TOP500 Report
1993

TOP500 REPORT 1993

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Preface

The Aims

This report is a snapshot of the state of supercomputer installations in the world. It is based on the TOP500 list that was first published in June 1993 and is updated twice a year (June and November).

Statistics on high-performance computers are of major interest to manufacturers; users or potential users; and decision makers in universities, government, and industry. These people wish to know not only the number of systems installed, but also the locations of the various supercomputers within the high-performance computing community, and the applications for which a computer system is used. Such statistics provide a better understanding of the high-performance market and can facilitate the exchange of data and software.

In the past, several different system counts of the major vector computer manufacturers by continents and countries have been published. Such records have several limitations, however. The data was difficult to obtain, and often was not reliable. Most important, more extensive statistics (than simply a list of manufacturers' names) are now required because of 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.

This report is meant as an interface between the TOP500 list and the reader who wishes more background information and explanation. Here various experts present detailed analyses of the TOP500 and discuss the changes that have occurred in the supercomputing market over the past year.

We plan to update this report annually and to distribute it widely to the high-performance computing community.

The Contents

This report consists of nine chapters. Chapter 1 presents an overview of the supercomputer statistics of the past, including the "Mannheim Supercomputer Statistics". Chapter 2 is a complete reprint of the technical report RUM 34/93 on "TOP500 Supercomputer Sites" as of November 1993, which provides the basis of this report. Chapter 3 discusses different performance measures and benchmark efforts; the measure R_{max} chosen for our TOP500 is covered in detail, and the different performance figures shown in the TOP500 are sorted. Chapter 4 deals with the "Supercomputer Architectures in the TOP500". We group the 103 different models in the TOP500 list in 30 families, and then discuss the main architectural and technological features of these families.

After these four preparatory chapters, we present in Chapters 5 through 9 a detailed analysis of the high-performance computing situation as of November 1993. Chapter 5 starts with an overall examination of the "Worldwide Supercomputer Situation"; Chapter 6 focuses on "High Performance Computing in the United States"; Chapter 7 treats the present situation of "Supercomputing in Japan"; and Chapter 8 analyzes the situation of "High Performance Computing in Europe", with special emphasis on Germany, the UK, France, and the Benelux nations. Additionally, Chapters 6 through 8 include sublists of the TOP500 for special countries. Chapter 9 concludes this report with an in-depth discussion of "The TOP25 Supercomputer Centers in the World".

Lists of all tables, figures, and TOP500 sublists, as well as the reprint of the first "TOP500 Supercomputer Sites" as of June 1993 are included in the Appendix.

The Audience

The report has been prepared for the high-performance computing community in general, and specifically for managers of supercomputer centers, users of supercomputers, computer/supercomputer manufacturers, consultants, professional market analysts, decision makers, politicians, Wall Street analysts, computer science people, and students.

Acknowledgement

Without the help of high-performance experts, computational scientists, manufacturers, and the Internet community, our TOP500—the basis of this report—could not have been compiled. We cordially thank all colleagues supporting us, and we ask for their continued support in order to present future TOP500 lists and reports like the one presented here.

Mannheim / Tennessee, May 26, 1994

Jack J. Dongarra • Hans-Werner Meuer • Erich Strohmaier

Contents

1

The Mannheim Supercomputer Statistics 1986–1992

Hans-Werner Meuer

Abstract

Every year since 1986 the author published statistics on the supercomputer market at the Mannheim Supercomputer Seminar [1]. The statistics were primarily based on system counts of the major vector computer manufacturers. All the data used in these statistics from 1986–1992 had been given to us mainly by the manufacturers who provided us with information on their systems installed in the different continents/countries. While this data could be checked in Europe, and also in the US without difficulties, at least as far as the non-classified installations were concerned, we had no real chance to check this data in Japan. So we compared the data given by e.g. Hitachi for Hitachi, NEC, Fujitsu with the ones given by NEC for NEC, Hitachi, Fujitsu, etc. and builduing an appropriate average. Of course, the Japanese manufacturers were allowed to name not only their top end models but also their entry level sytems since we also had some Cray 1's in our statistics for a long time.

In this paper an overview on these statistics with respect to manufacturers and continents with special emphasis on the situation in Germany is given.

1.1 Overall Development

When we started our statistics in 1986, just 187 supercomputers had been installed worldwide: Cray 1, Cray XMP, Cray 2, CDC Cyber 205, Hitachi S-810, Fujitsu VP50/100/200, NEC SX2. More than half of them (53%) could be found in USA/Canada, 19% in Japan, 23% in Europe, i.e. 8% in France, resp. Great Britain and Germany 7% alone (Fig. 1.1).

Cray Research was, at this time, already the market leader with 63% of all supercomputers installed worldwide and far ahead of CDC and Fujitsu with 16% each, Hitachi with 4% and NEC with 1% (Fig. 1.2). While in 1986 Fujitsu already had a well established co-operation with Amdahl and Siemens (SAG) in order to export their supercomputers, Hitachi's operations were bound to Japan only.

Six years later, in 1992, the situation had changed tremendously as follows (Fig. 1.3): 530 vector computers had been installed worldwide, but now Japan with 41% was ahead of USA/Canada with 33% and Europe with 22%. Germany with 33% of the European portion had taken over the lead in Europe, followed by France with 25% and Great Britain with 19%.

The worldwide dominance of Japan was agreed upon at this time more or less by all experts in the field, but 1993 our first TOP500 showed [2]—to our greatest surprise—the USA far ahead in supercomputers.

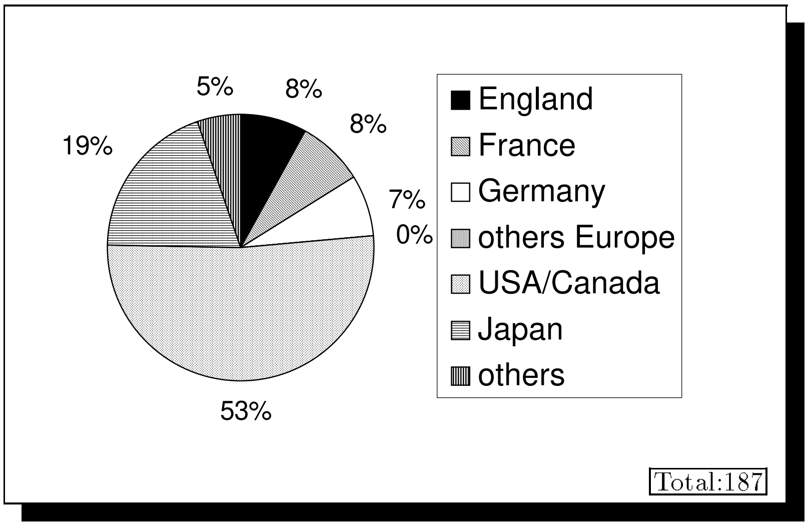


Figure 1.1:
Statistics 1986
— countries —

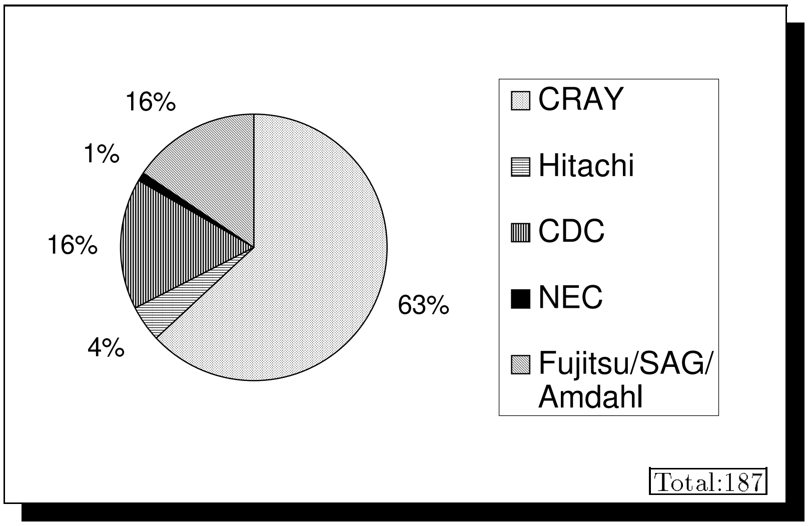


Figure 1.2:
Statistics 1986
— manufacturers —
(SAG means Siemens AG)

What was the reason for this discrepancy between the 1992 and 1993 results? As we expected when making up our minds to start with the TOP500 idea the smaller entry level systems of the Japanese manufacturers (e.g. Fujitsu VP30, VP50) installed especially in Japan had been overestimated always in the past, especially in the mid eighties until the beginning of the nineties. Only when the TOP500 list was established it proved the discrepancy.

The dominating role of Cray Research was preserved anyhow with 57% of all vector processor installations worldwide in 1992, ahead of Fujitsu with 27%, NEC 8% and Hitachi 8% (Fig. 1.4). Only 4 vector computer manufacturers were represented in the 1992 market: Cray Research, and Japan Inc. (Fujitsu, NEC and Hitachi). While Hitachi, as already in 1986, was operating in Japan only, NEC faced a lot of problems in the market outside of Japan since marketing and sales are mainly done by themselves. Fujitsu's success in Europe and especially in Germany originated in their strong cooperation with Siemens Nixdorf (SNI), which started early in the eighties.

The 1992 supercomputer market was no longer a vector computer market so to say: The market leader in parallel computers, the US manufacturer Thinking Machines was already represented worldwide with 86 systems installed, mainly with their very successful SIMD machine CM2.

The upcoming MPP vendors, the problem with the entry level models of the vector computer vendors and the powerful 'mini supercomputers' (e.g. C3 series of Convex) have been the main reasons to change the basis of our statistics, thus leading to the TOP500 idea in 1992/93.

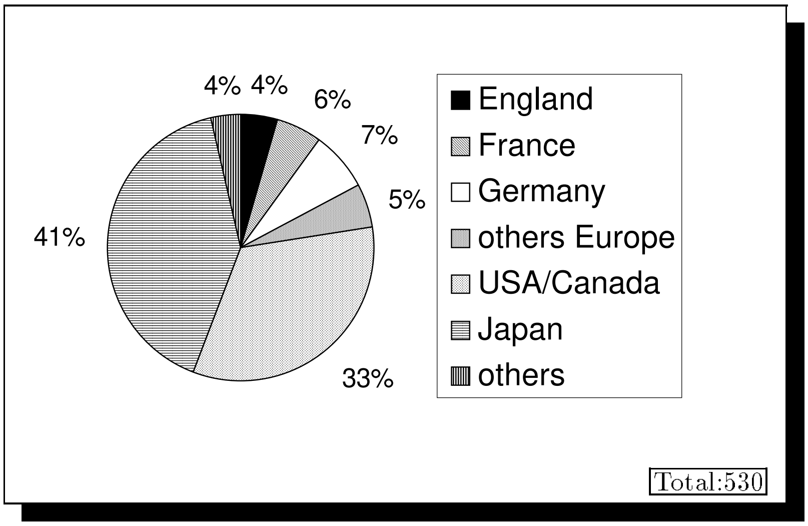


Figure 1.3:
Statistics 1992
— countries —

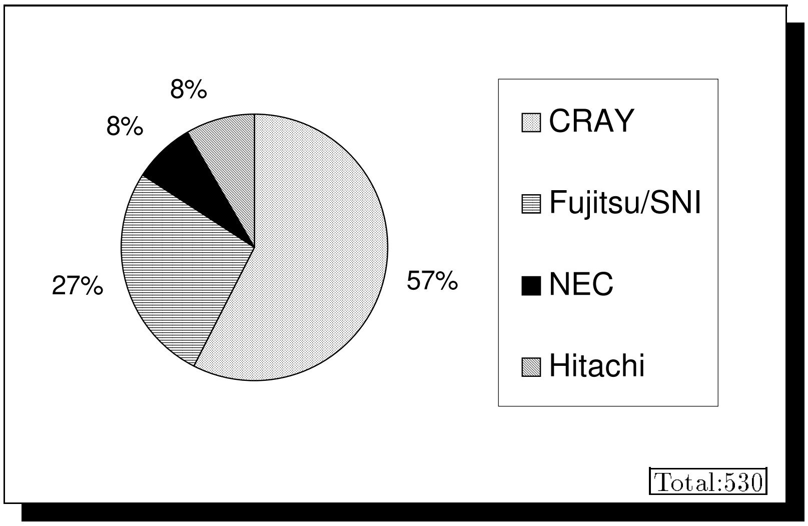


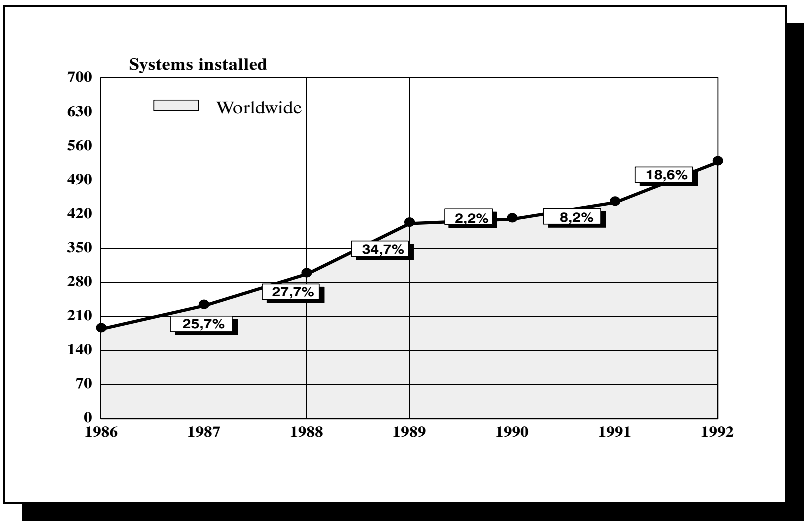
Figure 1.4:
Statistics 1992
— manufacturers —
(SNI means Siemens-Nixdorf Informationsystems)

Worldwide Statistics 1986–1992

In 1986 the vector computer technology was already proven and mature: vector computers were 10 years old, very sophisticated autovectorizing Fortran-compilers were available from both US vendors Cray Research and Control Data and the three Japanese vendors Fujitsu, NEC and Hitachi. Last but not least, a variety of Software packages, e.g. Nastran, Gaussian, PAM-crash, were on the market, making vector computers attractive not only to universities and research plants but also to the industry, especially to the automotive industry.

If we look at the market growth (Fig. 1.5) we see that the vector computer had an average of 15% annual growth, which is quite a bit above the growth of the DP-systems in general at the same time.

Figure 1.5:
Growth of the supercomputer market 1986–1992



The following list of figures shows the supercomputer distribution over the years 1986–1992 of the different countries (Fig. 1.6–1.12).

The recognizable major trends are:

- Steady decrease of the portion of US-installations in contrast to increase of the Japanese portion. As mentioned before this was mainly due to the fact that a bigger number of relatively small entry level systems of Japanese vendors have been installed in Japan and that there was an early orientation of US researchers towards MPP systems. The TOP500 list (see chapter 2) demonstrates that the portions of both countries are almost the same in 1993 as in 1986 with the USA clearly dominating.

- The European portion kept rather stable over these 6 years with a little less than 25%. But inside Europe the decreasing portion of UK from 8% in 1986 down to 4% in 1992 is remarkable (and can be explained by the funding policy of the UK government, see chapter 8.3) The portion of France slightly decreased from 8% to 6%, while the portion of Germany kept stable over the years with 7%. Other countries in Europe, e.g. Italy, Spain, the Netherlands and Denmark took over 5% of the worldwide supercomputer distribution.

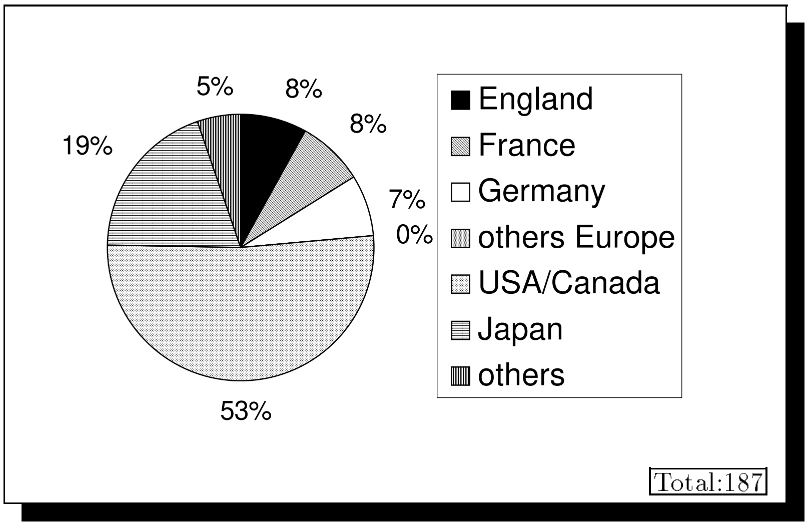


Figure 1.6:
Statistics 1986
— countries —

Figure 1.7:
Statistics 1987
— countries —

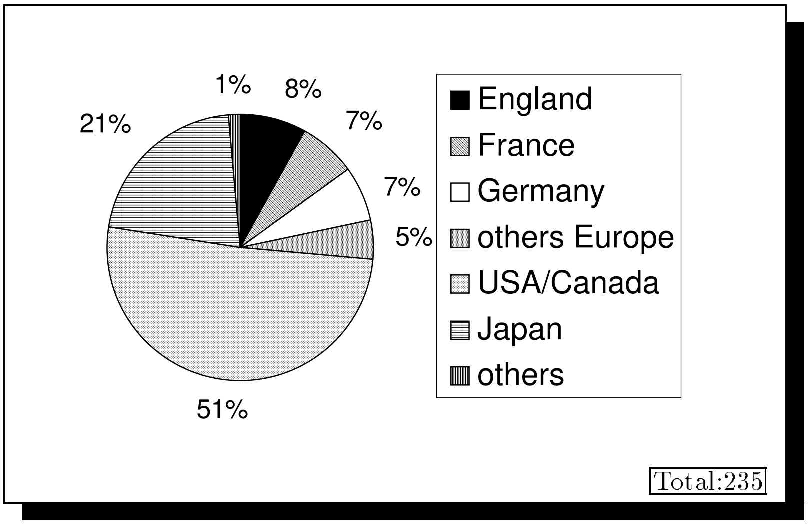


Figure 1.8:
Statistics 1988
— countries —

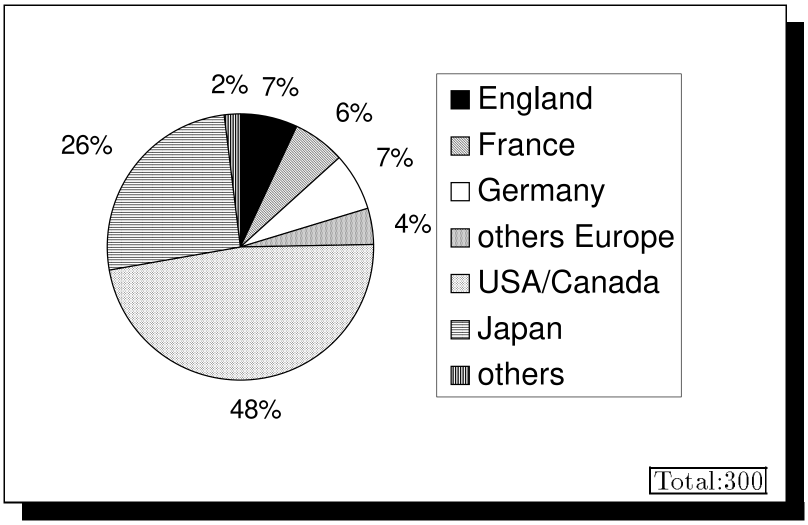
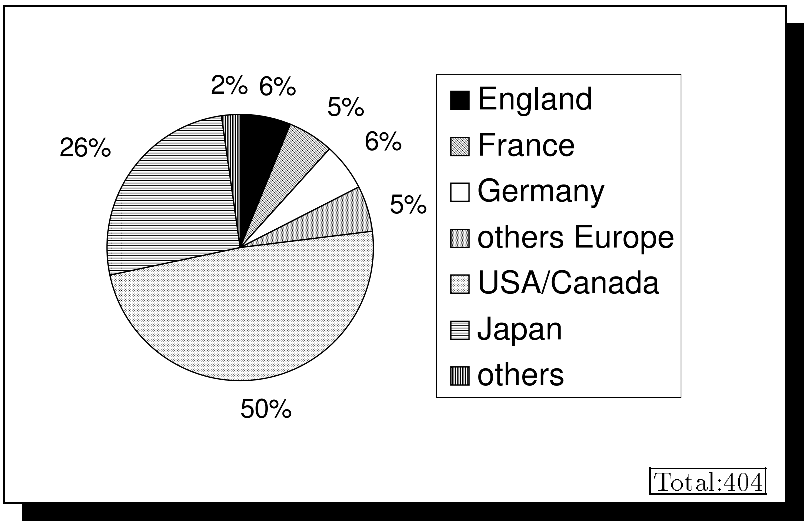


Figure 1.9:
Statistics 1989
— countries —



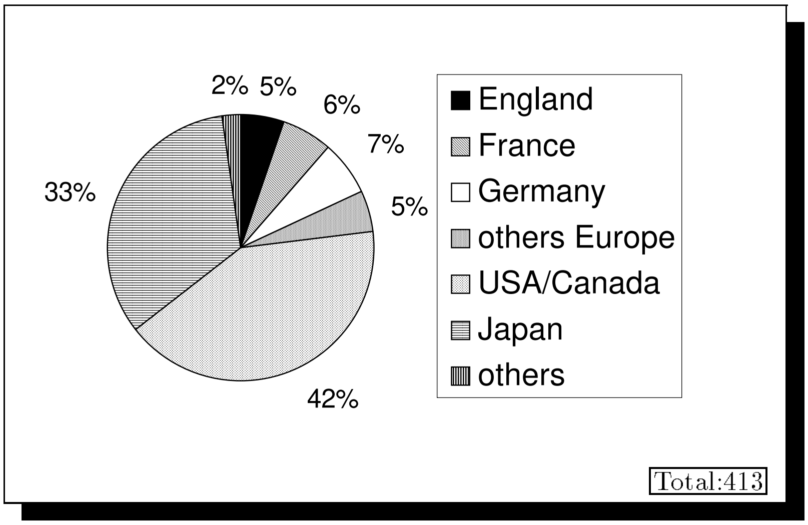


Figure 1.10:
Statistics 1990
— countries —

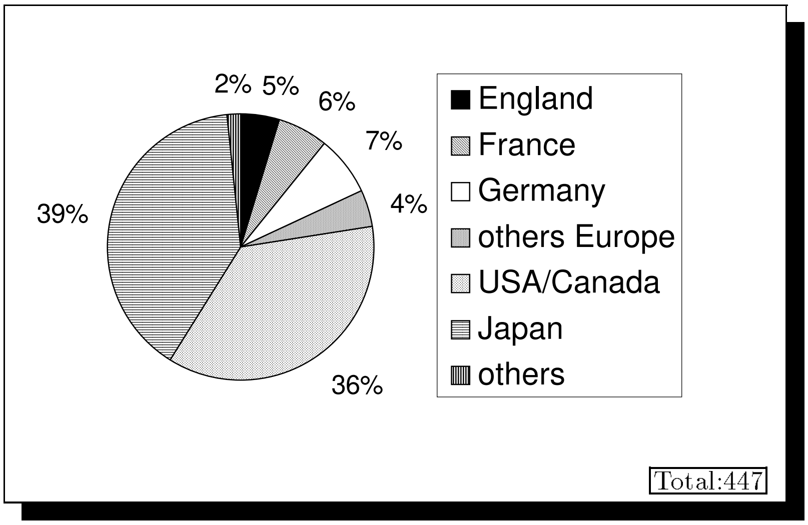


Figure 1.11:
Statistics 1991
— countries —

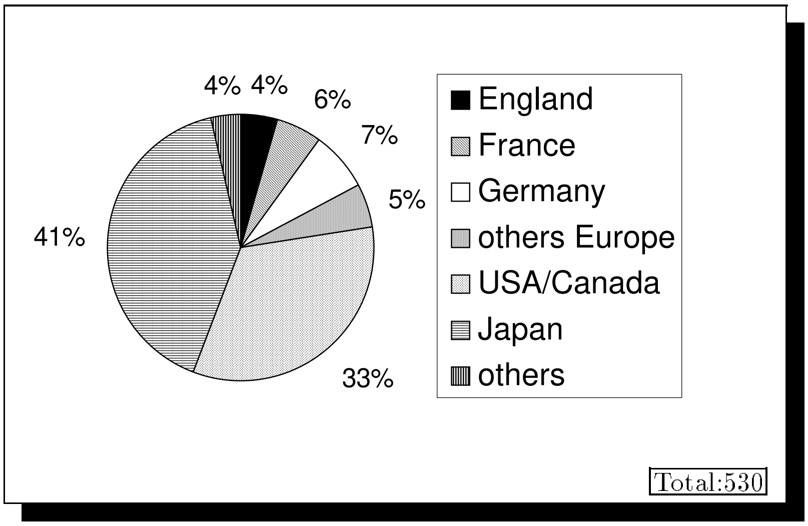


Figure 1.12:
Statistics 1992
— countries —

Looking at the distribution for the different vendors (Table 1.1 and Fig. 1.13–1.19) the dominating role of Cray Research in this market becomes immediately visible. In 1992 their market share had decreased only slightly from 63% in 1986 to 57%. This decrease contrasts with an increase of the market share of Fujitsu from 16% in 1986 to 27% in 1992, NEC from 1% to 8% and Hitachi from 4% to 8%. But we have to keep in mind the high portion of the entry level systems of these Japanese manufacturers as already mentioned before.

The major event however was the withdrawal of CDC/ETA from the market in 1989. The main impact of this was the relatively small overall growth of the market (Fig. 1.5) in 1990 and 1991. Many of the former CDC installations did not switch to one of the other big vector computer manufacturers like Cray Research. It seems to us, that in many cases they bought mini-supercomputers like Convex or Alliant.

Year	Cray	CDC	Hit.	Fuj.	Amd.	SNI	NEC	Total
1986	118	30	8	22	5	4	2	187
1987	148	34	9	27	5	4	8	235
1988	178	45	11	46	5	5	10	300
1989	235	62	17	56	9	7	18	404
1990	248	24	27	69	9	9	27	413
1991	268		36	85		23	35	447
1992	305		44	121		20	40	530

Table 1.1:
Vector computer installations
Worlwide —manufacturers—

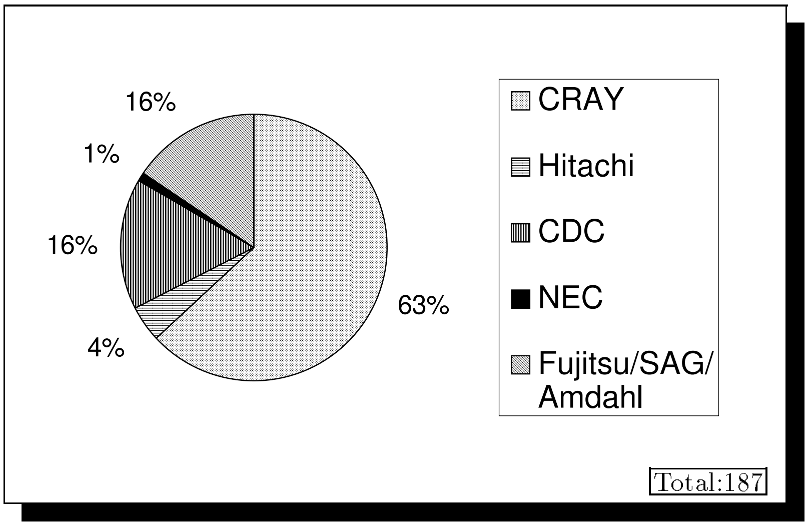


Figure 1.13:
Statistics 1986
— manufacturers —

Figure 1.14:
Statistics 1987
— manufacturers —

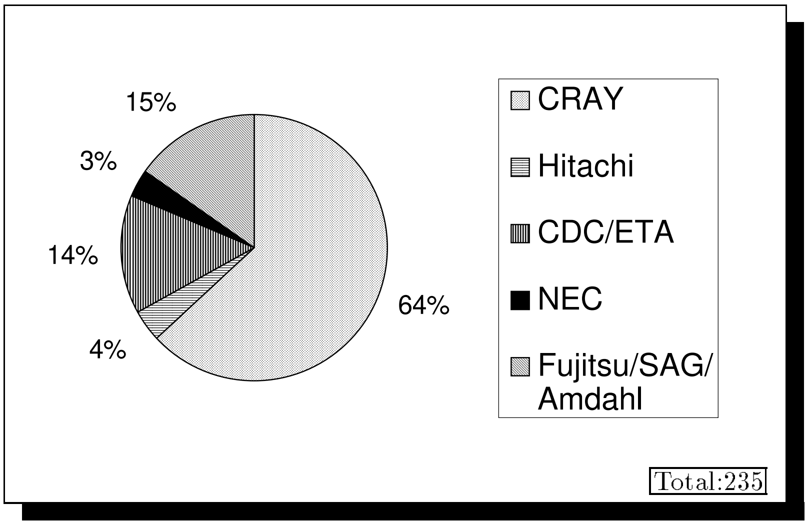


Figure 1.15:
Statistics 1988
— manufacturers —

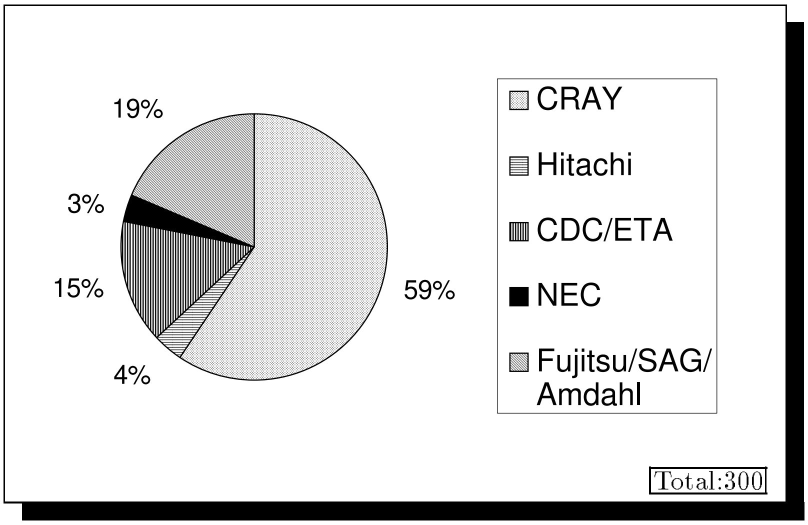
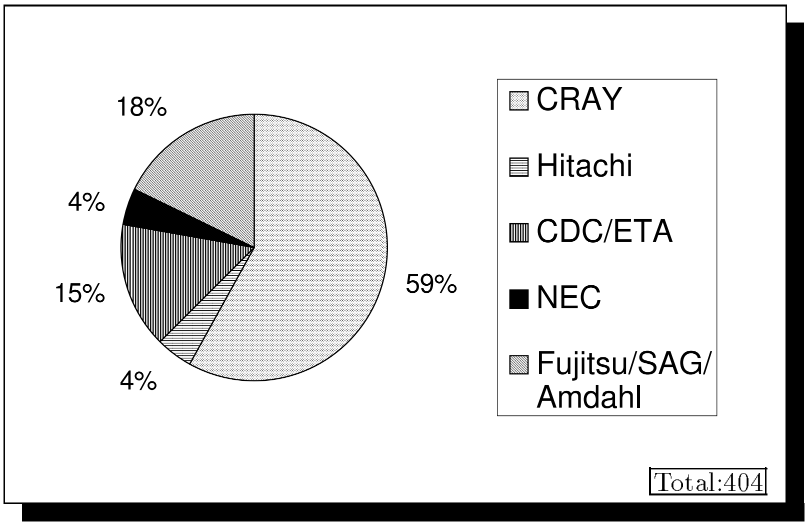


Figure 1.16:
Statistics 1989
— manufacturers —



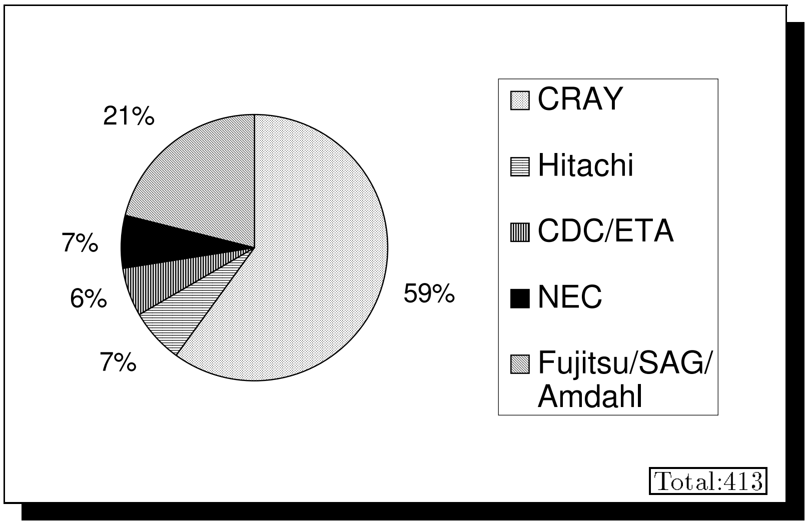


Figure 1.17:
Statistics 1990
— manufacturers —

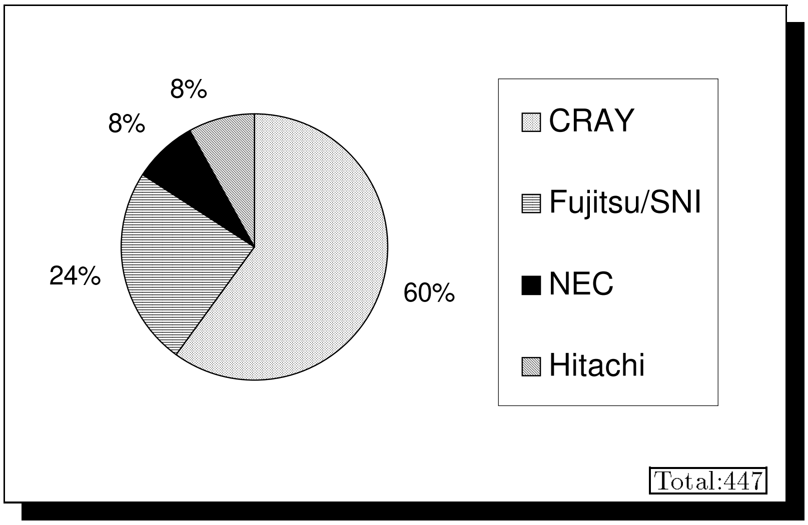


Figure 1.18:
Statistics 1991
— manufacturers —

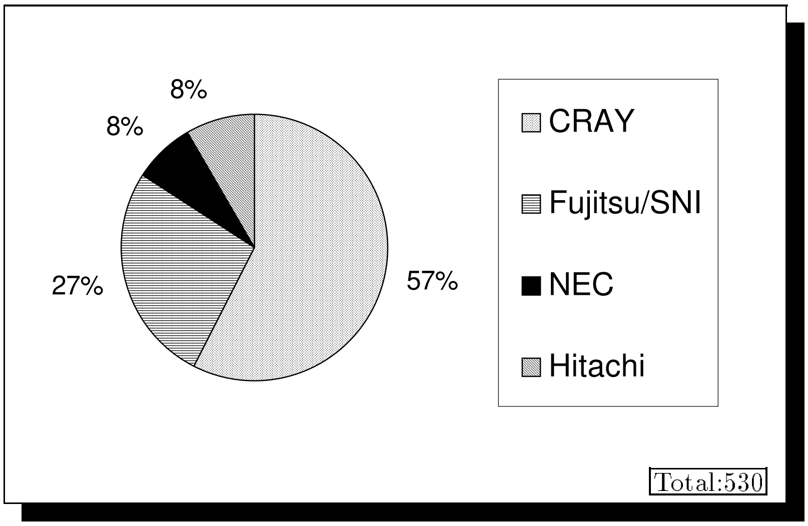


Figure 1.19:
Statistics 1992
— manufacturers —

German Situation 1986–1992

In Germany the vector computer activities started in 1980 with two Cray 1's installed at the MPI in Garching and at the DLR in Oberpfaffenhofen. The supercomputer community in the world was looking at Germany when in 1986 the Cray 2, the first one outside the USA, and one of the very first models (Nr. 6) of Seymour Cray's darling was installed in Baden-Württemberg at Stuttgart University. At the same time we started our Mannheim 'Supercomputer Seminars' and 'Supercomputer Statistics'.

