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Department of Informatics and Industrial Engineering
Distributed Computing Group

High Performance Computing

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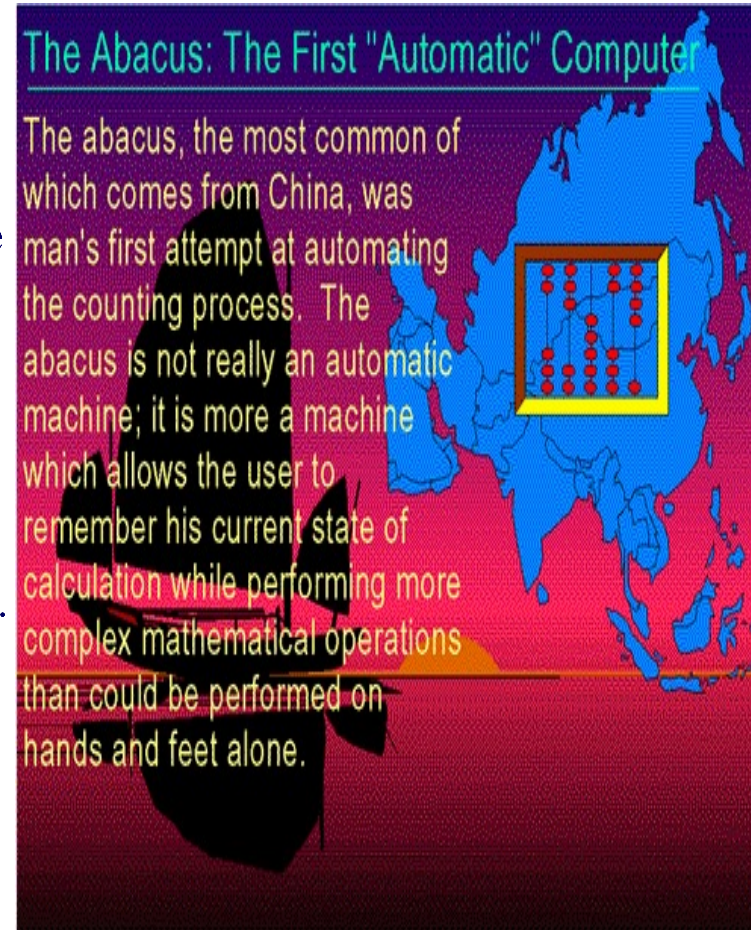
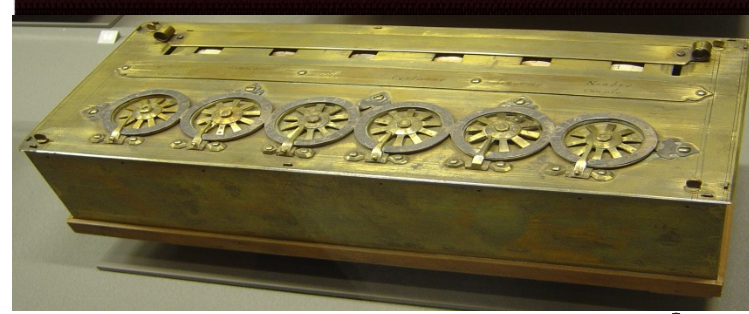
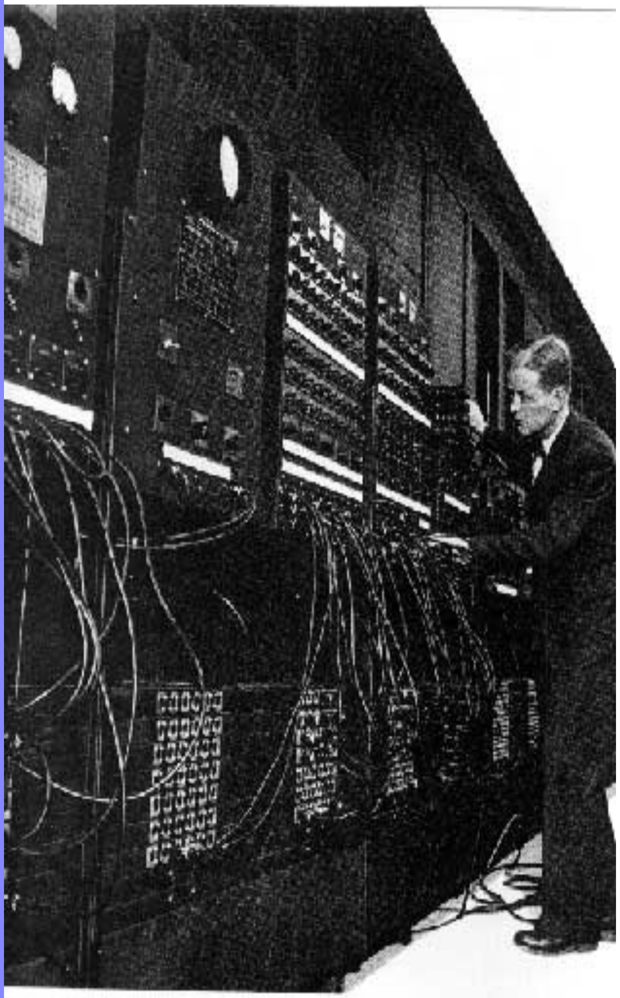
Precedents

