo by více jak 4 roky, než by spočítali tolik, kolik spočítá exa scale superpočítač za 1 sekundu.

Frontier – HPE Cray EX235a
AMD EPYC 64C 2GHz, AMD Instinct MI250X, Slingshot, HPE
DOE/SC/Oak Ridge NL
Cores: 8 730 112
Rmax: 1,1 EFlop/s
Rpeak: 1,68 EFlop/s
Power: 21,1 MW
Price: ~ 600M USD

TOP500 žebříček nejvýkonnějších superpočítačích

Rank	System	Cores	Rmax (PFlop/s)	Rpeak (PFlop/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	442.01	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
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	1,572,480	94.64	125.71	7,438
7	Sunway TaihuLight - Sunway MPP, Sunway SW26010 260C 1.45GHz, Sunway, NRCPC National Supercomputing Center in Wuxi China	10,649,600	93.01	125.44	15,371
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
9	Selene - NVIDIA DGX A100, AMD EPYC 7742 64C 2.25GHz, NVIDIA A100, Mellanox HDR Infiniband, Nvidia NVIDIA Corporation United States	555,520	63.46	79.22	2,646
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
85	Karolina, GPU partition - Apollo 6500, AMD EPYC 7763 64C 2.45GHz, NVIDIA A100 SXM4 40 GB, Infiniband HDR200, HPE IT4Innovations National Supercomputing Center, VSB-Technical University of Ostrava Czechia	71,424	6.75	9.08	311

Vývoj Linpack benchmarku (flop/s)