Looking at the distribution over the different years (Table 1.2) a rising share of SAG/SNI from 14% in 1986 to 43% in 1992 in Germany is visible. Over the six years (Fig. 1.20) the overall growth was approximately the same in Germany as in the world. Only in 1988 Germany has had a tremendous growth of 31%, which was mainly caused by all the automotive manufacturers like Opel, Volkswagen, Mercedes and BMW equipping themselves with Cray XMPs.

In 1992 the market share of Cray Research was 54% in Germany. Even though they are market leader, their general position in Europe (74%) was much better than in Germany. Without the SNI sold Fujitsu systems they totally dominate the European market (88 of 99 systems, i.e. 89%) as they also do in the USA (170 of 177 systems 96%). There are no European vector computer manufacturers and the Japanese play only a bigger role through their successful cooperation with SNI in Germany.

Bibliography

[1] H. W. Meuer, *Supercomputer Statistics*, Handouts at the Supercomputer Seminar in Mannheim, yearly in June from 1986 to 1992

[2] J. J. Dongarra, H. W. Meuer, and E. Strohmaier, *TOP500 Supercomputer Sites*, Technical Report RUM 33/93, Computing Centre, Univ. of Mannheim, 68131 Mannheim, Germany, June 1993

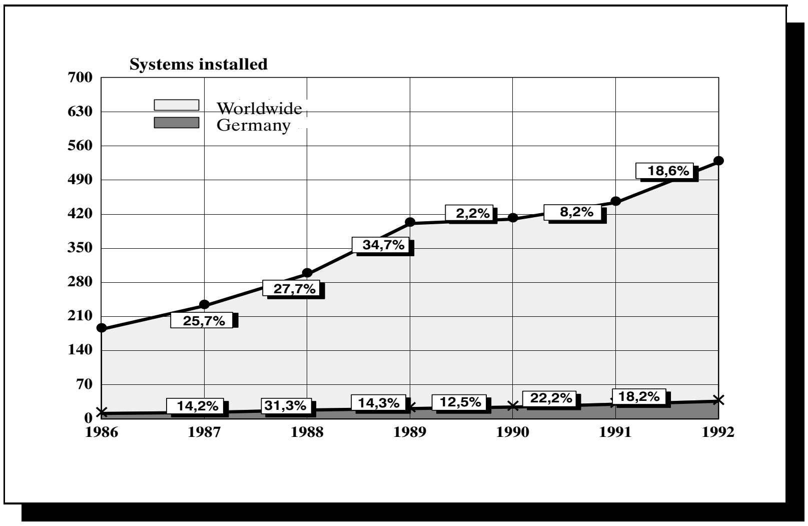


Figure 1.20:
Growth of the supercomputer market 1986–1992

Year	Cray	CDC	SNI	NEC	Total
1986	7	4	2		13
1987	9	4	3		16
1988	12	5	4		21
1989	14	4	6		24
1990	18	1	8		27
1991	19		13	1	33
1992	21		17	1	43

Table 1.2:
Vector computer installations in Germany

2

TOP500 Supercomputer Sites

Jack J. Dongarra

Hans-Werner Meuer

Erich Strohmaier

Abstract

To provide a better basis for statistics on high-performance computers, we list the sites that have the 500 most powerful computer systems installed. The best LINPACK benchmark performance achieved is used as a performance measure in ranking the computers.

2.1 Introduction and Objectives

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.

Statistical lists of supercomputers are not new. Every year since 1986 Hans Meuer [1] has published system counts of the major vector computer manufacturers, based principally on those at the Mannheim Supercomputer Seminar. Statistics based merely on the name of the manufacturer are no longer useful, however. 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.

To provide this new statistical foundation, we have decided to assemble and maintain a list of the 500 most powerful computer sys-

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[1] This chapter is a reprint of the Technical Report RUM 34/93, Computing Center, University of Mannheim, November 11, 1993

tems. Our list has been compiled with the help of high-performance computer experts, computational scientists, manufacturers, and the Internet community in general who responded to a questionnaire we sent out; we thank all the contributors for their cooperation. We have also used parts of statistical lists published by others for different purposes [2] [3].

In the present list (which we call the Top500), we list computers ranked by their performance on the Linpack Benchmark. While we make every attempt to verify the results obtained from users and vendors, errors are bound to exist and should be brought to our attention. We intend to update this list half-yearly and, in this way, to keep track with the evolution of computers. Hence, we welcome any comments and information; please send electronic mail to *top500@rz.uni-mannheim.de*.

2.2 The Linpack Benchmark

As a yardstick of performance we are using the 'best' performance as measured by the Linpack Benchmark [5]. Linpack was chosen because it is widely used and performance numbers are available for almost all relevant systems.

The Linpack Benchmark was introduced by Jack Dongarra. A detailed description as well as a list of performance results on a wide variety of machines is available in postscript form from *netlib*. To retrieve a copy send electronic mail to *netlib@ornl.gov* and by typing the message *send performance from benchmark* or from any machine on the internet type:
rcp anon@netlib2.cs.utk.edu:benchmark/performance performance.

The benchmark used in the LINPACK Benchmark is to solve a dense system of linear equations. For the TOP500 list, 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.

By measuring the actual performance for different problem sizes n, a user can get not only the maximal achieved performance R_{max} for the problem size N_{max} but also the problem size $N_{1/2}$ where half of the performance R_{max} is achieved. These numbers together with the theoretical peak performance R_{peak} are the numbers given in the TOP500 list. 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.

2.3 The TOP500 List

Table 2.1 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:

N_{world}	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	
# Proc.	Number of processors
Rmax	Maximal LINPACK performance achieved
R_{peak}	Theoretical peak performance
N_{max}	Problemsize for achieving R_{max}
$N_{1/2}$	Problemsize for achieving half of R_{max}

"A table with the used performances can be found in chapter 3 of this volume."

If R_{max} from Table 3 of the LINPACK Report [5] is not available, we use the TPP performance given in Table 1 of [5] for solving a system of 1000 equations. 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 (e.g., Hitachi S3800/480, KSR1-256, bigger models of Paragon XPS), the performance of the next smaller system measured is used.

In Table 2.1, the computers are ordered first by their R_{max} value. In the case of equal performances (R_{max} value) for different computers, we have chosen to order by R_{peak}. For sites that have the same computer, the order is alphabetically.

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1	Fujitsu Numerical Wind Tunnel	NAL/Fujitsu Japan /1993	Research Aerospace	140	**124500** 236000	31920 11950
2	TMC CM-5/1024	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	1024	**59700** 131000	52224 24064
3	TMC CM-5/544	Minnesota Supercomputer Center USA / .	Academic	544	**30400** 70000	36864 16384
4	TMC CM-5/512	NCSA Urbana-Champaign USA / .	Academic	512	**30400** 66000	36864 16384
5	TMC CM-5/512	National Security Agency USA / .	Classified	512	**30400** 66000	36864 16384
6	NEC SX-3/44R	NEC Fuchu Plant Japan /1990	Vendor	4	**23200** 26000	6400 830
7	NEC SX-3/44	Atmospheric Environment Service (AES) Dorval Canada /1991	Research Weather	4	**20000** 22000	6144 832
8	Intel XP/S135	Sandia National Labs Albuquerque USA /1993	Research	1840	**15200** 92000	23000 9000
9	Intel XP/S35	Oak Ridge National Laboratory Oak Ridge USA /1992	Research	512	**15200** 26000	23000 9000
10	TMC CM-5/256	Goverment USA /1993	Classified	256	**15100** 33000	26112 12032
11	TMC CM-5/256	Thinking Machines USA /1993	Vendor	256	**15100** 33000	26112 12032
12	TMC CM-5/256	US Naval Research Laboratory USA /1992	Research	256	**15100** 33000	26112 12032
13	Intel Delta	Caltech Pasadena USA / .	Academic	512	**13900** 20480	25000 7500
14	Cray Y-MP C916/16256	Cray Research Eagan USA / .	Vendor	16	**13700** 15238	10000 650
15	Cray Y-MP C916/16256	DOD/CEWES Vicksburg USA /1993	Research Mechanics	16	**13700** 15238	10000 650
16	Cray Y-MP C916/16256	DOE/Bettis Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
17	Cray Y-MP C916/16256	DOE/Knolls Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
18	Cray Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650
19	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
20	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
22	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
23	Cray Y-MP C916	KIST/System Engineering Research Institute Korea /1993	Academic	16	**13700** 15238	10000 650
24	Cray Y-MP C916/16256	Lawrence Livermore National Laboratory NERSC USA /1992	Research Energy	16	**13700** 15238	10000 650
25	Cray Y-MP C916/16256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	16	**13700** 15238	10000 650
26	Cray Y-MP C916/16256	Pittsburgh Supercomputing Center Pittsburgh USA /1992	Academic	16	**13700** 15238	10000 650
27	Cray Y-MP C916	US Naval Oceanographic Command Bay Saint Louis USA / .	Research Weather	16	**13700** 15238	10000 650
28	Intel XP/S30	UCSD/San Diego Supercomputer Center San Diego USA /1993	Academic	400	**11900** 20000	. .
29	NEC SX-3/24R	National Institute of Fusion Science (NIFS) Japan /1993	Research	2	**11600** 13000	4352 516
30	NEC SX-3/24	NEC Daito Supercomputer Center Japan /1991	Vendor	2	**10000** 11000	4352 500
31	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
32	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
33	TMC CM-200/64k	NCSA USA / .	Academic	2048	**9800** 20000	29696 11264
34	Cray Y-MP C916/11256	Ford Motor Company Dearborn USA /1992	Industry Automotive	11	**9418** 10476	. .
35	TMC CM-5/128	AMEX USA /1993	Industry	128	**7700** 16000	18432 8192
36	TMC CM-5/128	Goverment USA /1993	Classified	128	**7700** 16000	18432 8192
37	TMC CM-5/128	Institut de Physique du Globe de Paris (IPG) Paris France /1992	Research	128	**7700** 16000	18432 8192
38	TMC CM-5/128	MIT Cambridge USA / .	Research	128	**7700** 16000	18432 8192
39	TMC CM-5/128	Mobil / Technical Center Tulsa USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
40	TMC CM-5/128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	128	**7700** 16000	18432 8192

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41	TMC CM-5/128	Schlumberger Well Services USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
42	Hitachi S-3800/480	Tokyo University Tokyo Japan /1993	Academic	4	**7016** 32000	. .
43	Cray Y-MP C916/8256	Minnesota Supercomputer Center USA / .	Academic	8	**6850** 7619	. .
44	Cray Y-MP C916/8256	NASA/Ames Research Center/CCF Moffett Field USA /1993	Research Aerospace	8	**6850** 7619	. .
45	Cray Y-MP C98/8128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**6850** 7619	. .
46	Cray Y-MP C916/8128	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	8	**6850** 7619	. .
47	Intel XP/S15	Intel SSD Development Centers USA /1993	Vendor	208	**6200** 10400	. .
48	Intel XP/S15	NASA/Ames Research Center/NAS Moffett Field USA /1992	Research	208	**6200** 10400	. .
49	NEC SX-3/14R	German Aerospace Laboratory (DLR) Goettingen Germany /1993	Research Aerospace	1	**5800** 6400	2816 282
50	NEC SX-3/41R	Japan Atomic Energy Research Japan /1992	Research	4	**5800** 6400	3584 414
51	NEC SX-3/14R	Osaka University Osaka Japan /1993	Academic	1	**5800** 6400	2816 282
52	NEC SX-3/14R	Toyota Central Research Japan /1992	Industry Automotive	1	**5800** 6400	2816 282
53	TMC CM-2/64k	Brandeis University USA / .	Academic	2048	**5200** 14000	26624 11000
54	TMC CM-2/64k	Florida State University Tallahassee USA / .	Academic	2048	**5200** 14000	26624 11000
55	TMC CM-2/64k	SRC USA /1993	Industry	2048	**5200** 14000	26624 11000
56	TMC CM-200/32k	Minnesota Supercomputer Center USA / .	Academic	1024	**5000** 10000	21504 8192
57	NEC SX-3/22	Houston Advanced Research Center Houston USA / .	Research	2	**5000** 5500	3072 384
58	NEC SX-3/14	IBM Japan Tokyo Japan /1991	Industry Electronics	1	**5000** 5500	3072 384
59	NEC SX-3/22	National Aerospace Laboratory (NLR) Nordoostpolder Netherlands/1992	Research Aerospace	2	**5000** 5500	3072 384
60	NEC SX-3/14	National Institute of Environmental Studies Japan /1992	Research Environment	1	**5000** 5500	3072 384

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
61	NEC SX-3/22	Swiss Scientific Computing Center Manno Switzerland/1991	Research	2	**5000** 5500	3072 384
62	Cray Y-MP C98/6256	NASA/Goddard Space Flight Center Greenbelt USA /1993	Research Weather	6	**4630** 5715	. .
63	Intel XP/S10	Intel SSD Development Centers USA /1992	Vendor	140	**4100** 7000	. .
64	Fujitsu VP2600/10	Fuji Heavy Japan /1990	Industry Heavy Ind.	1	**4009** 5000	. .
65	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
66	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
67	Fujitsu VP2600/20	Kyoto University Kyoto Japan /1990	Academic	1	**4009** 5000	. .
68	Fujitsu VP2600/10	Kyushu University Kyushu Japan /1992	Academic	1	**4009** 5000	. .
69	Fujitsu VP2600/10	NAL (Space Technology) Japan /1990	Research	1	**4009** 5000	. .
70	Fujitsu VP2600/10	Nagoya University Nagoya Japan /1991	Academic	1	**4009** 5000	. .
71	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
72	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
73	Fujitsu VP2600/10	Taisei Construction Japan /1992	Industry Construction	1	**4009** 5000	. .
74	SNI S600/20	Universitaet Aachen Aachen Germany /1991	Academic	1	**4009** 5000	. .
75	SNI S600/20	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	1	**4009** 5000	. .
76	IBM 9076-005 SP1	Argonne Nat. Lab USA /1993	Academic	128	**3861** 16000	26500 8000
77	IBM 9076-004 SP1	Cornell University USA /1993	Academic	64	**3861** 8000	26500 8000
78	TMC CM-5/64	AMOCO Tulsa USA / .	Industry Geophysics	64	**3800** 8192	13056 6016
79	TMC CM-5/64	ATR Kyoto Japan / .		64	**3800** 8192	13056 6016
80	TMC CM-5/64	Australian National University Canberra Australia / .	Academic	64	**3800** 8192	13056 6016

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
81	TMC CM-5/64	Boston University Boston USA / .	Academic	64	**3800** 8192	13056 6016
82	TMC CM-5/64	EPS USA /1993	Industry	64	**3800** 8192	13056 6016
83	TMC CM-5/64	GMD Birlinghoven Germany /1993	Research	64	**3800** 8192	13056 6016
84	TMC CM-5/64	Japanese AIST Hokuriku Japan /1993		64	**3800** 8192	13056 6016
85	TMC CM-5/64	Real World Computing (RWCP) Tokyo Japan /1992		64	**3800** 8192	13056 6016
86	TMC CM-5/64	University of Wisconsin USA / .	Academic	64	**3800** 8192	13056 6016
87	SNI S400/40	Universitaet Darmstadt Darmstadt Germany /1991	Academic	2	**3624** 5000	10239 .
88	SNI S400/40	Universitaet Hannover Hannover Germany /1991	Academic	2	**3624** 5000	10239 .
89	KSR KSR1-256	KSR Boston USA /1992	Vendor	256	**3380** 10240	10240 1824
90	KSR KSR1-256	US Army Research Laboratory Aberdeen USA /1993	Research	256	**3380** 10240	10240 1824
91	KSR KSR1-128	Cornell Theory Center Ithaca USA /1992	Academic	128	**3380** 5120	10240 1824
92	Cray Y-MP C98/4256	Direction de la Meteorologie Nationale Toulouse France /1993	Research Weather	4	**3275** 3810	. .
93	NEC SX-3/12R	Institute of Space Science (INPE) Brazil /1993	Research Weather	1	**2900** 3200	2048 174
94	NEC SX-3/12R	NEC Scientific Information (NSIS) Japan /1992	Research	1	**2900** 3200	2048 174
95	NEC SX-3/21R	Obayashi Corporation Japan /1992	Industry	2	**2900** 3200	2560 257
96	TMC CM-2/32k	AMK Bonn Germany /1990	Classified	1024	**2600** 7000	. .
97	Intel iPSC/860	Alliant Techsystems Inc. USA /1990	Industry Biochemistry	128	**2600** 5120	12000 4500
98	Intel iPSC/860	Grant Tensor UK /1991	Industry Geophysics	128	**2600** 5120	12000 4500
99	Intel iPSC/860	Grant Tensor USA /1991	Industry Geophysics	128	**2600** 5120	12000 4500
100	Intel iPSC/860	Grant Tensor Houston USA /1992	Industry Geophysics	128	**2600** 5120	12000 4500

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	Rmax R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
101	Intel iPSC/860	Honeywell USA /1990	Industry	128	**2600** 5120	12000 4500
102	Intel iPSC/860	Lockheed Advanced Development Palmdale USA /1992	Industry Aerospace	128	**2600** 5120	12000 4500
103	Intel iPSC/860	NASA/Ames Research Center/NAS Moffett Field USA /1990	Research	128	**2600** 5120	12000 4500
104	Intel iPSC/860	NIH Frederick USA /1990	Research	128	**2600** 5120	12000 4500
105	Intel iPSC/860	ONERA Chatillon France /1991	Research Aerospace	128	**2600** 5120	12000 4500
106	Intel iPSC/860	Oak Ridge National Laboratory Oak Ridge USA /1989	Research	128	**2600** 5120	12000 4500
107	KSR KSR1-96	Florida State University Tallahassee USA /1993	Academic	96	**2535** 3840	. .
108	KSR KSR1-96	Lockheed USA /1993	Industry	96	**2535** 3840	. .
109	KSR KSR1-96	University of Cincinati USA /1993	Academic	96	**2535** 3840	. .
110	TMC CM-200/16k	INRIA - Sophia Antipolis Rennes France /1992	Research	512	**2400** 5000	14848 5632
111	TMC CM-200/16k	US Naval Research Laboratory USA /1987	Research	512	**2400** 5000	14848 5632
112	TMC CM-200/16k	University of Edinburgh Edinburgh UK / .	Research	512	**2400** 5000	14848 5632
113	Cray CRAY-2s/8-128	Lawrence Livermore National Laboratory NERSC USA /1990	Research Energy	8	**2171** 3902	. .
114	Cray Y-MP8E/8256	Arabian American Oil Company USA /1991	Industry Geophysics	8	**2144** 2667	. .
115	Cray Y-MP8/864	Atomic Weapons Establishment USA /1990	Classified	8	**2144** 2667	. .
116	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
117	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
118	Cray Y-MP8/832	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
119	Cray Y-MP8/864	DOE/Bettis Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .
120	Cray Y-MP8/864	DOE/Knolls Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
121	Cray Y-MP8/8256	DOE/National Security Agency USA / .	Classified	8	**2144** 2667	. .
122	Cray Y-MP8/864	Government Communications Headquarters Benhall UK / .	Classified	8	**2144** 2667	. .
123	Cray Y-MP8/832	KFA Juelich Germany /1989	Research	8	**2144** 2667	. .
124	Cray Y-MP8/8128	Lawrence Livermore National Laboratory Livermore USA /1991	Research	8	**2144** 2667	. .
125	Cray Y-MP8/864	Lawrence Livermore National Laboratory Livermore USA /1992	Research	8	**2144** 2667	. .
126	Cray Y-MP8/8128	Leibniz Rechenzentrum Muenchen Germany /1992	Academic	8	**2144** 2667	. .
127	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
128	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
129	Cray Y-MP8/864	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
130	Cray Y-MP8/8256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**2144** 2667	. .
131	Cray Y-MP8E/8256	NASA/Langley Research Center Hampton USA /1992	Research	8	**2144** 2667	. .
132	Cray Y-MP8/8128	NASA/Lewis Research Center USA /1991	Research	8	**2144** 2667	. .
133	Cray Y-MP8/864	NOAA USA /1990	Research Weather	8	**2144** 2667	. .
134	Cray Y-MP8/832	NOAA/GFDL USA /1990	Research Weather	8	**2144** 2667	. .
135	Cray Y-MP8/8128	National Cancer Institute USA /1991	Research Chemistry	8	**2144** 2667	. .
136	Cray Y-MP8/864	National Center for Atmospheric Research Boulder USA /1990	Research Weather	8	**2144** 2667	. .
137	Cray Y-MP8E/8128	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	8	**2144** 2667	. .
138	Cray Y-MP8/864	Ohio Supercomputer Center Columbus USA /1989	Academic	8	**2144** 2667	. .
139	Cray Y-MP8I/8128	Rutherford Appleton Laboratory UK /1992	Research	8	**2144** 2667	. .
140	Cray Y-MP8/864	Sandia National Labs Albuquerque USA / .	Research	8	**2144** 2667	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
141	Cray Y-MP8/8128	Tohoku University, Institute of Fluid Science Aramaki Japan /1992	Academic	8	**2144** 2667	. .
142	Cray Y-MP8/864	UCSD/San Diego Supercomputer Center San Diego USA /1989	Academic	8	**2144** 2667	. .
143	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
144	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
145	Cray Y-MP8/864	University of Texas Austin USA /1990	Academic	8	**2144** 2667	. .
146	Fujitsu VPX240/10	CESGA Sant. de Compostella Spain /1992	Academic	1	**2110** 2500	. .
147	Fujitsu VPX240/20	Fujitsu San Jose USA / .	Vendor	1	**2110** 2500	. .
148	Fujitsu VPX240/10	High Performance Computing Center Alberta Canada / .	Research	1	**2110** 2500	. .
149	SNI S400/10	IFP (Institute Francais du Petrole) Rueil-Malmaison France /1992	Academic Geophysics	1	**2110** 2500	. .
150	Fujitsu VPX240/10	University of Manchester Manchester UK /1993	Academic	1	**2110** 2500	. .
151	IBM 9076-003 SP1	Penn State University USA /1993	Academic	32	**2033** 4000	15000 4390
152	Intel XP/S5	Boeing Seattle USA /1992	Industry Aerospace	66	**2000** 3300	8000 .
153	Intel XP/S5	Intel SSD Development Centers USA /1993	Vendor	66	**2000** 3300	8000 .
154	Intel XP/S5	KFA Juelich Germany /1992	Research	66	**2000** 3300	8000 .
155	Intel XP/S5-32	NASA/Langley Research Center Hampton USA /1992	Research	66	**2000** 3300	8000 .
156	Intel XP/S5	Oak Ridge National Laboratory Oak Ridge USA / .	Research	66	**2000** 3300	8000 .
157	Intel XP/S5	Prudential Bache Securities New York USA /1993	Industry	66	**2000** 3300	8000 .
158	Intel XP/S5	Real World Computing (RWC) Tokyo Japan /1993		66	**2000** 3300	8000 .
159	Intel XP/S5-32	Universitaet Stuttgart Stuttgart Germany /1992	Academic	66	**2000** 3300	8000 .
160	TMC CM-5/32	Booz-Allen Hamilton Washington DC USA / .	Industry Consulting	32	**1900** 4096	9216 4096

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161	TMC CM-5/32	CRIEPI Japan /1993		32	**1900** 4096	9216 4096
162	TMC CM-5/32	Columbia University New York City USA / .	Academic	32	**1900** 4096	9216 4096
163	TMC CM-5/32	Compagnie Generale de Geophysique (CGG) Massy France /1993	Industry Geophysics	32	**1900** 4096	9216 4096
164	TMC CM-5/32	Duke University Durham USA / .	Academic	32	**1900** 4096	9216 4096
165	TMC CM-5/32	JPL Pasadena USA / .	Research	32	**1900** 4096	9216 4096
166	TMC CM-5/32	Madentech USA /1993	Industry	32	**1900** 4096	9216 4096
167	TMC CM-5/32	NPAC USA /1993	Research	32	**1900** 4096	9216 4096
168	TMC CM-5/32	National Center for Atmospheric Research Boulder USA / .	Research Weather	32	**1900** 4096	9216 4096
169	TMC CM-5/32	Oregon State University USA / .	Academic	32	**1900** 4096	9216 4096
170	TMC CM-5/32	RUG (Rijksuniversiteit Groningen) Groningen Netherlands/1993	Academic	32	**1900** 4096	9216 4096
171	TMC CM-5/32	Site Experimental Hyperparallelisme (SEH/ETCA) Arcueil France / .	Research	32	**1900** 4096	9216 4096
172	TMC CM-5/32	Stanford University USA / .	Academic	32	**1900** 4096	9216 4096
173	TMC CM-5/32	Syracuse University Syracuse USA / .	Academic	32	**1900** 4096	9216 4096
174	TMC CM-5/32	TEC USA /1993	Industry	32	**1900** 4096	9216 4096
175	TMC CM-5/32	Tokyo University, Medical Lab Tokyo Japan /1993	Academic	32	**1900** 4096	9216 4096
176	TMC CM-5/32	Universitaet Wuppertal Wuppertal Germany /1992	Academic	32	**1900** 4096	9216 4096
177	TMC CM-5/32	University of Adelaide Adelaide Australia / .	Academic	32	**1900** 4096	9216 4096
178	TMC CM-5/32	University of California at Berkeley USA / .	Academic	32	**1900** 4096	9216 4096
179	TMC CM-5/32	University of Maryland USA / .	Academic	32	**1900** 4096	9216 4096
180	TMC CM-5/32	University of New South Wales Kensington Australia / .	Academic	32	**1900** 4096	9216 4096

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181	TMC CM-5/32	University of Tennessee Knoxville USA / .	Academic	32	**1900** 4096	9216 4096
182	NCube nCUBE2	Sandia National Labs Albuquerque USA / .	Research	1024	**1900** 2400	21376 3193
183	KSR KSR1-64	Caltech Pasadena USA /1992	Academic	64	**1838** 2560	9216 1536
184	KSR KSR1-64	Canon Japan /1993	Industry	64	**1838** 2560	9216 1536
185	KSR KSR1-64	Canon Japan /1993	Industry	64	**1838** 2560	9216 1536
186	KSR KSR1-64	Georgia Institute of Technology USA /1993	Research	64	**1838** 2560	9216 1536
187	KSR KSR1-64	Government UK /1992	Classified	64	**1838** 2560	9216 1536
188	KSR KSR1-64	Oak Ridge National Laboratory Oak Ridge USA /1991	Research	64	**1838** 2560	9216 1536
189	KSR KSR1-64	University of Colorado USA /1992	Academic	64	**1838** 2560	9216 1536
190	KSR KSR1-64	University of Massachusetts Amherst USA /1993	Academic	64	**1838** 2560	9216 1536
191	KSR KSR1-64	University of Michigan Michigan USA /1993	Academic	64	**1838** 2560	9216 1536
192	KSR KSR1-64	University of Washington Seattle USA /1993	Academic	64	**1838** 2560	9216 1536
193	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	. .
194	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	. .
195	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	. .
196	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	. .
197	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1990	Vendor	1	**1817** 3000	. .
198	Hitachi S-820/80	Hitachi Ltd. SSD Japan /1989	Vendor	1	**1817** 3000	. .
199	Hitachi S-820/80	Hokkaido University Sapporo Japan /1989	Academic	1	**1817** 3000	. .
200	Hitachi S-820/80	Institute of Molecular Science Japan /1988	Research	1	**1817** 3000	. .

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201	Hitachi S-820/80	Nat. Lab. for High Energy Physics Japan /1988	Research	1	**1817** 3000	. .
202	Hitachi S-820/80	Nihon University Japan /1993	Academic	1	**1817** 3000	. .
203	Hitachi S-820/80	Senshu University Japan / .	Academic	1	**1817** 3000	. .
204	Cray Y-MP M98	Cray Research Eagan USA / .	Vendor	8	**1733** 2667	. .
205	Cray Y-MP C94A/2128	Instituto National de Meteorologia (INM) Spain /1993	Research Weather	2	**1703** 1905	. .
206	Cray Y-MP C92A/2128	Mitsubishi Motors Company Kawasaki Japan /1993	Industry Automotive	2	**1703** 1905	. .
207	Fujitsu VP2400/20	Computer Technology Integrated (CTI) Japan /1991	Industry	1	**1688** 2000	. .
208	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	. .
209	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	. .
210	Cray Y-MP8/664	Cray Research Eagan USA / .	Vendor	6	**1651** 2000	. .
211	Cray Y-MP8I/6128	NASA/Marshall Space Flight Center USA /1993	Research Aerospace	6	**1651** 2000	. .
212	Cray Y-MP8/664	Nissan Motor Kanagawa Japan /1990	Academic	6	**1651** 2000	. .
213	Cray Y-MP8I/632	Taiwan Central Weather Bureau Taiwan /1992	Research Weather	6	**1651** 2000	. .
214	Cray Y-MP8/632	Toyota Motor Company Japan /1991	Industry Automotive	6	**1651** 2000	. .
215	MasPar MP-2216	Lockheed Missiles and Space Company USA /1993	Industry Aerospace	16384	**1600** 2400	11264 1920
216	MasPar MP-2216	National Cancer Institute USA /1993	Research Chemistry	16384	**1600** 2400	11264 1920
217	DEC DECmpp SX 200	University of Bergen Bergen Norway / .	Academic	16384	**1600** 2400	11264 1920
218	Intel XP/A4	Caltech Pasadena USA /1993	Academic	56	**1500** 4200	6000 .
219	Intel XP/A4	Hiroshima University Japan /1993	Academic	56	**1500** 4200	6000 .
220	Intel XP/A4E	IRISA Rennes France /1993	Research Aerospace	56	**1500** 4200	6000 .