1. **Storing the information:**
   - Guttenberg printing (s. XV)
   - Photography (s. XIX)
2. **Processing the Information: From the Abacus to the Babbage Machine**
   - Abacus (s. III a C)
   - Pascal Machine (s. XVII): Add and sub
   - Leibnitz Machine (s. XVII): Addition, substraction, multiplication and division.
   - Babbage Machine (s. XIX): Memory+ALU+E/S→ It does not built.
   - Holleritch codifies information by means of punched card→ 1924 makes IBM
3. **Transmission of the Information**:
   - Telegraph by Samuel Morse (1837)
   - Telephone by Graham Bell (1876)
   - Radio by Marconi (1895)





ENIAC: Electronic Numerical Integrator and Calculator



- Quick development of electronic: diodes, vacuum tubes, cathodics beams, ...
- First computer electro-mechanical "**MARK1**" (1944) →Add (0.3 seconds) and Multiplication (3 seconds)
- First electronic machine "**ENIAC**" (1946) →Multiplication (0.003 seconds)
- Von Neumann, Eckert and Mauchly built the first electronic computer with the program stored inside the computer "**EDVAC**".
- First commercial computer "**UNIVAC**" built in 1951 by "Eckert-Mauchly Computer Corporation ". Price: 1 million of dollars. 48 units were built.

Second Generation: The Transistor

- Transistor built by Shockley (1947).
- Use of transistors in computers →**Second generation** (1958-1964)
  - **IBM 7090**
  - **UNIVAC 1107**
  - **HoneyWell 800**, etc..
- "Fairchild" company, sited in Palo Alto, develops the **Planar Technical** , which allows to build cheaper transistors. →**Beginning of Microelectronics.**

Third Generation: Integrated circuits

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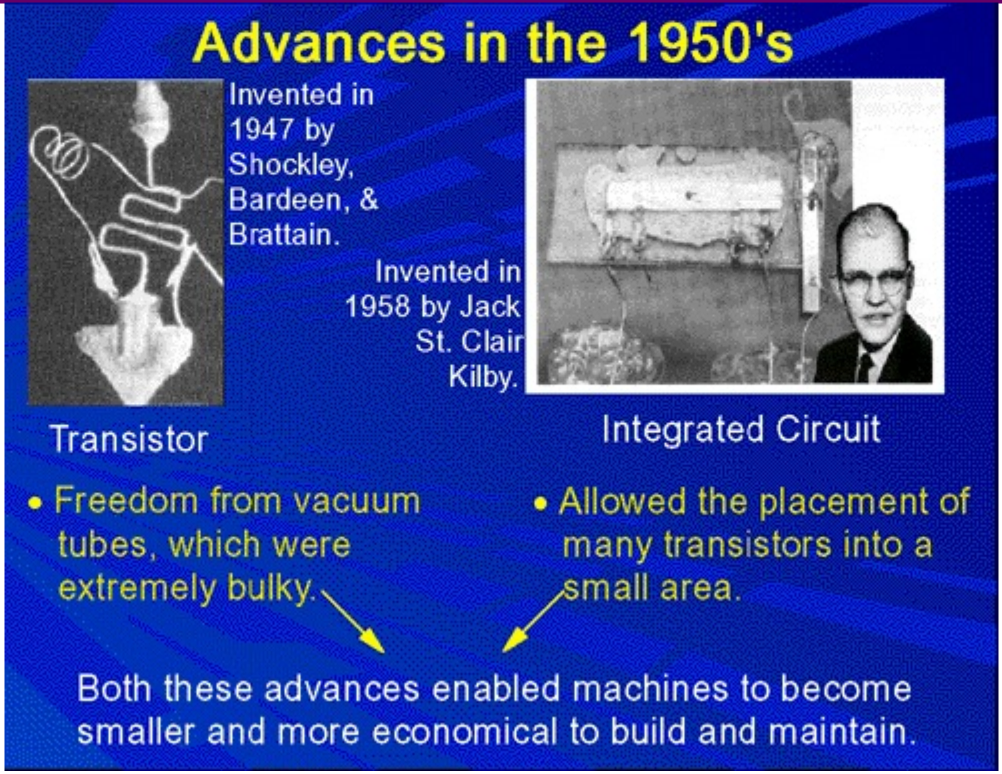

