PEE-5793 Commercial Applications in High Performance Computing

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Lec-02
Top-500 Supercomputer Sites (06/99)
Jack Dongarra et Al.

http://www.netlib.org/benchmark/top500.html

1

Introduction and Objetives

Statistics on high-performance computers are of major interest to manufacturers, users, and potential users. These people wish to know not only the number of systems installed, but also the location of the various supercomputers within the high-performance computing community and the applications for which a computer system is being used.

Such statistics can facilitate the establishment of collaborations, the exchange of data and software, and provide a better understanding of the high-performance computer market.

New statistics are required that reflect the diversification of supercomputers, the enormous performance difference between low-end and high-end models, the increasing availability of **massively parallel processing (MPP) systems**, and the strong increase in computing power of **the high-end models of workstation suppliers (SMP).**

2

The Linpack Benchmark (1)

In the present list (which we call the TOP500), we list computers ranked by their performance on the **LINPACK Benchmark**.

As a yardstick of performance we are using the `best' performance as measured by the LINPACK Benchmark. LINPACK was chosen because it is widely used and performance numbers are available for almost all relevant systems.

The benchmark used in the LINPACK Benchmark is to solve a dense system of linear equations. For the TOP500, we used that version of the benchmark that allows the user to scale the size of the problem and to optimize the software in order to achieve the best performance for a given machine.

This performance does not reflect the overall performance of a given system, as no single number ever can. It does, however, reflect the performance of a dedicated system for solving a dense system of linear equations.

Since the problem is very regular, the performance achieved is quite high, and the performance numbers give a good correction of peak performance.

3

The Linpack Benchmark (2)

In an attempt to obtain uniformity across all computers in performance reporting, the algorithm used in solving the system of equations in the benchmark procedure must confirm to the standard operation count for LU factorization with partial pivoting.

In particular, the operation count for the algorithm must be 2/3 n^3 + O(n^2) floating point operations.
This excludes the use of a fast matrix multiply algorithm like ``Strassian's Method''

This is done to provide a comparable set of performance numbers across all computers. If in the future a more realistic metric finds widespread usage, so that numbers for all systems in question are available, we may convert to that performance measure.

4

The TOP500 List (1)

The following table shows the 500 most powerful commercially available computer systems known to us. To keep the list as compact as possible, we show only a part of our information here:

• Nworld -	Position within the TOP500 ranking
• Manufacturer -	Manufacturer or vendor
• **Computer -**	**Type indicated by manufacturer or vendor**
• **Installation Site -**	**Customer**
• Location -	Location and country
• Year -	Year of installation/last major update
• **Field of Application**	**Applications**
• **#Proc. -**	**Number of processors**
• Rmax -	Maximal LINPACK performance achieved
• Rpeak -	Theoretical peak performance
• Nmax -	Problemsize for achieving Rmax
• N1/2 -	Problem size for achieving half of Rmax

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The TOP500 List (2)

If Rmax from Table 3 of the LINPACK Report is not available, we use the TPP performance given in Table 1 of the LINPACK Report for solving a system of 1000 equations.

To use a consistent yardstick for all systems, we do not use results achieved by advanced parallel algorithm as defined in [Dongarra,94].

> Performance of Various Computers Using Standard Linear Equations Software. TR-CS-89-85-94, Univ. of Tennesse, U.S.A.

I case of the CRAY T90, C90 and J90 systems we had to use older table 3 or table 1 results.

In a few cases we interpolated between two measured system sizes or we scaled by cycle times.

For models where we did not receive the requested data, the performance of the next smaller system measured is used.

As the TOP500 should provide a basis for statistics on the market of high-performance computers, we limit the number of systems installed at vendor sites.

Examples: The first 10 in the Top-500 List

#	Manufacturer	Computer	Rmax	Installation Site	Country	Year	Area of Installation	# Proc	Rpeak	Nmax	N1/2
1	Intel	ASCI Red	2121.3	Sandia National Labs Albuquerque	USA	1999	Research	9472	3154	251904	66000
2	SGI	ASCI Blue Mountain	1608	Los Alamos National Laboratory	Los Alamos	USA	1998	Research	6144	3072	3744(
3	SGI	T3E1200	891.5	Government	USA	1998	Classified	1084	1300.8	259200	26400
4	Hitachi	SR8000/128	873.6	University of Tokyo	Tokyo	Japan	1999	Academic	128	1024	120000	16000
5	SGI	T3E900	815.1	Government	USA	1997	Classified	1324	1191.6	134400	26880
6	SGI	ORIGIN 2000 250 MHz	690.9	Los Alamos National Laboratory/ACL	Los Alamos	USA	1999	Research	2048	1(
7	SGI	T3E900	552.92	United Kingdom Meteorological Office	Bracknell	UK	1997	Research Weather	876	788.4	. .
8	IBM	SP Silver 547	IBM	Poughkeepsie	USA	1998	Vendor	Energy	1952	1296	244000	58000
9	SGI	T3E900	515.1	Naval Oceanographic Office (NAVOCEANO)	Bay Saint Louis	USA	1999	Research Weather	81
10	SGI	T3E1200	509.9	UK Centre for Science	Manchester	UK	1998	Academic	612	734.4	. .

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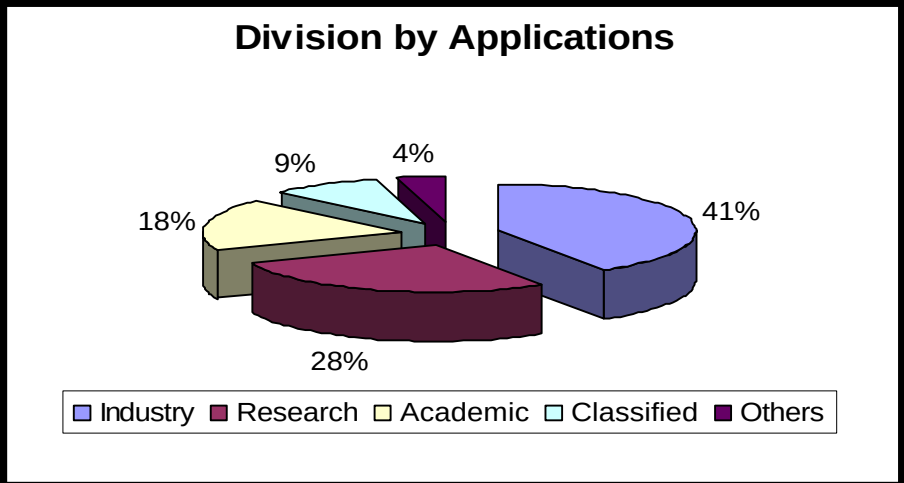
Data Analysis of Top500 (Nov-1998)