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221	Intel XP/A4	Rice University USA /1993	Academic	56	**1500** 4200	6000 .
222	Intel XP/A4	Sandia National Labs Livermore USA /1993	Research Energy	56	**1500** 4200	6000 .
223	Intel XP/A4E	Technische Universitaet Graz Graz Austria /1993	Academic	56	**1500** 4200	6000 .
224	Intel XP/A4	University of Indiana USA /1993	Academic	56	**1500** 4200	6000 .
225	Intel XP/A4	University of Melbourne Australia /1993	Academic	56	**1500** 4200	6000 .
226	Intel XP/A4	University of South Carolina USA /1992	Academic	56	**1500** 4200	6000 .
227	Intel XP/A4	University of Trondheim Norway /1992	Academic	56	**1500** 4200	6000 .
228	IBM ES 9000-900	CERN Geneva Switzerland/ .	Research	6	**1457** 2664	. .
229	IBM ES 9000-900	Cornell Theory Center Ithaca USA / .	Academic	6	**1457** 2664	. .
230	IBM ES 9000-900	UCLA Los Angeles USA / .	Academic	6	**1457** 2664	. .
231	Cray CRAY-2s/4-128	DKRZ Hamburg Germany /1988	Research Weather	4	**1406** 1952	. .
232	Cray CRAY-2s/4-128	Lawrence Livermore National Laboratory NERSC USA /1988	Research Energy	4	**1406** 1952	. .
233	Cray CRAY-2s/4-128	NASA/Langley Research Center Hampton USA /1989	Research	4	**1406** 1952	. .
234	Cray CRAY-2s/4-128	NCSA Urbana-Champaign USA /1988	Academic	4	**1406** 1952	. .
235	Cray CRAY-2/4-256	Air Force/Phillips Lab USA /1987	Research Aerospace	4	**1406** 1951	. .
236	Cray CRAY-2/4-512	Arabian American Oil Company USA /1992	Industry Geophysics	4	**1406** 1951	. .
237	Cray CRAY-2/4-256	Commissariat a l'Energie Atomique Grenoble France /1989	Research Energy	4	**1406** 1951	. .
238	Cray CRAY-2/4-128	Cray Research Eagan USA / .	Vendor	4	**1406** 1951	. .
239	Cray CRAY-2/4-256	Defense Research Agency Farnborough UK /1990	Classified	4	**1406** 1951	. .
240	Cray CRAY-2/4-256	Direction de la Meteorologie Nationale Toulouse France /1989	Research Weather	4	**1406** 1951	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
241	Cray CRAY-2/4-256	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1990	Academic	4	**1406** 1951	. .
242	Cray CRAY-2/4-512	Minnesota Supercomputer Center USA /1988	Academic	4	**1406** 1951	. .
243	Cray CRAY-2/4-256	NTT Japan /1987	Industry Electronics	4	**1406** 1951	. .
244	Cray CRAY-2/4-512	US Air Force/National Test Facility USA /1990	Classified	4	**1406** 1951	. .
245	Cray CRAY-2/4-256	Universitaet Stuttgart Stuttgart Germany /1986	Research	4	**1406** 1951	. .
246	Intel iPSC/860	Caltech Pasadena USA /1990	Academic	64	**1400** 2560	9000 3500
247	Intel iPSC/860	Daresbury Laboratory Warrington UK / .	Research	64	**1400** 2560	9000 3500
248	Intel iPSC/860	McDonnell Douglas USA /1991	Industry Aerospace	64	**1400** 2560	9000 3500
249	Intel iPSC/860	SERC USA /1990	Research	64	**1400** 2560	9000 3500
250	Intel iPSC/860	Sandia National Labs Albuquerque USA /1991	Research	64	**1400** 2560	9000 3500
251	Intel iPSC/860	Superconducting Supercollider Lab USA /1990	Research	64	**1400** 2560	9000 3500
252	Intel iPSC/860	UCSD/San Diego Supercomputer Center San Diego USA /1990	Academic	64	**1400** 2560	9000 3500
253	Intel iPSC/860	Westinghouse Electric USA /1992	Industry Energy	64	**1400** 2560	9000 3500
254	KSR KSR1-48	North Carolina Supercomputer Center USA /1992	Academic	48	**1350** 1920	. .
255	TMC CM-2/16k	ATR Japan /1990		512	**1300** 3500	. .
256	TMC CM-2/16k	Australian National University Canberra Australia / .	Academic	512	**1300** 3500	. .
257	TMC CM-2/16k	GMD Birlinghoven Germany /1990	Research	512	**1300** 3500	. .
258	TMC CM-2/16k	ICFD Japan /1991	Research	512	**1300** 3500	. .
259	Meiko CS/i860/64	University of Edinburgh Edinburgh UK /1990	Academic	64	**1300** 2500	8500 3500
260	NEC SX-3/11	Sanyo Electric Moriguchi City Japan /1991	Industry Electronics	1	**1300** 1370	2816 192

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
261	NEC SX-3/11	Tokai University Tokai Japan /1992	Academic	1	**1300** 1370	2816 192
262	NEC SX-3/11	Universitaet Koeln Koeln Germany /1990	Academic	1	**1300** 1370	2816 192
263	TMC CM-200/8k	Uni-C Copenhagen Denmark /1992	Academic	256	**1200** 2500	10752 4096
264	Cray Y-MP8/4128	BMW AG Muenchen Germany /1992	Industry Automotive	4	**1159** 1333	. .
265	Cray Y-MP8E/4128	Boeing Seattle USA / .	Industry Aerospace	4	**1159** 1333	. .
266	Cray Y-MP8/464	CINECA Bologna Italy /1992	Academic	4	**1159** 1333	. .
267	Cray Y-MP8I/464	Chrysler Motors Company USA /1992	Industry Automotive	4	**1159** 1333	. .
268	Cray Y-MP4E/464	Citroen Peugeot Velizy France /1992	Industry Automotive	4	**1159** 1333	. .
269	Cray Y-MP4E/464	Compagnie Generale de Geophysique (CGG) Fletham UK /1993	Industry Geophysics	4	**1159** 1333	. .
270	Cray Y-MP4/432	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**1159** 1333	. .
271	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
272	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
273	Cray Y-MP8/432	Defense Research Agency Ford Halstead UK /1990	Research	4	**1159** 1333	. .
274	Cray Y-MP4/432	Deutscher Wetterdienst Offenbach Germany /1990	Research Weather	4	**1159** 1333	. .
275	Cray Y-MP8/464	EXXON USA /1992	Industry Geophysics	4	**1159** 1333	. .
276	Cray Y-MP4/464	Eidgenoessische Technische Hochschule Zuerich Switzerland/1992	Academic	4	**1159** 1333	. .
277	Cray Y-MP8/4128	Electricite de France Clamart France /1990	Industry Energy	4	**1159** 1333	. .
278	Cray Y-MP4/432	Florida State University Tallahassee USA /1990	Academic	4	**1159** 1333	. .
279	Cray Y-MP4E/464	Hyundai Korea /1993	Industry Automotive	4	**1159** 1333	. .
280	Cray Y-MP4E/464	Lockheed Aeronautical Systems Company USA /1992	Industry Aerospace	4	**1159** 1333	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
281	Cray Y-MP8I/4128	Lockheed Aeronautical Systems Company USA /1993	Industry Aerospace	4	**1159** 1333	. .
282	Cray Y-MP4E/464	MPI Garching Germany /1991	Research	4	**1159** 1333	. .
283	Cray Y-MP4E/464	Matsushita Electric Osaka Japan /1992	Academic	4	**1159** 1333	. .
284	Cray Y-MP8I/4128	Merck Co USA /1993	Industry Chemistry	4	**1159** 1333	. .
285	Cray Y-MP4/464	Mitsubishi Motors Company Okazaki Japan /1992	Industry Automotive	4	**1159** 1333	. .
286	Cray Y-MP4/464	NCSA Urbana-Champaign USA /1990	Academic	4	**1159** 1333	. .
287	Cray Y-MP8/464	North Carolina Supercomputer Center USA /1991	Academic	4	**1159** 1333	. .
288	Cray Y-MP8/4128	ONERA Chatillon France /1991	Research Aerospace	4	**1159** 1333	. .
289	Cray Y-MP4/464	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	4	**1159** 1333	. .
290	Cray Y-MP4E/464	Samsung Korea /1991	Industry Electronics	4	**1159** 1333	. .
291	Cray Y-MP8/4128	Toshiba Kanagawa Japan /1990	Academic	4	**1159** 1333	. .
292	Cray Y-MP4/432	Universidad Nacional Autonoma de Mexico Mexico /1991	Academic	4	**1159** 1333	. .
293	Cray Y-MP4E/464	Universitaet Kaiserslautern Kiel Germany /1993	Academic	4	**1159** 1333	. .
294	Cray Y-MP4/464	University of Trondheim Norway /1992	Academic	4	**1159** 1333	. .
295	Cray Y-MP8/464	VW (Volkswagen AG) Wolfsburg Germany /1993	Industry Automotive	4	**1159** 1333	. .
296	Cray Y-MP M94/4256	KFA Juelich Germany /1993	Research	4	**1114** 1333	. .
297	Cray Y-MP M98/41024	University of Alaska Fairbanks USA /1992	Academic	4	**1114** 1333	. .
298	Fujitsu VPX220/10	GECO-PRAKLA Houston USA /1993	Industry Geophysics	1	**1048** 1250	. .
299	Fujitsu VPX220/10	Keio Daigaku University Japan /1992	Academic	1	**1048** 1250	. .
300	SNI S200/10	Schering Berlin Germany /1991	Industry Chemistry	1	**1048** 1250	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
301	SNI S200/20	Siemens Muenchen Germany /1991	Industry Electronics	1	**1048** 1250	. .
302	TMC CM-5/16	Goverment USA /1993	Classified	16	**980** 2048	6528 3008
303	TMC CM-5/16	Kyushu University Kyushu Japan / .	Academic	16	**980** 2048	6528 3008
304	TMC CM-5/16	LOREN Taiwan /1993		16	**980** 2048	6528 3008
305	TMC CM-5/16	NCSA USA /1993	Academic	16	**980** 2048	6528 3008
306	TMC CM-5/16	Pittsburgh Supercomputing Center Pittsburgh USA / .	Academic	16	**980** 2048	6528 3008
307	TMC CM-5/16	Thinking Machines USA /1993	Vendor	16	**980** 2048	6528 3008
308	TMC CM-5/16	West Virginia University USA / .	Academic	16	**980** 2048	6528 3008
309	Parsytec GCel 3/1024	Universitaet Koeln/DLR Koeln Germany /1992	Academic	1024	**971** 1540	15999 2073
310	Parsytec GCel 3/1024	Universitaet Paderborn Paderborn Germany /1992	Academic	1024	**971** 1540	15999 2073
311	Meiko CS/i860/42	Ensign Geophysics Weybridge UK /1987	Academic	42	**970** 1700	. .
312	NCube nCUBE2	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	512	**958** 1200	15200 2240
313	NCube nCUBE2	Rockwell USA /1992	Industry Aerospace	512	**958** 1200	15200 2240
314	Hitachi S-820/60	Defence Agency Land Japan /1989	Classified	1	**905** 1500	. .
315	Hitachi S-820/60	Hitachi Ltd. Adv. Res. Lab Japan /1993	Vendor	1	**905** 1500	. .
316	Hitachi S-820/60	Hitachi Ltd. Cent. Res. Lab. Japan /1992	Vendor	1	**905** 1500	. .
317	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
318	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
319	Hitachi S-820/60	Hitachi Ltd. STRD Japan /1991	Vendor	1	**905** 1500	. .
320	Hitachi S-820/60	Kajima Corporation Japan /1990	Industry Construction	1	**905** 1500	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
321	Hitachi S-820/60	Suzuki Motor Japan /1989	Industry Automotive	1	**905** 1500	. .
322	Hitachi S-820/60	Yamaichi Information Systems Japan /1989	Research Economics	1	**905** 1500	. .
323	KSR KSR1-32	GWDG Goettingen Germany /1992	Academic	32	**893** 1280	6144 896
324	KSR KSR1-32	INRIA - Sophia Antipolis Rennes France /1992	Research	32	**893** 1280	6144 896
325	KSR KSR1-32	Leibniz Rechenzentrum Muenchen Germany /1993	Academic	32	**893** 1280	6144 896
326	KSR KSR1-32	Siemens Nixdorf Muenchen Germany /1993	Vendor	32	**893** 1280	6144 896
327	KSR KSR1-32	Universitaet Mannheim Mannheim Germany /1992	Academic	32	**893** 1280	6144 896
328	KSR KSR1-32	University of Houston USA /1992	Academic	32	**893** 1280	6144 896
329	KSR KSR1-32	University of Manchester Manchester UK /1992	Academic	32	**893** 1280	6144 896
330	KSR KSR1-32	University of Toronto Toronto Canada /1993	Academic	32	**893** 1280	6144 896
331	NEC SX-2	Aoyama Gakuin University Japan /1988	Academic	1	**885** 1333	. .
332	NEC SX-2	Institute Laser Eng Osaka Univ. Osaka Japan /1985	Academic	1	**885** 1333	. .
333	NEC SX-2	Institute of Computational Fluid Dynamics Japan /1987	Research	1	**885** 1333	. .
334	NEC SX-2A	Mazda Motor Corporation Yokohama Japan /1989	Industry Automotive	1	**885** 1333	. .
335	NEC SX-2	NEC Fuchu Plant Japan /1987	Vendor	1	**885** 1333	. .
336	NEC SX-2	NEC Scientific Information (NSIS) Japan /1985	Research	1	**885** 1333	. .
337	NEC SX-2	Sumitomo Metal Industries Japan /1988	Industry	1	**885** 1333	. .
338	NEC SX-2	Tohoku University Tohoku Japan /1988	Academic	1	**885** 1333	. .
339	Cray Y-MP4/332	Arco Oil and Gas Company USA /1992	Industry Geophysics	3	**881** 999	. .
340	Cray Y-MP4E/364	British Aerospace PLC Farnborough UK /1991	Industry Aerospace	3	**881** 999	. .

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341	Cray Y-MP4E/332	Bureau of Meterology Melbourne Australia /1993	Research Weather	3	**881** 999	. .
342	Cray Y-MP4E/364	DKRZ Hamburg Germany /1991	Research Weather	3	**881** 999	. .
343	Cray Y-MP4/332	Du Pont De Nemours Company USA /1990	Industry Chemistry	3	**881** 999	. .
344	Cray Y-MP8/364	Honda Research and Development Company Tokyo Japan /1990	Industry Automotive	3	**881** 999	. .
345	Cray Y-MP4/364	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	3	**881** 999	. .
346	Cray Y-MP4E/364	Mobil / Technical Center Tulsa USA /1993	Industry Geophysics	3	**881** 999	. .
347	Cray Y-MP4E/364	Renault Rueil-Malmaison France /1992	Industry Automotive	3	**881** 999	. .
348	Cray Y-MP4/332	Shell USA USA /1992	Industry Geophysics	3	**881** 999	. .
349	Cray Y-MP4/364	debis Stuttgart Germany /1991	Industry Automotive	3	**881** 999	. .
350	Cray Y-MP M98/31024	General Motors/Research Environment Staff USA /1993	Industry Automotive	3	**855** 999	. .
351	Hitachi S-3600/160	Hitachi Zosen Corp. Japan /1992	Vendor	1	**851** 1000	. .
352	Hitachi S-3600/160	Toyo Tire Rubber Japan /1993	Industry	1	**851** 1000	. .
353	Fujitsu VP2200/10	ANSTO Australia /1991	Academic	1	**842** 1000	. .
354	Fujitsu VP2200/10	Australian National University Canberra Australia /1991	Academic	1	**842** 1000	. .
355	Fujitsu VP2200/10	Kawasaki Heavy Industry Japan /1990	Industry Heavy Ind.	1	**842** 1000	. .
356	Fujitsu VP2200/10	Kawasaki Steel Japan /1991	Industry Heavy Ind.	1	**842** 1000	. .
357	Fujitsu VP2200/10	Meiji University Japan /1990	Academic	1	**842** 1000	. .
358	Fujitsu VP2200/10	Nikko Securities Japan /1991	Industry finance	1	**842** 1000	. .
359	Fujitsu VP2200/10	Nippon Steel Japan /1992	Industry Heavy Ind.	1	**842** 1000	. .
360	Fujitsu VP2200/10	Sharp Japan /1990	Industry Electronics	1	**842** 1000	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
361	Fujitsu VP2200/10	Sony Japan /1990	Industry	1	**842** 1000	. .
362	Fujitsu VP2200/20	Toyota Motor Company Japan /1991	Industry Automotive	1	**842** 1000	. .
363	SNI S200/10 (4ns)	Universitaet Frankfurt Frankfurt Germany /1991	Academic	1	**842** 1000	. .
364	Meiko CS/i860/32	DRA Malvern Weybridge UK /1990	Research	32	**825** 1300	7000 3000
365	Cray X-MP/416	AMK Bonn Germany /1990	Classified	4	**822** 940	. .
366	Cray X-MP EA/432	BP Exploration Inc./U.S. USA /1990	Industry Geophysics	4	**822** 940	. .
367	Cray X-MP/48	Battelle Software Seattle USA / .	Industry Energy	4	**822** 940	. .
368	Cray X-MP/4	Chevron La Habra USA / .	Industry Geophysics	4	**822** 940	. .
369	Cray X-MP/416	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**822** 940	. .
370	Cray X-MP/416	Cray Research Eagan USA / .	Vendor	4	**822** 940	. .
371	Cray X-MP EA/464	Finish State Computer Centre Espoo Finland /1990	Academic	4	**822** 940	. .
372	Cray X-MP/416	Lawrence Livermore National Laboratory Livermore USA /1987	Research	4	**822** 940	. .
373	Cray X-MP EA/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
374	Cray X-MP EA/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
375	Cray X-MP EA/464	MIT Cambridge USA / .	Research	4	**822** 940	. .
376	Cray X-MP/416	Michelin Clermont-Ferrand France /1992	Industry Automotive	4	**822** 940	. .
377	Cray X-MP EA/464	Minnesota Supercomputer Center USA /1992	Academic	4	**822** 940	. .
378	Cray X-MP/416	NASA/Marshall Space Flight Center USA /1988	Research Aerospace	4	**822** 940	. .
379	Cray X-MP/416	Swedish National Supercomputer Centre Linkoping Sweden /1991	Academic	4	**822** 940	. .
380	Convex C3880	CONVEX Dallas USA /1992	Vendor	8	**795** 960	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
381	Convex C3880	DKRZ Hamburg Germany /1993	Research Weather	8	**795** 960	. .
382	Convex C3880	Danish Meteorological Institute Copenhagen Denmark /1992	Research	8	**795** 960	. .
383	Convex C3880	Ford Dearborn USA /1992	Industry Automotive	8	**795** 960	. .
384	Convex C3880	NCSA Urbana-Champaign USA /1992	Academic	8	**795** 960	. .
385	Convex C3880	SICAN Hannover Germany /1993	Industry	8	**795** 960	. .
386	Convex C3880	UNOCAL USA /1992	Industry	8	**795** 960	. .
387	SNI VP400EX	KFK Karlsruhe Germany /1990	Research	1	**794** 1714	. .
388	Fujitsu VP-400E	NAL Japan /1987		1	**794** 1714	. .
389	NEC SX-3/1LR	Sumitomo Rubber Industries Japan /1992	Industry Chemistry	1	**780** 800	2304 112
390	MasPar MP-2208	Arizona State University USA /1993	Academic	8192	**766** 1200	9386 1374
391	Cray S-MP/MCP784	Canon USA / .	Industry	84	**742** 3360	. .
392	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
393	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
394	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
395	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
396	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
397	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
398	Cray CRAY-2s/2-128	Eli Lilly and Company USA /1990	Industry Chemistry	2	**741** 976	. .
399	Cray CRAY-2s/2-128	US Air Force/National Test Facility USA /1988	Classified	2	**741** 976	. .
400	Cray S-MP/MCP756	CNR-Napoli USA / .		56	**678** 2210	. .

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401	Cray S-MP/MCP256	Cray Research Eagan USA / .	Vendor	56	**678** 2210	. .
402	Cray S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
403	Cray S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
404	NEC SX-3/1L	Hino Motor Japan /1992	Industry Automotive	1	**670** 680	2048 128
405	NEC SX-3/1L	Kajima Construction Japan /1991	Industry	1	**670** 680	2048 128
406	NEC SX-3/1L	Komatsu MFG Japan /1991	Industry	1	**670** 680	2048 128
407	IBM 9076-001 SP1	Halliburton USA /1993	Academic	8	**664** 1000	10000 1662
408	IBM 9076-001 SP1	ITESM Mexico /1993	Academic	8	**664** 1000	10000 1662
409	IBM 9076-001 SP1	NCAR USA /1993	Research	8	**664** 1000	10000 1662
410	TMC CM-2/8k	Universitaet Wuppertal Wuppertal Germany /1990	Academic	256	**650** 1750	. .
411	TMC CM-2/8k	University of Parma Parma Italy / .	Academic	256	**650** 1750	. .
412	Intel iPSC/860	Fermi National Accelerator Laboratory Batavia USA / .	Research	32	**640** 1280	6000 2500
413	Intel iPSC/860	GSF Neuherberg Germany /1990	Research	32	**640** 1280	6000 2500
414	Intel iPSC/860	KFA Juelich Germany /1991	Research	32	**640** 1280	6000 2500
415	Intel iPSC/860	Universitaet Saarbruecken Saarbruecken Germany /1990	Academic	32	**640** 1280	6000 2500
416	Convex M3860/8	CIRA Capua Italy /1993		6	**615** 720	. .
417	Convex C3860	GRS (Gesellschaft fuer Reaktorsicherheit) Muenchen Germany /1993	Research	6	**615** 720	. .
418	Convex C3860	Josef Stefan Institut Ljubljana Slovenia /1993	Research	6	**615** 720	. .
419	Convex C3860	MIT Cambridge USA /1993	Research	6	**615** 720	. .
420	Convex C3860	Universitaet Tuebingen Tuebingen Germany /1992	Academic	6	**615** 720	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
421	Cray Y-MP4/264	AEA Technology Harwell UK /1993	Research Energy	2	**604** 666	. .
422	Cray Y-MP4E/264	AGIP Milano Italy /1993	Industry Geophysics	2	**604** 666	. .
423	Cray Y-MP2E/232	Agency for Defense Development Korea /1992	Classified	2	**604** 666	. .
424	Cray Y-MP8/2128	Air Force/Eglin Air Force Base USA /1990	Classified	2	**604** 666	. .
425	Cray Y-MP2E/232	Apple Computer Inc. USA /1991	Industry Electronics	2	**604** 666	. .
426	Cray Y-MP2E/264	Audi AG Ingolstadt Germany /1992	Industry Automotive	2	**604** 666	. .
427	Cray Y-MP2E/232	Bundesanstalt fuer Wasserbau Hamburg Germany /1992	Research Geophysics	2	**604** 666	. .
428	Cray Y-MP2E/232	CONOCO Inc. USA /1991	Industry Geophysics	2	**604** 666	. .
429	Cray Y-MP4E/264	CSIRO (Commonwealth Scientific) Carlton Australia / .	Research	2	**604** 666	. .
430	Cray Y-MP4E/232	Canon Sales Tokyo Japan /1992	Industry	2	**604** 666	. .
431	Cray Y-MP2E/232	Centro de Supercomputacion de Catalunya Barcelona Spain /1992	Academic	2	**604** 666	. .
432	Cray Y-MP2/232	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
433	Cray Y-MP8/21024	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
434	Cray Y-MP2/232	DLR Oberpfaffenhofen Germany /1990	Research	2	**604** 666	. .
435	Cray Y-MP2E/232	Daihatsu Motor Company Japan /1992	Industry Automotive	2	**604** 666	. .
436	Cray Y-MP2E/264	Disaster Prevention Research Japan /1992	Research	2	**604** 666	. .
437	Cray Y-MP2E/232	EDS/ Adam Opel AG Ruesselsheim Germany /1992	Industry auot	2	**604** 666	. .
438	Cray Y-MP2E/232	ELF Aquitaine Pau France /1992	Industry Geophysics	2	**604** 666	. .
439	Cray Y-MP4E/264	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1992	Academic	2	**604** 666	. .
440	Cray Y-MP4/264	Electricite de France Clamart France /1992	Industry Energy	2	**604** 666	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
441	Cray Y-MP4/216	Fiat Torino Italy /1991	Industry Automotive	2	**604** 666	. .
442	Cray Y-MP2E/232	Grumman Aerospace Corporation USA /1991	Industry Aerospace	2	**604** 666	. .
443	Cray Y-MP2E/232	Institute Mediterraneen de Technologie Marseille France /1991	Academic	2	**604** 666	. .
444	Cray Y-MP2E/232	Isuzu Motor Tokyo Japan /1991	Industry Automotive	2	**604** 666	. .
445	Cray Y-MP2E/264	Kyoto University, Chemical Research Kyoto Japan /1992	Academic	2	**604** 666	. .
446	Cray Y-MP8/264	Los Alamos National Laboratory Los Alamos USA /1990	Research Energy	2	**604** 666	. .
447	Cray Y-MP2E/264	Marion Merrell Dow Inc USA /1992	Industry Chemistry	2	**604** 666	. .
448	Cray Y-MP2E/232	Mazda Motor Corporation Yokohama Japan /1991	Industry Automotive	2	**604** 666	. .
449	Cray Y-MP2E/216	Mazda Motor Corporation Yokohama Japan /1992	Industry Automotive	2	**604** 666	. .
450	Cray Y-MP2/216	NBS USA /1991	Research Weather	2	**604** 666	. .
451	Cray Y-MP2	National Center for Atmospheric Research Boulder USA / .	Research Weather	2	**604** 666	. .
452	Cray Y-MP2E/216	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	2	**604** 666	. .
453	Cray Y-MP8/232	Nippon Denso Japan /1991		2	**604** 666	. .
454	Cray Y-MP2E/232	Pennsylvania State University USA /1993	Academic	2	**604** 666	. .
455	Cray Y-MP2/232	Phillips Petroleum Company USA /1992	Industry Geophysics	2	**604** 666	. .
456	Cray Y-MP4/216	Rolls-Royce PLC UK /1990	Industry Aerospace	2	**604** 666	. .
457	Cray Y-MP2/264	Sandia National Labs Livermore USA / .	Research Energy	2	**604** 666	. .
458	Cray Y-MP2E/264	TEXACO USA /1991	Industry Geophysics	2	**604** 666	. .
459	Cray Y-MP2/216	Texas AM University USA /1993	Academic	2	**604** 666	. .
460	Cray Y-MP2E/264	The Scripps Research Institute USA /1992	Industry Chemistry	2	**604** 666	. .

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
461	Cray Y-MP2E/232	UFRGS/Uni. Federal do Rio Grande do Sul Brazil /1992	Academic	2	**604** 666	. .
462	Cray Y-MP2E/232	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	2	**604** 666	. .
463	Cray Y-MP2E/264	Universitaet Stuttgart Stuttgart Germany /1993	Academic	2	**604** 666	. .
464	Cray Y-MP2/216	University of Nevada at Las Vegas USA /1990	Academic	2	**604** 666	. .
465	Cray Y-MP2/232	University of Rochester - Laboratory for Laser E. USA /1991	Academic	2	**604** 666	. .
466	Cray Y-MP2E/264	debis Muenchen Germany /1993	Industry	2	**604** 666	. .
467	Fujitsu AP1000/128	Australian National University Canberra Australia / .	Academic	128	**566** 710	12800 1100
468	SNI S100/10	GEOVOR Traben Trabach Germany /1991	Industry Weather	1	**556** 625	. .
469	SNI S100/10	Technische Universitaet Wien Wien Austria /1992	Academic	1	**556** 625	. .
470	SNI S100/10	Universitaet Hamburg Hamnburg Germany /1992	Academic	1	**556** 625	. .
471	KSR KSR1-20	AWI (Alfred Wegener Institut) Bremerhaven Germany /1993	Research	20	**550** 800	. .
472	Cray Y-MP M92/2256	ATT Bell Laboratories USA /1992	Industry Electronics	2	**550** 666	. .
473	Cray Y-MP M92/21024	Minnesota Supercomputer Center USA /1992	Academic	2	**550** 666	. .
474	IBM 3090-600J	Centro de Supercomputacion de Catalunya Barcelona Spain / .	Academic	6	**540** 828	. .
475	IBM 3090-600J	GSI Darmstadt Germany /1987	Academic	6	**540** 828	. .
476	IBM 3090-600J	TU Braunschweig Braunschweig Germany / .	Academic	6	**540** 828	. .
477	IBM 3090-600E	University of Leuven Belgium / .	Academic	6	**540** 828	. .
478	IBM 3090-600S	Utah Supercomputing Institute USA / .	Academic	6	**540** 828	. .
479	IBM ES 9000-720	DESY Hamburg Germany / .	Research	6	**540** 828	. .
480	IBM ES 9000-720	SARA/IC3A (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	6	**540** 828	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
481	Convex C3850	NASA/Johnson Space Center Houston USA /1992	Research	5	**522** 600	. .
482	Cray S-MP/MCP728	CWI/Centrum voor Wiskunde en Informatica Amsterdam Netherlands/1992	Research	28	**508** 1120	. .
483	Parsytec GCel 3/512	Athens HPC Lab, Athen Greece /1993	Research	512	**485** 770	. .
484	Parsytec GCel 3/512	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1993	Academic	512	**485** 770	. .
485	MasPar MP-1216	ATT USA /1991	Industry Electronics	16384	**473** 550	11264 1280
486	MasPar MP-1216	Bellcore USA /1990	Industry	16384	**473** 550	11264 1280
487	MasPar MP-1216	Chevron La Habra USA / .	Industry Geophysics	16384	**473** 550	11264 1280
488	MasPar MP-1216	Harvard University Cambridge USA / .	Academic	16384	**473** 550	11264 1280
489	MasPar MP-1216	Iowa State University USA /1990	Academic	16384	**473** 550	11264 1280
490	MasPar MP-1216	NASA/Goddard Space Flight Center Greenbelt USA /1990	Research Aerospace	16384	**473** 550	11264 1280
491	MasPar MP-1216	Purdue University West Laffayette USA /1991	Academic	16384	**473** 550	11264 1280
492	DEC DECmpp SX 100	Thompson LER Rennes France / .	Industry Electronics	16384	**473** 550	11264 1280
493	MasPar MP-1216	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	16384	**473** 550	11264 1280
494	MasPar MP-1216	Universitaet Stuttgart Stuttgart Germany /1991	Academic	16384	**473** 550	11264 1280
495	Fujitsu VP-200E	MOE Nobeyama Observatory Japan /1989	Research	1	**472** 857	. .
496	Fujitsu VP-200E	MOE Space Science Research Japan /1987	Research	1	**472** 857	. .
497	Fujitsu VP-200E	Nat. Space Observatory Japan /1986	Research	1	**472** 857	. .
498	Fujitsu VP-200E	National Fusion Research Japan /1988	Research	1	**472** 857	. .
499	SNI VP200EX	Universitaet Bremen Bremen Germany /1991	Academic	1	**472** 857	. .
500	SNI VP200EX	Universitaet Dresden Dresden Germany /1991	Academic	1	**472** 857	. .

2.4
Statistics on Manufacturers and Continents

As basic statistics of the complete list, we give the number of systems installed with respect to the different manufacturers in the different countries or continents (Table 2.2) as well as the accumulated R_{max} values (Table 2.3) and R_{peak} values (Table 2.4) for those systems. A comprehensive report of more than 200 pages, based on the data of the TOP500 list, will be published [4].

"This volume"

Table 2.2:
Number of Systems Installed

TOP500 Statistics — Number of Systems Installed						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		7		6		13
Cray Research	2	56	18	117	7	200
DEC		2				2
Fujitsu	3	2	26	3		34
Hitachi			25			25
IBM		7		8	1	16
Intel	1	11	2	33		47
KSR		8	2	16		26
MasPar		2		10		12
Meiko		3				3
nCube			1	2		3
NEC		4	24	2	1	31
Parsytec		4				4
SNI		14				14
TMC	4	13	8	44	1	70
Total	10	133	106	241	10	**500**

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Table 2.3:
Installed R_{max}

TOP500 Statistics — Installed R_{max} [Gflop/s]						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		4.8		4.3		9.1
Cray Research	1.5	75.7	18.6	326.9	20.0	442.7
DEC		2.1				2.1
Fujitsu	2.3	4.2	176.7	5.3		188.5
Hitachi			40.2			40.2
IBM		4.7		14.5	0.7	19.9
Intel	1.5	17.0	3.5	121.5		143.5
KSR		7.8	3.7	33.7		45.2
MasPar		1.0		7.3		8.3
Meiko		3.1			0.4	3.5
nCube			1.0	2.9		3.9
NEC		17.1	90.5	25.0	2.9	135.5
Parsytec		2.9				2.9
SNI		23.7				23.7
TMC	8.9	30.3	18.8	341.5	1.0	400.5
Total	14.2	194.4	353.0	882.9	25.0	**1469.5**

Mannheim/Tennessee November 11, 1993

Table 2.4:
Installed R_{peak}

TOP500 Statistics — Installed R_{peak} [Gflop/s]						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		5.8		5.2		11.0
Cray Research	1.7	89.8	21.9	401.7	22.6	537.7
DEC		3.0				3.0
Fujitsu	2.7	5.0	302.4	6.3		316.4
Hitachi			84.5			84.5
IBM		7.6		36.2	1.0	44.8
Intel	4.2	35.9	7.5	282.9		331.5
KSR		11.0	5.1	59.5		75.6
MasPar		1.1		9.9		11.0
Meiko		5.5				5.5
nCube			1.2	3.6		4.8
NEC		18.8	102.8	27.5	3.2	152.3
Parsytec		4.6				4.6
SNI		31.3				31.3
TMC	19.9	67.1	41.8	745.4	2.0	876.2
Total	28.5	286.5	567.2	1579.2	28.8	**2490.2**

Mannheim/Tennessee November 11, 1993

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[3] G. Ahrendt, *Weekly posting to comp.sys.super*, 1993

[4] J. J. Dongarra, H. W. Meuer and E. Strohmaier, eds. *TOP500 Report 1993*, University of Mannheim, 1994

[5] J. J. Dongarra, *Performance of Various Computers Using Standard Linear Equations Software*, Computer Science Department, University of Tennessee, CS-89-85, 1993

3

Performance of Supercomputers

Erich Strohmaier

Abstract

As a variety of manufacturers is competing in a relatively small market, performance considerations are of big interest especially in the field of supercomputing. But more than in other computer classes reliable and meaningful data is hard to get. Design and implementation of hardware, operating systems and software spread out over a large variety of architectures. And as the price for a single machine is usually found in the million dollar range, vendors are often willing to play tricks to achieve better benchmark results.