- Noyce manufactured the first integrated circuit or chip. (Noyce, 1958)
- **IBM 360** (1964)→ First family of computers
- **PDP-8** (DEC, 1964) → First desktop computer. Price 16.000 dollars in relation to the hundred of thousands of IBM 360
- **Supercomputing** birth (1970) by "Cray Research": **CDC 7600 and Cray-I.**

History

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- **MOS transistor** is created by Kahng and Atalla (1965) (it improves the density of integration.)
- Moore, Noyce i Grove founded "**Intel**→ **Int**egrated **El**ectronics"" oriented to the built of integrated circuits.
- Intel developed the **DRAM memory** built up with MOS transistors.
- Ted Hoff (b. 1937) and Federico Faggin at Intel designed the first microprocessor (computer on a chip) in 1969-1971. The 4004 had **a CPU of 4 bits**.
- **Moore Law** "The number of transistors that can be placed inexpensively on an integrated circuit has doubled approximately every 1,5year." The trend has continued for more than half a century and is not expected to stop until 2020 or later

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Evolution of memory –Moore Law

Year	70	73	76	79	82	85
Size	1K	4k	16k	64k	256k	1M
Technology (1)	8m	6m	4m	2,5m	1,6m	1,2m
Price (2)	760	190	36	8,1	1,08	0,3
Year	88	92	94	97	00	
Size	4M	16M	64M	256M	1G	
Technology (1)	0,8m	0,5m	0,35m	0,25m	0,15m	
Price (2)	0,28	0,054	0,036	0,022	0,005	

(1) 1m=0,001mm

(2) 0,001 dollar per bit

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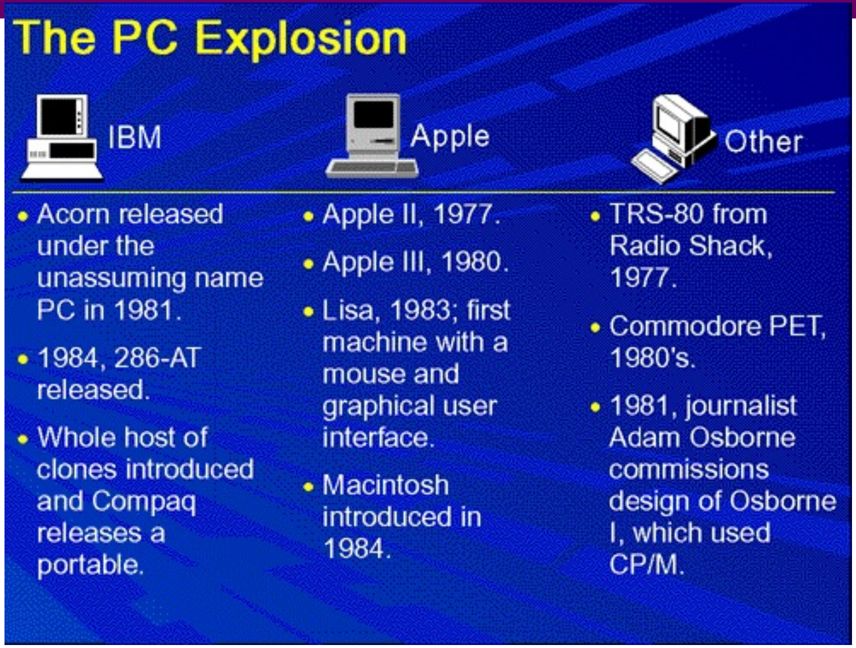
Evolution of Microprocessors