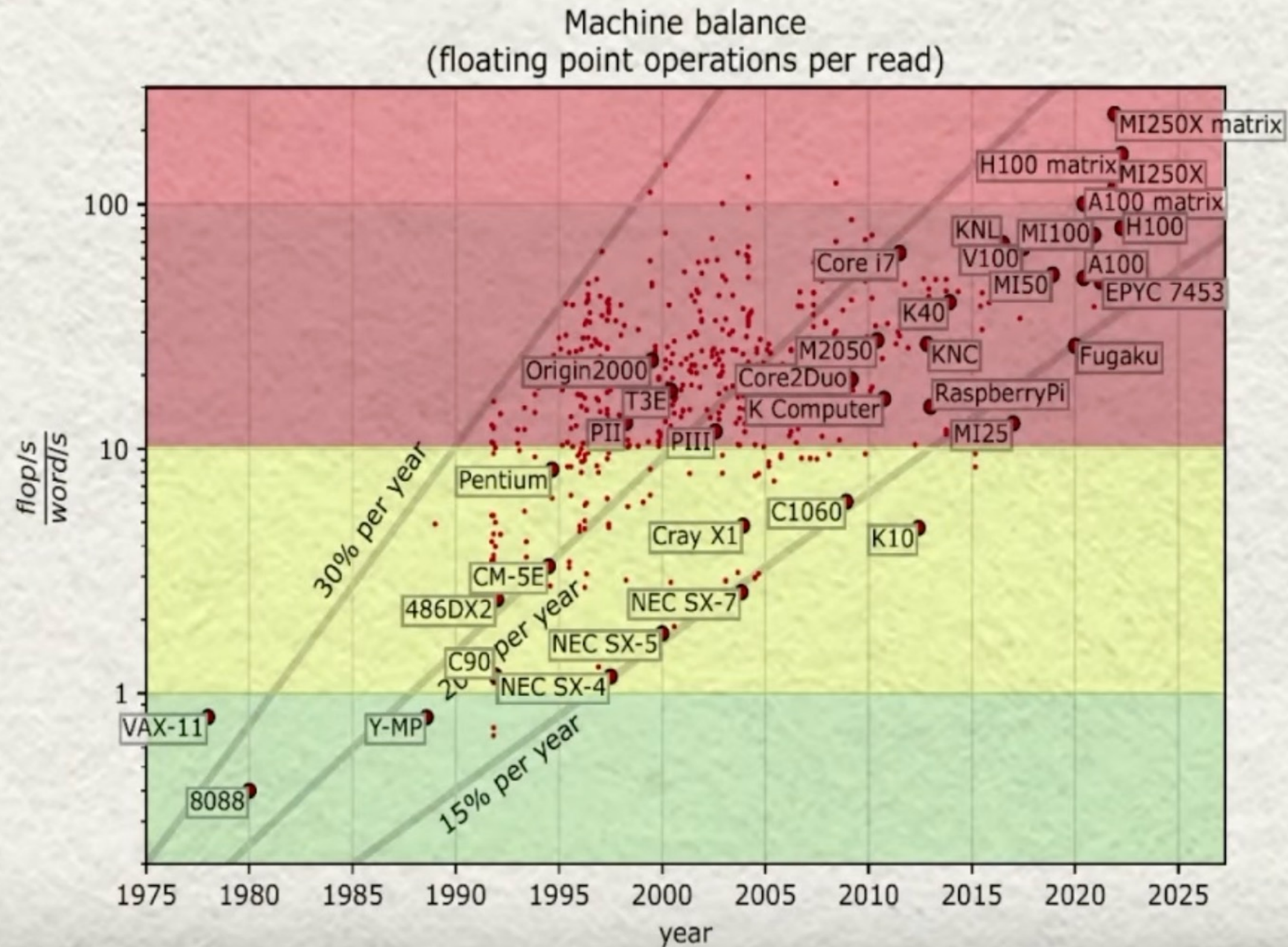


HPCG Top 10, November 2022

Rank	Site	Computer	Country	Cores	Rmax [Pflop/s]	Top 500 Rank	HPCG [Pflop/s]	% of Peak
1	RIKEN Center for Computational Science	Fugaku , Fujitsu A64FX 48C 2.2 GHz, Tofu D, Fujitsu	Japan	7,630,848	422	2	16.0	3.0%
2	DOE / SC / ORNL	Frontier , HPE Cray Ex235a, AMD 3rd EPYC 64C 2 GHz, AMD Instinct MI250X, Slingshot 10	USA	8,730,112	1,102	1	14.1	0.8%
3	EuroHPC / CSC	LUMI , HPE Cray EX235a, AMD Zen 3 (Milan) 64C 2GHz, AMD MI250X, Slingshot-11	Finland	2,174,976	304	3	3.41	0.8%
4	DOE / SC / ORNL	Summit , AC922, IBM POWER9 22C 3.7 GHz, Dual-rail Mellanox FDR, NVIDIA Volta V100, IBM	USA	2,414,592	149	5	2.93	1.5%
5	EuroHPC / CINECA	Leonardo , BullSequana XH2000, Xeon Platinum 8358 32C 2.6 GHz, NVIDIA A100 SXM4 40 GB, Quad-rail NVIDIA HDR100 InfiniBand	Italy	1,463,616	175	4	2.57	1.0%
6	DOE / SC / LBNL	Perlmutter , HPE Cray EX235n, AMD EPYC 7763 64C 2.45 GHz, NVIDIA A100 SXM4 40 GB, Slingshot-10	USA	761,856	70.9	8	1.91	2.0%
7	DOE / NNSA / LLNL	Sierra , S922LC, IBM POWER9 20C 3.1 GHz, Mellanox EDR, NVIDIA Volta V100, IBM	USA	1,572,480	94.6	6	1.80	1.4%
8	NVIDIA	Selene , DGX SuperPOD, AMD EPYC 7742 64C 2.25 GHz, Mellanox HDR, NVIDIA Ampere A100	USA	555,520	63.5	9	1.62	2.0%
9	Forschungszentrum Juelich (FZJ)	JUWELS Booster Module , Bull Sequana XH2000, AMD EPYC 7402 24C 2.8 GHz, Mellanox HDR InfiniBand, NVIDIA Ampere A100, Atos	Germany	449,280	44.1	12	1.28	1.8%
10	Saudi Aramco	Dammam-7 , Cray CS-Storm, Xeon Gold 6252 20C 2.5 GHz, InfiniBand HDR 100, NVIDIA Volta V100, HPE	Saudi Arabia	672,520	22.4	20	0.88	1.6%