In this chapter we first present an overview on the most popular benchmarks, before we discuss the LINPACK benchmark, which we have chosen to compile our TOP500. Finally we will analyse the general informations on the distribution of performance of supercomputers in the TOP500.

3.1 Overview

Single synthetic benchmarks like Drystone, Whetstone have been quite common for small machines for a decade [1]. But due to increasing cache sizes and better optimizing compilers, which are able to detect and eliminate unnecessary code, they became obsolete.

SPEC

In the workstation class the SPEC initiative was a quite successful attempt to create a standardised multi-application benchmark [2]. A set of 13 different full size application codes is used to evaluate the capabilities of workstations in a more realistic way. But still there are a lot of problems left which have to be solved by the SPEC-consortium as well as by other benchmark initiatives in the future, e.g.:

- As time goes by, new applications have to substitute outdated ones and problem sizes have to be increased.

Table 3.1:
Benchmark Suite of the Perfect Club [3]

Code	Application Area	Fortran Lines
ADM	Fluid Dynamics	6105
ARC2D	Fluid Dynamics	3964
BDNA	Chem&Phys Modelling	3977
DYFESM	Engineering Design	7608
FLO52	Fluid Dynamics	1986
MDG	Chem&Phys Modelling	1238
MG3D	Signal Processing	2812
OCEAN	Fluid Dynamics	4343
QCD	Chem&Phys Modelling	2327
SPEC77	Fluid Dynamics	2885
SPICE	Engineering Design	18521
TRACK	Signal Processing	3784
TRFD	Chem&Phys Modelling	485

- To evaluate the whole range of workstations different problem sizes are needed.

- In most citations only mean values of results are quoted, but they can be misleading.

- As no optimizations are permitted the initial set of codes and details of their implementations can be crucial for the absolute and relative performance of machines.

Perfect Club

In 1987, a group of supercomputer vendors and researchers from universities started an effort known as 'Perfect Club' to overcome these problems, especially for the class of vector supercomputers [3]. Due to their complex architecture there was a very big interest in developing a methodology for fair benchmarking including the possibility of optimization of the codes. The optimization of codes is very important in the case of vector or parallel computers, as their architectures are too different to be equally treated by a single implementaion of a given problem. Therefore, the Perfect Club collected a set of 13 full size scientific application codes (Table 3.1) and described a procedure for optimizing the code and reporting results. In the case of vector computers the Perfect Club was quite successful, but due to the big amount of work needed for such an effort, they are falling behind in creating a similar benchmark suite for MPPs as they had done for vector machines.

A big problem with benchmarks including optimization of full size codes is just the effort and time you have to put in to do the job properly. This is one of the major reasons why kernel based bench-

Benchmark Name	Abbreviation
Embarrassingly Parallel	EP
Multigrid	MG
Conjugate Gradient	CG
3-D FFT PDE	FT
Integer Sort	IS
LU Simulated CFD Application	LU
SP Simulated CFD Application	SP
BT Simulated CFD Application	BT

Table 3.2: Benchmark Suite of the NAS Parallel Benchmark

marks are still very important. Also in many cases they can be good first approximations to what can be expected for the performance of full codes. The sizes of many kernels themselves can range between a hundred up to a few thousand lines of code.

Livermore Kernels

In the eighties the 'Livermore Fortran Kernels' were quite popular [4]. All 24 kernels add up to about a thousand lines of Fortran code and were mainly designed to test vector computers. Because of this they are not well suited for MPPs.

NAS PB

In the last two years the 'NAS Parallel Benchmark' became very widespread [5]. Most important about this benchmark is, that it was designed for studying the performance of parallel supercomputers. The eight problems shown in Table 3.2 are specified as "pencil and paper" benchmarks, but examples of their implementations are also available. To achieve comparable results the definition as well as the reporting of results are exactly specified. The latest results may be found in [6]. The big interest the NAS PB found in the high performance community show the big need for such reliable, fair and appropriate benchmarks.

Parkbench

Not too long ago a new initiative was formed to establish a scientific methodology for benchmarking especially suited for MPP systems, the 'Parkbench' initiative [7]. The Parkbench will include not only statement and kernel based benchmarks but also full size application code benchmarks. It is an initiative of many scientists working in this field and the benchmark will include the NAS PB as well as a variant of the LINPACK benchmark. Its major goal is not just to create another suite of benchmarks, but to continue the development of the scientific foundation of the field of supercomputer performance evaluation.

3.2
The LINPACK Benchmark

When we looked for a suitable yardstick of performance to rank the TOP500 supercomputers, the availability of results for a wide range of machines was very important for us, as we do not want to exclude machines just because we do not have benchmark data. Looking on the different benchmarks, it was quite clear that we could only take the LINPACK benchmark. This benchmark was introduced by J. Dongarra more than a decade ago and he has been collecting performance data since then [10]. A detailed description as well as a list of performance results on a wide variety of machines is available in postscript form from *netlib*. To retrieve a copy send electronic mail to *netlib@ornl.gov* and by typing the message *send performance from benchmark* or from any machine on the internet type:
rcp anon@netlib2.cs.utk.edu:benchmark/performance performance.

LINPACK 100×100

The LINPACK benchmark is a single application benchmark and nowadays has three different variants. The selected problem is to solve a dense system of linear equations. In the first and original variant a system of order 100 has to be solved, also no modifications of the code are allowed at all.

TPP

To cope with increasing capabilities of hard- and software a second variant called 'Toward Peak Performance (TPP)' was defined by J. Dongarra. In this case the number of equations is 1000 and optimization of the code is permitted, as long as the required precision of the results is achieved.

HPC

In the case of MPPs it turned out that the restriction to a system of order 1000 was still too limited to get a realistic impression of the capabilities of these systems. In a third variant called 'High parallel

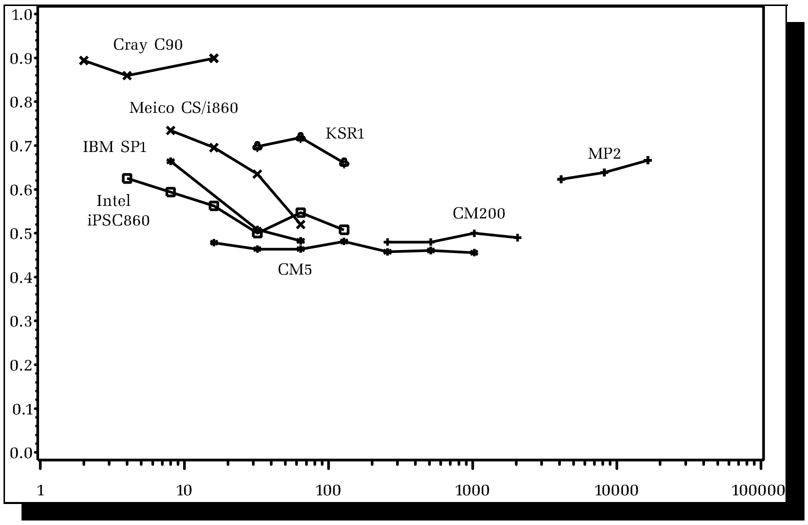


Figure 3.1:
Efficiencies of different computer types for the LINPACK benchmark over the number of processors.
The efficiency η is defined as:

$$\eta = \frac{R_{max}}{R_{peak}}$$

computing (HPC)' you are also allowed to scale the problem size to value N_{max} where you can get optimal performance R_{max}. As additional information you also have to determine the problem size for which half of the optimal performance is achieved ($N_{1/2}$). Going to bigger machines you can enlarge the problem size to demonstrate the higher capabilities of the system. The achievable performance is now limited by real constraints of the systems like CPU-performance and memory size. 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.* As the reported results in general show quite high efficiencies as shown in Figure 3.1, they can be seen as a first realistic correction to the non-achievable peak performance R_{peak}. Also there are examples of other real application codes exceeding the R_{max} performances [8]. However compared to other application benchmarks (e.g. the NAS PB) the performances especially of MPP systems are quite high.

Due to these properties of LINPACK HPC and TPP and the big number of systems for which results are available, we have chosen the best of both as the basic measure for the TOP500. 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. But we do not see this happening in the near future due to the big effort involved in it.

To get our list as complete as possible, for the first two releases we used not only numbers published by J. Dongarra, but also reliable numbers we received by communication with the vendors or by linear interpolations between measured results. However, *we never* *used estimates or extrapolations.* We will continue to use reliable benchmark results only. The performances we used are shown in Table 3.3, where we also indicate their sources. This table does not show the present LINPACK numbers which can be found in [10], but the ones of 11 November '93, the release date of our second list [9], on which the present TOP500 (Chapter 2) is based.

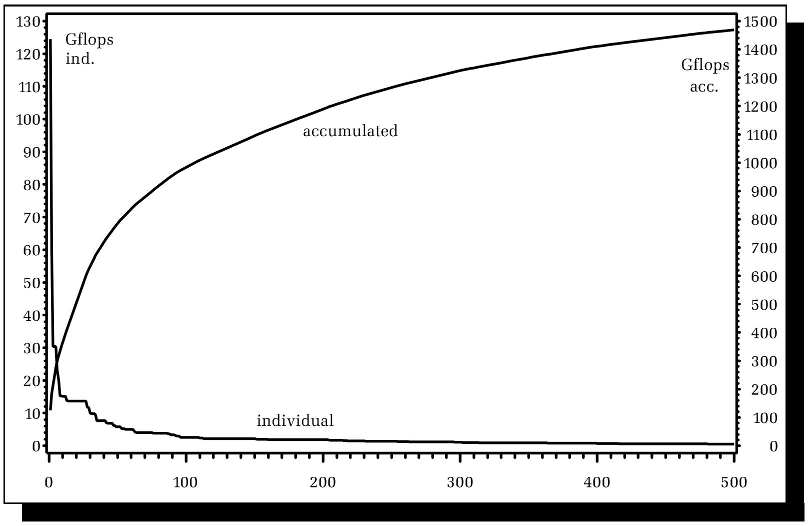
3.3 Analysis of the TOP500

First 10 Systems: 364 Gflop/s
First 42 Systems: 733 Gflop/s
Last 100 Systems: 58 Gflop/s

In Table 3.3 we have sorted all different performance types showing up in the TOP500 and include the number of their appearances. Figure 3.2 shows individual as well as accumulated performances with respect to the positon in the TOP500. Figure 3.3 shows the same data for the first hundred entries only. The first 10 systems already contribute 364 Gflop/s R_{max} (24.8%) to the list. The first 42 systems achieve half of the total performance in the TOP500! On the contrary, the last 100 systems contribute only 58 Gflop/s (4%).

Unfortunatly the $N_{1/2}$ values are not complete in our list. Looking at them in Figure 3.4 you can see that the values of $N_{1/2}$ are quite widespread. Low values are typical for vector machines where MPPs often show quite high ones. This indicates that you have to run bigger problems on MPPs to achieve good efficiencies. Figure 3.5 shows N_{max} values. The difference between vector machines and MPPs is not so big, nevertheless MPPs tend to have higher N_{max} values, which shows that they often have bigger memory. This is due to the fact, that their DRAM memory chips are cheaper than the SRAM memory chips of the vector machines.

Figure 3.2:
R_{max} values of the computers over their position in the TOP500



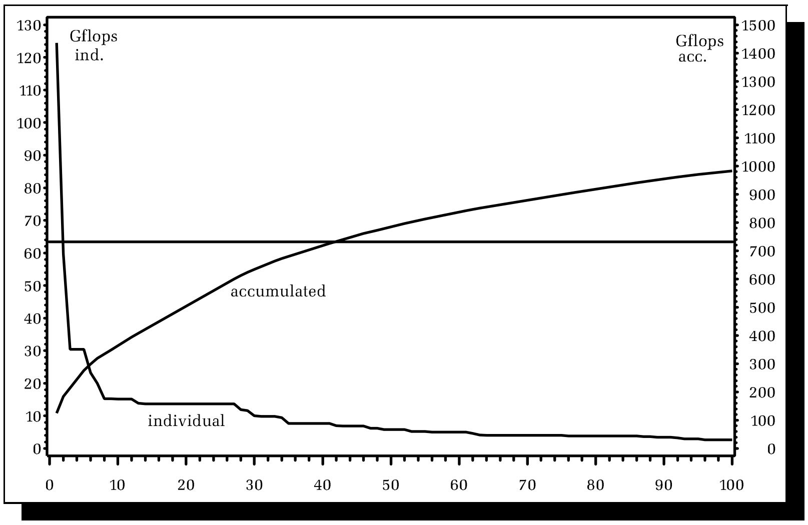


Figure 3.3:
R_{max} values of the computers over their position in the TOP100 only.
A line for referencing half or the total accumulated R_{max} performance is also included.

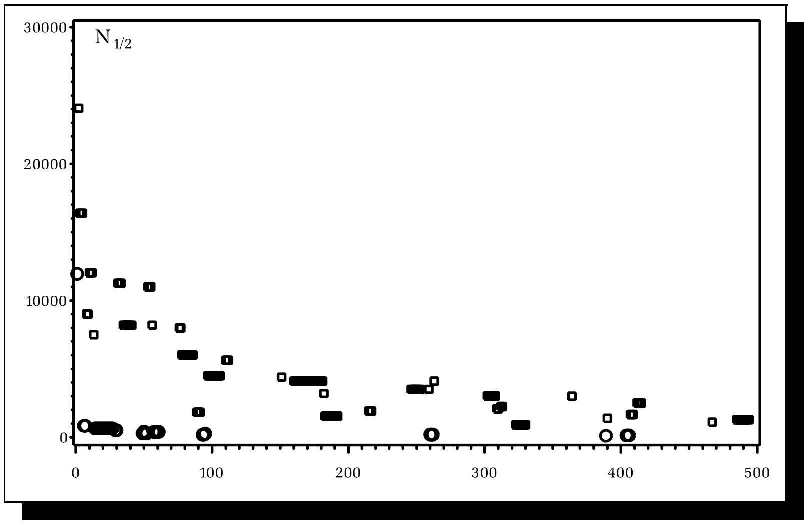


Figure 3.4:
$N_{1/2}$ values of the computers over their position in the TOP500.
Circles denote MP vector computers and squares denote MPP systems.

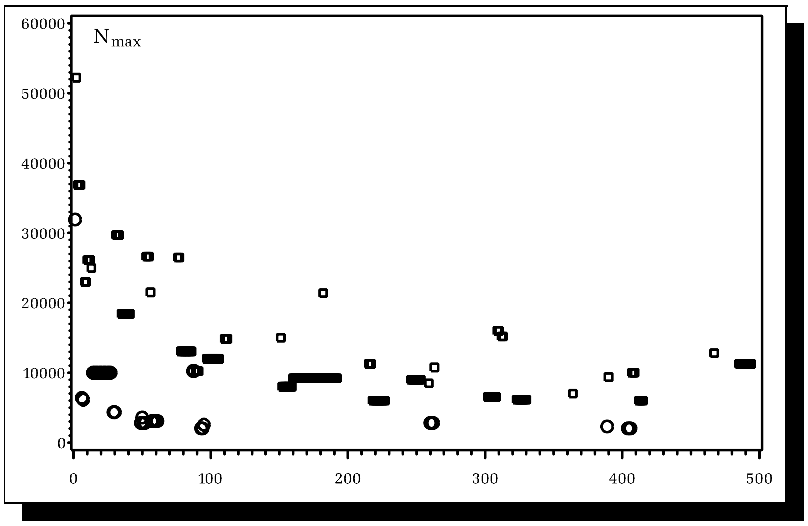


Figure 3.5:
N_{max} values of the computers over their position in the TOP500.
Circles denote MP vector computers and squares denote MPP systems.

Table 3.3: All types of computers with different performance in the TOP500

Computer	# Proc.	t_{cycl} [ns]	**Rmax** [Mflop/s]	R_{peak} [Mflop/s]	N_{max}	$N_{1/2}$	
Num. Wind Tunnel	140	9.5	**124500**	236000	31920	11950	HPC
CM-5/1024	1024	31.2	**59700**	131000	52224	24064	HPC
CM-5/544	544	31.2	**30400**	70000	36864	16384	HPC[2]
CM-5/512	512	31.2	**30400**	66000	36864	16384	HPC
SX-3/44R	4	2.5	**23200**	26000	6400	830	HPC
SX-3/44	4	2.9	**20000**	22000	6144	832	HPC
XP/S135	1840	20.0	**15200**	92000	23000	9000	TOP500[2]
XP/S35	512	20.0	**15200**	26000	23000	9000	TOP500
CM-5/256	256	31.2	**15100**	33000	26112	12032	HPC
Delta	512	25.0	**13900**	20480	25000	7500	HPC
Y-MP C916/16	16	4.2	**13700**	15238	10000	650	HPC
XP/S30	400	20.0	**11900**	20000			TOP500[1]
SX-3/24R	2	2.5	**11600**	13000	4352	516	HPC
SX-3/24	2	2.9	**10000**	11000	4352	500	HPC
CM-200/64k	2048	100.0	**9800**	20000	29696	11264	HPC
Y-MP C916/11	11	4.2	**9418**	10476			HPC[1]
CM-5/128	128	31.2	**7700**	16000	18432	8192	HPC
S-3800/480	4	2.0	**7016**	32000			TOP500
Y-MP C916/8	8	4.2	**6850**	7619			HPC[1]
XP/S15	208	20.0	**6200**	10400			TOP500[1]
SX-3/14R	1	2.5	**5800**	6400	2816	282	HPC
SX-3/41R	4	2.5	**5800**	6400	3584	414	HPC
CM-2/64k	2048	142.0	**5200**	14000	26624	11000	HPC
CM-200/32k	1024	100.0	**5000**	10000	21504	8192	HPC
SX-3/14	1	2.9	**5000**	5500	3072	384	HPC
SX-3/22	2	2.9	**5000**	5500	3072	384	HPC
Y-MP C916/6	6	4.2	**4630**	5715			HPC[1]
XP/S10	140	20.0	**4100**	7000			TOP500[1]
VP2600	1	3.2	**4009**	5000			TPP
9076-005 SP1	128	16.0	**3861**	16000	26500	8000	TOP500[2]
9076-004 SP1	64	16.0	**3861**	8000	26500	8000	TOP500
CM-5/64	64	31.2	**3800**	8192	13056	6016	HPC
VP2400/40	2	3.2	**3624**	5000	10239		TOP500
KSR1-256	256	50.0	**3380**	10240	10240	1824	TOP500[2]
KSR1-128	128	50.0	**3380**	5120	10240	1824	TOP500
Y-MP C916/4	4	4.2	**3275**	3810			TPP
SX-3/12R	1	2.5	**2900**	3200	2048	174	HPC
SX-3/21R	2	2.5	**2900**	3200	2560	257	HPC
CM-2/32k	1024	142.0	**2600**	7000			HPC[1]
iPSC/860	128	25.0	**2600**	5120	12000	4500	HPC

Table 3.3: All types of computers with different performance in the TOP500

Computer	# Proc.	t_{cycl} [ns]	**Rmax** [Mflop/s]	R_{peak} [Mflop/s]	N_{max}	$N_{1/2}$	
KSR1-96	96	50.0	**2535**	3840			TOP500[1]
CM-200/16k	512	100.0	**2400**	5000	14848	5632	HPC
CRAY-2s/8	8	4.0	**2171**	3902			TPP
Y-MP8/8	8	6.0	**2144**	2667			TPP
VP2400	1	3.2	**2110**	2500			TPP[1]
9076-003 SP1	32	16.0	**2033**	4000	15000	4390	TOP500
XP/S5	66	20.0	**2000**	3300	8000		TOP500
XP/S5-32	66	20.0	**2000**	3300	8000		TOP500
CM-5/32	32	31.2	**1900**	4096	9216	4096	HPC
nCUBE2	1024	50.0	**1900**	2400	21376	3193	HPC
KSR1-64	64	50.0	**1838**	2560	9216	1536	TOP500
S-820/80	1	4.0	**1817**	3000			TOP500
Y-MP M98/8	8	6.0	**1733**	2667			TPP
Y-MP C916/2	2	4.2	**1703**	1905			TPP
VP2400	1	4.0	**1688**	2000			TPP
S-3600/180	1	4.0	**1672**	2000			TOP500
Y-MP8/6	6	6.0	**1651**	2000			TPP[1]
MP-2216	16384	80.0	**1600**	2400	11264	1920	HPC
XP/A4	56	20.0	**1500**	4200	6000		TOP500
XP/A4E	56	20.0	**1500**	4200	6000		TOP500
ES 9000-900	6	9.0	**1457**	2664			TPP
CRAY-2s/4	4	4.0	**1406**	1952			TPP
CRAY-2/4	4	4.0	**1406**	1951			TPP
iPSC/860	64	25.0	**1400**	2560	9000	3500	HPC
KSR1-48	48	50.0	**1350**	1920			TOP500[1]
CM-2/16k	512	142.0	**1300**	3500			HPC[1]
CS/i860/64	64	25.0	**1300**	2500	8500	3500	HPC
SX-3/11	1	2.9	**1300**	1370	2816	192	HPC
CM-200/8k	256	100.0	**1200**	2500	10752	4096	HPC
Y-MP8/4	4	6.0	**1159**	1333			TPP
Y-MP M94/4	4	6.0	**1114**	1333			TPP
VP2200	1	3.2	**1048**	1250			TPP
CM-5/16	16	31.2	**980**	2048	6528	3008	HPC
GCel 3/1024	1024	33.0	**971**	1540	15999	2073	TOP500
CS/i860/42	42	25.0	**970**	1700			HPC[1]
nCUBE2	512	50.0	**958**	1200	15200	2240	HPC
S-820/60	1	4.0	**905**	1500			TOP500
KSR1-32	32	50.0	**893**	1280	6144	896	TOP500
SX-2	1	6.0	**885**	1333			TPP
SX-2A	1	6.0	**885**	1333			TPP

Table 3.3: All types of computers with different performance in the TOP500

Computer	# Proc.	t_{cycl} [ns]	**Rmax** [Mflop/s]	R_{peak} [Mflop/s]	N_{max}	$N_{1/2}$	
Y-MP8/3	3	6.0	**881**	999			TPP[1]
Y-MP M94/3	3	6.0	**855**	999			TPP[1]
S-3600/160	1	4.0	**851**	1000			TOP500
VP2200	1	4.0	**842**	1000			TPP
CS/i860/32	32	25.0	**825**	1300	7000	3000	HPC
X-MP/4	4	8.5	**822**	940			TPP
C3880	8	16.7	**795**	960			TPP
VP400EX	1	7.0	**794**	1714			TPP
SX-3/1LR	1	2.5	**780**	800	2304	112	HPC
MP-2208	8192	80.0	**766**	1200	9386	1374	TOP500
S-MP/MCP784	84	25.0	**742**	3360			TPP
CRAY-2s/2	2	4.0	**741**	976			TPP
S-MP/MCP756	56	25.0	**678**	2210			TPP
SX-3/1L	1	2.9	**670**	680	2048	128	HPC
9076-001 SP1	8	16.0	**664**	1000	10000	1662	TOP500
CM-2/8k	256	142.0	**650**	1750			HPC[1]
iPSC/860	32	25.0	**640**	1280	6000	2500	HPC
C3860	6	16.7	**615**	720			TPP[1]
Y-MP8/2	2	6.0	**604**	666			TPP
AP1000/128	128	40.0	**566**	710	12800	1100	HPC
vp2100/10	1	3.2	**556**	625			TPP[1]
KSR1-20	20	50.0	**550**	800			TOP500[1]
Y-MP M92/2	2	6.0	**550**	666			TPP
3090-600E	6	14.5	**540**	828			TPP
3090-600J	6	14.5	**540**	828			TPP
3090-600S	6	14.5	**540**	828			TPP
ES 9000-720	6	14.5	**540**	828			TPP
C3850	5	16.7	**522**	600			TPP[1]
S-MP/MCP728	28	25.0	**508**	1120			TPP
GCel 3/512	512	33.0	**485**	770			TOP500
MP-1216	16384	83.0	**473**	550	11264	1280	HPC
VP200EX	1	7.0	**472**	857			TPP

The different types of sources have the following meaning:

HPC:	Linpack Table 3: Highly Parallel Computing
TPP:	Linpack Table 1: 'TPP' (Towards Peak Performance) best effort
TOP500:	Measurements we received for the TOP500
List[1]:	Linear interpolation between values of 'List' (HPC, TPP or TOP500)
List[2]:	R_{max} results of next smaller system measured used out of 'List' (HPC, TPP or TOP500)

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4

The different Supercomputers in the TOP500

Erich Strohmaier

4.1 Introduction

Phrases like 'supercomputer' or 'supercomputer on a chip' are quite widespread nowadays. The TOP500 gives us the instrument to analyse and define which machine can be called and which one should not be called a supercomputer. The TOP500 so far shows only MP vector computers or MPP systems. We do not think that the list will be restricted to these two classes in the future, especially high end multi CPU workstations will undoubtedly enter the list in one of the next releases. In this chapter we will first look at the different classes of computers and families of systems in the TOP500. We will then present the main technological and architectural features of each family shortly.

4.2 Overview on the different computer families in the TOP500

In detail we can see 103 different models in the TOP500 which are shown in Chapter 3 in table 3.3 together with their performance. We can group these models in the 30 families shown in Table 4.1 sorted by their numbers of entries in the TOP500. In Table 4.2 we show them sorted by their accumulated R_{max}. You can derive the numbers of MP vector computers and MPP systems from this list quite easily. These numbers and their relative ratios are discussed in detail in the following chapters of this report.

Table 4.1:
The different computer families in the TOP500, sorted by the number of entries.

Computer Family	# Entries	R_{max} [Gflop/s]	R_{peak} [Gflop/s]	position of entries first	mean	last
YMP	126	151.4	179.6	114	304	466
CM5	52	333.0	722.2	2	133	308
VP2000	38	82.7	102.4	64	224	470
KSR1	26	45.2	75.7	89	223	471
XP	25	103.7	254.7	8	147	227
C90	23	239.9	267.6	14	46	206
SX3	23	128.4	141.7	6	141	406
iPSC/860	22	39.8	76.8	97	212	415
S-820	20	28.1	46.5	193	252	322
Cray 2	18	24.7	35.1	113	249	399
XMP	15	12.3	14.1	365	372	379
C3800	13	9.2	10.9	380	404	481
SMP	12	8.4	33.5	391	404	482
CM2	10	24.7	66.5	53	211	411
MP1	10	4.7	5.5	485	490	494
CM200	8	42.8	87.5	31	94	263
SX2	8	7.1	10.7	331	335	338
VP-EX	8	4.4	8.6	387	470	500
SP1	6	11.7	31.0	76	255	409
M90	6	5.9	7.7	204	349	473
ES9000	5	5.5	9.6	228	329	480
3090	5	2.7	4.1	474	476	478
MP2	4	5.6	8.4	215	260	390
S-3600	4	5.0	6.0	208	280	352
GC-EL	4	2.9	4.6	309	397	484
nCube2	3	3.8	4.8	182	269	313
CS/i860	3	3.1	5.5	259	311	364
VPP500	1	124.5	236.0	1	1	1
S-3800	1	7.0	32.0	42	42	42
AP1000	1	0.6	0.7	467	467	467
Total	500	1468.9	2489.9			

Computer Family	# Entries	R_{max} [Gflop/s]	R_{peak} [Gflop/s]	position of entries first	mean	last
CM5	52	333.0	722.2	2	133	308
C90	23	239.9	267.6	14	46	206
YMP	126	151.4	179.6	114	304	466
SX3	23	128.4	141.7	6	141	406
VPP500	1	124.5	236.0	1	1	1
XP	25	103.7	254.7	8	147	227
VP2000	38	82.7	102.4	64	224	470
KSR1	26	45.2	75.7	89	223	471
CM200	8	42.8	87.5	31	94	263
iPSC/860	22	39.8	76.8	97	212	415
S-820	20	28.1	46.5	193	252	322
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SX2	8	7.1	10.7	331	335	338
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S-3600	4	5.0	6.0	208	280	352
MP1	10	4.7	5.5	485	490	494
VP-EX	8	4.4	8.6	387	470	500
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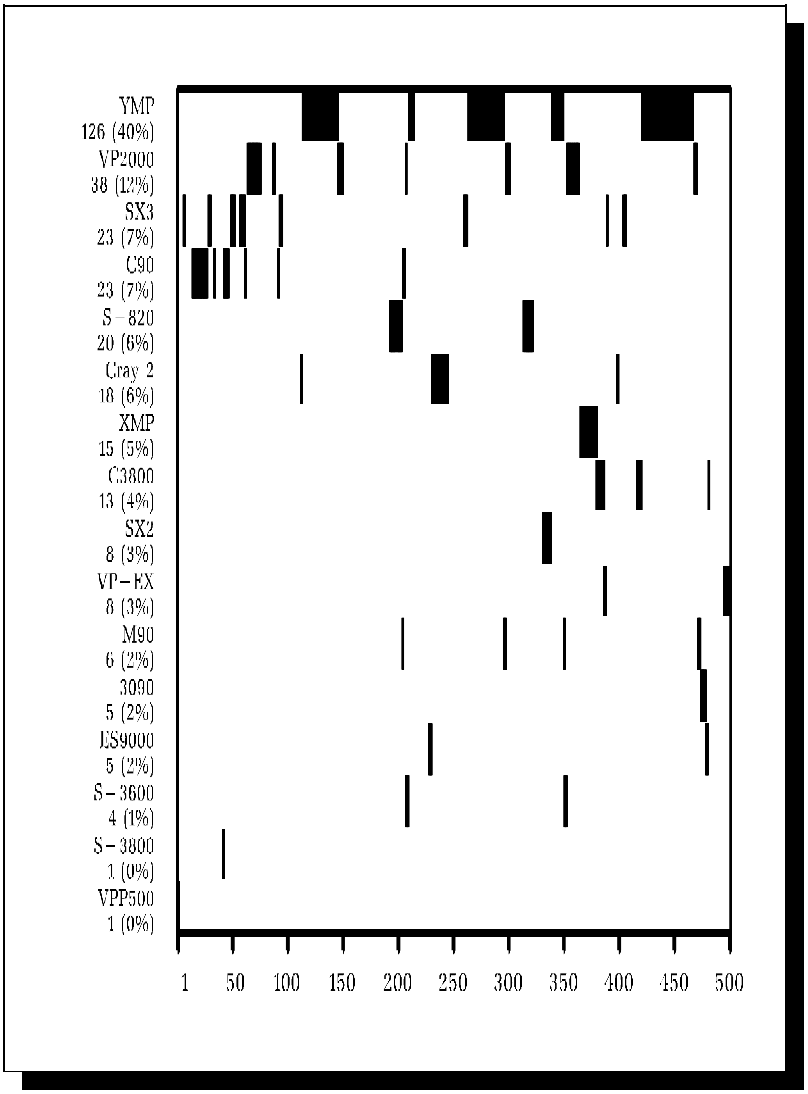
GC-EL	4	2.9	4.6	309	397	484
3090	5	2.7	4.1	474	476	478
AP1000	1	0.6	0.7	467	467	467
Total	500	1468.9	2489.9			

Table 4.2:
The different computer families in the Top500, sorted by the accumulated R_{max}.

To get a more detailed view of the distribution of different systems in the TOP500 we show the position of the different classes and families in Figure 4.2 for MP vector computers versus MPPs, in Figure 4.1 for the different vector families and in Figure 4.3 for the different MPP families. The position of a system within the TOP500 is marked by a black line, so you can identify the distribution over the complete list easily.

We see that there is no strict relationship between families with a higher number of entries (see on top of the graphs) and higher performances (see on left of the graphs). But there is a tendency for such a correlation.

Figure 4.1:
Different vector computer series over their position N in the TOP500 sorted by their number of entries.