Year	71	74	78	82	85
Micro	4004	8080	8086	80286	80386
Bits	4	8	16	16	32
Transistors	2.300	8.000	29.000	134.000	278.000
Year	**89**	**93**	**97**	**99**	
Micro	80486	Pentium	Pentium II	Pentium III	
Bits	32	32	32	32	
Transistors	1.200.000	3.100.000	7.500.000	9.500.000	

Fifth Generation: Personal Computers



- Steve Jobs and Steve Wozniak exhibites the first **Apple II** for only $1298.
- IBM introduces the **IBM PC**. The PC was the first computer designed for the home market which would feature modular design so that pieces could easily be added to the architecture. The operating system (MSDOS) comes from **Microsoft**.
- By 1984, Apple released the first generation Macintosh, which was the first computer to come with a **Graphical User Interface(GUI)** and a mouse.

Sixth Generation: Supecomputing

http://www.top500.org

	MANUFACTURER/COMPUTER	LOCATION		RMAX (GFLOP/S)	PROCESSORS
1	IBM eServer Blue Gene Solution / BlueGene/L	Lawrence Livermore National Lab	USA	280600	131072
2	Cray XT3 Red Storm	Sandia National Lab	USA	101400	26544
3	IBM eServer Blue Gene Solution / BlueGene W	IBM Thomas J. Watson Research Center	USA	91290	40960
4	IBM eServer pSeries p5 575 / ASCI Purple	Lawrence Livermore National Lab	USA	75760	12208
5	IBM BladeCenter JS21 Cluster, PPC 970 w/Myrinet	Barcelona Supercomputer Center	Spain	62630	10240

Sixth Generation: Supecomputing

http://www.top500.org

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http://www.top500.org/

TOP500®

NOVEMBER 2008

PRESENTED BY

UNIVERSITY OF MANNHEIM — http://www.uni-mannheim.de/english/

ICL UT INNOVATIVE COMPUTING LABORATORY — http://icl.cs.utk.edu/

BERKELEY LAB — http://www.lbl.gov/

	MANUFACTURER/COMPUTER	LOCATION	COUNTRY	CORES	R_{max}
1	IBM BladeCenter QS22/LS21, PowerXCell 3.2 Ghz / Opteron 1.8 GHz , Voltaire Iband	DOE/NNSA/LANL	USA	129600	1105000
2	Cray XT5 QC 2.3 GHz	DOE/OS/ORNL	USA	150152	1059000
3	SGI Altix ICE 8200EX, Xeon QC 3.0/2.8 GHz	NASA/Ames Research Center/NAS	USA	51200	487000
4	IBM eServer Blue Gene Solution	DOE/NNSA/LLNL	USA	212992	478200
5	IBM Blue Gene/P Solution	DOE/OS/ANL	USA	163840	450300

Els SuperComputadors(Sexta Generació)

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TOP500® NOVEMBER 2010

	NAME/MANUFACTURER/COMPUTER	LOCATION	COUNTRY	CORES	R_{max} Pflop/s
1	**Tianhe-1A** NUDT 6-core Intel X5670 2.93 GHz + Nvidia M2050 GPU w/custom interconnect	NUDT/NSCC/Tianjin	China	186,368	2.57
2	**Jaguar** Cray XT-5 6-core AMD 2.6 GHz w/custom interconnect	DOE/SC/ORNL	USA	224,162	1.76
3	**Nebulae** Dawning TC3600 Blade Intel X5650 2.67 GHz, NVidia Tesla C2050 GPU w/ Iband	NSCS	China	120,640	1.27
4	**Tsubame 2.0** HP ProLiant SL390s G7 nodes (Xeon X5670 2.93GHz), NVIDIA Tesla M2050 GPU w/Iband	TITech	Japan	73,278	1.19
5	**Hopper** Cray XE-6 12-core AMD 2.1 GHz w/custom interconnect	DOE/SC/LBNL	USA	153,408	1.05

https://www.youtube.com/watch?feature=player_embedded&v=-P28LKWTzrI
https://www.youtube.com/watch?v=5OtXBeu0RKw

Els SuperComputadors(Sexta Generació)

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TOP500 NOVEMBER 2012

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FIND OUT MORE AT www.top500.org