Plot for 64-bit floating point data movement & operations

(Bandwidth from CPU or GPU memory to registers)



Závěry

HPC hardware/architektury se rychle mění:

- Scalární
- Vektorové
- Distribuované
- Akcelerované
- Mixed precision

Tři koncepty superpočítání:

- High performance computing (HPC)
- Deep learning (AI)
- Edge (AI)

Algoritmy a software mají obrovský potenciál urychlit výpočty na nových platformách

Různé HPC/AI architektury
Přenosy dat jsou drahé!
Důraz na udržitelnost
Composability??
Algoritmy a software!

Scaling of AI models

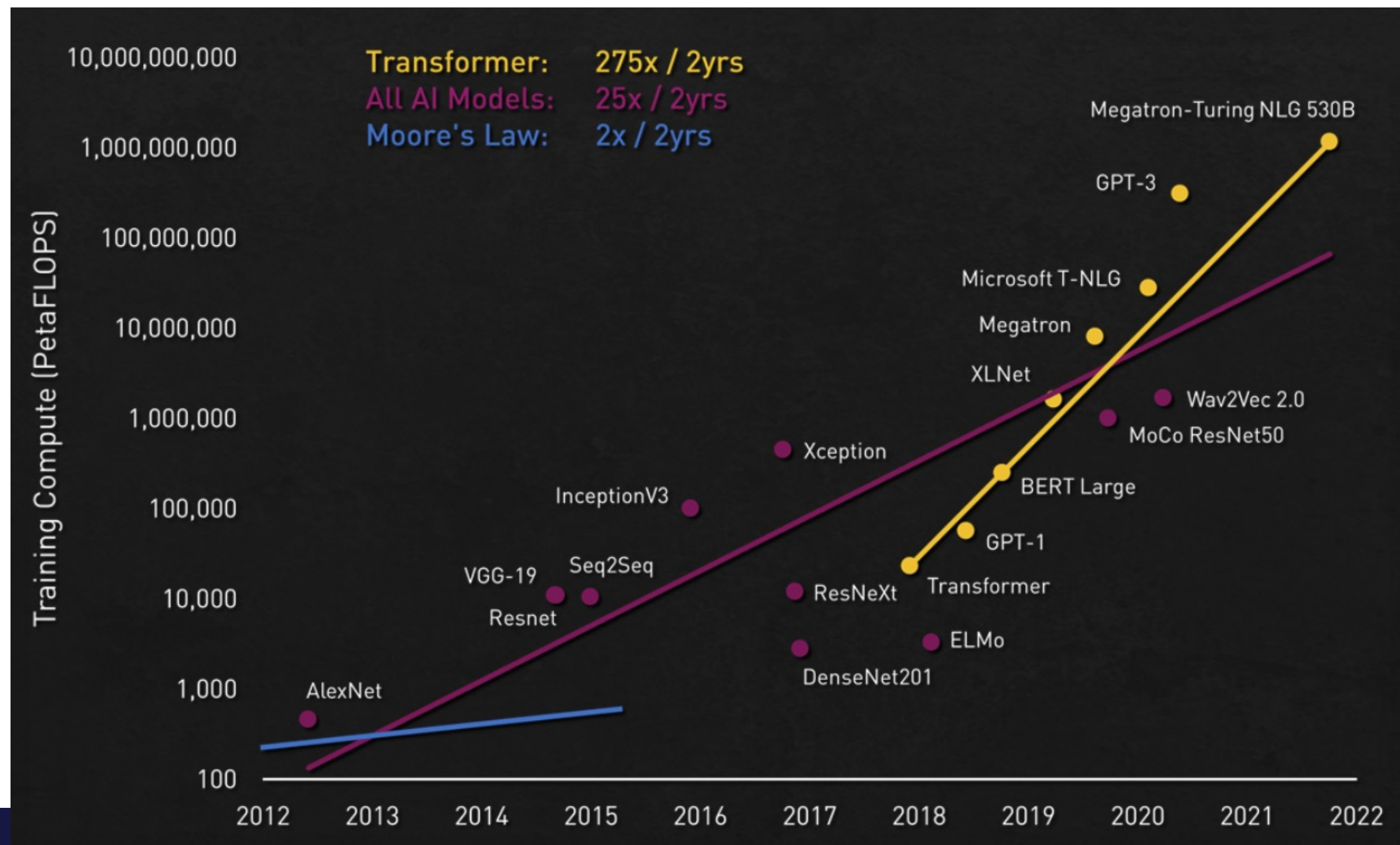
Hardware performance ([Moore's Law – blue line](#)):