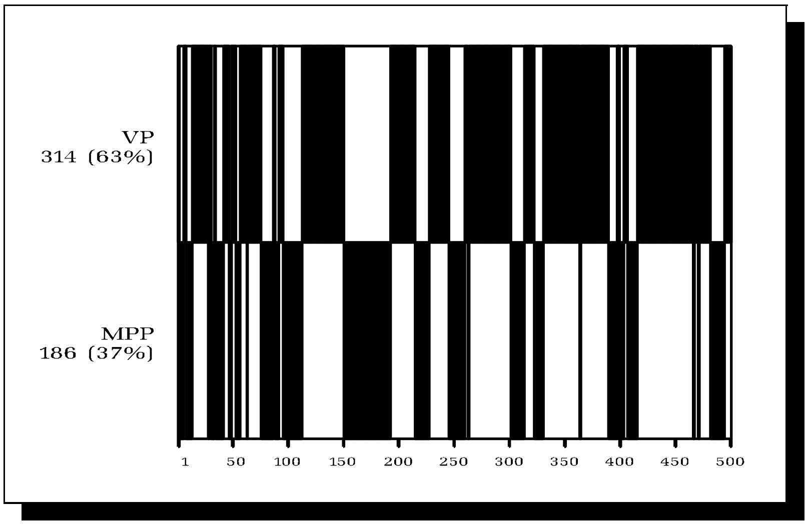


Figure 4.2:
MP vector and MPP systems over their position N in the TOP500

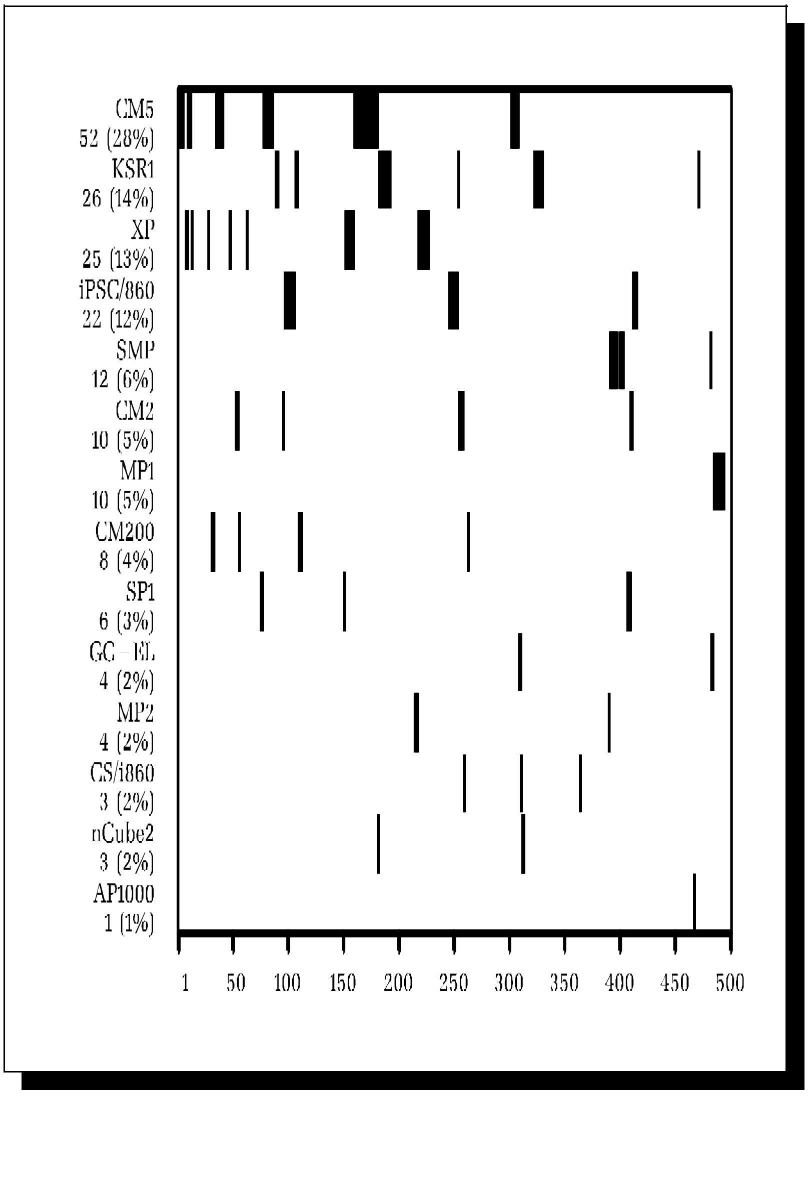


Figure 4.3:
Different MPP series over their position N in the TOP500 sorted by their number of entries.

In the case of MP vector machines (Figure 4.1) the Cray YMP is clearly dominating the TOP500 as a working horse. Following the leading families of the competitors Fujitsu (VP200) and NEC (SX-3), the C90 already has a quite good position which is especially due to the 14 full size machines installed.

In the case of MPP (Figure 4.3) the systems CM5 of Thinking Machines and Paragon XP of Intel show up on top as well as on the left of the graph. The KSR1 also has quite a lot of entries and slightly outranks even the Paragon XP. But the KSR1 is lacking high end installations as well as performance data for their biggest machines. Also for the high end Paragon XP systems performance informations were missing when we compiled the second TOP500, which is the basis for this report. In the meantime we received data for the Paragon XP.

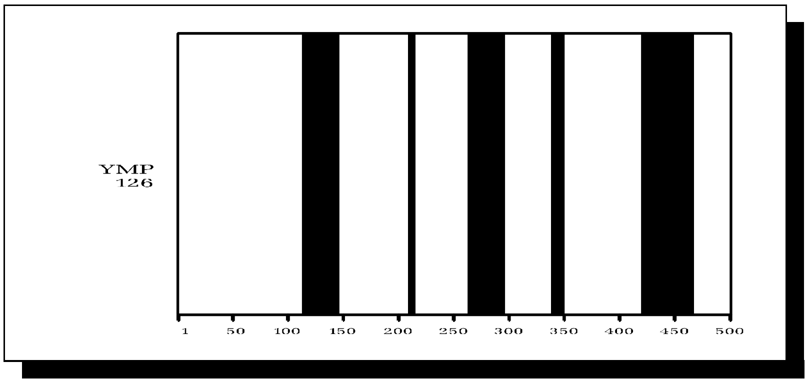
4.3 The different computer families

After the distribution of the different families, we would now like to brief you on their main features. For a more detailed description of supercomputer architectures we refer, for instance, to the excellent book of Kai Hwang, Advanced Computer Architecture (McGraw-Hill, New York, 1993).

For the presentation on the following pages we have ordered the families first by vendors according to their numbers of entries in the TOP500. For each vendor we order the families by their number of entries for the system in question in the TOP500 (Table 4.3).

Table 4.3:
List of the different computer families in the TOP500, as presented on the following pages.

Cray Y-MP

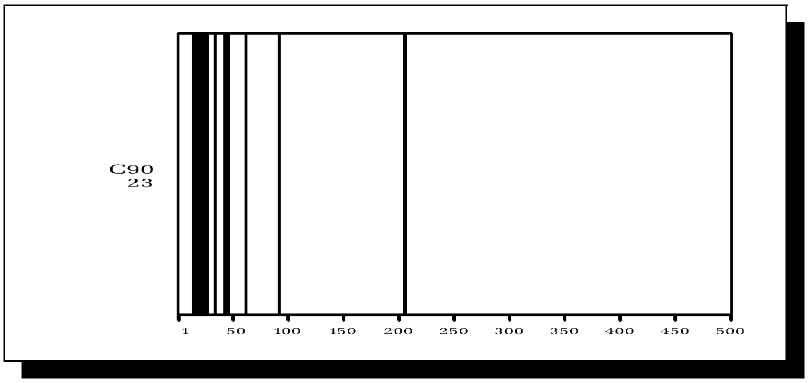


Number of entries	126 (25.2%)
Accumulated R_{max}	151 Gflop/s (10.3%)
Accumulated R_{peak}	180 Gflop/s (7.2%)
First entry	114
Model	Y-MP8/8256
Last entry	466
Model	Y-MP2/216
Processors	1–8
Memory	$\leq$ 2 GB
Cycle time	6 ns
R_{max} performance	2.144 Gflop/s
Peak performance R_{peak}	2.667 Gflop/s
Peak performance/processor	0.333 Gflop/s
First machine delivered	1988

The Y-MP is by far the most succesful series of the market leader Cray Research. It is with a share of 25% quite dominant in the TOP500, but it is no longer able to enter the TOP100. It is the predecessor of the C90 and followed the X-MP as shared memory MP vector computer with up to 8 processors. Built with ECL chip technology it has a cycle time of 6 ns.

The X-MP and Y-MP series, which Steve Chen designed before he left Cray Research, are well known for their exceptional high memory bandwidth and sophisticated shared memory access subsystem. This is together with the big amount of available software the main reason for its success.

Cray Y-MP C90

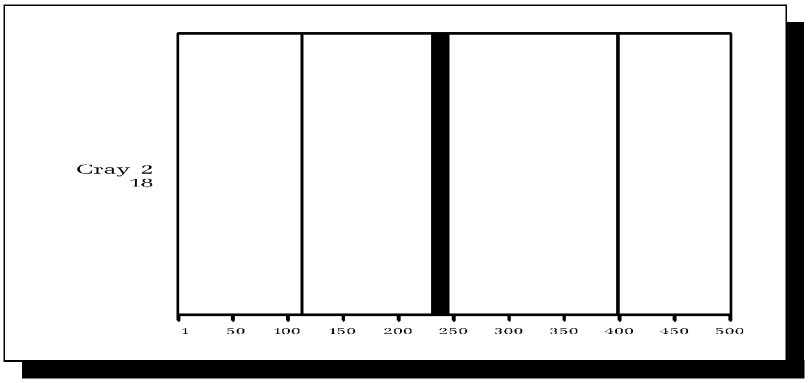


23 (4.6%)	Number of entries
240 Gflop/s (16.3%)	Accumulated R_{max}
268 Gflop/s (10.7%)	Accumulated R_{peak}
14	First entry
Y-MP C916/161024	Model
206	Last entry
Y-MP C92A/2128	Model
2–16	Processors
$\leq$ 2 GB	Memory
4.2 ns	Cycle time
13.7 Gflop/s	R_{max} performance
15.2 Gflop/s	Peak performance R_{peak}
0.95 Gflop/s	Peak performance/processor
1992	First machine delivered

The C90 is top model of the market leader Cray Research. The number of systems sold is still a magnitude lower than of the predecessor series Y-MP, but even so the accumulated performance is yet higher by about 50%. The position figure shows the big number (14) of 16 processor systems installed, which are the main reason for the big accumulated performance. It is a shared memory MP vector computer with up to 16 processors. Built with ECL chip technology it has a cycle time of 4.2 ns and doubled pipelines.

The X-MP and Y-MP series are well known for their exceptional high memory bandwidth and sophisticated shared memory access subsystem. In developing the C90, Cray Research has taken special care to keep the efficiency as high as on the former models, even so the number of Load/Store units has quadrupled (16 instead of 8 processors and doubled pipes).

Cray 2

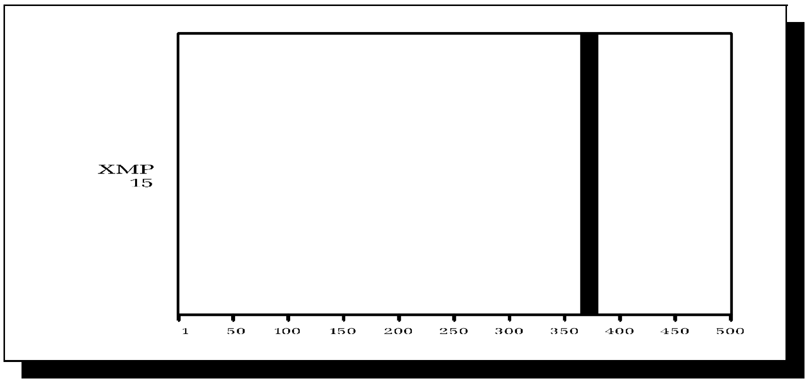


Number of entries	18 (3.6%)
Accumulated R_{max}	24.7 Gflop/s (1.7%)
Accumulated R_{peak}	35.1 Gflop/s (1.4%)
First entry	113
Model	Cray 2s/8-128
Last entry	399
Model	Cray 2s/2-128
Processors	1–4(8)
Memory	$\leq$ 2 GB
Cycle time	4 ns
R_{max} performance	1.4(2.17) Gflop/s
Peak performance R_{peak}	2(4) Gflop/s
Peak performance/processor	0.5 Gflop/s
First machine delivered	1985

#113 is a special model

The Cray 2 was developed at Cray by Seymour Cray before he left Cray Research with his own company Cray Computer. It is a shared memory MP vector computer with up to 4 processors. The 8 processor model in the TOP500 is a special construction. Built with ECL chip technology the Cray 2 has a cycle time of 2 ns.

The architecture especially of the memory access subsystem is quite different from the X-MP or Y-MP series. At the time of its introduction it was the machine with by far the biggest main memory. The processor itself is of similar design, as all three families came out of the legendary Cray 1. The Cray 2 is one of the oldest architectures in the TOP500, still with a quite respectful positioning, but it is no longer able to enter the TOP100.

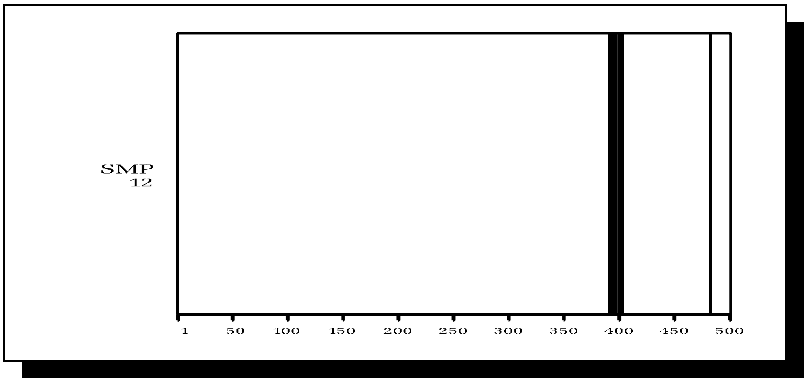


Cray X-MP

15 (3.0%)	Number of entries
12.3 Gflop/s (0.8%)	Accumulated R_{max}
14.1 Gflop/s (0.6%)	Accumulated R_{peak}
365	First entry
X-MP/464	Model
379	Last entry
X-MP/48	Model
1–4	Processors
$\leq$ 0.5 GB	Memory
8.5 ns	Cycle time
0.82 Gflop/s	R_{max} performance
0.94 Gflop/s	Peak performance R_{peak}
0.235 Gflop/s	Peak performance/processor
1983	First machine delivered

The X-MP was the first shared memory MP vector computer with more than one processor (up to 4). It was the first machine designed by Steve Chen at Cray Research, who developed later on the Y-MP. Built with ECL chip technology it has a cycle time of 8.5 ns. The remaining X-MP models all have 4 processors, as the smaller ones did not make it in the TOP500.

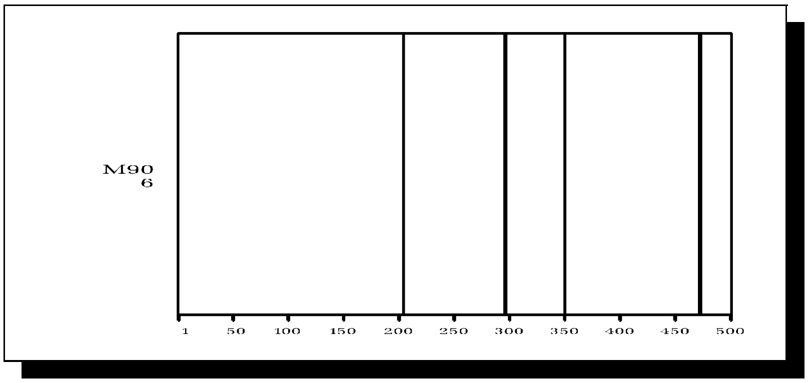
Cray SMP



Number of entries	12 (2.4%)
Accumulated R_{max}	8.4 Gflop/s (0.6%)
Accumulated R_{peak}	33.5 Gflop/s (1.3%)
First entry	391
Model	S-MP/MCP784
Last entry	482
Model	S-MP/MCP728
Processors	7–84
Memory	$\leq$ 1 GB
Cycle time	25 ns
R_{max} performance	0.74 Gflop/s
Peak performance R_{peak}	3.36 Gflop/s
Peak performance/processor	0.04 Gflop/s
First machine delivered	1989

This system is one of the remainders of the company FPS (Floating Point Systems) known before as FPS System 500. Cray Research bought the company after their bankruptcy. The design of the system is modular and based on up to two scalar nodes on SPARC basis, up to two proprietary vector nodes and an array unit based on 7 up to 84 intel i860 chips. Cray Research is now developing its own series of superservers, which not yet show up in the TOP500.

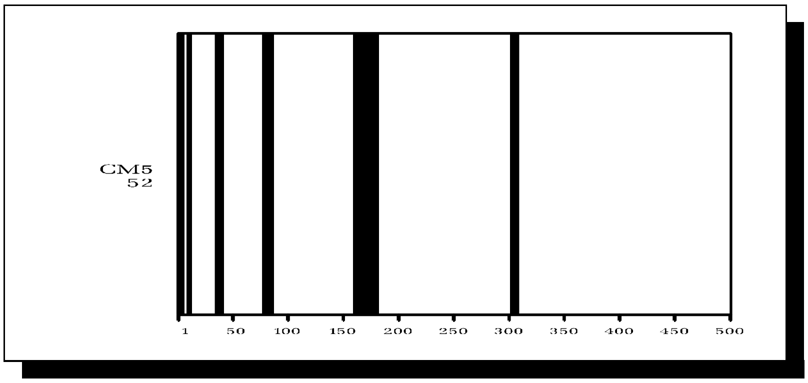
Y-MP M90



6 (1.2%)	Number of entries
5.9 Gflop/s (0.4%)	Accumulated R_{max}
7.7 Gflop/s (0.3%)	Accumulated R_{peak}
204	First entry
Y-MP M98/81024	Model
473	Last entry
Y-MP M92/2256	Model
1–8	Processors
$\leq$ 32 GB	Memory
6 ns	Cycle time
1.733 Gflop/s	R_{max} performance
2.667 Gflop/s	Peak performance R_{peak}
0.333 Gflop/s	Peak performance/processor
1993	First machine delivered

The M90 is not as the name might indicate similar to the C90 system, but much more to the Y-MP/8. Actually it is a Y-MP/8 system with a main memory built of DRAM chips rather than SRAM chips like the Y-MP or the C90. By this the main memory can be much bigger for the same price. Therefore the M90 is very well suited to run very big memory intensive jobs, but does not show top of the line performance.

Thinking Machines CM-5

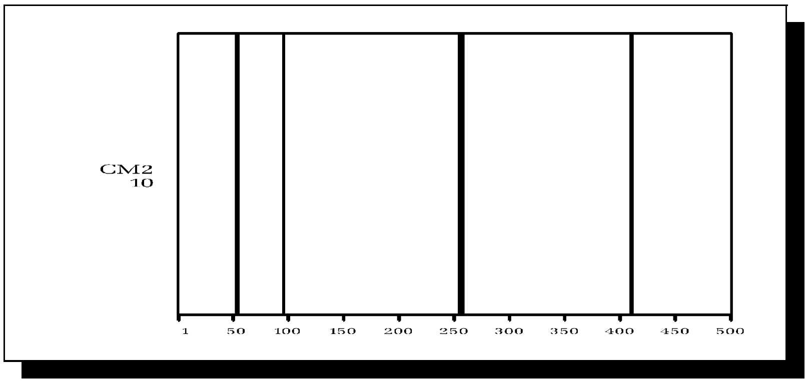


Number of entries	52 (10.4%)
Accumulated R_{max}	333 Gflop/s (22.7%)
Accumulated R_{peak}	722 Gflop/s (29.0%)
First entry	2
Model	CM-5/1024
Last entry	308
Model	CM-5/16
Processors	16–1024
Memory	$\leq$ 32 GB
Cycle time	31.25 ns
R_{max} performance	59.7 Gflop/s
Peak performance R_{peak}	131 Gflop/s
Peak performance/processor	0.132 Gflop/s
First machine delivered	1992

The CM-5 is one of the highest performing systems at present. It is by number behind the Y-MP at position two in the TOP500 (10%), but with regards to performance it is already in front with 22.7% of the total TOP500 performance.

The nodes of the CM-5 consist of a SPARC scalar unit and four vector co-processors, each with its own memory. The data transmission network has a fat tree topology. The smallest unit within this network is a group of 16–32 processors and an additional control processor, which manages timesharing and similar tasks. Till now the software focuses on the data parallel programming paradigm, which comes from the former model CM-2, which was a hardware SIMD machine. However due to the enhanced flexibility of the architecture of the CM-5, there is also programming with message passing possible. The maximal number of processors is 16,384, but such a large machine seems not to be affordable for anybody.

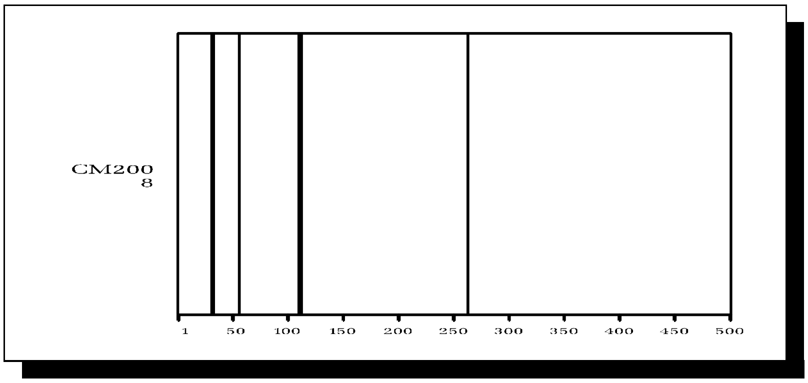
Thinking Machines CM-2



10 (2.0%)	Number of entries
24.7 Gflop/s (1.7%)	Accumulated R_{max}
66.5 Gflop/s (2.7%)	Accumulated R_{peak}
53	First entry
CM-2/64k	Model
411	Last entry
CM-2/8k	Model
256–2048 (Weitek)	Processors
$\leq$ 8 GB	Memory
142 ns	Cycle time
5.2 Gflop/s	R_{max} performance
14 Gflop/s	Peak performance R_{peak}
0.007 Gflop/s	Peak performance/processor
1987	First machine delivered

The CM-2 was the first commercial successful MPP system, which reached at least for certain applications performance values similar to the fastest MP vector computers at that time. It is a hardware based SIMD machine with bitslice processors, 32 of which share- a Weitek floating point coprocessor. As these co-processors dominate the floating-point performance of the system, we show the number of these and not the number of the bitslice processors.

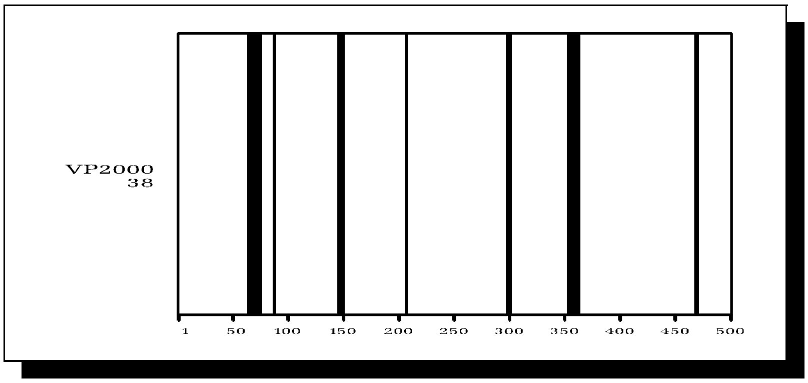
Thinking Machines
CM-200



Number of entries	8 (1.6%)
Accumulated R_{max}	42.8 Gflop/s (2.9%)
Accumulated R_{peak}	87.5 Gflop/s (3.5%)
First entry	31
Model	CM-200/64k
Last entry	263
Model	CM-200/8k
Processors	256–2048 (Weitek)
Memory	$\leq$ 8 GB
Cycle time	100 ns
R_{max} performance	9.8 Gflop/s
Peak performance R_{peak}	20 Gflop/s
Peak performance/processor	0.01 Gflop/s
First machine delivered	1991

The CM-200 is of the same architecture as the CM-2, but with lower cycle time of 100 ns instead of 142 ns. As the CM-5 was announced shortly after the CM-200 was available, it is not as widespread as the other two families of Thinking Machines.

Fujitsu VP2000



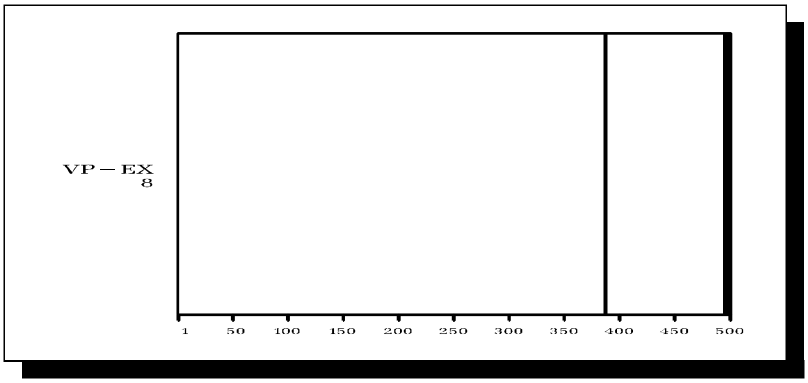
38 (7.6%)	Number of entries
82.7 Gflop/s (5.6%)	Accumulated R_{max}
102 Gflop/s (4.1%)	Accumulated R_{peak}
64	First entry
VP2600/20	Model
470	Last entry
VP2100/10	Model
1–2	Processors
$\leq$ 2 GB	Memory
3.2 ns (4 ns)	Cycle time
4.0 Gflop/s	R_{max} performance
5 Gflop/s	Peak performance R_{peak}
5 Gflop/s	Peak performance/processor
1991	First machine delivered

The VP2000 is the latest series of vector computers from Fujitsu. It was mainly designed as uniprocessor, but has a dual scalar architecture, which means that two scalar units share the vector unit. By this the throughput of a system should be improved, as a typical workload is not perfectly vectorised. The cycle time was reduced from the initial 4 ns to 3.2 ns, so the performance of the same computer type might differ. The top model is not only available as single vector unit machine with fourfold vector piplines (VP2600/20) but also as two vector unit machine with four scalar units and doubled vector piplines (VP2400/40), which results in the same peak performance of 5 Gflop/s. The VP2000 is the first Fujitsu vector computer, which can run the UNIX derivative UXP/M, which is in widespread use in Europe only.

VP2600/20: #64–75
VP2400/40: #87–88

Siemens Nixdorf is marketing and selling the Fujitsu supercomputers in Europe. In the TOP500 11 VP2000 called Sx00 sold by SNI are present.

Fujitsu VP-EX

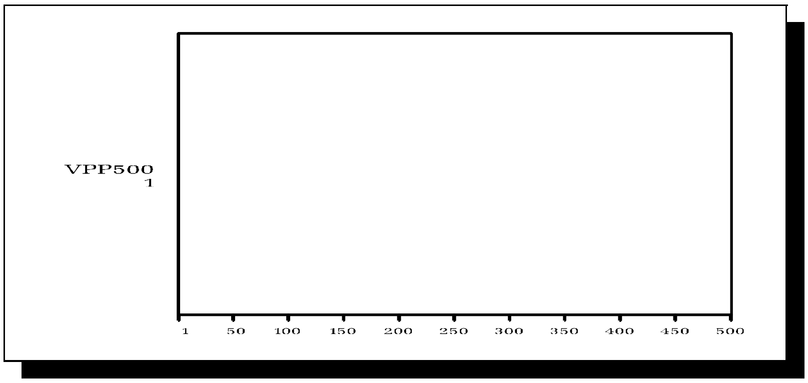


Number of entries	8 (1.6%)
Accumulated R_{max}	4.4 Gflop/s (0.3%)
Accumulated R_{peak}	8.6 Gflop/s (0.3%)
First entry	387
Model	VP-400E
Last entry	500
Model	VP-200E
Processors	1
Memory	$\leq$ 1 GB
Cycle time	7 ns
R_{max} performance	0.79 Gflop/s
Peak performance R_{peak}	1.71 Gflop/s
Peak performance/processor	1.71 Gflop/s
First machine delivered	1987

The EX series was the second generation of vector computers from Fujitsu. The uniprocessor machine has the asymmetrical number of 2 add and 1 multiply units, each of which up to fourfold. It is however the only Fujitsu series with such an asymmetrical design, as it came out that only certain applications can benefit from it.

Siemens Nixdorf is marketing and selling the Fujitsu supercomputers in Europe. In the TOP500 3 VP-EX models sold by SNI are present.

Fujitsu VPP500



1 (0.2%)	Number of entries
124.5 Gflop/s (8.5%)	Accumulated R_{max}
236 Gflop/s (9.5%)	Accumulated R_{peak}
1	First entry
Numerical Wind Tunnel	Model
-	Last entry
-	Model
7–222	Processors
$\leq$ 55 GB	Memory
10 ns	Cycle time
124.5 Gflop/s	R_{max} performance
355 Gflop/s	Peak performance R_{peak}
1.6 Gflop/s	Peak performance/processor
1993	First machine delivered

The VPP500 is based on Fujitsu's VP architecture and a new RISC scalar unit. It is built in BICMOS chip technology giving a cycle time of 10 ns, which is higher than the one of the VP series (3.2 ns). But due to eightfold piplines the single processor peak is 1.6 Gflop/s. However by improvements in the starting phases of the vector piplines, the startup times are even lower than those of the VP series! It is a distributed memory machine with a global address space. The interconnect network is a 222 $\times$ 222 crossbar in GaAs technology. Till now the VPP500 needs an VP2000 model as a front end, to handle all I/O. The connection to this VP is realized by a shared SSU (Solid State Unit).

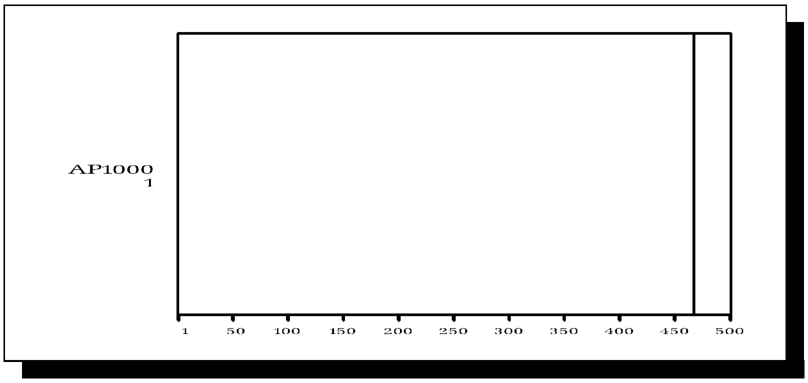
BICMOS

eightfolded piplines

Biggest crossbar ever build

The only entry in the TOP500 as of November 1993 is a special model called 'Numerical Wind Tunnel'. It alone contributes already 8.5% of the accumulated R_{max} to the TOP500!

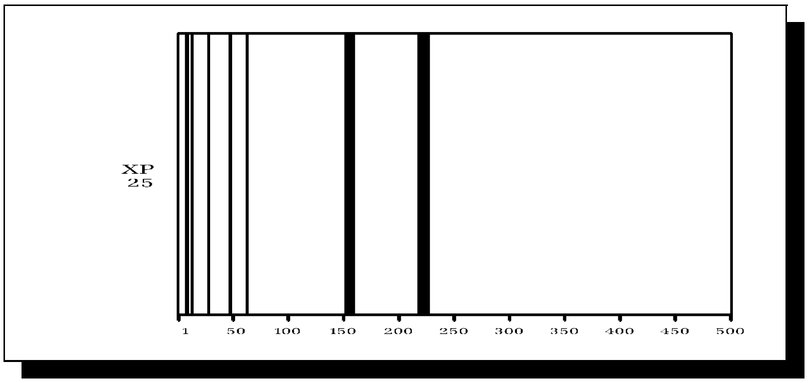
Fujitsu AP1000



Number of entries	1 (0.2%)
Accumulated R_{max}	0.566 Gflop/s (0.0%)
Accumulated R_{peak}	0.71 Gflop/s (0.0%)
First entry	467
Model	AP1000/128
Last entry	-
Model	-
Processors	64–1024
Memory	$\leq$ 16 GB
Cycle time	40 ns
R_{max} performance	0.566 Gflop/s (128 nodes)
Peak performance R_{peak}	12.8 Gflop/s
Peak performance/processor	0.0125 Gflop/s
First machine delivered	1991

The AP1000 series is a hardware based SIMD machine built by Fujitsu mainly for cooperations with universities and research labs in computer science. The only model in the TOP500 is installed in Australia at the National University in Canberra.

Intel Paragon XP

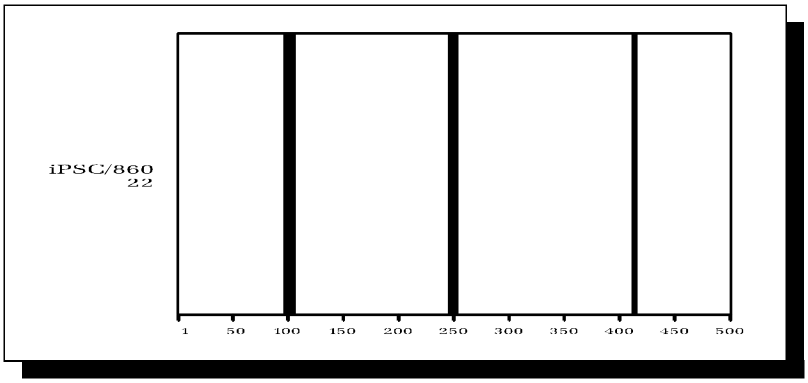


25 (5.0%)	Number of entries
103.7 Gflop/s (7.1%)	Accumulated R_{max}
255 Gflop/s (10.2%)	Accumulated R_{peak}
8	First entry
XP/S135	Model
227	Last entry
XP/A4	Model
56–2048	Processors
$\leq$ 64 GB	Memory
20 ns	Cycle time
15.2 Gflop/s (512 nodes)	R_{max} performance
100 Gflop/s	Peak performance R_{peak}
0.05 Gflop/s	Peak performance/processor
1992	First machine delivered

The Paragon XP series is the latest series of MPP systems by Intel. Based on a twodimensional grid interconnect, the single nodes are using two i860XP chips, one for computation and one for communication.

Shortly after the release date of the TOP500 intel published new LINPACK results. That's why the importance of this series will even be higher in the next release of the TOP500. Especially the entry number 6 (Sandia National Labs) will improve further.