	NAME	SPECS	SITE	COUNTRY	CORES	RMAX PFLOP/S	POWER MW
1	TITAN	Cray XK7, Operon 6274 16C 2.2 GHz + Nvidia Kepler GPU, Custom interconnect	DOE/OS/ORNL	USA	560,640	17.6	8.3
2	SEQUOIA	IBM BlueGene/Q, Power BQC 16C 1.60 GHz, Custom interconnect	DOE/NNSA/LLNL	USA	1,572,864	16.3	7.9
3	K COMPUTER	Fujitsu SPARC64 VIIIfx 2.0GHz, Custom interconnect	RIKEN AICS	Japan	705,024	10.5	12.7
4	MIRA	IBM BlueGene/Q, Power BQC 16C 1.60 GHz, Custom interconnect	DOE/OS/ANL	USA	786,432	8.16	3.95
5	JUQUEEN	IBM BlueGene/Q, Power BQC 16C 1.60 GHz, Custom interconnect	Forschungszentrum Jülich	Germany	393,216	4.14	1.97

- **Energy Consumption begins to be a challenge.**

TOP500 LIST - NOVEMBER 2014

TOP 500 The List.

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	NAME	SPECS	SITE	COUNTRY	CORES	RMAX PFLOP/S	POWER MW
1	Tianhe-2 (Milkyway-2)	NUDT, Intel Ivy Bridge (12C, 2.2 GHz) & Xeon Phi (57C, 1.1 GHz), Custom interconnect	NSCC Guangzhou	China	3,120,000	33.9	17.8
2	Titan	Cray XK7, Opteron 6274 (16C 2.2 GHz) + Nvidia Kepler GPU, Custom interconnect	DOE/SC/ORNL	USA	560,640	17.6	8.2
3	Sequoia	IBM BlueGene/Q, Power BQC (16C 1.60 GHz), Custom interconnect	DOE/NNSA/LLNL	USA	1,572,864	17.2	7.9
4	K computer	Fujitsu SPARC64 VIIIfx (8C, 2.0GHz), Custom interconnect	RIKEN AICS	Japan	705,024	10.5	12.7
5	Mira	IBM BlueGene/Q, Power BQC (16C, 1.60 GHz), Custom interconnect	DOE/SC/ANL	USA	786,432	8.59	3.95

TOP 500 – NOVEMBER 2018

TOP 500 The List.

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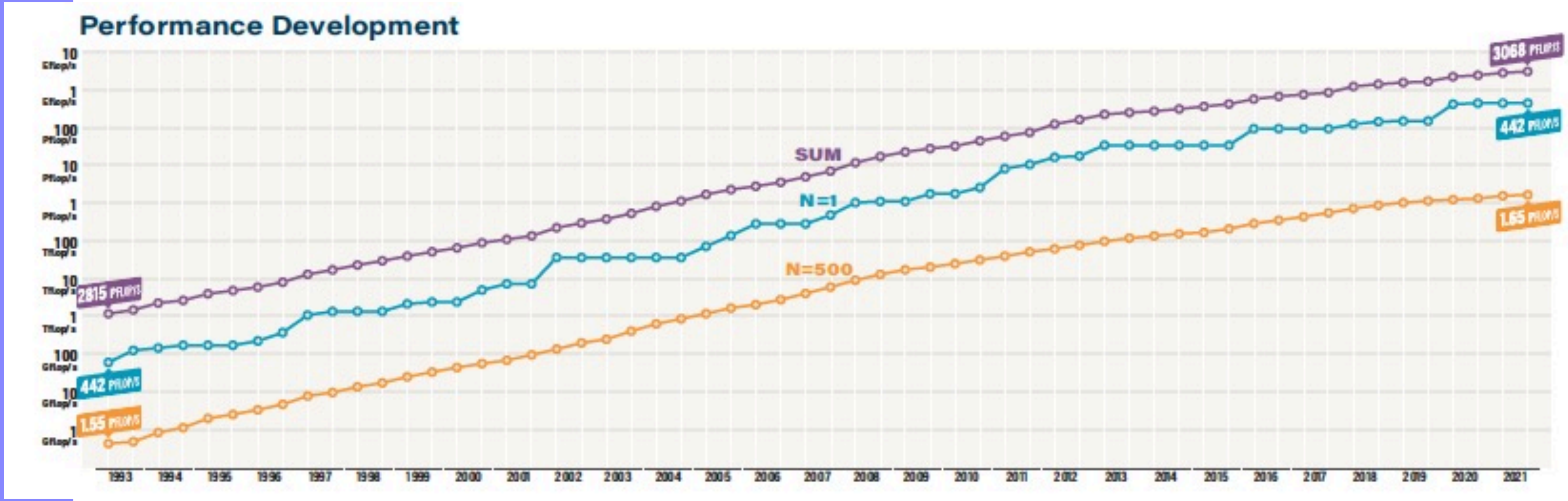
		SPECS	SITE	COUNTRY	CORES	RMAX PFLOP/S	POWER MW
1	Summit	IBM POWER9 (22C, 3.07GHz), NVIDIA Volta GV100 (80C), Dual-rail Mellanox EDR Infiniband	DOE/SC/ORNL	USA	2,282,544	143.5	11.1
2	Sierra	IBM POWER9 (22C, 3.1GHz), NVIDIA Tesla V100 (80C), Dual-rail Mellanox EDR Infiniband	DOE/NNSA/LLNL	USA	1,572,480	94.6	7.44
3	Sunway TaihuLight	Shenwei SW26010 (260C 1.45 GHz) Custom interconnect	NSCC in Wuxi	China	10,649,600	93.0	15.4
4	Tianhe-2A (Milkyway-2A)	Intel Ivy Bridge (12C 2.2 GHz) & TH Express-2, Matrix-2000	NSCC Guangzhou	China	4,981,760	61.4	18.5
5	Piz Daint	Cray XC50, Xeon E5-2690v3 (12C 2.6GHz), Aries interconnect , NVIDIA Tesla P100	CSCS	Switzerland	319,424	21.2	2.38