1997 1 teraFLOPs (IBM ASCII Red)

2008 1 petaFLOPs (IBM RoadRunner)

2022 1 exaFLOPs (HPE Frontier)

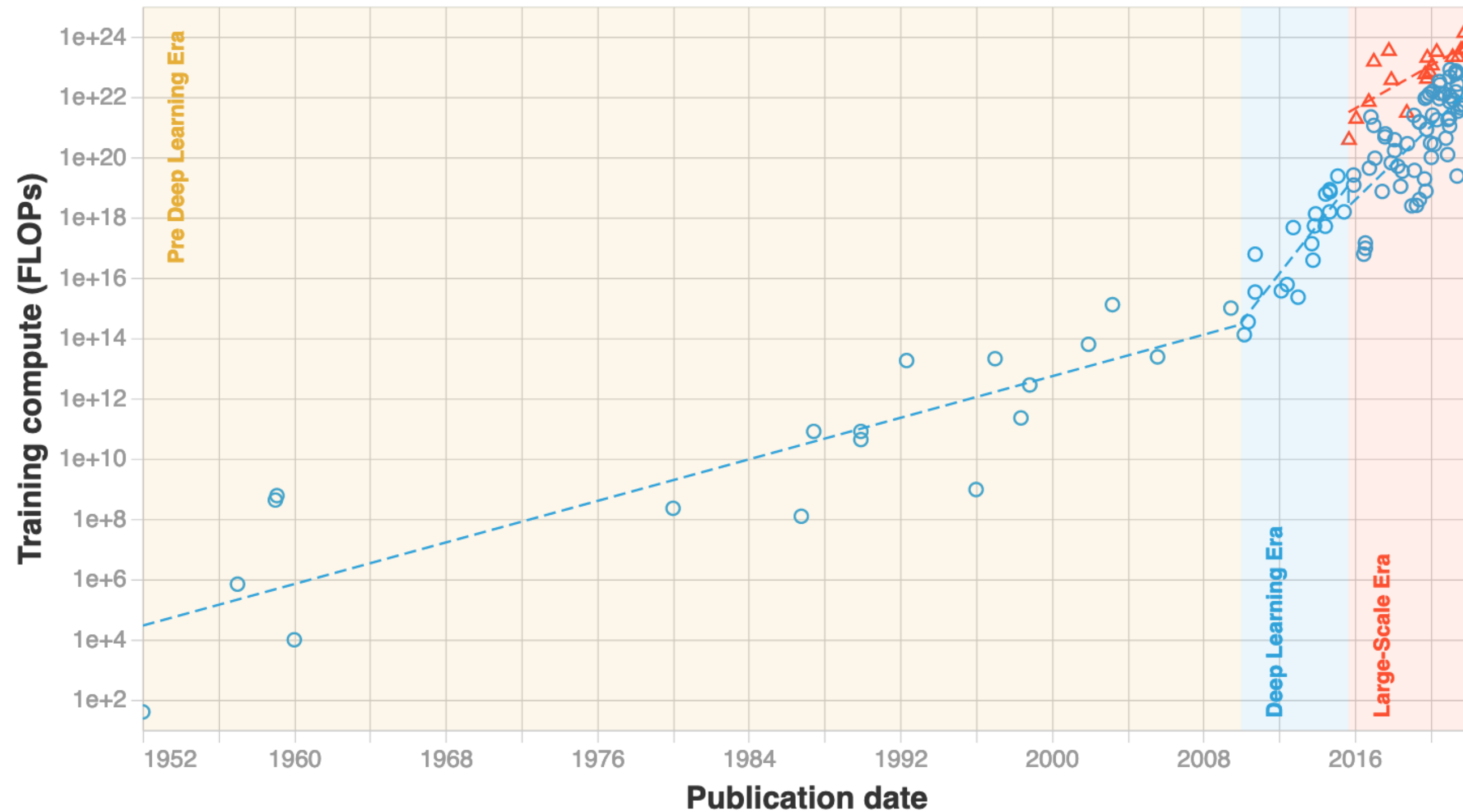
Scaling of AI models:



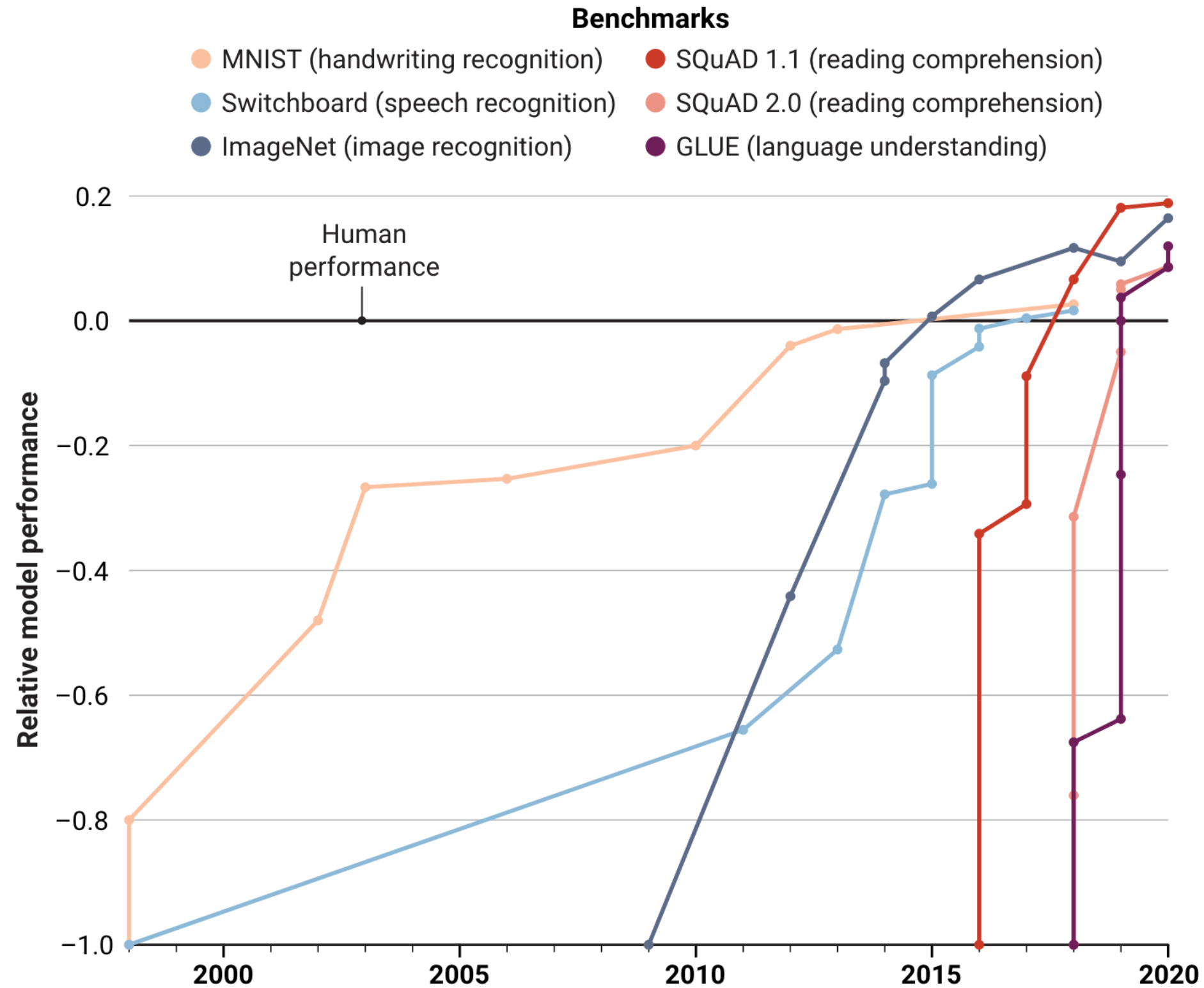
Výpočetní trendy v oblasti učení strojů

Training compute (FLOPs) of milestone Machine Learning systems over time

n = 121



Výkonnost AI modelů a porovnání s lidmi



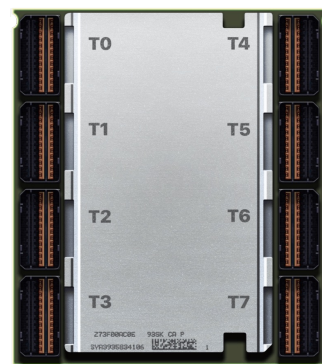
(GRAPHIC) K. FRANKLIN/SCIENCE; (DATA) D. KIELA ET AL., DYNABENCH: RETHINKING BENCHMARKING IN NLP, DOI:10.48550/ARXIV.2104.14337