Intel iPSC/860



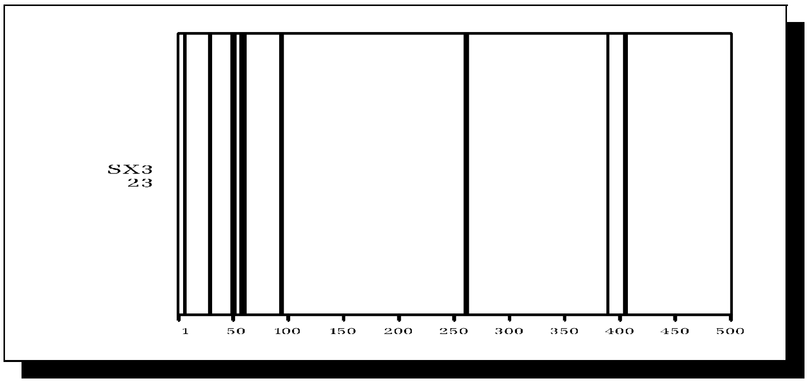
Number of entries	22 (4.4%)
Accumulated R_{max}	39.8 Gflop/s (2.7%)
Accumulated R_{peak}	76.8 Gflop/s (3.1%)
First entry	97
Model	iPSC/860-128
Last entry	415
Model	iPSC/860-32
Processors	16–128
Memory	$\leq$ 8 GB
Cycle time	25 ns
R_{max} performance	2.6 Gflop/s
Peak performance R_{peak}	5.1 Gflop/s
Peak performance/processor	0.04 Gflop/s
First machine delivered	1990

The second generation of MPPs by intel is based on a hypercube interconnect and used as the first machine of the Intel supercomputer division the i860 chip as node.

#97–106

The size of the machine was limited by the maximal dimension of the connecting hypercube (dimension 7) and 10 of these large systems are installed.

NEC SX-3

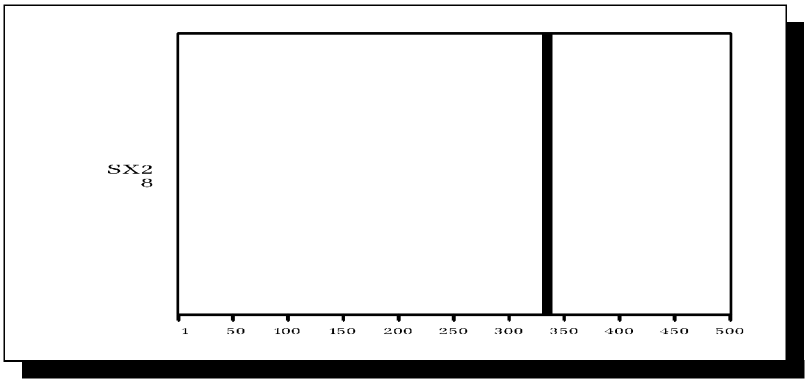


23 (4.6%)	Number of entries
128.4 Gflop/s (8.7%)	Accumulated R_{max}
142 Gflop/s (5.7%)	Accumulated R_{peak}
6	First entry
SX-3/44R	Model
406	Last entry
SX-3/1L	Model
1–4	Processors
$\leq$ 2 GB	Memory
2.5 ns	Cycle time
20 Gflop/s	R_{max} performance
26 Gflop/s	Peak performance R_{peak}
6.5 Gflop/s	Peak performance/processor
1990	First machine delivered

The SX-3 is the latest series of vector machines made by NEC. Originally introduced with a cycle time of 2.9 ns, this was reduced in the 'R' models to 2.5 ns. It is the first MP vector machine made by NEC and can be built with up to four processors. But as two processors have to share a single memory access path, the effective bandwidth to memory of the four processor models is comparably low. Nevertheless, the top models show up at positions 6 and 7 in the TOP500, which shows the big potential of this series.

#6 SX-3/44R NEC, Japan
#7 SX-3/44 AES, Canada

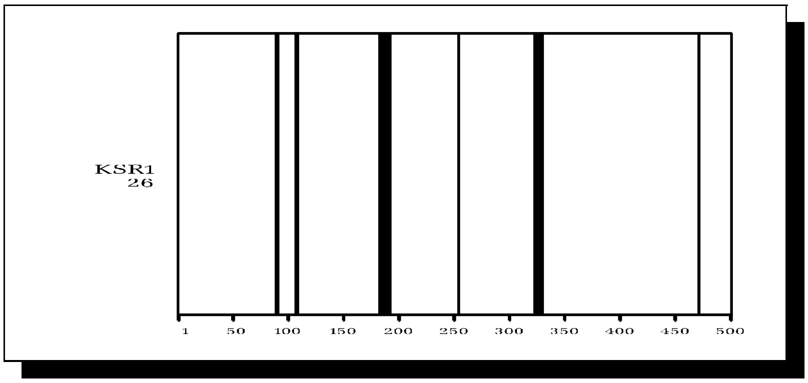
NEC SX-2



Number of entries	8 (1.6%)
Accumulated R_{max}	7.1 Gflop/s (0.5%)
Accumulated R_{peak}	10.7 Gflop/s (0.4%)
First entry	331
Model	NEC SX-2
Last entry	338
Model	NEC SX-2
Processors	1
Memory	$\leq$ 0.256 GB
Cycle time	6 ns
R_{max} performance	0.885 Gflop/s
Peak performance R_{peak}	1.333 Gflop/s
Peak performance/processor	1.333 Gflop/s
First machine delivered	1984

The SX-2 was the second generation of uniprocessor vector machines built by NEC. NEC tried to sell this architecture outside of Japan, but only with limited success, that's why all remaining systems in the TOP500 are installed in Japan.

KSR1



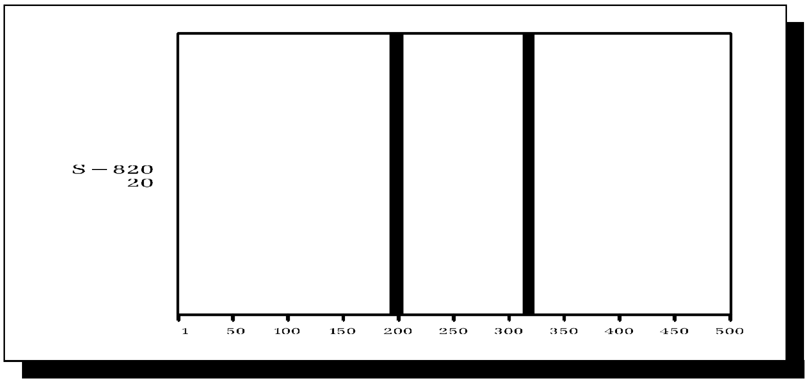
26 (5.2%)	Number of entries
45.2 Gflop/s (3.1%)	Accumulated R_{max}
75.7 Gflop/s (3.0%)	Accumulated R_{peak}
89	First entry
KSR1-256	Model
471	Last entry
KSR1-20	Model
8–1088	Processors
$\leq$ 34 GB	Memory
50 ns	Cycle time
3.38 Gflop/s (128 nodes)	R_{max} performance
40 Gflop/s	Peak performance R_{peak}
0.04 Gflop/s	Peak performance/processor
1992	First machine delivered

The KSR1 system of Kendall Square Research is the first commercial virtual shared memory system. Built as physically distributed memory machine, the whole memory of the machine is a single address space and managed as cache, that's why it is called an ALLCACHE architecture. This management is done in hardware built in the proprietary processor of the nodes. The interconnect is a multistage fully piplined ring.

As no benchmark data of the 256 node machines are available, they are at the same position as the 128 node machine in the TOP500. The family comes after the CM5 and almost equal with the Paragon XP concerning the number of entries in the TOP500 in the class of MPP systems. Due to missing installations of high end models the share of accumulated R_{max} is lower

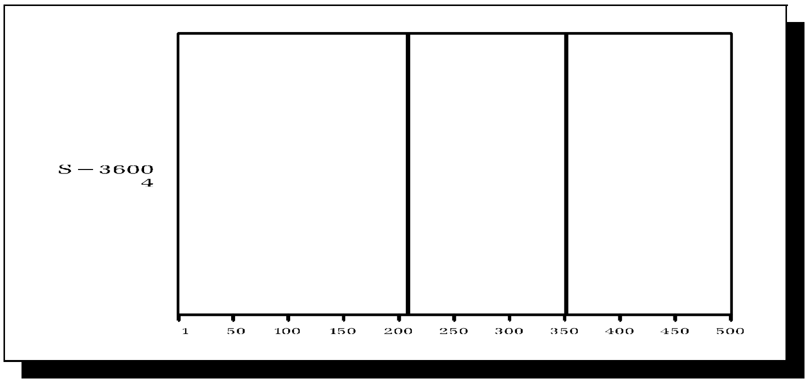
#89–90 KSR; US Army
#91 Cornell

Hitachi S820



Number of entries	20 (5.0%)
Accumulated R_{max}	7.1 Gflop/s (0.5%)
Accumulated R_{peak}	46.5 Gflop/s (3.0%)
First entry	193
Model	S-820/80
Last entry	322
Model	S-820/60
Processors	1
Memory	$\leq$ 0.512 GB
Cycle time	4 ns
R_{max} performance	1.817 Gflop/s
Peak performance R_{peak}	3 Gflop/s
Peak performance/processor	3 Gflop/s
First machine delivered	1988

The S820 was the second generation of Hitachi's uniprocessor vector computers, but not sold outside of Japan.

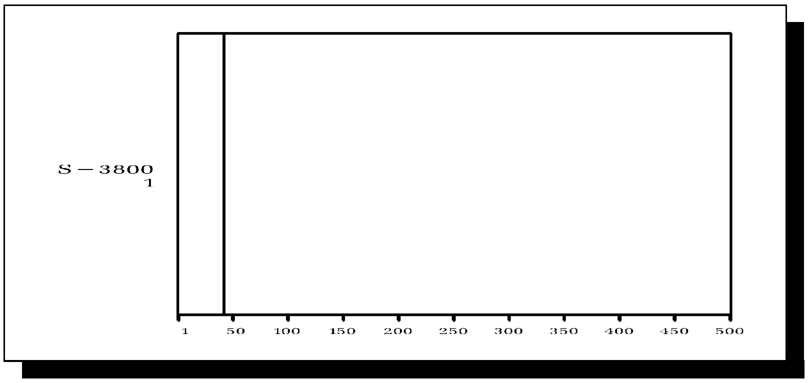


Hitachi S3600

4 (0.8%)	Number of entries
5.0 Gflop/s (0.3%)	Accumulated R_{max}
6.0 Gflop/s (0.2%)	Accumulated R_{peak}
208	First entry
S-3600/180	Model
352	Last entry
S-3600/160	Model
1	Processors
$\leq$ 1 GB	Memory
4 ns	Cycle time
1.672 Gflop/s	R_{max} performance
2 Gflop/s	Peak performance R_{peak}
2 Gflop/s	Peak performance/processor
1992	First machine delivered

The S3600 system family contains aircooled uniprocessor systems. The architecture of the system is similar to the predecessor S820, but built with modern technology.

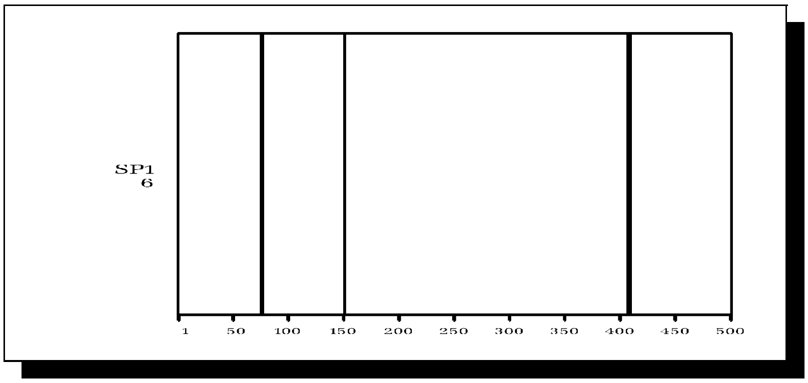
Hitachi S3800



Number of entries	1 (0.2%)
Accumulated R_{max}	7.0 Gflop/s (0.5%)
Accumulated R_{peak}	32 Gflop/s (1.3%)
First entry	42
Model	S-3800/480
Last entry	-
Model	-
Processors	1–4
Memory	$\leq$ 2 GB
Cycle time	2 ns
R_{max} performance	7.016 Gflop/s[single node]
Peak performance R_{peak}	32 Gflop/s
Peak performance/processor	8 Gflop/s
First machine delivered	1993

The S3800 is the latest generation of Hitachi's vector machines and their first MP vector system with up to four processors. Due to the low cycle time of 2 ns the peak performance of the top model is 32 Gflop/s. Such a machine is installed at the Tokyo University, but as we only have benchmark results for a single processor system, it is only at position 42 in the TOP500.

IBM SP1

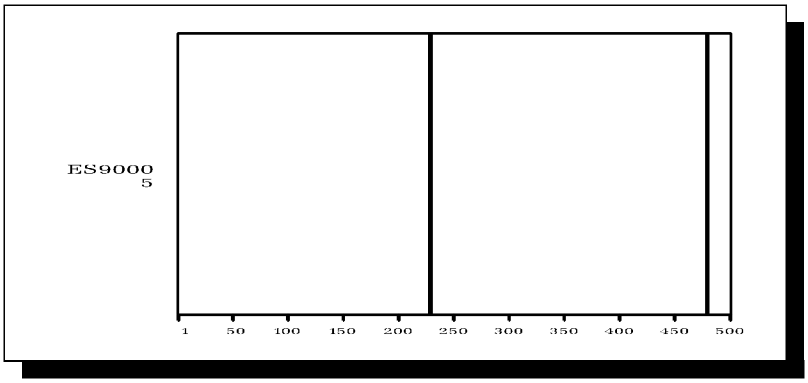


6 (1.2%)	Number of entries
11.7 Gflop/s (0.8%)	Accumulated R_{max}
31 Gflop/s (1.2%)	Accumulated R_{peak}
76	First entry
9076-005 SP1	Model
409	Last entry
9076-001 SP1	Model
8–128	Processors
$\leq$ 32 GB	Memory
16 ns	Cycle time
3.861 Gflop/s (64 nodes)	R_{max} performance
16 Gflop/s	Peak performance R_{peak}
0.125 Gflop/s	Peak performance/processor
1993	First machine delivered

The SP1 is the first generation of IBM MPPs. As nodes top of the end RS6000 units are used, which are coupled more like in a workstation cluster, than in a traditional MPP. Nevertheless, this conservative approach gives some advantages to IBM, like reliability of the system. The efficiency of the measured LINPACK performance is about the same as of many other MPP systems and shows that the SP1 is not just a workstation cluster but a real MPP system. Due to the maximal number of processors of 64 the system does not show up at the very top of the TOP500, but the coming SP2 will definitely do.

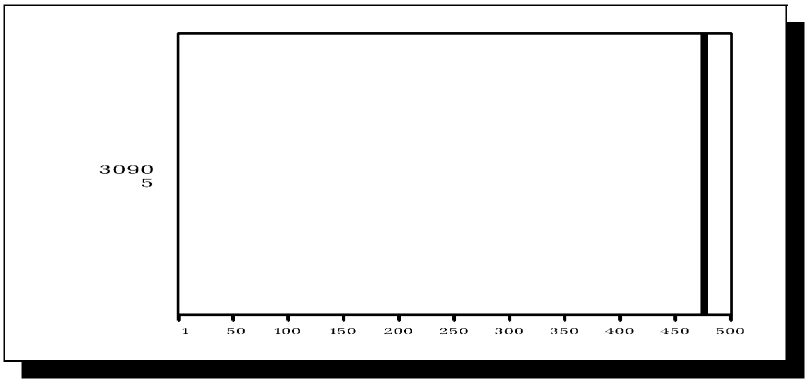
#76 is a special 128 node system at Cornell

IBM ES 9000



Number of entries	5 (1.0%)
Accumulated R_{max}	5.5 Gflop/s (0.4%)
Accumulated R_{peak}	9.6 Gflop/s (0.4%)
First entry	228
Model	ES 9000-900
Last entry	480
Model	ES 9000-720
Processors	1–6
Memory	$\leq$ 1 GB
Cycle time	9 ns
R_{max} performance	1.457 Gflop/s
Peak performance R_{peak}	2.664 Gflop/s
Peak performance/processor	0.444 Gflop/s
First machine delivered	1990

The ES9000 is the latest series of traditional mainframes built by IBM. To each processor a vector unit of moderate performance can be attached. The mainframe series of IBM as well as the original operating system MVS have a long history. Due to this long evolution, the stability and reliability of these systems is exceptionally high. The major distribution of these families is not and was never the scientific market, but the industrial market, where they still play a major role.



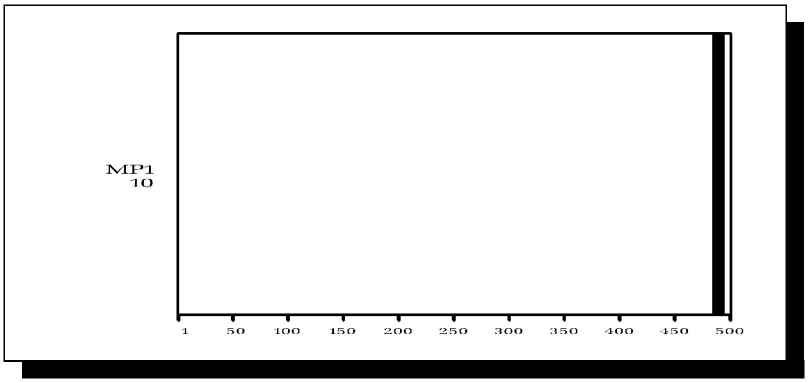
IBM 3090

5 (1.0%)	Number of entries
2.7 Gflop/s (0.2%)	Accumulated R_{max}
4.1 Gflop/s (0.2%)	Accumulated R_{peak}
474	First entry
3090-600S	Model
478	Last entry
3090-600E	Model
1–6	Processors
$\leq$ 0.256 GB	Memory
14.5 ns	Cycle time
0.540 Gflop/s	R_{max} performance
0.828 Gflop/s	Peak performance R_{peak}
0.138 Gflop/s	Peak performance/processor
1985	First machine delivered

The 3090 was the first MP mainframe system of IBM to which vector units could be attached. The design goal of IBM was not to reach highest performance, but to achieve reasonable accelerations on a broad band of applications at a low price. There exist quite a lot of different models with varying cycle times, which makes it difficult to track the exact installed system and its performance.

Due to the position at the end of the TOP500, we expect that the 3090 will not show up any more in the TOP500 in the future.

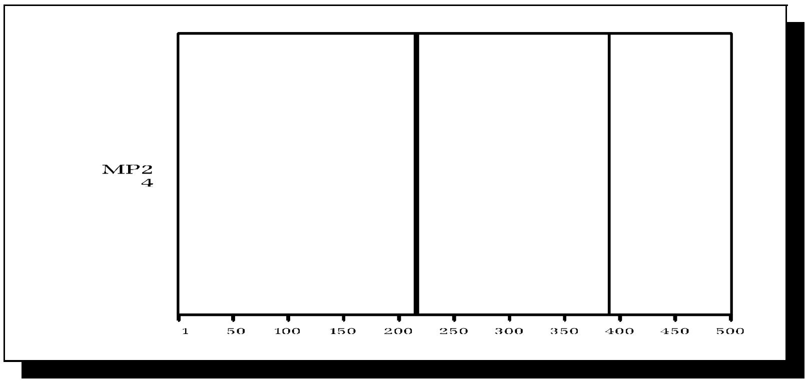
MasPar MP-1



Number of entries	10 (2.0%)
Accumulated R_{max}	4.7 Gflop/s (0.3%)
Accumulated R_{peak}	5.5 Gflop/s (0.2%)
First entry	485
Model	MP-1216
Last entry	494
Model	MP-1216
Processors	1024–16384
Memory	$\leq$ 1 GB
Cycle time	83 ns
R_{max} performance	0.473 Gflop/s
Peak performance R_{peak}	0.55 Gflop/s
Peak performance/processor	0.000034 Gflop/s
First machine delivered	1990

The MP-1 is MasPar's first generation of hardware based SIMD machines, which are also sold by DEC. The single processor is a 4bit processor, which is the reason for the overall not so high floating point performance of this system and its position at the end of the TOP500.

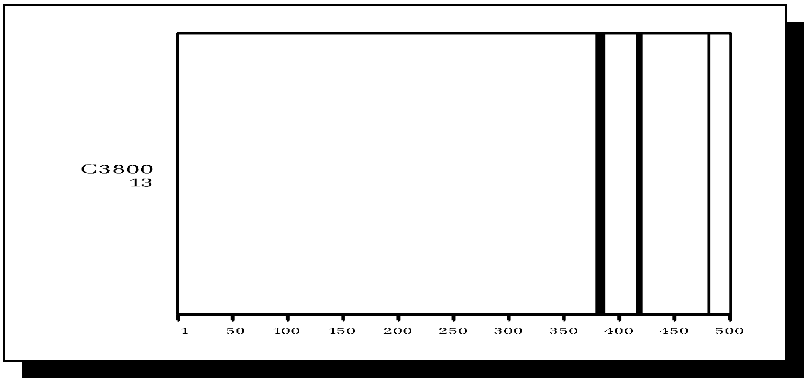
MasPar MP-2



4 (0.8%)	Number of entries
5.6 Gflop/s (0.4%)	Accumulated R_{max}
8.4 Gflop/s (0.3%)	Accumulated R_{peak}
215	First entry
MP-2216	Model
390	Last entry
MP-2208	Model
1024–16384	Processors
$\leq$ 1 GB	Memory
80 ns	Cycle time
1.6 Gflop/s	R_{max} performance
2.4 Gflop/s	Peak performance R_{peak}
0.00015 Gflop/s	Peak performance/processor
1992	First machine delivered

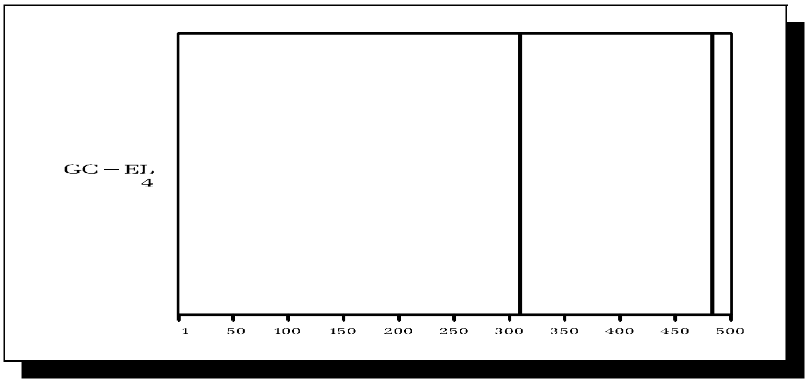
The MP-2 is the second generation of SIMD machines by MasPar, which are also sold by DEC. It has essentially the same architecture as the MP-1 but 8bit processors, which is the main reason for the higher performance of the system. The cycle time did not change very much (80 ns instead of 83 ns).

Convex C3800



Number of entries	13 (2.6%)
Accumulated R_{max}	9.2 Gflop/s (0.6%)
Accumulated R_{peak}	10.9 Gflop/s (0.4%)
First entry	380
Model	C3880
Last entry	481
Model	C3850
Processors	1–8
Memory	$\leq$ 4 GB
Cycle time	16.7 ns
R_{max} performance	0.795 Gflop/s
Peak performance R_{peak}	0.96 Gflop/s
Peak performance/processor	0.120 Gflop/s
First machine delivered	1991

The C3800 is the top model of the MP vector computer series of Convex, the last traditional minisupercomputer manufacturer in business. This class of machines faces strong competition by high end workstations. Convex is currently developing its own MPP system.

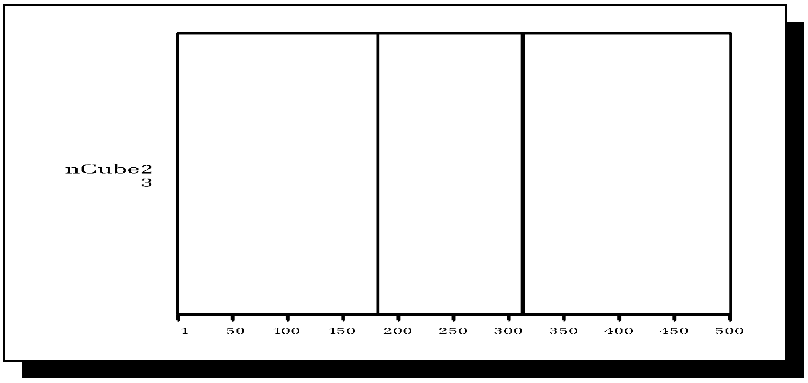


Parsytec GCel

4 (0.8%)	Number of entries
2.9 Gflop/s (0.2%)	Accumulated R_{max}
4.6 Gflop/s (0.2%)	Accumulated R_{peak}
309	First entry
GCel 3/1024	Model
484	Last entry
GCel 3/512	Model
–1024	Processors
$\leq$ 4 GB	Memory
33 ns	Cycle time
0.971 Gflop/s	R_{max} performance
1.54 Gflop/s	Peak performance R_{peak}
0.0015 Gflop/s	Peak performance/processor
1992	First machine delivered

The German company Parsytec is building Transputer based systems for quite a while. They announced a T9000 based big MPP system called GC series (Grand Challenges) quite early in 1991. Due to the big delay of this chip they introduced an intermediate system (GCeL) with the same macro architecture as the GC, but with the T805 chip as processor. In the meantime they switched to the Power PC601 chip as processor for their next system. The systems in the TOP500 are T805 based GCeL systems with 1024 or 512 nodes.

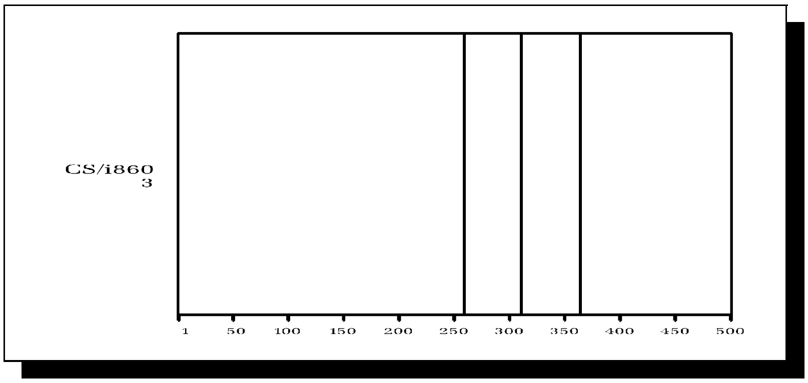
nCube2



Number of entries	3 (0.6%)
Accumulated R_{max}	3.8 Gflop/s (0.3%)
Accumulated R_{peak}	4.8 Gflop/s (0.2%)
First entry	182
Model	nCube2-1024
Last entry	313
Model	nCube2-512
Processors	–1024
Memory	$\leq$ 16 GB
Cycle time	50 ns
R_{max} performance	1.9 Gflop/s
Peak performance R_{peak}	2.4 Gflop/s
Peak performance/processor	0.0024 Gflop/s
First machine delivered	1989

The nCube2 is a hypercube based system with highly integrated proprietary processors. The size of the machine is limited by the maximal dimension (13) of the hypercube connection network, but such a big system was not built yet. Due to the stability of the system it is often in use for applications, where highest floating point performance is not needed.

Meiko Computing Surface



3 (0.6%)	Number of entries
3.1 Gflop/s (0.2%)	Accumulated R_{max}
5.5 Gflop/s (0.2%)	Accumulated R_{peak}
259	First entry
CS/i860/64	Model
364	Last entry
CS/i860/32	Model
1–64 (unlimited)	Processors
$\leq$ 8 GB	Memory
25 ns	Cycle time
1.3 Gflop/s	R_{max} performance
2.5 Gflop/s	Peak performance R_{peak}
0.04 Gflop/s	Peak performance/processor
1989	First machine delivered

The Computing Surface of Meiko is a heterogenous system, with the possible integration of nodes based on Inmos T800, Sparc or i860 chips. Due to the different performances of these different nodes in the TOP500 are only systems with i860 based nodes. The size of the machine is not technically limited, but the biggest one installed so far has 64 nodes.

5

The Worldwide Supercomputer Situation

Hans-Werner Meuer

Abstract

In this paper we discuss the situation world-wide in the field of high-performance computing, based on the latest TOP500 (chapter 2). We focus especially on statistics of the complete list, i.e. the number of systems installed with respect to the different manufacturers and the different continents. Especially we look at the traditional vector computers in comparison to the MPP systems on the different continents. Finally we outline the dominating role of the USA with respect to the number of systems manufactured and installed.

5.1 Worldwide Statistics

During the last few years several manufacturers promised a Teraflop Computer soon to come. When establishing our TOP500 list we questioned if all 500 computers put together would reach 1 Tflop/s (10^{12} floating point operations per second). As it turned out with 1.47 Tflop/s this mark was even exceeded in our second TOP500. The entries in the first TOP500 just add up to 1.17 Tflop/s.

A special model by Fujitsu in cooperation with NAL, the so called 'Numerical Wind Tunnel' with 140 processors and a Linpack performance R_{max} of 124.5 Gflop/s made the top of the list, followed by four CM5 systems by Thinking Machines with 1024, 544 as well as two times 512 processors. The most powerful installed CM5 system in Los Alamos reached R_{max} of almost 60 Gflop/s, the other three CM5-systems a bit more than 30 Gflop/s.

At the bottom of the list is the VP 200EX at the University of Dresden with 472 Mflop/s, so the list includes computer systems with two scales of different performance results. On the other hand the listed systems are much more powerful than all workstations available today. The entry level model from Cray Research, Convex or other smaller models of the MPP manufacturers like nCube, Parsytec, Kendall Square Research and others are not listed, which means that we have reached our goal to include only true supercomputers into our list.

Looking at the figure of systems installed per continent (Fig. 5.1) it stands out that Japan with 21% even falls behind Europe (27%) and has noticeable less supercomputers than the USA (48%). Our statistics of the last years (see chapter 1)—based on system counts—showed clearly different results but it must be taken into consideration that all small vector computer models by Fujitsu, NEC and Hitachi—which did not make it into the TOP500 this time—had been included in these old statistics.

Viewing the installed performance (Fig. 5.2) the dominance of the USA with 60% in comparison to Japan (24%) and Europe (13%) is even more evident. This is because of the larger amount of MPP systems in the USA where already 50% of all supercomputers belong to this computer category and surpass the vector computers in the USA with their accumulated performance by appr. 50%. Obviously this is a consequence of the HPCC program, prefering the selection of MPP systems at least at sites funded by the government. Even though 33% of the systems in Europe are MPP systems, their accumulated performance is still clearly smaller than the installed vector computer performance, according to their number these are 34% of all supercomputer performance installed. On the contrary almost only the traditional vector computers are installed in Japan, the MPP systems are rather under-represented with 12% altogether. This could change if the Japanese manufacturers would enter the market with their own MPP models.

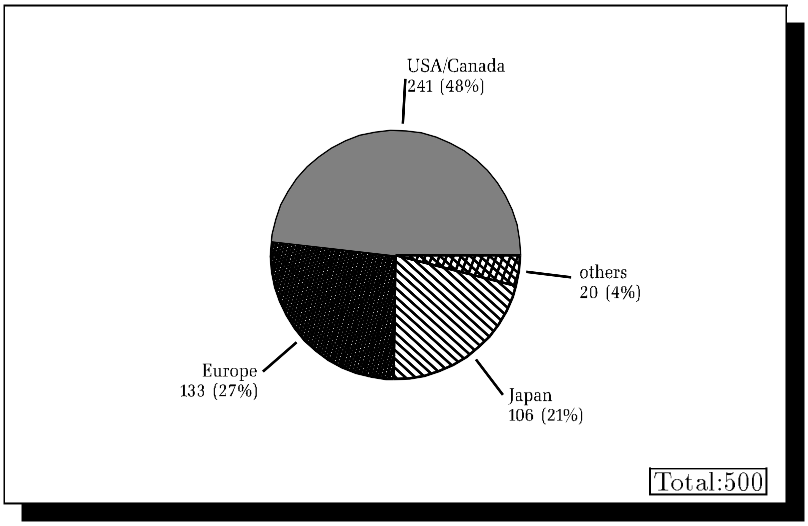


Figure 5.1:
Systems installed in the world
— countries —

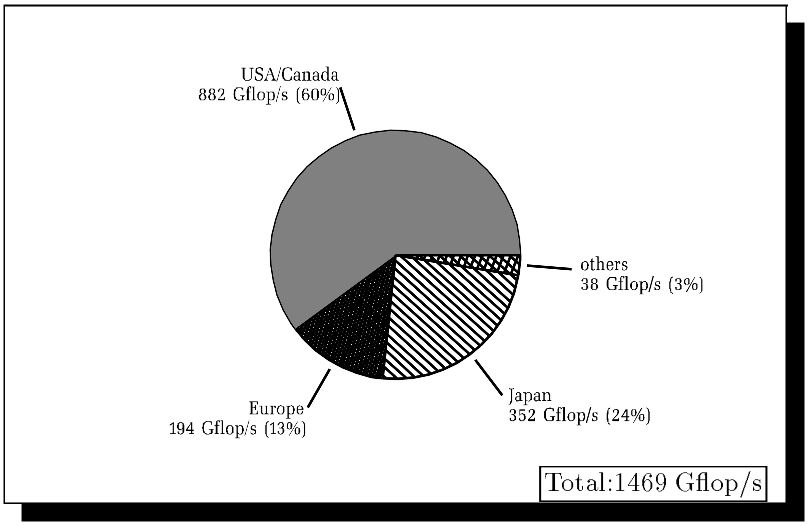


Figure 5.2:
R_{max} installed in the world
— countries —

Broken down into manufacturers (Fig. 5.3 and 5.4) Cray Research is up front as well in numbers of systems (40%) as in installed performance (30%). While the number of installed Cray systems is clearly ahead of MPP systems market leader Thinking Machines (14%), Fujitsu with Siemens Nixdorf (10%), Intel (9%), NEC (6%), Hitachi (5%) and KSR (5%) it looks totally different compared to the installed performance R_{max}. Here TMC comes (27%) shortly behind Cray Research (30%), again because of the partly overproportionately powerful systems in the USA, ahead of Fujitsu with SNI (15%), Intel (10%) and NEC (9%). nCube and DEC as well as the 'Europeans' Meiko and Parsytec could place less than ten systems into the TOP500. From IBM we expect an upswing in the future because of the parallel computer SP2.