TOP 500 – NOVEMBER 2021

NOVEMBER 2021			SITE	COUNTRY	CORES	RMAX PFLOP/S	POWER MW
1	Fugaku	Fujitsu A64FX (48C, 2.2GHz), Tofu Interconnect D	RIKEN R-CCS	Japan	7,630,848	442.0	29.9
2	Summit	IBM POWER9 (22C, 3.07 GHz), NVIDIA Volta GV100 (80C), Dual-Rail Mellanox EDR Infiniband	DOE/SC/ORNL	USA	2,414,592	148.6	10.1
3	Sierra	IBM POWER9 (22C, 3.1GHz), NVIDIA Tesla V100 (80C), Dual-Rail Mellanox EDR Infiniband	DOE/NNSA/LLNL	USA	1,572,480	94.6	7.44
4	Sunway TaihuLight	Shenwei SW26010 (260C, 1.45 GHz) Custom Interconnect	NSCC in Wuxi	China	10,649,600	93.0	15.4
5	Perlmutter	HPE Cray EX235n, AMD EPYC 7763 64C 2.45GHz, NVIDIA A100 SXM4 40 GB, Slingshot-10 (274 GB)	LBNL	USA	761,856	70.9	2.58

Sixth Generation: Supecomputing



Sixth Generation: Supecomputing

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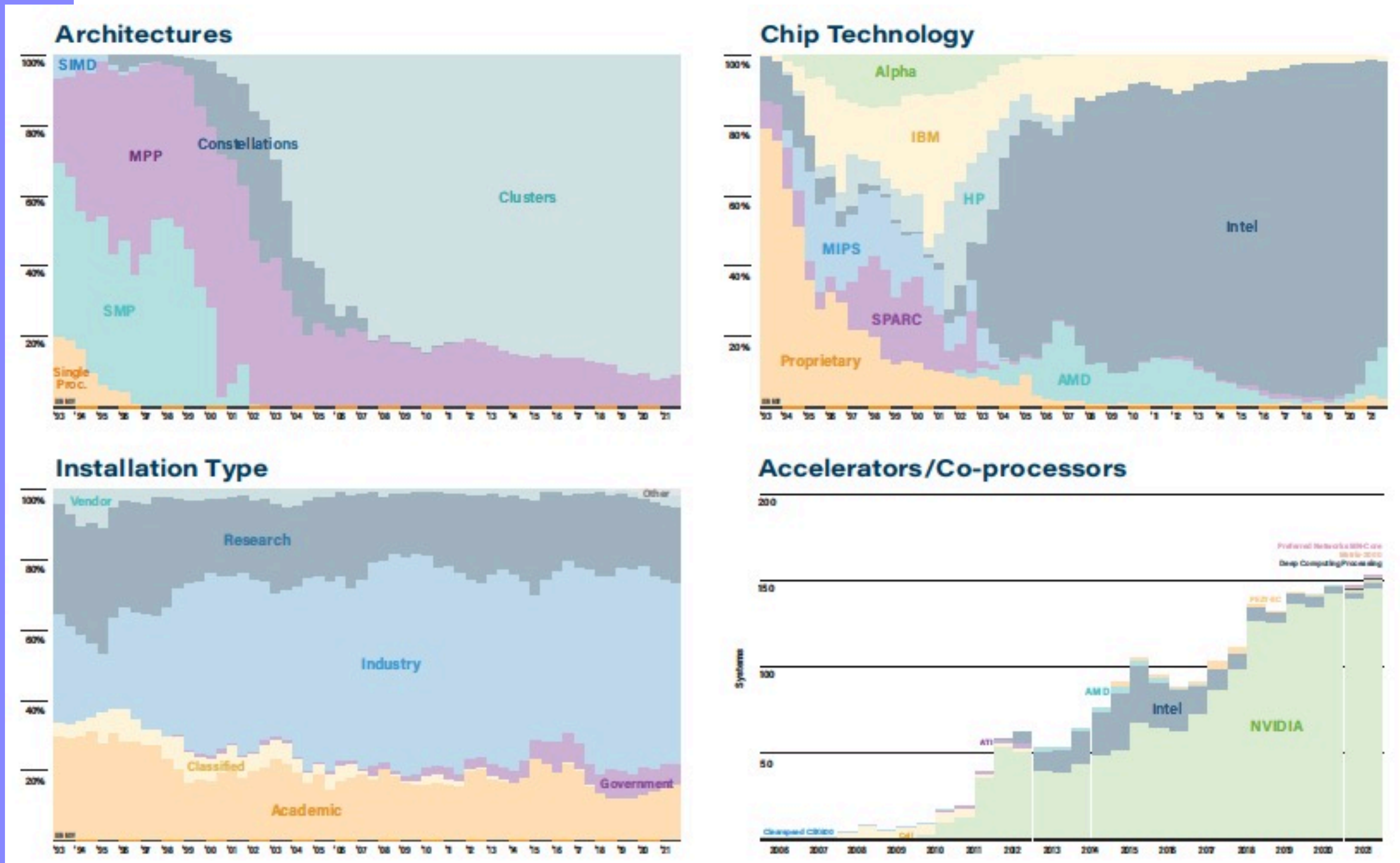