Jaký hardware pro HPC a AI v roce 2023?

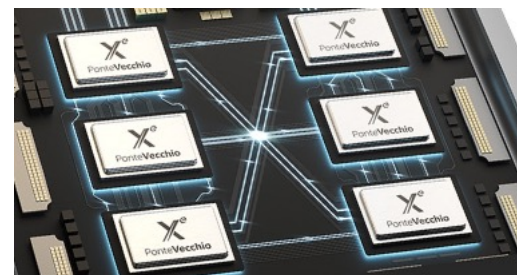
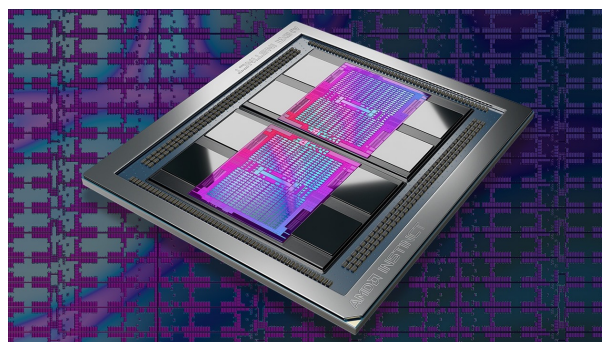
Alternativní akcelerátory: Graphcore, Habana Labs, Groq, Cerebras, Samba Nova, ...

GRAPHCORE

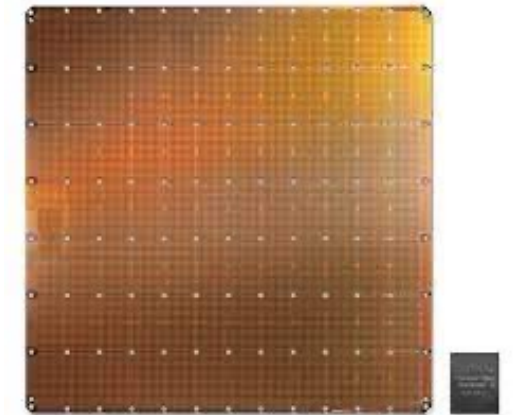
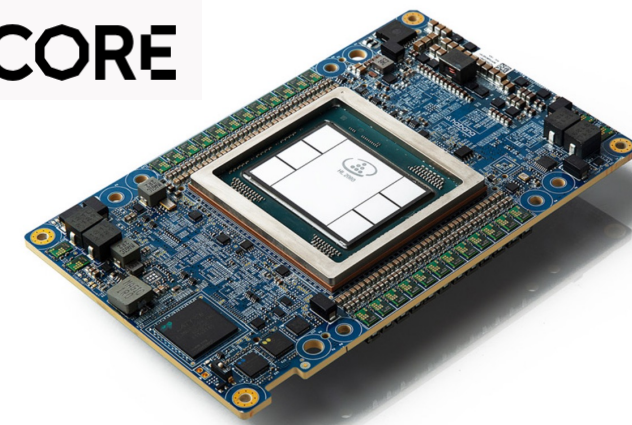
CPU: Intel, AMD, IBM, arm, Nvidia, RISC-V