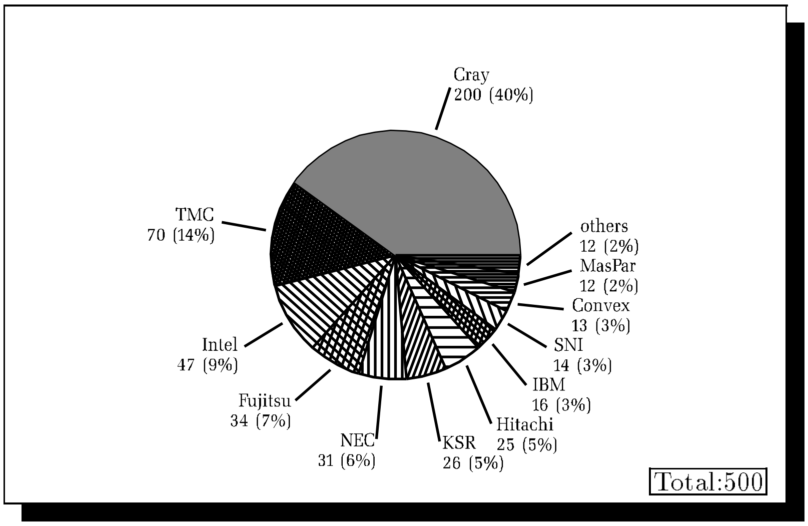


Figure 5.3:
Systems installed in the world
— manufacturers —

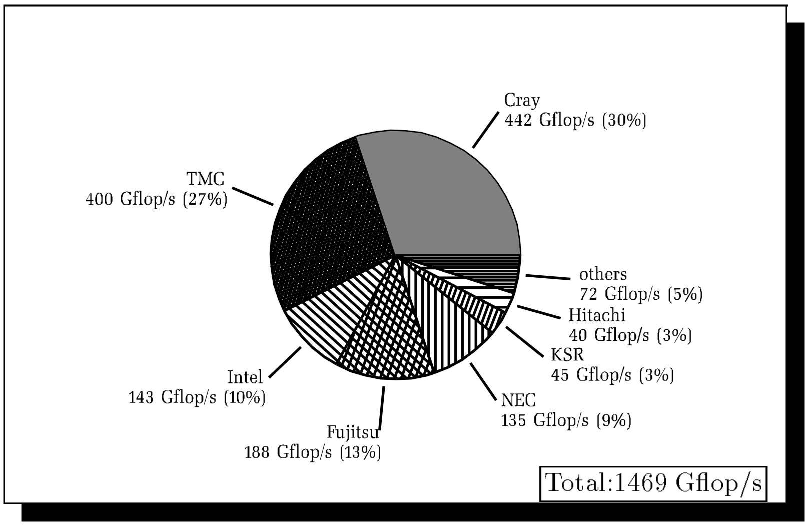


Figure 5.4:
R_{max} installed in the world
— manufacturers —

After all 25% of all systems are used by the industry (Fig. 5.5, 5.6 and 5.7), a little less than in the university (31%) and research sector (29%). While the number of systems for classified operations are 4%, the installed performance is overproportionately high with 9%. The performance of supercomputers in the industry on the contrary comes to 13%, here smaller and middle sized vector computers are often used, the first industry user ranks on place 34 in our TOP500 list. At the moment the industry is rather restrained using MPP systems, only 16% of these parallel computers are installed there and the accumulated performance is only 16%. From these figures can be concluded that the big MPP systems are not yet in use there. The only two industry segments, where MPP systems can already be found are aerospace and geophysics in the USA.

#34 Ford: Y-MP C916/11256

Aerospace e.g.: #101, 102, 108
Geophysics e.g.: #39, 41

Universities on the contrary have 39% of MPP systems in use with 33% of accumulated performance. The most powerful MPP parallel computers can be found in the research sector showing like the university sector 33% of the accumulated performance with only 26% of the installed MPP systems. The most powerful vector systems can also be found in the research sector, with the Numerical Wind Tunnel by Fujitsu up front.

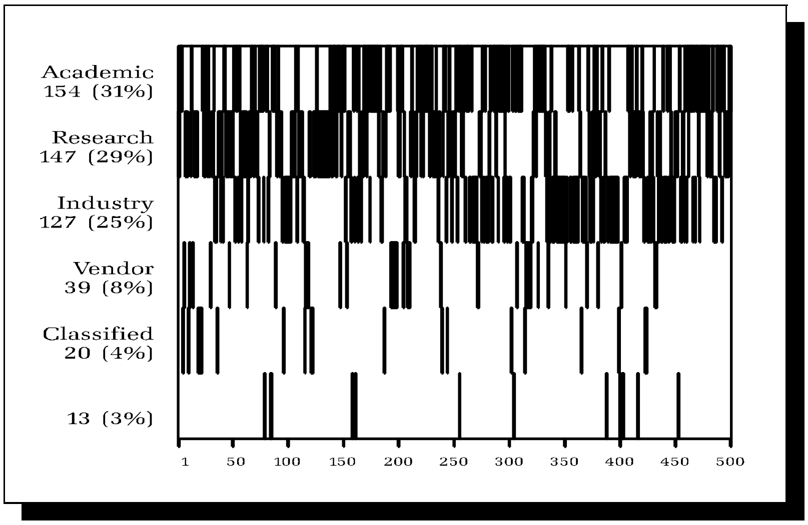


Figure 5.5:
Distribution of the systems in the TOP500 over the application areas

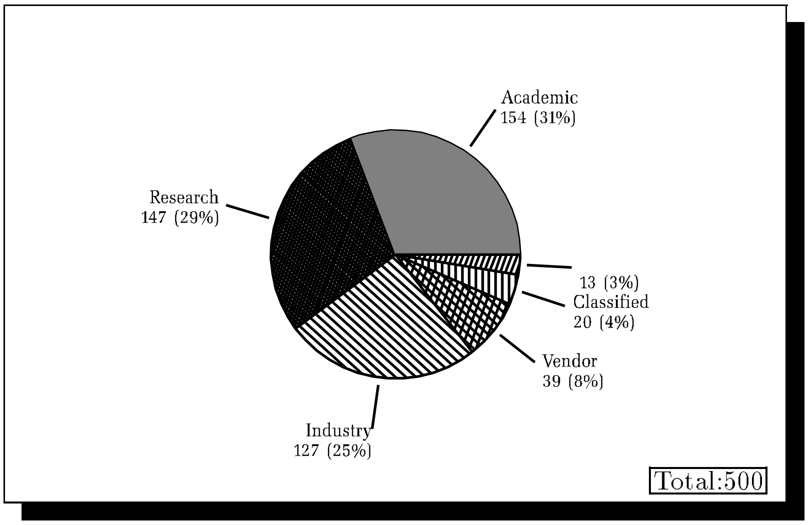


Figure 5.6:
Systems installed in the world
—application areas—

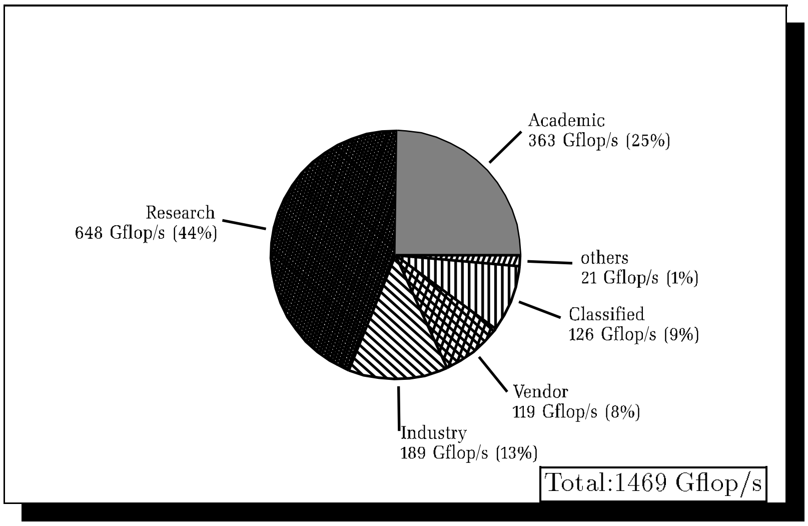


Figure 5.7:
R_{max} installed in the world
—application areas—

5.2
Vector Computers versus MPP

As we expected the vector computers (still) clearly dominate among the 500 most powerful computers with 314 of the installed systems which are 63% (Fig. 5.8 and 5.9). Interesting here is the MPP penetration in the continents as already mentioned in chapter 5.1:

While in the USA vector versus MPP are proportionately already 50:50 and in Europe 67:33, the MPP penetration in Japan is with 88:12 in favour of the vector computer very weak. It looks as if Japan clings heavily to the use of vector computers, an MPP industry is not yet present there. The similarity to RISC microprocessors is evident here, Japan is not present there either and left or rather had to leave this section of the market to the USA.

Viewing the installed performance—again we have to keep in mind the R_{max} measure of the LINPACK benchmark—the MPP systems are with 43% (Fig. 5.10 and 5.11) already represented worldwide. The MPP computers—if only big equations would be solved—already overtook the vector computers by 59% installed performance in the USA. Europe is below average with 34% while in Japan just 8% of the installed performance are MPP systems.

Table 5.1 and Table 5.2 list the TOP40 vector computer and MPP computer sites.

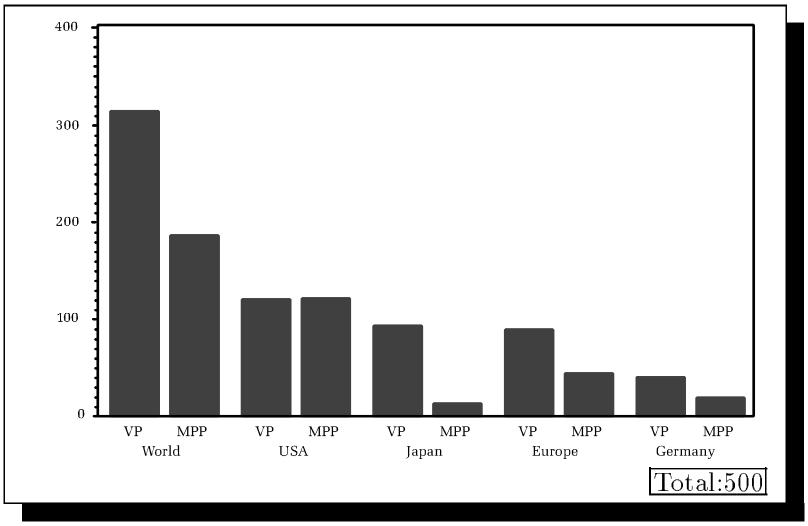


Figure 5.8:
Systems installed in the world.

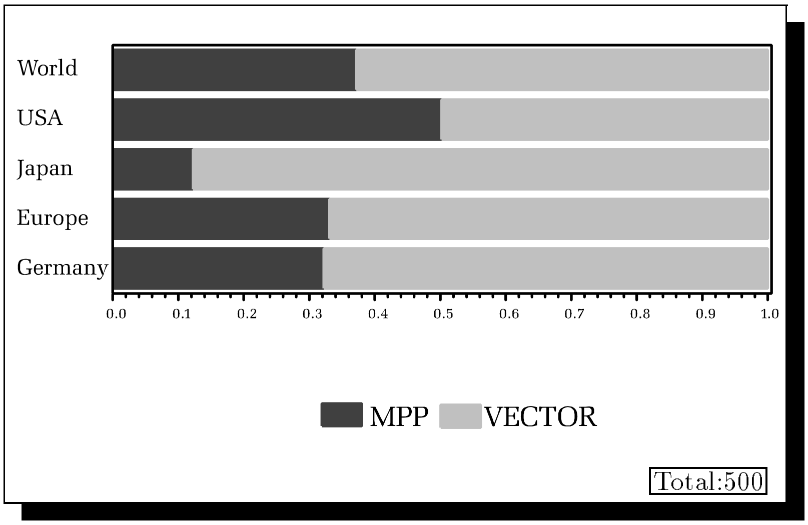


Figure 5.9:
Systems installed in the world.
—Percentages of MPP systems versus vector systems—

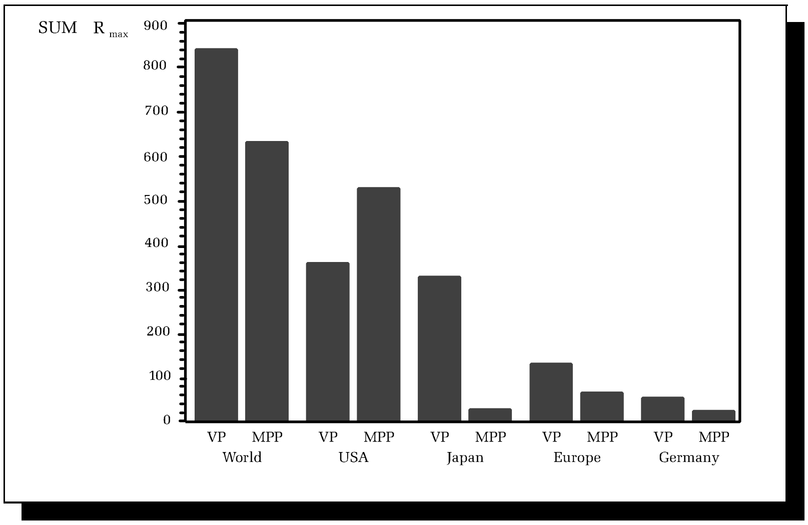


Figure 5.10:
R_{max} in Gflop/s installed in the world

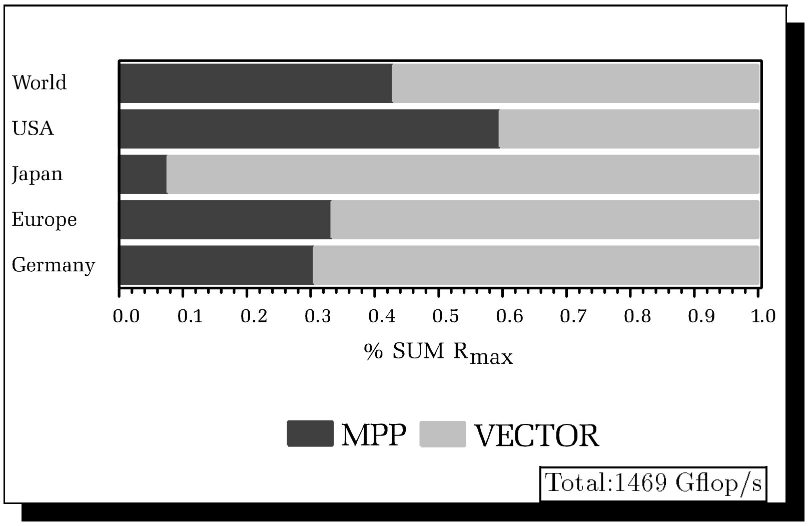


Figure 5.11:
R_{max} installed in the world
—Percentages of MPP systems versus vector systems—

Table 5.1: TOP40 Vector Computer Sites

N Vector World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 1	Fujitsu Numerical Wind Tunnel	NAL/Fujitsu Japan /1993	Research Aerospace	140	**124500** 236000	31920 11950
2 6	NEC SX-3/44R	NEC Fuchu Plant Japan /1990	Vendor	4	**23200** 26000	6400 830
3 7	NEC SX-3/44	Atmospheric Environment Service (AES) Dorval Canada /1991	Research Weather	4	**20000** 22000	6144 832
4 14	Cray Y-MP C916/16256	Cray Research Eagan USA / .	Vendor	16	**13700** 15238	10000 650
5 15	Cray Y-MP C916/16256	DOD/CEWES Vicksburg USA /1993	Research Mechanics	16	**13700** 15238	10000 650
6 16	Cray Y-MP C916/16256	DOE/Bettis Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
7 17	Cray Y-MP C916/16256	DOE/Knolls Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
8 18	Cray Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650
9 19	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
10 20	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
11 21	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
12 22	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
13 23	Cray Y-MP C916	KIST/System Engineering Research Institute Korea /1993	Academic	16	**13700** 15238	10000 650
14 24	Cray Y-MP C916/16256	Lawrence Livermore National Laboratory NERSC USA /1992	Research Energy	16	**13700** 15238	10000 650
15 25	Cray Y-MP C916/16256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	16	**13700** 15238	10000 650
16 26	Cray Y-MP C916/16256	Pittsburgh Supercomputing Center Pittsburgh USA /1992	Academic	16	**13700** 15238	10000 650
17 27	Cray Y-MP C916	US Naval Oceanographic Command Bay Saint Louis USA / .	Research Weather	16	**13700** 15238	10000 650
18 29	NEC SX-3/24R	National Institute of Fusion Science (NIFS) Japan /1993	Research	2	**11600** 13000	4352 516
19 30	NEC SX-3/24	NEC Daito Supercomputer Center Japan /1991	Vendor	2	**10000** 11000	4352 500
20 34	Cray Y-MP C916/11256	Ford Motor Company Dearborn USA /1992	Industry Automotive	11	**9418** 10476	. .

Table 5.1: TOP40 Vector Computer Sites

N *Vector* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 42	Hitachi S-3800/480	Tokyo University Tokyo Japan /1993	Academic	4	**7016** 32000	. .
22 43	Cray Y-MP C916/8256	Minnesota Supercomputer Center USA / .	Academic	8	**6850** 7619	. .
23 44	Cray Y-MP C916/8256	NASA/Ames Research Center/CCF Moffett Field USA /1993	Research Aerospace	8	**6850** 7619	. .
24 45	Cray Y-MP C98/8128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**6850** 7619	. .
25 46	Cray Y-MP C916/8128	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	8	**6850** 7619	. .
26 49	NEC SX-3/14R	German Aerospace Labatory (DLR) Goettingen Germany /1993	Research Aerospace	1	**5800** 6400	2816 282
27 50	NEC SX-3/41R	Japan Atomic Energy Research Japan /1992	Research	4	**5800** 6400	3584 414
28 51	NEC SX-3/14R	Osaka University Osaka Japan /1993	Academic	1	**5800** 6400	2816 282
29 52	NEC SX-3/14R	Toyota Central Research Japan /1992	Industry Automotive	1	**5800** 6400	2816 282
30 57	NEC SX-3/22	Houston Advanced Research Center Houston USA / .	Research	2	**5000** 5500	3072 384
31 58	NEC SX-3/14	IBM Japan Tokyo Japan /1991	Industry Electronics	1	**5000** 5500	3072 384
32 59	NEC SX-3/22	National Aerospace Laboratory (NLR) Nordoostpolder Netherlands/1992	Research Aerospace	2	**5000** 5500	3072 384
33 60	NEC SX-3/14	National Institute of Environmental Studies Japan /1992	Research Environment	1	**5000** 5500	3072 384
34 61	NEC SX-3/22	Swiss Scientific Computing Center Manno Switzerland/1991	Research	2	**5000** 5500	3072 384
35 62	Cray Y-MP C98/6256	NASA/Goddard Space Flight Center Greenbelt USA /1993	Research Weather	6	**4630** 5715	. .
36 64	Fujitsu VP2600/10	Fuji Heavy Japan /1990	Industry Heavy Ind.	1	**4009** 5000	. .
37 65	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
38 66	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
39 67	Fujitsu VP2600/20	Kyoto University Kyoto Japan /1990	Academic	1	**4009** 5000	. .
40 68	Fujitsu VP2600/10	Kyushu University Kyushu Japan /1992	Academic	1	**4009** 5000	. .

Table 5.2: TOP40 MPP Computer Sites

N *MPP* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 2	TMC CM-5/1024	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	1024	**59700** 131000	52224 24064
2 3	TMC CM-5/544	Minnesota Supercomputer Center USA / .	Academic	544	**30400** 70000	36864 16384
3 4	TMC CM-5/512	NCSA Urbana-Champaign USA / .	Academic	512	**30400** 66000	36864 16384
4 5	TMC CM-5/512	National Security Agency USA / .	Classified	512	**30400** 66000	36864 16384
5 8	Intel XP/S135	Sandia National Labs Albuquerque USA /1993	Research	1840	**15200** 92000	23000 9000
6 9	Intel XP/S35	Oak Ridge National Laboratory Oak Ridge USA /1992	Research	512	**15200** 26000	23000 9000
7 10	TMC CM-5/256	Goverment USA /1993	Classified	256	**15100** 33000	26112 12032
8 11	TMC CM-5/256	Thinking Machines USA /1993	Vendor	256	**15100** 33000	26112 12032
9 12	TMC CM-5/256	US Naval Research Laboratory USA /1992	Research	256	**15100** 33000	26112 12032
10 13	Intel Delta	Caltech Pasadena USA / .	Academic	512	**13900** 20480	25000 7500
11 28	Intel XP/S30	UCSD/San Diego Supercomputer Center San Diego USA /1993	Academic	400	**11900** 20000	. .
12 31	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
13 32	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
14 33	TMC CM-200/64k	NCSA USA / .	Academic	2048	**9800** 20000	29696 11264
15 35	TMC CM-5/128	AMEX USA /1993	Industry	128	**7700** 16000	18432 8192
16 36	TMC CM-5/128	Goverment USA /1993	Classified	128	**7700** 16000	18432 8192
17 37	TMC CM-5/128	Institut de Physique du Globe de Paris (IPG) Paris France /1992	Research	128	**7700** 16000	18432 8192
18 38	TMC CM-5/128	MIT Cambridge USA / .	Research	128	**7700** 16000	18432 8192
19 39	TMC CM-5/128	Mobil / Technical Center Tulsa USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
20 40	TMC CM-5/128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	128	**7700** 16000	18432 8192

Table 5.2: TOP40 MPP Computer Sites

N *MPP* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 41	TMC CM-5/128	Schlumberger Well Services USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
22 47	Intel XP/S15	Intel SSD Development Centers USA /1993	Vendor	208	**6200** 10400	. .
23 48	Intel XP/S15	NASA/Ames Research Center/NAS Moffett Field USA /1992	Research	208	**6200** 10400	. .
24 53	TMC CM-2/64k	Brandeis University USA / .	Academic	2048	**5200** 14000	26624 11000
25 54	TMC CM-2/64k	Florida State University Tallahassee USA / .	Academic	2048	**5200** 14000	26624 11000
26 55	TMC CM-2/64k	SRC USA /1993	Industry	2048	**5200** 14000	26624 11000
27 56	TMC CM-200/32k	Minnesota Supercomputer Center USA / .	Academic	1024	**5000** 10000	21504 8192
28 63	Intel XP/S10	Intel SSD Development Centers USA /1992	Vendor	140	**4100** 7000	. .
29 76	IBM 9076-005 SP1	Argonne Nat. Lab USA /1993	Academic	128	**3861** 16000	26500 8000
30 77	IBM 9076-004 SP1	Cornell University USA /1993	Academic	64	**3861** 8000	26500 8000
31 78	TMC CM-5/64	AMOCO Tulsa USA / .	Industry Geophysics	64	**3800** 8192	13056 6016
32 79	TMC CM-5/64	ATR Kyoto Japan / .		64	**3800** 8192	13056 6016
33 80	TMC CM-5/64	Australian National University Canberra Australia / .	Academic	64	**3800** 8192	13056 6016
34 81	TMC CM-5/64	Boston University Boston USA / .	Academic	64	**3800** 8192	13056 6016
35 82	TMC CM-5/64	EPS USA /1993	Industry	64	**3800** 8192	13056 6016
36 83	TMC CM-5/64	GMD Birlinghoven Germany /1993	Research	64	**3800** 8192	13056 6016
37 84	TMC CM-5/64	Japanese AIST Hokuriku Japan /1993		64	**3800** 8192	13056 6016
38 85	TMC CM-5/64	Real World Computing (RWCP) Tokyo Japan /1992		64	**3800** 8192	13056 6016
39 86	TMC CM-5/64	University of Wisconsin USA / .	Academic	64	**3800** 8192	13056 6016
40 89	KSR KSR1-256	KSR Boston USA /1992	Vendor	256	**3380** 10240	10240 1824

5.3
USA, Japan and Europe

If we focus on Table 2.2 of chapter 2 where the number of systems installed is given with respect to the different manufacturers in the different continents/countries, we may extract the table 5.3.

77.8% of all supercomputers out of the TOP500 are manufactured in the USA, 20.8% in Japan while only 7 systems (4 from Parsytec and 3 from Meiko), i.e. 1.4% are manufactured in Europe. This stands in contrary to the fact that Europe is playing a strong role in applying supercomputers, and is with 27% even stronger than Japan with 21%. Figure 5.12 again demonstrates the dominance of USA using supercomputers by showing the distribution over the continents.

We should wait and see how the German manufacturer Parsytec who recently incorporated the Power PC-chip of Motorola/IBM into their architecture, will be able to play a significant role in the forthcoming penetration of the commercial market. Both America and Japan protect their own markets quite well; only 8% of the US products are placed in Japan, and only 5% of the Japanese products are installed in the US, while 27% of the American supercomputers are installed in Europe versus 19% of the Japanese.

Additional consideration concerning USA, Japan and Europe is given in chapter 6.2 of this report.

Systems Manufactured In	Systems Installed In USA	Japan	Europe	Other	Total
USA	236	31	106	16	389
Japan	5	75	20	4	104
Europe	0	0	7	0	7
Total	241	106	133	20	500

Table 5.3:
Systems installed by manufacturers in the USA, Japan and Europe

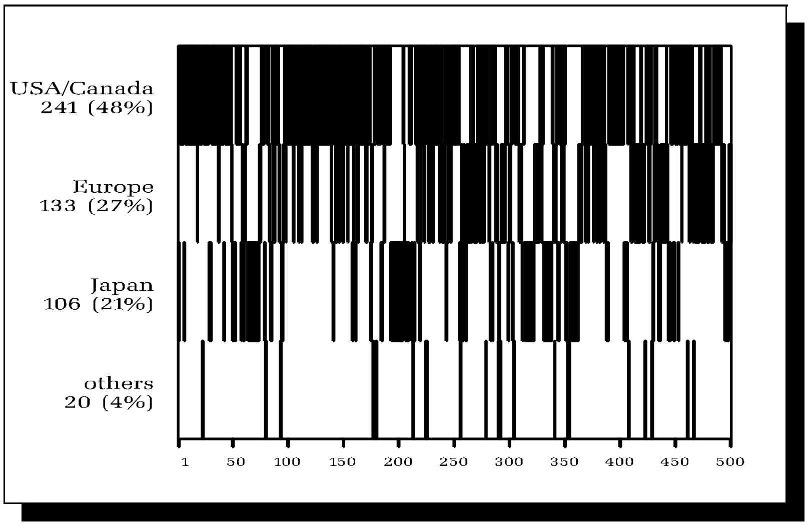


Figure 5.12:
Distribution over the Continents

6

High Performance Computing in the U.S.

Horst D. Simon

Abstract

In 1993 for the first time a list of the top 500 supercomputer sites worldwide has been made available [6]. The TOP500 list allows a much more detailed and well founded analysis of the state of high performance computing. Previously data such as the number and geographical distribution of supercomputer installations were difficult to obtain, and only a few analysts undertook the effort to track the press releases by dozens of vendors. With the TOP500 report now generally and easily available[1] it is possible to present an analysis of the state of High Performance Computing (HPC) in the U.S. This note summarizes some of the most important observations about HPC in the U.S. as of late 1993 or early 1994, in particular with respect to the continued dominance of the world market in HPC by the U.S, the market penetration of massively parallel systems (MPP), and the industrial use of supercomputers.

6.1 Introduction

In 1994 high performance computing in the U.S. appears to be undergoing a major transition. With the introduction of powerful new massively parallel processors (MPP) by established vendors in the high performance computing field such as the T3D by Cray Research, the SP-2 by IBM, and the Exemplar SPP by Convex there are strong indications that MPP is now finally in the mainstream of scientific supercomputing. These new entries compete with existing MPP vendors such as Intel, Kendall Square, Ncube, and Thinking Machines for shares of a market, which is not as rapidly increasing as expected. Traditional parallel vector supercomputes such as the Cray C90 continue to dominate both performance benchmarks [1], and show strong results when the breadth and complexity of applications is concerned (see [9]). The strength of the market (more in

[1] The latest TOP500 report is available via anonymous ftp by
`ftp ftp.uni-mannheim.de`, then `cd info/rumdoc`, and `get top500.ps`

Table 6.1:
Commerical HPC Vendors in the U.S. (early 1994)

Status	Vendors
Out of business	Alliant, American, Ametek, Culler, Cydrome, Denelcor, Elexsi, Multiflow, Myrias, Prisma, Saxpy, SCS, SSI(2), Trilogy, Wavetracer
Division closed	Astronautics, BBN, CDC/ETA Systems, E&S, Gould, Vitesse
Merged	Celerity, FPS, Key, Supertek
Down, not out	AMT(Cambridge), CHoPP, Encore, Stardent/Kubota
Currently active	Convex/HP, Cray Computer, Cray Research, Fujitsu, IBM, Intel, KSR, nCUBE, Meiko, NEC, Parsytec, SGI, Tera, TMC

terms of expectations, than in real dollars) can be seen from the list of vendors in Table 6.1, which is updated from Smaby [11]. The consequences of such a large number of vendors competing for such a small (but highly visible and important) market are widely discussed, for example in [10].

At the same time the federal High Performance Computing and Communications Program (HPCC) is in high gear and considerable progress has been made as documented in the famous 'Blue Book' [3]. On the other hand there has been criticism on the this very program, e.g., in the form of a report by the Congressional Budget Office [4]. The discussion about HPC in the commercial and in the government market place is mainly based on beliefs and impressions, and often lacks hard data. It is surprising that a field such as HPC that is deemed so critically important to the national agenda lacks almost completely any quantitative assessment of its progress.

In this report it is attempted to shed some light on recent developments in HPC in the U.S. and present some quantitative data on the type and distribution of HPC technology. All the information here is based on the TOP500 list of November 1993. The report [7] ranks the 500 top performing supercomputers worldwide. The measure of performance is the maximal achieved R_{max} value for the computer on the LINPACK benchmark as reported in [5]. Using this measure the cutoff to make the list of the TOP500 systems worldwide is a performance of 472 Mflop/s on the LINPACK benchmark. Six Fujitsu VP-200E computers take on the ranks from 495 to 500. Interestingly the top ranked machine is also made by Fujitsu: the 140 processor specially built computer for the Numerical Windtunnel project at NAL in Japan is rated at 124.5 Gflop/s.

Before investigating some of the data in [7] in more detail, it is important to understand the limitations of the TOP500 study. These limitations can be summarized as follows:

- The list is a snapshot in time. The TOP500 list reflects the state of supercomputer installations as of November 1993. Since the market is extremely dynamic, such a study is almost out of date, by the moment it is published. For example the November 1993 report does not list any of the Cray T3D installations, by March 94 there are about 15. It lists only six IBM SP-1 machines, and by March 94 there are more than 75 installed. However, since the data were collected consistently, we have at least an accurate reflection of the distribution at this time.

- The LINPACK R_{max} value overestimates the performance of parallel machines. It is known that solving dense linear systems is a task that is well suited to highly parallel systems. MPPs therefore tend to exhibit a proportionally much higher performance than parallel vector processors (PVP). Even though the NAS Parallel Benchmarks [2], for example, would be a more accurate measure of parallel system performance, LINPACK figures are more widely available. They also provide an upper limit of the best possible performance of a computer on *any* application. If understood this way, the results in TOP500 take on a different, but at least consistent meaning.

- A large number of systems are in classified or highly proprietary areas. Both government and industrial users of HPC are for different reasons reluctant to provide details on the type and number of systems used. This may lead to double counts in some cases, and to undercounts in others, for example a large Ncube2 system to be rumored to be installed at Shell is not on the list. On the other hand the TOP500 contains many 'government' listings where location and use is competely unknown, and where is it possible that the same machine is counted twice.

- The TOP500 does not reflect actual usage of machines. For example several of the Intel Paragon machines are listed with high R_{max} value, however, it is known that many of the larger Paragon systems in 1993 were not yet able to deliver their full compute power for application users (see for example [12] for machine #48). Other systems, such as the Cray 2 at Phillips Laboratory (#235) have been decommissioned and are no longer in active use. However, there is no reasonable way to consistently estimate the actual compute cycles delivered by any of the computers on the list.

In spite of these inherent limitations the TOP500 can provide extremely useful information, and valuable insights. It is more accurate than many marketing studies, and the possible sources of error discussed above are probably statistically insignificant, if we consider only summary statistics, and not individual data. All Mflop/s or Gflop/s performance figures here refer to performance in terms of Linpack R_{max}.

In the analysis of geographical distribution, machines in Canada have been included in the figures for the U.S., and the figures for Europe include all European countries, not just EC members. The other country category includes mostly countries of the Pacific Rim with the exclusion of Japan, and a few Latin American Countries.

6.2 U.S. Dominance of the World Wide HPC Market

The TOP500 clearly demonstrates the dominant position the U.S. assumes in the world both as producer and as consumer of high performance computers. In Table 6.2 the total number of installed systems in the major world regions is given with respect to the origin of the computers.