Industry	Research	Academic	Classified	Others
206	*138*	*91*	*46*	*19*



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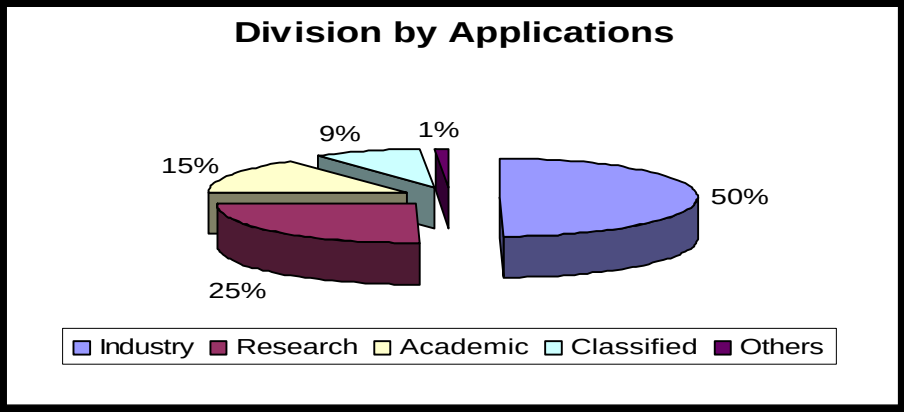
Industrial Sector using HPC

Ano	Industry	Research	Academic	Classified	Others
96	136 (20)	159 (32)	138 (31)	50 (10)	17 (3)
97	156 (31)	177 (35)	118 (24)	26 (5)	23 (5)
98	206 (41)	*138 (28)*	*91 (18)*	*46 (9)*	*19* (4)
99	241 (50)	123 (25)	71 (15)	44 (9)	05 (1)



1999

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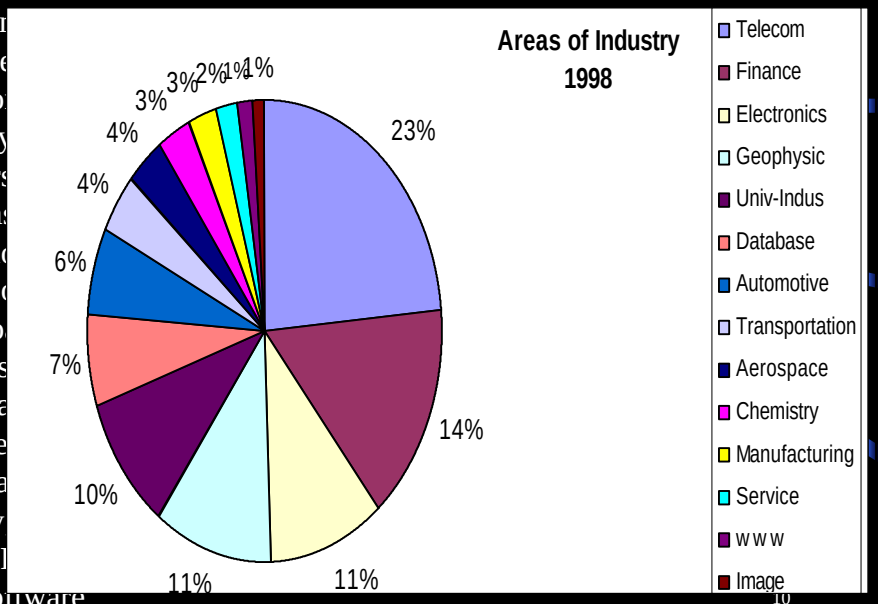
Division of Industrial Applications (1998)

1. Telecor
2. Finance
3. Electro
4. Geophy
5. Univers
6. Databas
7. Automo
8. Transp
9. Aerosp
10. Chemis
11. Manufa
12. Service
13. Pharma
    Energy
14. Image
Media, Software



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Exemplos de Empresas/Industrias Usando HPC

1. Tele 22.8% BCT - British Columbia Telec., Deutsche Telekom AG, Korean Tel., NTT - Nippon Telegraph and Telephone, ATT CFO, Bell Canada, GTE Comm., O-tel-o, Sprint, GTE Comm., France Telecom, Telcel, Viag Interkom, Cincinnati Bell Information Systems (CBIS), Telecom Denmark, MCI, Ameritech, Worldcom, US West Comm.,

2. Fina 14.5% Charles Schwab, Chase Manhattan, Commerzbank, Deutsche Morgan Grenfell, Prudential Insurance, SMVG, KPMG Peat Marwick, Financial Corporation, American Express, Bear Stearns, Dresdner Bank, National Reserve Bank (Moscow), Citicorp, NatWest Markets, Toronto Stock Exchange, Union Bank of Switzerland,

3. Elec 10.2% Chip Manufacturer, Philips Research, Motorola, Lincoln Electric, Samsung, Texas Instruments, Raytheon, FDK Corporation, Micron Technology, E-Systems & Raytheon, Toshiba, Cisco, Lucent Technologies,

4. Geop 10.2% Exxon, P-Petroleum Company, Baker Hughes, Vastar, EP Company, Western Geophysical, Veritas DGC, Ensign, Mobil, Texaco,

5. Univ 09.2% KIST, Universities, Thyssen, ICAM-Alcatel, UKI IS, Montgomery Ward, Origin IT, ATAC, Xerox, Miele GmbH, Moodys,

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6. Data 06.3% State Farm, Oracle Corporation, IBM, Sears, Allstate Insurance, Daiei Information, Kwuiksave, W.W.Grainger, American Express, Krupp Hoesch Info., Federal Express

7. Auto 05.8% Toyota Central Researh Development, Audi AG, TRW, Automotive Manufacturing, EDS/General Motors, BMW, Ford Motor Company, Nissan Motor,

8. Trans 4.0% Deutsche Bahn AG, Lufthansa, American Airlines, EDS de Mexico, Emery Worldwide, Sabre Group, Delta Airlines,

9. Aero 3.4% CSC, Lockheed Martin, Hughes Space Communication,

10.Chem 2.9% BASF, Owens Corning, Bayer AG, Witco, Osaka Gas. Ltd.,

11.Manu 2.4% Allied Signal Federal, Kawasaki Heavy Industrie, Medline Industries, Becton Dickinson,