GP GPU: NVIDIA, AMD, Intel



NVIDIA HOPPER



FPGA:



Quantum?

Ray Kurzweil: The Singularity Is Near (2005)

1 The accelerating pace of change ...

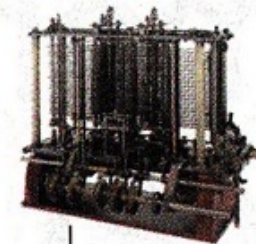


2 ... and exponential growth in computing power ...

Computer technology, shown here climbing dramatically by powers of 10, is now progressing more each hour than it did in its entire first 90 years

COMPUTER RANKINGS

By calculations per second per \$1,000



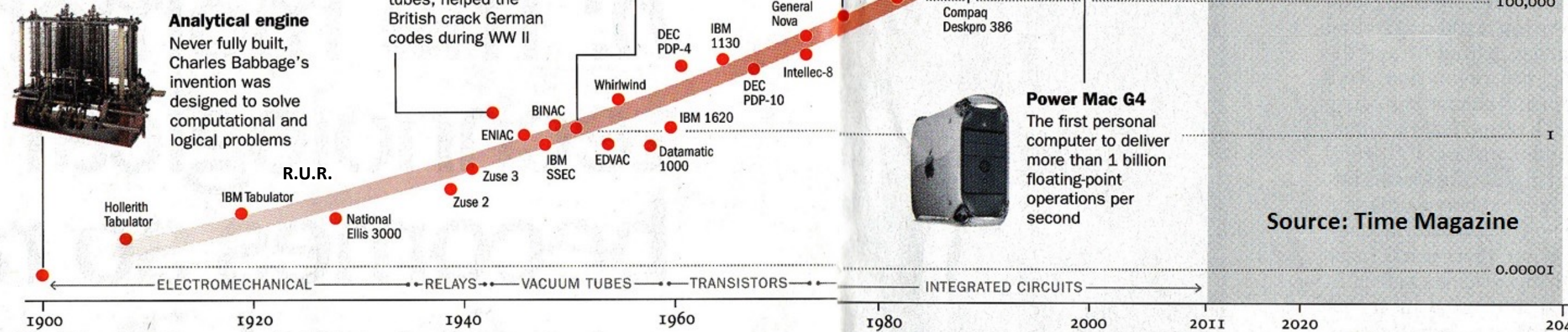
Analytical engine
Never fully built, Charles Babbage's invention was designed to solve computational and logical problems



Colossus
The electronic computer, with 1,500 vacuum tubes, helped the British crack German codes during WW II



UNIVAC I
The first commercially marketed computer, used to tabulate the U.S. Census, occupied 943 cu. ft.



3 ... will lead to the Singularity



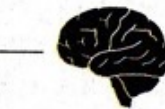
Apple II
At a price of \$1,298, the compact machine was one of the first massively popular personal computers



Power Mac G4
The first personal computer to deliver more than 1 billion floating-point operations per second

2045
Surpasses brainpower equivalent to that of all human brains combined

Surpasses brainpower of human in 2023



Surpasses brainpower of mouse in 2015

source: Time Magazine

QUESTIONS?

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