Sixth Generation: Supecomputing

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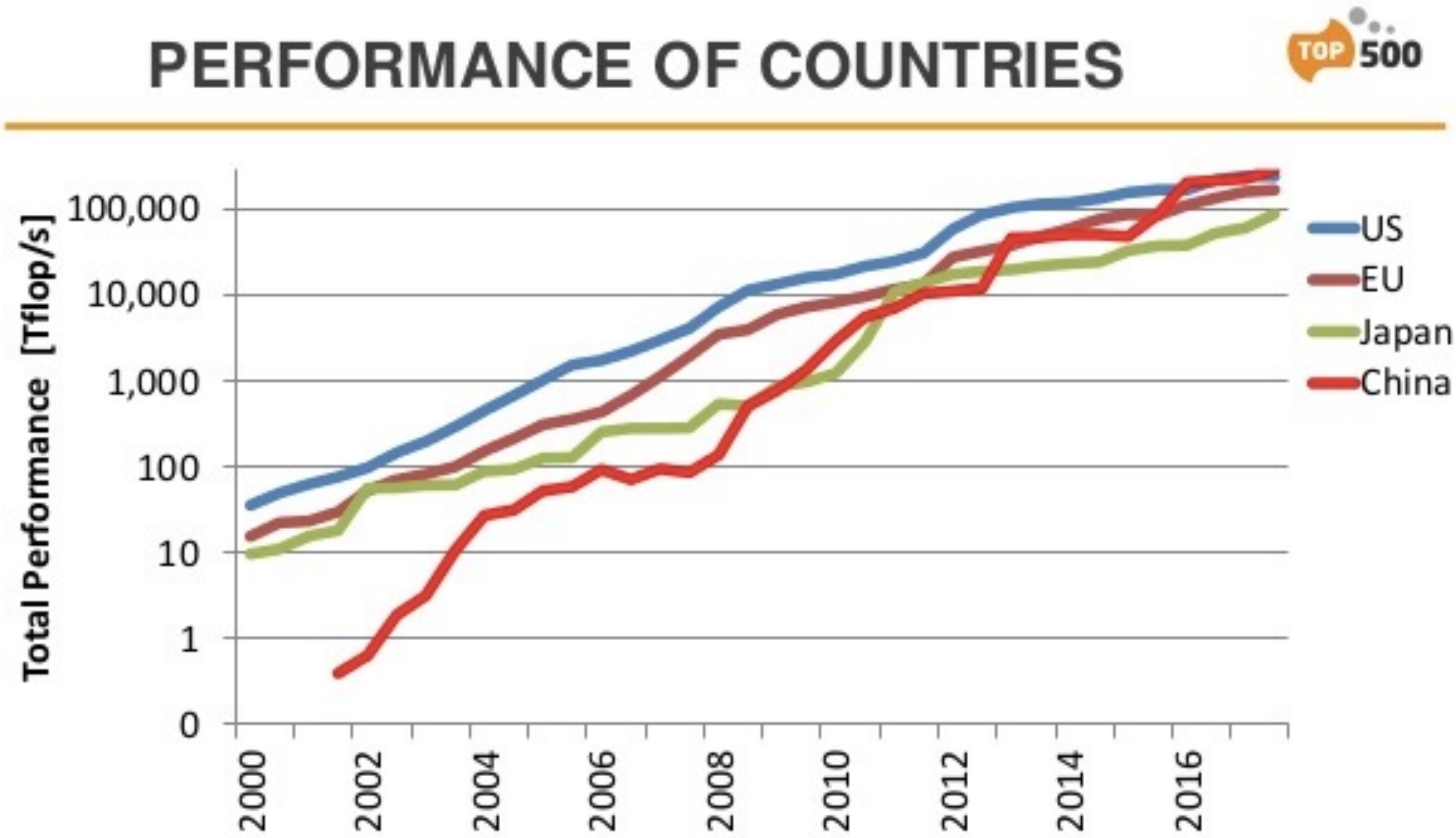

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Some Videos:

- Brief History of Computers:

http://www.youtube.com/watch?feature=player_detailpage&v=ETVAIcMXitk

- Computers Pioneers:

http://www.youtube.com/watch?feature=player_detailpage&v=qundvme1Tik

- History of Computers:

- http://www.computerhistory.org/timeline/?
- https://www.youtube.com/watch?v=LvKxJ3bQRKE

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Year	Computers	Performance	Technology (Mhz)
49	EDVAC	100 oper/s	0,5
51	UNIVAC I	1000 mult/s	
75	CRAY I	138 MFLOPS	80
88	CRAY Y (4 proc)	940 MFLOPS	160
90	IBM RS/6000	60 MFLOPS	30
90	CRAY C90 (16 proc)	16 GFLOPS	
91	CM-2 (65.536 proc)	14,2 GFLOPS	
93	POWER 2	286 MFLOPS	71,5
95	DEC ALPHA 21164	600 MFLOPS	300

FLOPS: FLoating Operations per Second

- Gain for Technology (GT):

1950 0,500Mhz

$GT=10^3$

1995 300Mhz

- Gain for Performance(GP):

Monoprocessors

1950 1000mul/s

$GP=6x10^5$

1995 600MFlops

Supercomputers

1950 1000mul/s

$GP=16x10^6$

1995 16GFlops

- GP>>>GT →Gain due to Architecture (Garq)=GP/GT

Monoprocessors: Garq=$6x10^2$

Supercomputers: Garq=$16x10^3$

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Gain by Architecture: The challenge is not how to build an integrated circuit capable of 1,000 million transistors, but how to use these devices in the most efficient way

Aims of the subject

The main objective of the course is to know how to exploit the huge performance provided by a distributed and parallel computer. So, We will

analyse and evaluate the performance achieved by parallel computers from a critical perspective and rigorous application of **benchmarking** tools. The second part of the course introduces the **parallel and distributed programming**. Finally, the main trends in **parallel computing** are analyzed.

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The assessment system and bibliography can be looked up into the virtual campus of the subject. http://cv.udl.es/portal

Bibliography

•**10 impactes de la ciència del segle XX**. Joaquim Pla editor, Editorial Eumo, pagines 167-171.