12.Serv 1.9% Lexis Nexis, Sylvest Management Systems, R.L. Polk, RAG Informatik,

13.Phar 1.4% NRC (Nichols Research Corp.) Vertex Pharm., Government, Eli Lilly and Company, Recruit (www), eBAY (www), Tennessee Valley Authority (NTA)-energy, Bristol-Myers Squibb, Enron Capital (energy),

Energy, Defense, WWW

14.Imag. 1.0% SAP, HTC, MediaOne, Media, Software

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	98	99
	41%	49%
1. Telecomm	23	16
2. Finance	14	14
3. Electronics	11	6.6
4. Geophysics	11	6.2
5. Univ.-Indus	10	28
6. Database	7.0	5.4
7. Automotive	6.0	9.5
8. Transportation	4.0	2.5
9. Aerospace	4.0	2.5
10.Chemistry	3.0	3.0
11.Manufacturing	3.0	1.0
12.Service	2.0	2.5
13.Pharmaceutics	1.0	1.7
Energy, Defense, WWW		
14.Image Processing	1.0	1.5
Media, Software		

Industry 1998 & 1999

Total, HPC no setor industrial aumentou em 7% (em seis meses)

Diminuiu

Aumentou

Manteve

Novos setores interesse

Univ-Industry
Automotive
Service
Pharmaceutics & Energy
Image Processing, Media

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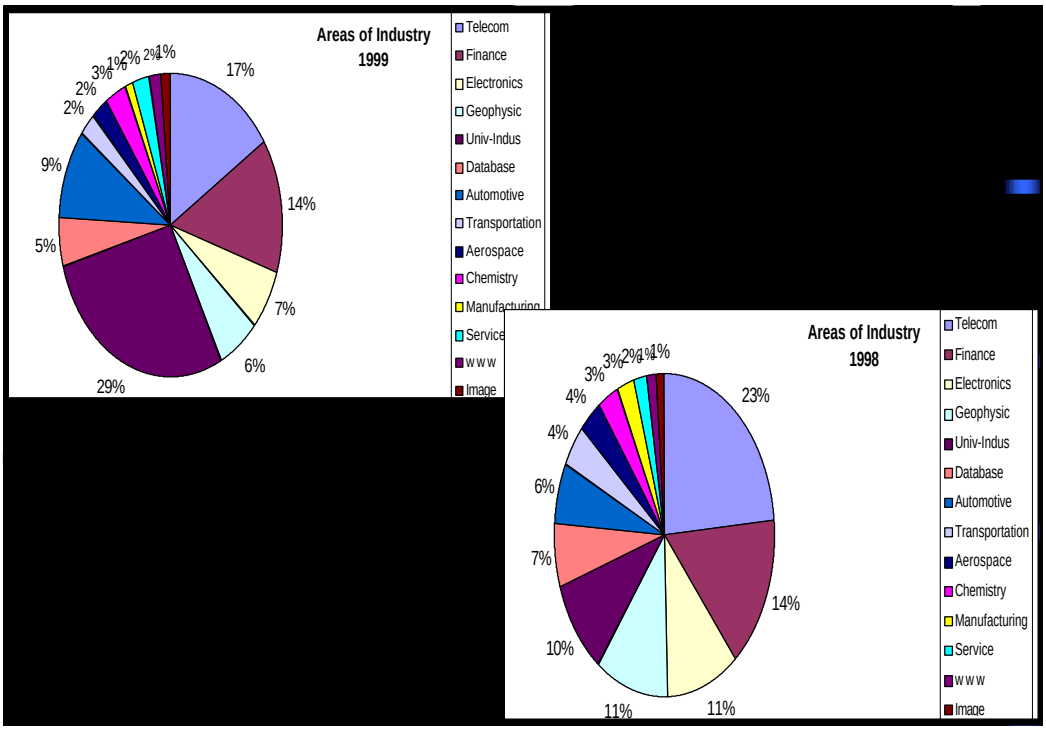

	1998	1999	USA	Europe	Japan	Others
1. Telecomm	**23**	**16**	31	10	4	2
2. Finance	14	14	11	16	2	1
3. Electronics	**11**	**6.6**	**17**	**1**	**2**	**1**
4. Geophysics	11	6.2	16	5		
5. Univ.-Indus	**10**	**28**	**08**	**10**		**1**
6. Database	**7.0**	**5.4**	**8**	**3**	**2**	
7. Automotive	**6.0**	**9.5**	**3**	**2**	**6**	
8. Transportation	4.0	2.5	5	2		1
9. Aerospace	4.0	2.5	6	1		
10.Chemistry	3.0	3.0	3	2	1	
11.Manufacturing	3.0	1.0	3		2	
12.Service	**2.0**	**2.5**	**3**	**1**		
13.Pharmaceutics	**1.0**	**1.7**	**10**			
Energy, Defense, WWW						
14.Image Processing	**1.0**	**1.5**	**2**	**1**		
Media, Software						

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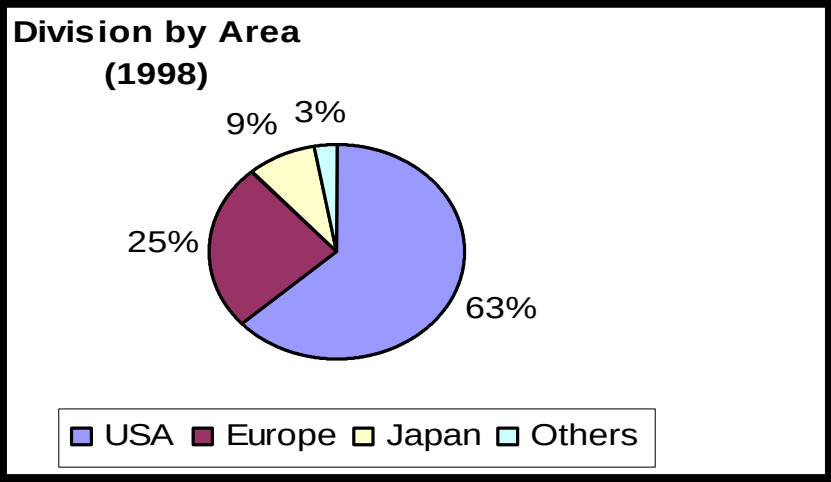
Industry by area (1998)



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Companies & Industry

	1998	SGI	IBM	SUN	NEC	HP	FUJ	HI
1. Telecomm	**23**	**1**	**18**	**29**				
2. Finance	14	2	7	22				
3. Electronics	**11**	**6**	**6**	**7**		**1**	**1**	
4. Geophysics	11	8	9	2	1			
5. Univ.-Indus	**10**	**4**	**13**	**2**				
6. Database	**7.0**	**1**	**3**	**9**				
7. Automotive	**6.0**	**8**	**1**		**1**		**1**	
8. Transportation	4.0		1	7				
9. Aerospace	4.0	5		2				
10.Chemistry	3.0		3	2			1	
11.Manufacturing	3.0	1	1	3				
12.Service	**2.0**	**1**		**3**				
13.Pharmaceutics	**1.0**	**3**	**1**	**6**				
Energy, Defense, WWW								
14.Image Processing	**1.0**		**1**	**1**		**1**		
Media, Software								

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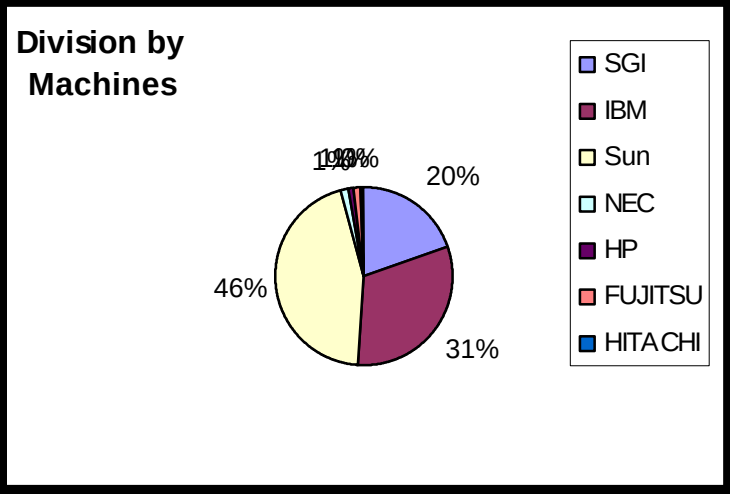
Industry by Machines



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Machines

SGI	T3E1200/900 T3D-MC-512 SGI-Origin-2000
IBM	ASCI-Blue-Mountain SP-P2SC SP-PC604
SUN	HPC-10000
NEC	SX-4/128M4 SX-4/128H4
HP	Exemplar X-Class
FUJITSU	Numerical-Wind-Tunnel VPP700
HITACHI	CP-PACS/2048 SR2201/1024
INTEL	ASCI-Red XP/S140

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Research Sector using HPC

Ano	Industry	Research	Academic	Classified	Others
96	136 (20)	159 (32)	138 (31)	50 (10)	17 (3)
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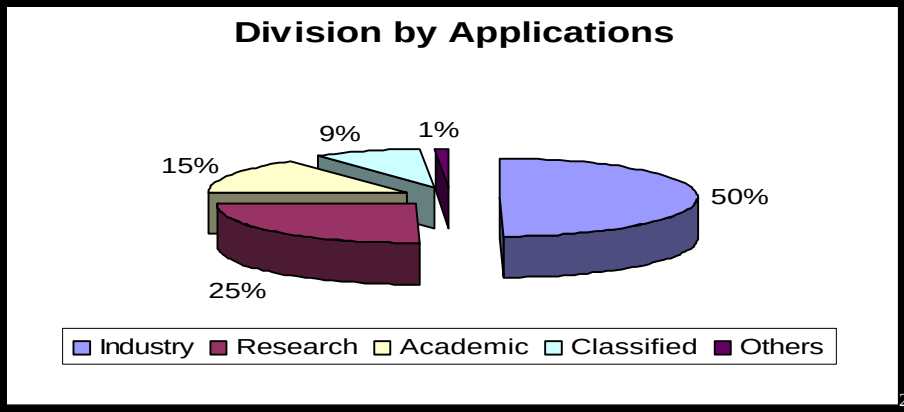

1999

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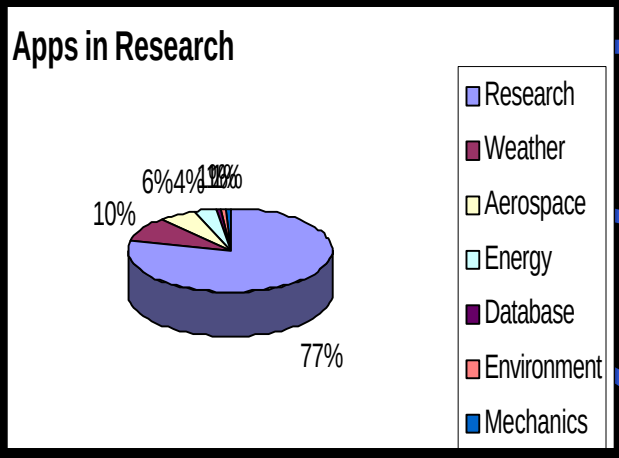
Division of Research's Applications (1998)

	138 of 500	28%
1.	Research	108
2.	Weather	14
3.	Aerospace	08
4.	Energy	05
5.	Database	01
6.	Environment	01
7.	Mechanics	01



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Research 1998 & 1999

	98	99
	28%	25%
1. Research	108	92
2. Weather	14	15
3. Aerospace	08	09
4. Energy	05	04
5. Database	01	01
6. Environment	01	01
7. Mechanics	01	01

Total, HPC no setor industrial aumentou em 7% (em seis meses)

Diminuiu

Aumentou

Manteve

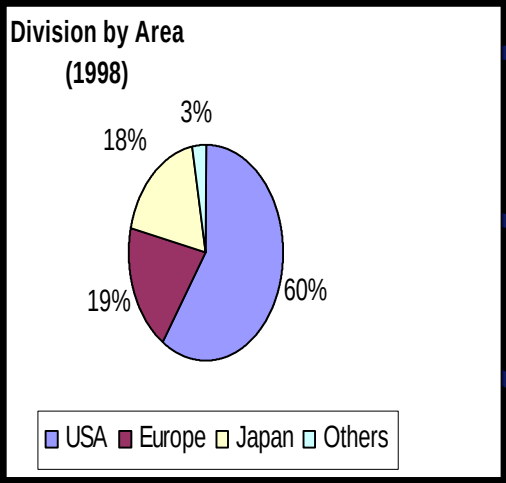
Novos setores interesse

Weather
Database
Environment
Mechanics

23

Research by Area

138 of 500	98	99
1. Research	108	92
2. Weather	14	15
3. Aerospace	08	09
4. Energy	05	04
5. Database	01	01
6. Environment	01	01
7. Mechanics	01	01



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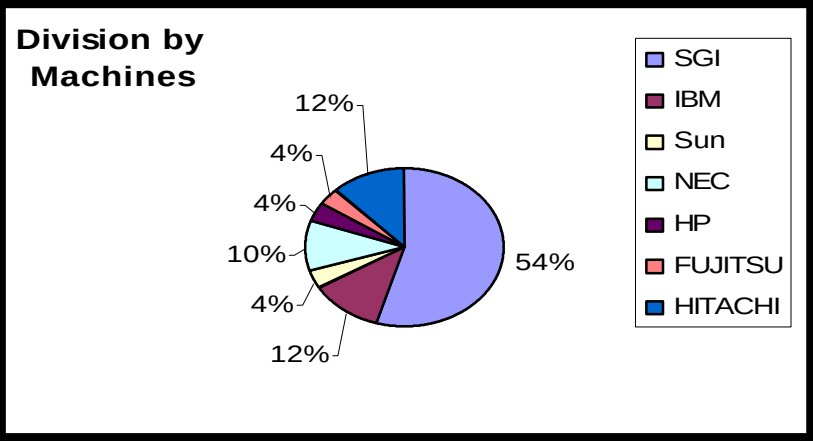
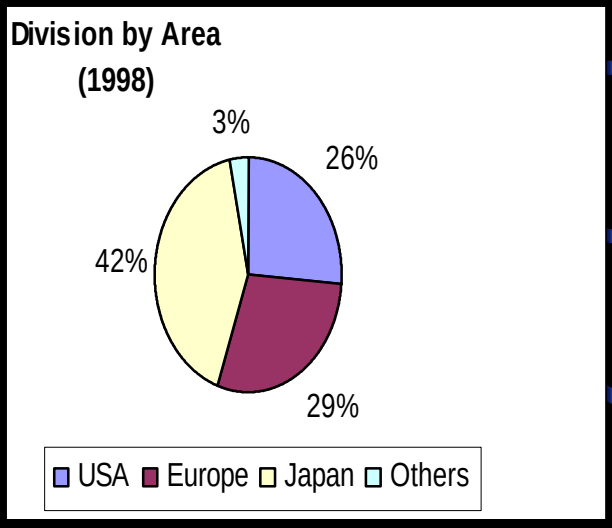
Research & Companies (1998)



25

Academic & HPC (area)

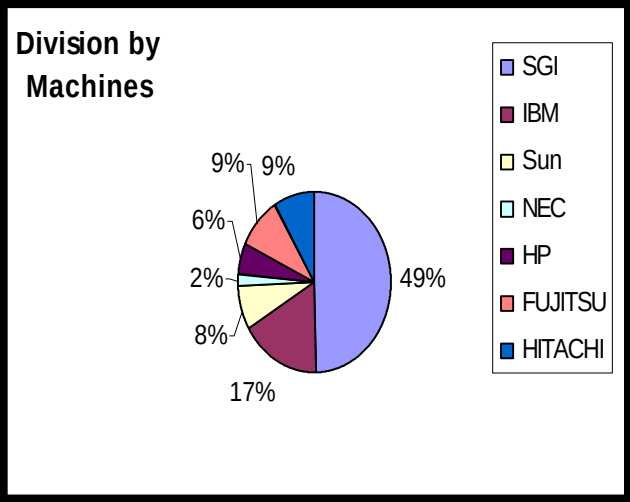
1998: 18.2%
1999: 14.2%



26

Academic & HPC (Companies)

1998: 18.2%
1999: 14.2%



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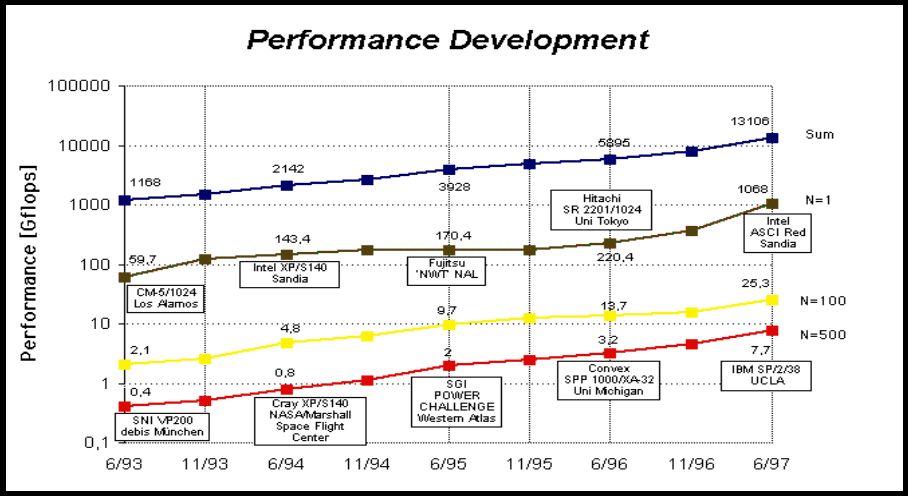
Data Information (1997)

28

Performance & Development 1997



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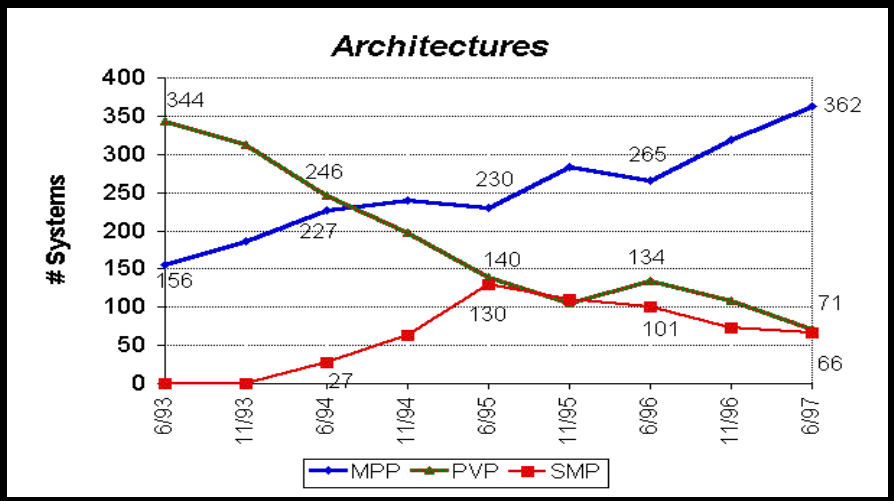
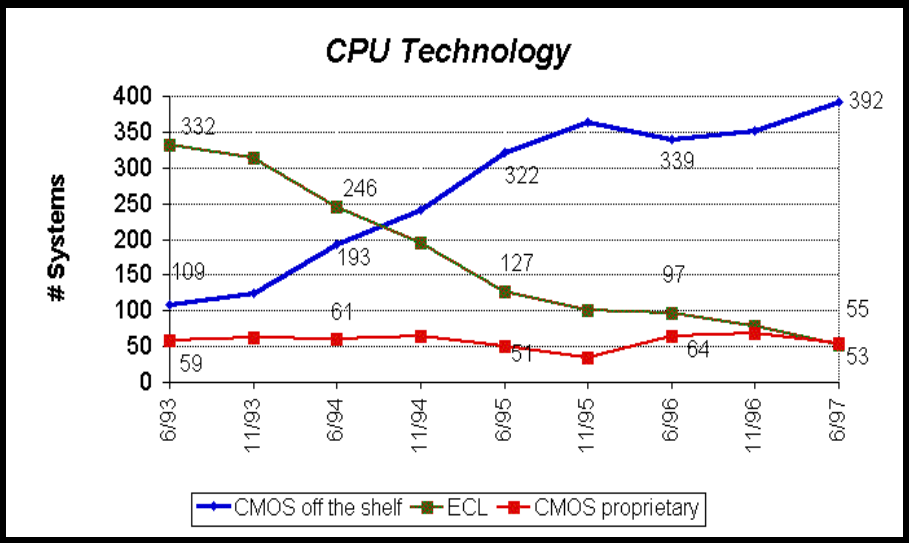
Architectures & Systems (1997)



30

CPU Technology & Systems(1997)



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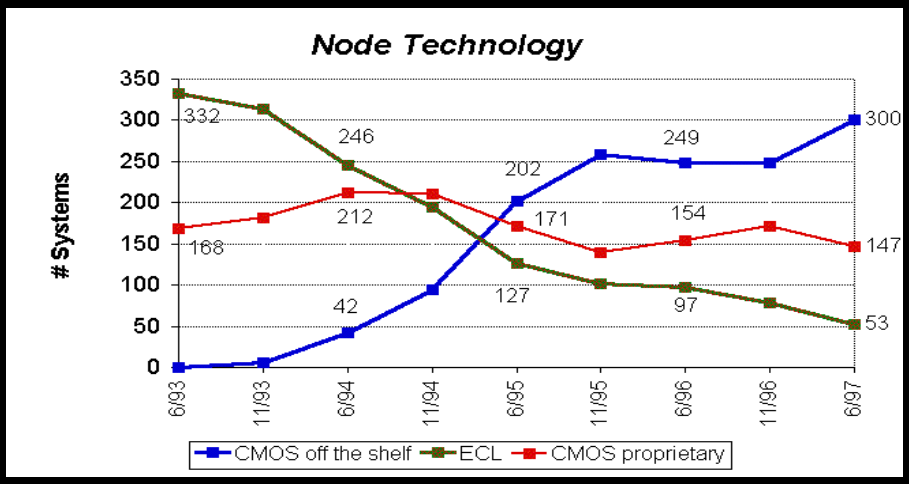
Node technology & Systems(1997)



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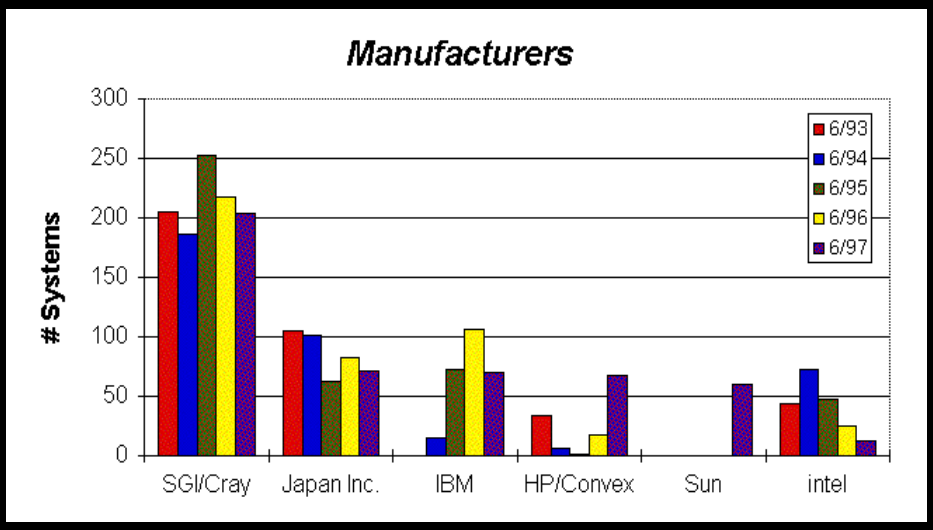
Manufactures & Systems (1997)



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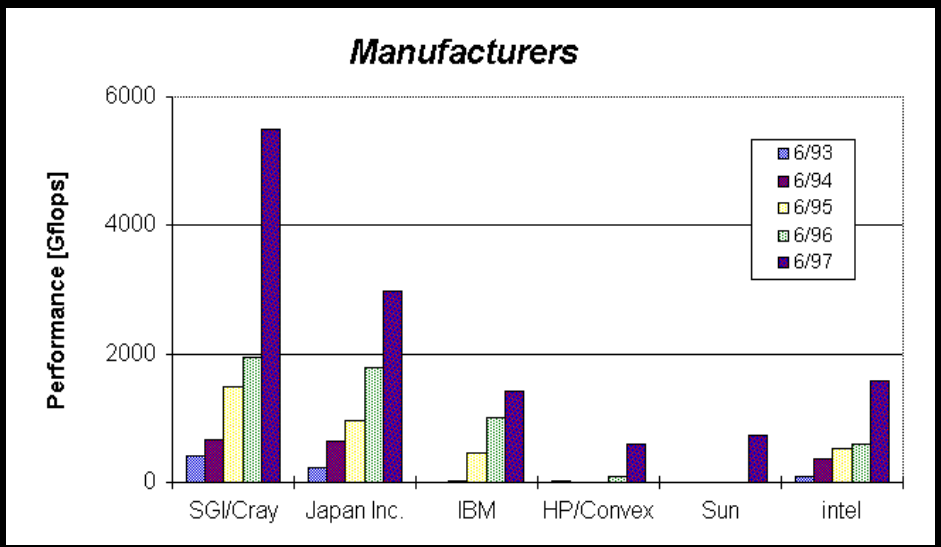
Manufactures & Performance (1997)



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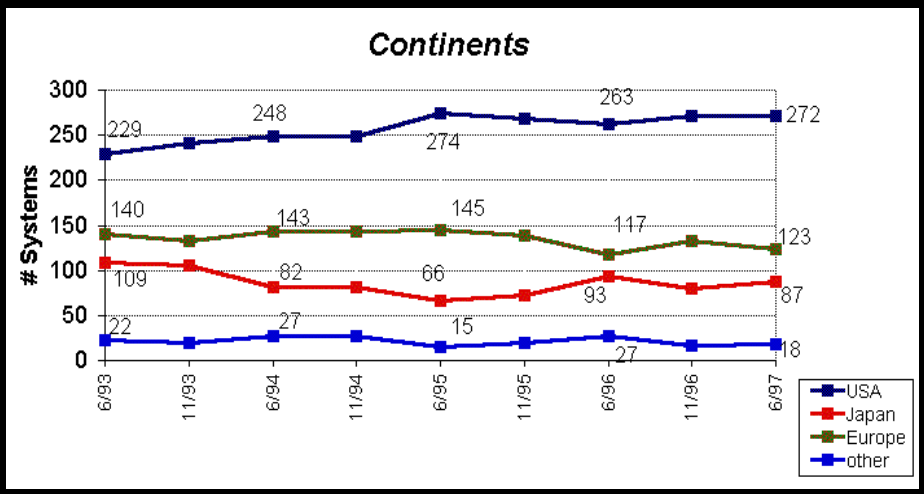
Continents & Systems (1997)



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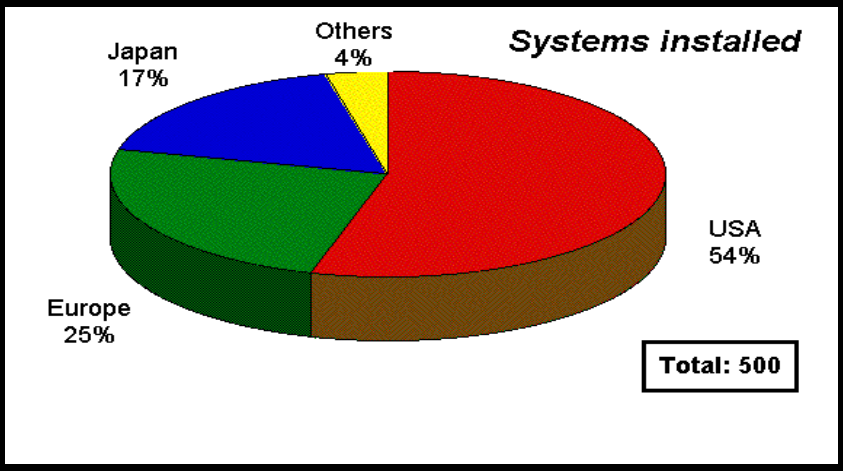
Systems Installed (1997)



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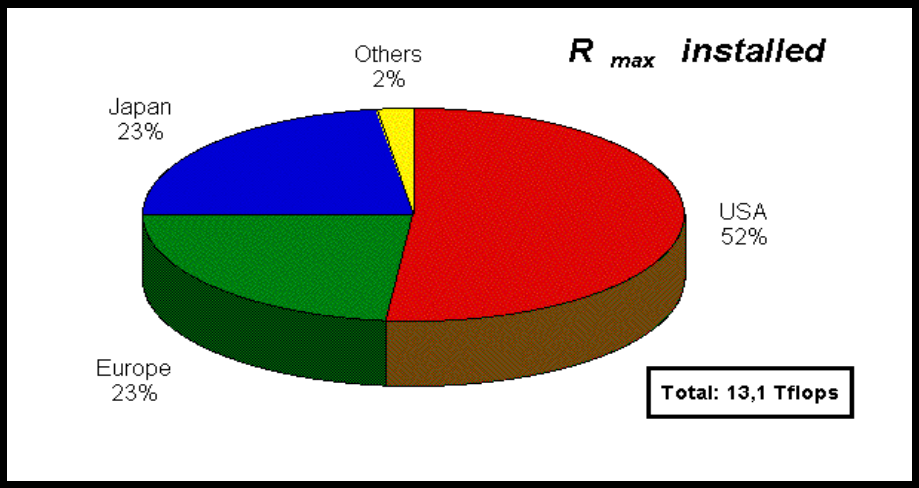
R max Installed (1997)



1999:
57.69 Tflops (Rpeak) & 39.10 Tflops (Rmax)

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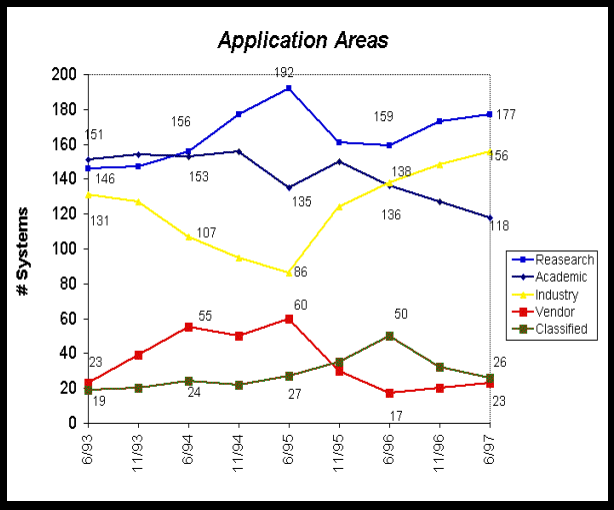
Applications areas & Systems (1997)



	98	99
R:	138	123
I:	206	241
A:	91	71
C:	46	44
O:	19	5

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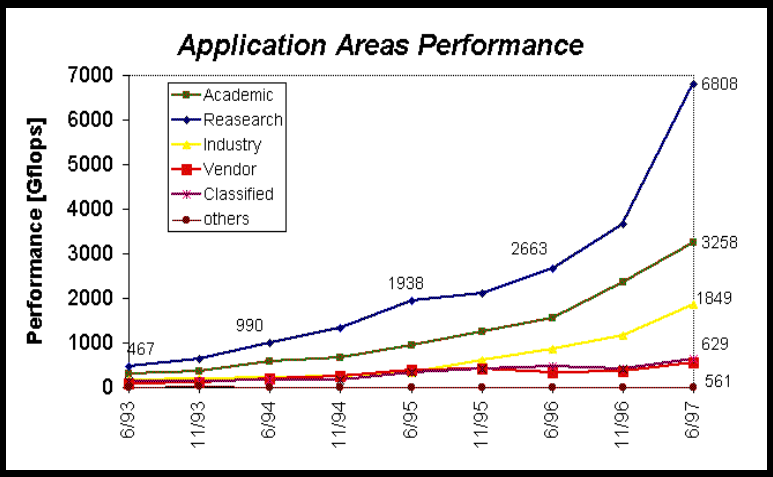
Application Areas & Performance (1997)



98 99

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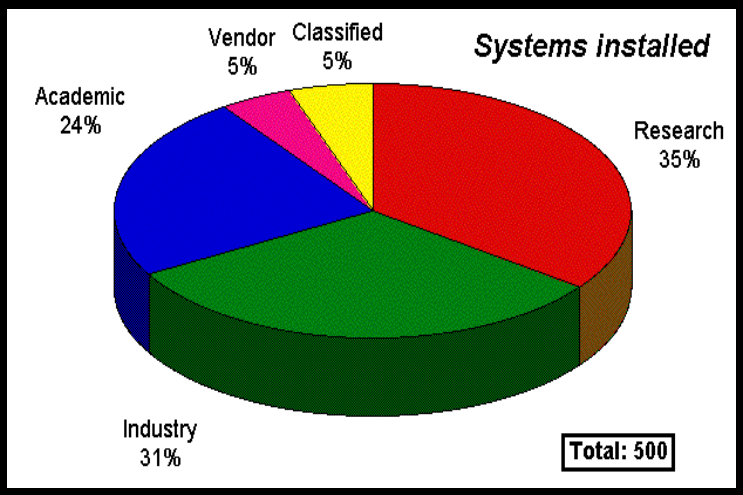
39

Systems Installed (1997)



	98	99
R:	138	123
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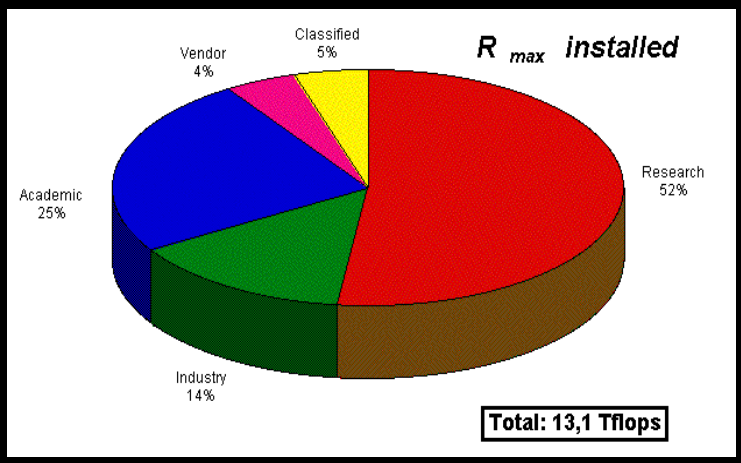
40

Rmax Installed (1997)



1998 1999

?????

??????

????

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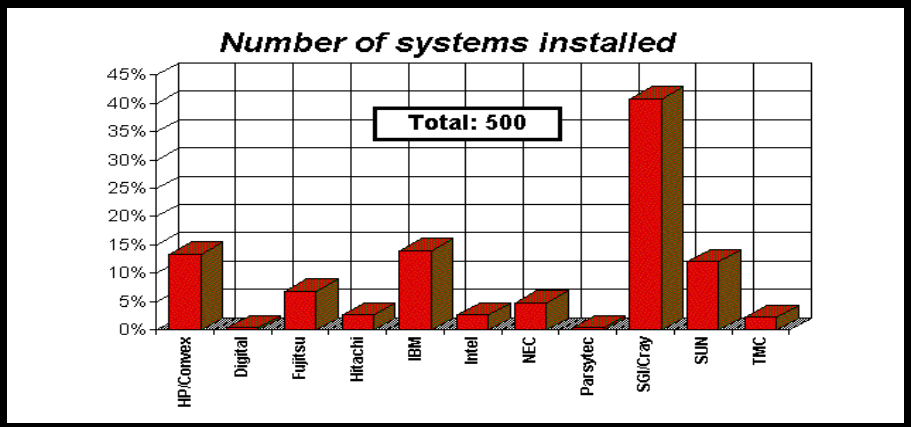
Number of Systems Installed (1997)



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•The architectures installed at industrial sites changed from vector systems to a substantial number of MPP systems. This change reflects the fact that parallel systems are ready for commercial use and environments.

•The most successful companies (IBM and SGI) are selling well to industrial customers. Their success is built on the fact that they are using standard workstation technologies for their MPP nodes. This approach provides a smooth migration path for applications from workstations up to parallel machines.

•The maturity of these advanced systems and the availability of key applications for them make the systems appealing to commercial customers. Especially important are database applications, since these can use highly parallel systems with more than 128 processors.

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In 1996,
the applications typically were numerically intensive applications,
for example,

•automotive applications,
•aerospace studies,
•chemical and pharmaceutical studies,
•electronics,
•energy research,
•geophysics and oil applications, and
•weather prediction.

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Recently, however, industrial systems in the TOP500 have been used for new application areas.

These include

•database applications,
•finance applications,
•image processing, and
•WWW servers.

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From the present ten releases of the TOP500 we see the following trends:

•The number of industrial customers in the TOP500 has risen steadily since June 1995.

•The most successful companies (IBM and SGI) are selling disproportionately well in the industrial market.

•The average system size at industrial sites is increasing strongly.

•Database applications are the most important and most successful new application area for supercomputers.

•Distributed-memory systems are being installed at industrial sites in reasonable numbers.

•The United States is the clear world leader in the industrial use of HPC systems.

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Therefore:

The strong increase in the number of processors in systems at industrial sites is another major reason for the rise of industrial sites in TOP500.

The industry is ready to use bigger parallel systems than in the past.

Then, Commercial and Industrial Applications are a good and Interesting area to work
(MONEY ??? Knowledge ++++ Books & Papers +++++

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