If one considers in Table 6.2 the country of origin then it is striking that 389 out of the TOP500 systems are produced in the U.S., which amounts to 78% of all installed systems. Japan accounts for 18% of the systems, and Europe produces only 4%. The extent of the American dominance of the market came to me as a surprise. For years, in particular in the mid 80es, there were ominous and ubiquitous warnings, that the American supercomputer industry (which was essentially Cray Research at that time) is highly vulnerable to an 'attack' by the Japanese vertically integrated computer giants Fujitsu, NEC, and Hitachi. Obviously this has not happened. How much various efforts such as the NSF Supercomputing Initiative in the mid 80s, or more recently the HPCC Program have contributed to the current vast superiority of the U.S. high performance computing industry, remains to be investigated. It is interesting to note that one view expressed outside the U.S. [13] is that strengthening the U.S. HPC industry and easing the transition to MPP was the *only* rationale for the HPCC Program.

The numbers for Europe are actually worse than Table 6.2 indicates, since 14 of the 21 'European' machines are actually Fujitsu VP products, which are resold in Europe by Siemens-Nixdorf. Hence the true European production is a total of only 7 machines (4 Parsytec and 3 Meiko), all of which are installed in Europe. In spite of a recent installation of a European system at a U.S. government laboratory

Table 6.2:
US Share of Total Number of Installed TOP500 Systems

Systems Manufactured In	Systems Installed In U.S.	Japan	Europe	Other	Total
U.S.	236	31	106	16	389
Japan	5	75	6	4	90
Europe	0	0	21	0	21
Total	241	106	133	20	500

(a Meiko CS-2 at Lawrence Livermore Natl. Lab.) the situation in Europe remains bleak. With lack of immediate access to the newest hardware, and the absence of the close interaction of users with vendors which is prevalent in the U.S., the best the European High Performance Computing and Networking Initiative can accomplish is maintaining the status quo of Europe as a distant third in high performance computing technologies.

Table 6.3 is analogous to Table 6.2, but instead of the number of systems, the aggregate performance in R_{max}-Gflop/s is listed. Table 6.4 lists the ratio of the corresponding entries in Tables 6.2 and 6.3, i.e., the average of R_{max}-Gflop/s per machine. From Table 6.4 we can see that on average the machines manufactured in Japan have higher performance ratings, than machine manufactured in the U.S. Also machines installed both in Japan and the U.S. appear to be more powerful than the machines installed in Europe or in other countries.

A more interesting analysis of Tables 6.2 and 6.3 addresses the ongoing question of who has the higher trade barriers with respect to high performance computing, the U.S. or Japan? Table 6.2 shows that obviously both countries favor their own machines over their competitor's. But let us assume for the sake or argument that the European market is equally open and accessible to both American and Japanese machines, i.e., the distribution of supercomputers in

Systems Manufactured In	Systems Installed In U.S.	Japan	Europe	Other	Total
U.S.	853	46	143	33	1075
Japan	30	307	21	5	363
Europe	0	0	30	0	30
Total	883	353	194	38	1468

Table 6.3:
US Share of Total R_{max} (in Gflop/s) of Installed TOP500 Systems.

Systems Manufactured In	Systems Installed In U.S.	Japan	Europe	Other	Total
U.S.	3.6	1.5	1.3	2.1	2.8
Japan	6.0	4.1	5.3	1.3	4.0
Europe	-	-	1.4	-	1.4
Total	3.7	3.3	1.5	1.9	2.9

Table 6.4:
Ratio Gflop/s per machine.

Europe reflects an open market. According to the distribution in Europe the split in an open market should be 83% American and 17% Japanese. Assuming these market shares worldwide, the number of Japanese machines in the U.S. would be 41 (as opposed to 5), and the number of U.S. made supercomputers installed in Japan would be 88 (as opposed to 31). Clearly both countries seem to have mechanism is place which restrict competition in favor of the local products. I will leave it up to the reader to decide whether only 5 out of 41 or only 31 out of 88 constitutes a more biased situation.

6.3 Market Penetration of MPP

The penetration of the supercomputer market by MPPs is another often debated issue. The TOP500 again delivers hard data, which come somewhat as a surprise. In Table 6.5 the share in % in number of installations for MPP machines among the TOP500 is given. Here the PVP category includes all machines manufactured by Cray Research (with the exception of the Cray Superserver and T3D machines), all machines manufactured by IBM (with the exception of SP-1 machines), as well as all machines from Convex, Fujitsu, Hitachi, NEC, and Siemens-Nixdorf (Fujitsu). All others are counted as MPPs. The MPP category thus includes a number of machines, which should rather be labeled SMPs, but their inclusion does not change the overall picture significantly.

Overall MPPs account for 37% of all installed supercomputers. The installed base of MPPs in the U.S. is significantly higher. In the U.S. MPPs are with 51% already in the majority, in Japan on contrast MPPs are with 13% considerably underrepresented. Table 6.6 shows that irrespective of the country of installation MPPs are generally more powerful than PVP in terms of R_{max}-Gflop/s.

The considerable higher number of MPPs in the U.S. compared to the world average is clearly a direct consequence of the U.S. HPCC program. How many *additional* machines in the U.S. have been installed because of the HPCC support, and other subsidies for parallel machines, e.g. (D)ARPA funding? Again this is difficult to estimate, but as before we can assume that Europe is an objective test market. This is probably a fair assumption, since at the time of this study the European HPCN Initiative probably had no effect on the selection of MPP machines versus PVPs. Under this assumption then the share of MPP machines in the U.S. would be

Region	PVP	MPP	% MPP
U.S.	119	122	51
Japan	92	14	13
Europe	90	43	32
other	12	8	40
Total	313	187	37

Table 6.5:
Market Share of MPPs (in number of installations).

Region	PVP	MPP	% MPP
U.S.	355	528	60
Japan	198	155	44
Europe	128	66	34
other	33	5	13
Total	714	754	51

Table 6.6:
Market Share of MPPs (in computational power in R_{max}-Gflop/s).

only 32%, which is about 77 machines. Following this analysis one therefore could credit the installation of about 45 machines in the U.S. to the strong government support for massive parallelism. At about $5M per installation this amounts to approximately $225M of direct support for parallel machines in the U.S. from 1990 to 1993. This figure appears to be in the right order of magnitude. For example the General Accounting Office report on ARPA [8] lists a total of $55M spent in connection with procurements of Intel and TMC supercomputers alone. The list of ARPA supported machines ends with installations in late 1992, and does not include any of the more recent large scale Paragon or CM-5 machines, which have made the TOP500, and which are also part of the HPCC program. Thus as a result of direct government support, the U.S. is clear world leader in the adaptation and use of MPP technology.

6.4
HPC usage in Government, Universities, and Industry

The discussion of the high level of government support for MPPs in the U.S. in section 6.3 should imply that there is a large installed base of supercomputers in the government sector in the U.S. This is indeed the case as Tables 6.7–6.9 show.

In Tables 6.7–6.8 the distribution of the TOP100 machines across different sectors is shown with respect to number of installations and performance in R_{max}-Gflop/s. Here government refers to all government agencies and laboratories, which ranges from basic research environments to more production oriented machines as in the national weather bureaus. The categories university and industry are self-explanatory. The column with vendor machines includes all the machines used by supercomputer vendors in house for benchmarking and software development.

From the data in Table 6.7 it is clear that the distribution of the largest supercomputers in the U.S. is fairly consistent with the distribution in Japan and Europe. In all three regions/countries government accounts for about half of the largest supercomputers and industry for around 20%.

Comparing the distribution of the TOP100 with the TOP500 is quite intriguing. First it is notable that industrial installations with about 27% of the total have world wide a much larger share among the TOP500 systems. This is to be expected since one can expect the really large machines to be predominant in research environments. However, what is surprising is that the distribution between industrial and government installations is quite different in the corresponding countries/regions. In Japan only about 21% of the supercomputers are installed in government laboratories, whereas 40%

	Gov	Uni	Ven	Ind	Total
U.S.	28	16	5	10	59
Japan	11	5	3	6	25
Europe	7	5	0	1	13
other	2	1	0	0	3
Total	48	27	8	17	100

Table 6.7: Distribution of TOP100 by Sector (Number of Installations).

	Gov	Uni	Ven	Ind	Total
U.S.	385	160	42	55	642
Japan	176	25	36	26	263
Europe	43	21	0	3	67
other	17	4	0	0	84
Total	621	210	78	84	993

Table 6.8: Distribution of TOP100 by Sector (Performance in R_{max}-Gflop/s).

	Gov	Uni	Ven	Ind	Total
U.S.	86	71	22	62	241
Japan	23	22	18	43	106
Europe	52	53	1	27	133
other	6	11	0	3	20
Total	167	157	41	135	500

Table 6.9: Distribution of TOP500 by Sector (Number of Installations).

can be found in industry. With 39% government and 20% industrial use the situation in Europe is exactly reverse. The U.S. takes a middle position, somewhat closer to the situation in Europe, with 33% government use and 25% industrial use.

These results seem to imply that industrial use of supercomputers in Japan is considerably more widespread than in the U.S. While this is probably true in general, the situation in the U.S. is biased because of the effects of HPCC. It is not that U.S. industry is using significantly less supercomputers than Japan, but rather that U.S. government laboratories due to government spending are using considerably more supercomputer power than their Japanese counterparts. It is the goal of the HPCC program that this heavy use in government laboratories will have eventually a positive effect on the industrial use of high performance computing technologies. If this type of technology transfer will occur remains to be seen. Future version of the TOP500 report will provide the necessary data.

6.5 Commercial Use of Supercomputers.

One of the strategic goals of the HPCC program was to "spur gains in U.S. productivity and industrial competitiveness by making high performance computing and networking technologies an integral part of the design and production processes". The TOP500 data can give some indication what progress has been towards this goal. In Table 6.10 the distribution of the 135 industrial supercomputers worldwide is given by industry segment, as well as by MPP versus PVP, and by use in the U.S. versus all other countries.

The most surprising fact is that in the U.S. the number of MPPs in industry is almost the same as the number of PVPs. Thus even in the most competitive environment MPPs have made already major inroads. These data contradict some of the conclusions made in a controversial study [4], where it is maintained that "conventional supercomputers ... (are) hard to displace in the market". The TOP500 data indicate that displacement of PVP has already occurred to a much larger extent than generally believed in areas, which have been traditionally claimed by PVPs. The two industry segments where MPPs have made most progress in displacing PVPs are aerospace and geophysics. The success of MPPs in these fields can be easily explained by the nature of some of the typical applications. Seismic processing in the oil industry is an application where MPPs excel, since most of the computation is of explicit nature and done on structured grids. Similarly both electro-magnetics applications using methods of moments algorithms, and signal processing applications account for the use of MPPs in the aerospace community. The parallel applications taxonomy in [10] explains this success of MPPs.

Similarly there are areas where MPPs had no success whatsoever. Not surprisingly these are for example in the automotive industry.

Industry	PVP		MPP		Total
	U.S.	Other	U.S.	Other	
Automotive	4	25	0	0	29
Geophysics	15	5	6	3	29
Aerospace	6	3	12	1	22
Electronics	2	10	3	4	19
Metal/Constr.	0	10	0	0	10
Chem./Bio.	5	2	1	0	8
Econ./Fin.	0	2	3	0	5
Energy	1	2	1	0	4
Other	0	2	3	4	9
Total	33	61	29	12	135

Table 6.10:
Distribution of Industrial Supercomputers by Sector.

This industry is characterized by using unstructured finite element codes with implicit solution algorithms. These type of applications are very difficult to solve efficiently on MPPs. Another characteristic of the automotive industry is reliance on third party applications such as crash codes and structural analysis packages. So far third party developers, mostly small software companies, have been reluctant to port their software to unproven new technology. In contrast, most oil companies employ proprietary in-house codes, and have been willing to make the investment in porting applications. Thus the data in Table 6.10 reflect exactly the difficulty in porting the applications in different industry segments.

Another observation is that MPPs so far have been replacing PVPs in established field of high performance computing use. There have been no significant inroads into new applications markets yet. Even though there are several MPPs now in financial institutions, or in chemical and biological applications, their numbers are still small. Hence MPPs have not (yet) opened up new markets for HPC technology.

There are a few other observations one can make from Table 6.10 concerning HPC use in industry comparison. For example all 10 supercomputers in the metal working and construction industry are installed in Japan, whereas in aerospace with 18 out of 22 installations the U.S. is the clear leader. The supercomputers in the automotive industry are almost evenly distributed worldwide. Every major car manufacturers owns a supercomputer (with the exception of Volvo). One can therefore assume that the use of supercomputers in industrial applications is a *consequence* of the leadership position each country enjoys in the respective applications field (and not vice versa). However, the topic of supercomputer use and industrial leadership deserves some further detailed investigation.

6.6 Conclusions

The analysis of the data provide by the TOP500 report has led us to a number of conclusions concerning the state of HPC in the U.S. Some of these conclusions are:

- The U.S. is the clear world leader both as producer and as consumer of high performance computers.
- Both the U.S. and Japan seem to have mechanism is place which restrict competition in favor of the local products.
- MPPs account for more than a third of all installed supercomputers worldwide. Market penetration by MPPs in the U.S. is significantly higher, where MPPs constitute already now a majority of the installed supercomputers. A sizable portion of this market share (but by far not all) can be attributed to government spending and the HPCC program.
- Government installations dominate the market for large systems both in the U.S. and worldwide. Overall, the U.S. lags somewhat in industrial use of supercomputers.
- MPPs have made major progress in replacing PVPs in several industries. In the U.S. MPP usage in aerospace and in the oil industry is very high. MPPs appear to be considerably more widespread in industrial environments than commonly thought.

Generally the TOP500 has proven itself to be an extremely valuable tool, evaluating trends in the HPC market. Future releases of this report should enable the HPC community to track important developments much more accurately than in the past.

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Figure 6.1:
Systems installed for the different manufacturers in the U.S.

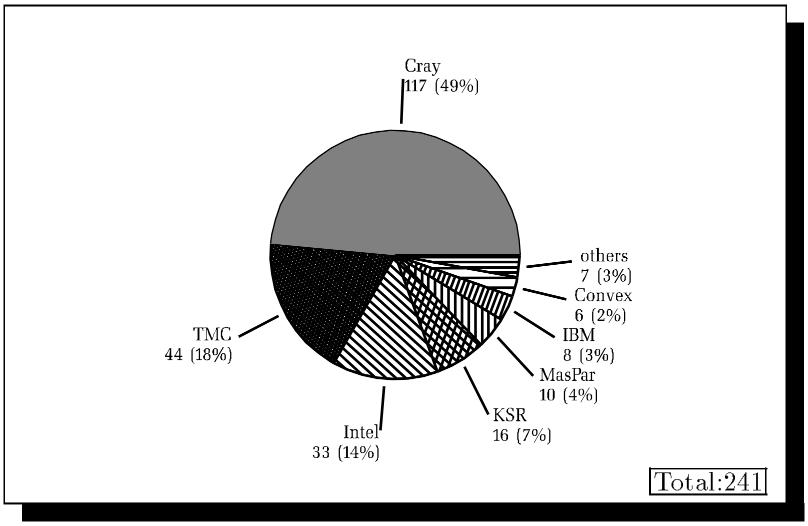
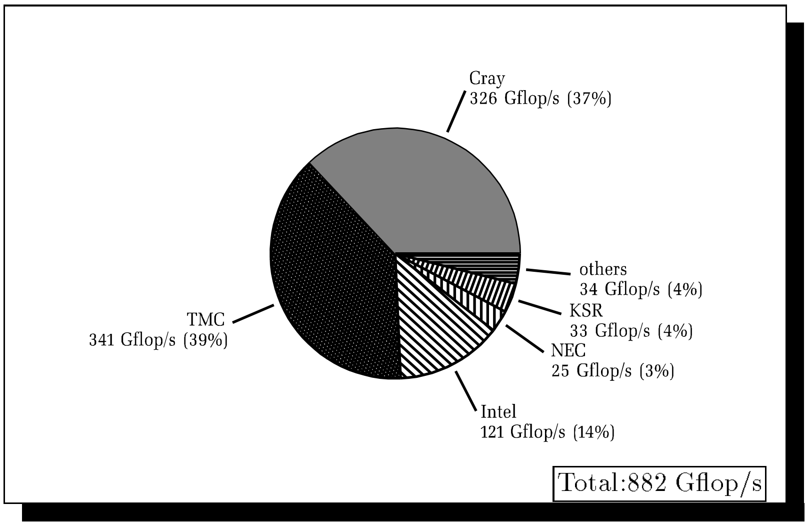


Figure 6.2:
R_{max} installed for the different manufacturers in the U.S.



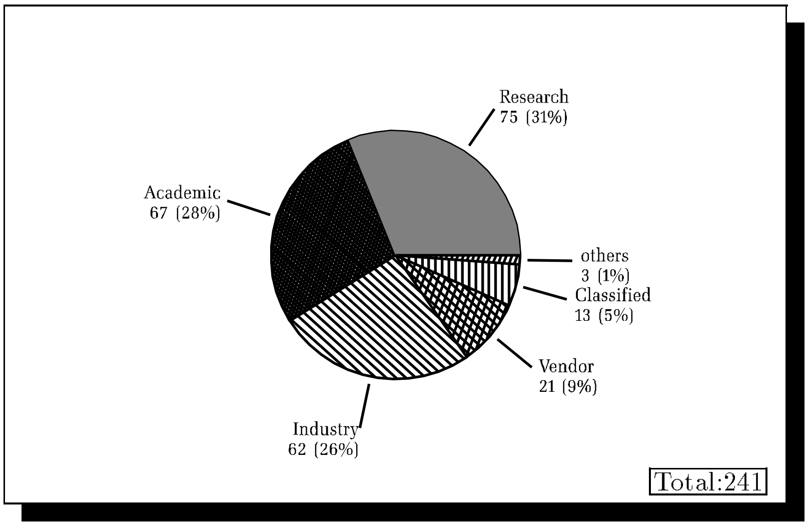


Figure 6.3:
Systems installed for the different application areas in the U.S.

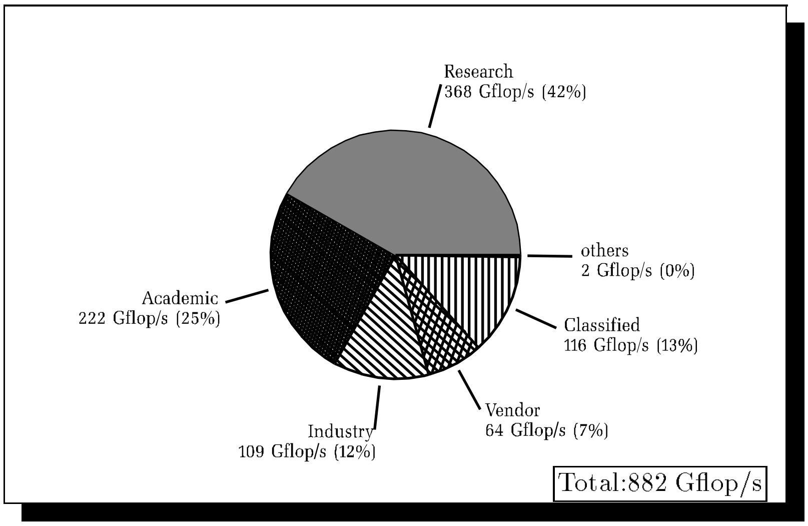


Figure 6.4:
R_{max} installed for the different application areas in the U.S.

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 2	TMC CM-5/1024	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	1024	**59700** 131000	52224 24064
2 3	TMC CM-5/544	Minnesota Supercomputer Center USA / .	Academic	544	**30400** 70000	36864 16384
3 4	TMC CM-5/512	NCSA Urbana-Champaign USA / .	Academic	512	**30400** 66000	36864 16384
4 5	TMC CM-5/512	National Security Agency USA / .	Classified	512	**30400** 66000	36864 16384
5 7	NEC SX-3/44	Atmospheric Environment Service (AES) Dorval Canada /1991	Research Weather	4	**20000** 22000	6144 832
6 8	Intel XP/S135	Sandia National Labs Albuquerque USA /1993	Research	1840	**15200** 92000	23000 9000
7 9	Intel XP/S35	Oak Ridge National Laboratory Oak Ridge USA /1992	Research	512	**15200** 26000	23000 9000
8 10	TMC CM-5/256	Goverment USA /1993	Classified	256	**15100** 33000	26112 12032
9 11	TMC CM-5/256	Thinking Machines USA /1993	Vendor	256	**15100** 33000	26112 12032
10 12	TMC CM-5/256	US Naval Research Laboratory USA /1992	Research	256	**15100** 33000	26112 12032
11 13	Intel Delta	Caltech Pasadena USA / .	Academic	512	**13900** 20480	25000 7500
12 14	Cray Y-MP C916/16256	Cray Research Eagan USA / .	Vendor	16	**13700** 15238	10000 650
13 15	Cray Y-MP C916/16256	DOD/CEWES Vicksburg USA /1993	Research Mechanics	16	**13700** 15238	10000 650
14 16	Cray Y-MP C916/16256	DOE/Bettis Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
15 17	Cray Y-MP C916/16256	DOE/Knolls Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
16 19	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
17 20	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
18 21	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
19 22	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
20 24	Cray Y-MP C916/16256	Lawrence Livermore National Laboratory NERSC USA /1992	Research Energy	16	**13700** 15238	10000 650

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 25	Cray Y-MP C916/16256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	16	**13700** 15238	10000 650
22 26	Cray Y-MP C916/16256	Pittsburgh Supercomputing Center Pittsburgh USA /1992	Academic	16	**13700** 15238	10000 650
23 27	Cray Y-MP C916	US Naval Oceanographic Command Bay Saint Louis USA / .	Research Weather	16	**13700** 15238	10000 650
24 28	Intel XP/S30	UCSD/San Diego Supercomputer Center San Diego USA /1993	Academic	400	**11900** 20000	. .
25 31	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
26 32	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
27 33	TMC CM-200/64k	NCSA USA / .	Academic	2048	**9800** 20000	29696 11264
28 34	Cray Y-MP C916/11256	Ford Motor Company Dearborn USA /1992	Industry Automotive	11	**9418** 10476	. .
29 35	TMC CM-5/128	AMEX USA /1993	Industry	128	**7700** 16000	18432 8192
30 36	TMC CM-5/128	Goverment USA /1993	Classified	128	**7700** 16000	18432 8192
31 38	TMC CM-5/128	MIT Cambridge USA / .	Research	128	**7700** 16000	18432 8192
32 39	TMC CM-5/128	Mobil / Technical Center Tulsa USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
33 40	TMC CM-5/128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	128	**7700** 16000	18432 8192
34 41	TMC CM-5/128	Schlumberger Well Services USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
35 43	Cray Y-MP C916/8256	Minnesota Supercomputer Center USA / .	Academic	8	**6850** 7619	. .
36 44	Cray Y-MP C916/8256	NASA/Ames Research Center/CCF Moffett Field USA /1993	Research Aerospace	8	**6850** 7619	. .
37 45	Cray Y-MP C98/8128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**6850** 7619	. .
38 46	Cray Y-MP C916/8128	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	8	**6850** 7619	. .
39 47	Intel XP/S15	Intel SSD Development Centers USA /1993	Vendor	208	**6200** 10400	. .
40 48	Intel XP/S15	NASA/Ames Research Center/NAS Moffett Field USA /1992	Research	208	**6200** 10400	. .

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41 53	TMC CM-2/64k	Brandeis University USA / .	Academic	2048	**5200** 14000	26624 11000
42 54	TMC CM-2/64k	Florida State University Tallahassee USA / .	Academic	2048	**5200** 14000	26624 11000
43 55	TMC CM-2/64k	SRC USA /1993	Industry	2048	**5200** 14000	26624 11000
44 56	TMC CM-200/32k	Minnesota Supercomputer Center USA / .	Academic	1024	**5000** 10000	21504 8192
45 57	NEC SX-3/22	Houston Advanced Research Center Houston USA / .	Research	2	**5000** 5500	3072 384
46 62	Cray Y-MP C98/6256	NASA/Goddard Space Flight Center Greenbelt USA /1993	Research Weather	6	**4630** 5715	. .
47 63	Intel XP/S10	Intel SSD Development Centers USA /1992	Vendor	140	**4100** 7000	. .
48 76	IBM 9076-005 SP1	Argonne Nat. Lab USA /1993	Academic	128	**3861** 16000	26500 8000
49 77	IBM 9076-004 SP1	Cornell University USA /1993	Academic	64	**3861** 8000	26500 8000
50 78	TMC CM-5/64	AMOCO Tulsa USA / .	Industry Geophysics	64	**3800** 8192	13056 6016
51 81	TMC CM-5/64	Boston University Boston USA / .	Academic	64	**3800** 8192	13056 6016
52 82	TMC CM-5/64	EPS USA /1993	Industry	64	**3800** 8192	13056 6016
53 86	TMC CM-5/64	University of Wisconsin USA / .	Academic	64	**3800** 8192	13056 6016
54 89	KSR KSR1-256	KSR Boston USA /1992	Vendor	256	**3380** 10240	10240 1824
55 90	KSR KSR1-256	US Army Research Laboratory Aberdeen USA /1993	Research	256	**3380** 10240	10240 1824
56 91	KSR KSR1-128	Cornell Theory Center Ithaca USA /1992	Academic	128	**3380** 5120	10240 1824
57 97	Intel iPSC/860	Alliant Techsystems Inc. USA /1990	Industry Biochemistry	128	**2600** 5120	12000 4500
58 99	Intel iPSC/860	Grant Tensor USA /1991	Industry Geophysics	128	**2600** 5120	12000 4500
59 100	Intel iPSC/860	Grant Tensor Houston USA /1992	Industry Geophysics	128	**2600** 5120	12000 4500
60 101	Intel iPSC/860	Honeywell USA /1990	Industry	128	**2600** 5120	12000 4500

TOP500 Supercomputer Sites — USA

N USA World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
61 102	Intel iPSC/860	Lockheed Advanced Development Palmdale USA /1992	Industry Aerospace	128	**2600** 5120	12000 4500
62 103	Intel iPSC/860	NASA/Ames Research Center/NAS Moffett Field USA /1990	Research	128	**2600** 5120	12000 4500
63 104	Intel iPSC/860	NIH Frederick USA /1990	Research	128	**2600** 5120	12000 4500
64 106	Intel iPSC/860	Oak Ridge National Laboratory Oak Ridge USA /1989	Research	128	**2600** 5120	12000 4500
65 107	KSR KSR1-96	Florida State University Tallahassee USA /1993	Academic	96	**2535** 3840	. .
66 108	KSR KSR1-96	Lockheed USA /1993	Industry	96	**2535** 3840	. .
67 109	KSR KSR1-96	University of Cincinati USA /1993	Academic	96	**2535** 3840	. .
68 111	TMC CM-200/16k	US Naval Research Laboratory USA /1987	Research	512	**2400** 5000	14848 5632
69 113	Cray CRAY-2s/8-128	Lawrence Livermore National Laboratory NERSC USA /1990	Research Energy	8	**2171** 3902	. .
70 114	Cray Y-MP8E/8256	Arabian American Oil Company USA /1991	Industry Geophysics	8	**2144** 2667	. .
71 115	Cray Y-MP8/864	Atomic Weapons Establishment USA /1990	Classified	8	**2144** 2667	. .
72 116	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
73 117	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
74 118	Cray Y-MP8/832	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
75 119	Cray Y-MP8/864	DOE/Bettis Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .
76 120	Cray Y-MP8/864	DOE/Knolls Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .
77 121	Cray Y-MP8/8256	DOE/National Security Agency USA / .	Classified	8	**2144** 2667	. .
78 124	Cray Y-MP8/8128	Lawrence Livermore National Laboratory Livermore USA /1991	Research	8	**2144** 2667	. .
79 125	Cray Y-MP8/864	Lawrence Livermore National Laboratory Livermore USA /1992	Research	8	**2144** 2667	. .
80 127	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
81 128	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
82 129	Cray Y-MP8/864	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
83 130	Cray Y-MP8/8256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**2144** 2667	. .
84 131	Cray Y-MP8E/8256	NASA/Langley Research Center Hampton USA /1992	Research	8	**2144** 2667	. .
85 132	Cray Y-MP8/8128	NASA/Lewis Research Center USA /1991	Research	8	**2144** 2667	. .
86 133	Cray Y-MP8/864	NOAA USA /1990	Research Weather	8	**2144** 2667	. .
87 134	Cray Y-MP8/832	NOAA/GFDL USA /1990	Research Weather	8	**2144** 2667	. .
88 135	Cray Y-MP8/8128	National Cancer Institute USA /1991	Research Chemistry	8	**2144** 2667	. .
89 136	Cray Y-MP8/864	National Center for Atmospheric Research Boulder USA /1990	Research Weather	8	**2144** 2667	. .
90 137	Cray Y-MP8E/8128	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	8	**2144** 2667	. .
91 138	Cray Y-MP8/864	Ohio Supercomputer Center Columbus USA /1989	Academic	8	**2144** 2667	. .
92 140	Cray Y-MP8/864	Sandia National Labs Albuquerque USA / .	Research	8	**2144** 2667	. .
93 142	Cray Y-MP8/864	UCSD/San Diego Supercomputer Center San Diego USA /1989	Academic	8	**2144** 2667	. .
94 145	Cray Y-MP8/864	University of Texas Austin USA /1990	Academic	8	**2144** 2667	. .
95 147	Fujitsu VPX240/20	Fujitsu San Jose USA / .	Vendor	1	**2110** 2500	. .
96 148	Fujitsu VPX240/10	High Performance Computing Center Alberta Canada / .	Research	1	**2110** 2500	. .
97 151	IBM 9076-003 SP1	Penn State University USA /1993	Academic	32	**2033** 4000	15000 4390
98 152	Intel XP/S5	Boeing Seattle USA /1992	Industry Aerospace	66	**2000** 3300	8000 .
99 153	Intel XP/S5	Intel SSD Development Centers USA /1993	Vendor	66	**2000** 3300	8000 .
100 155	Intel XP/S5-32	NASA/Langley Research Center Hampton USA /1992	Research	66	**2000** 3300	8000 .

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N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
101 156	Intel XP/S5	Oak Ridge National Laboratory Oak Ridge USA / .	Research	66	**2000** 3300	8000 .
102 157	Intel XP/S5	Prudential Bache Securities New York USA /1993	Industry	66	**2000** 3300	8000 .
103 160	TMC CM-5/32	Booz-Allen Hamilton Washington DC USA / .	Industry Consulting	32	**1900** 4096	9216 4096
104 162	TMC CM-5/32	Columbia University New York City USA / .	Academic	32	**1900** 4096	9216 4096
105 164	TMC CM-5/32	Duke University Durham USA / .	Academic	32	**1900** 4096	9216 4096
106 165	TMC CM-5/32	JPL Pasadena USA / .	Research	32	**1900** 4096	9216 4096
107 166	TMC CM-5/32	Madentech USA /1993	Industry	32	**1900** 4096	9216 4096
108 167	TMC CM-5/32	NPAC USA /1993	Research	32	**1900** 4096	9216 4096
109 168	TMC CM-5/32	National Center for Atmospheric Research Boulder USA / .	Research Weather	32	**1900** 4096	9216 4096
110 169	TMC CM-5/32	Oregon State University USA / .	Academic	32	**1900** 4096	9216 4096
111 172	TMC CM-5/32	Stanford University USA / .	Academic	32	**1900** 4096	9216 4096
112 173	TMC CM-5/32	Syracuse University Syracuse USA / .	Academic	32	**1900** 4096	9216 4096
113 174	TMC CM-5/32	TEC USA /1993	Industry	32	**1900** 4096	9216 4096
114 178	TMC CM-5/32	University of California at Berkeley USA / .	Academic	32	**1900** 4096	9216 4096
115 179	TMC CM-5/32	University of Maryland USA / .	Academic	32	**1900** 4096	9216 4096
116 181	TMC CM-5/32	University of Tennessee Knoxville USA / .	Academic	32	**1900** 4096	9216 4096
117 182	NCube nCUBE2	Sandia National Labs Albuquerque USA / .	Research	1024	**1900** 2400	21376 3193
118 183	KSR KSR1-64	Caltech Pasadena USA /1992	Academic	64	**1838** 2560	9216 1536
119 186	KSR KSR1-64	Georgia Institute of Technology USA /1993	Research	64	**1838** 2560	9216 1536
120 188	KSR KSR1-64	Oak Ridge National Laboratory Oak Ridge USA /1991	Research	64	**1838** 2560	9216 1536

TOP500 Supercomputer Sites — USA

N USA World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
121 189	KSR KSR1-64	University of Colorado USA /1992	Academic	64	**1838** 2560	9216 1536
122 190	KSR KSR1-64	University of Massachusetts Amherst USA /1993	Academic	64	**1838** 2560	9216 1536
123 191	KSR KSR1-64	University of Michigan Michigan USA /1993	Academic	64	**1838** 2560	9216 1536
124 192	KSR KSR1-64	University of Washington Seattle USA /1993	Academic	64	**1838** 2560	9216 1536
125 204	Cray Y-MP M98	Cray Research Eagan USA / .	Vendor	8	**1733** 2667	. .
126 210	Cray Y-MP8/664	Cray Research Eagan USA / .	Vendor	6	**1651** 2000	. .
127 211	Cray Y-MP8I/6128	NASA/Marshall Space Flight Center USA /1993	Research Aerospace	6	**1651** 2000	. .
128 215	MasPar MP-2216	Lockheed Missiles and Space Company USA /1993	Industry Aerospace	16384	**1600** 2400	11264 1920
129 216	MasPar MP-2216	National Cancer Institute USA /1993	Research Chemistry	16384	**1600** 2400	11264 1920
130 218	Intel XP/A4	Caltech Pasadena USA /1993	Academic	56	**1500** 4200	6000 .
131 221	Intel XP/A4	Rice University USA /1993	Academic	56	**1500** 4200	6000 .
132 222	Intel XP/A4	Sandia National Labs Livermore USA /1993	Research Energy	56	**1500** 4200	6000 .
133 224	Intel XP/A4	University of Indiana USA /1993	Academic	56	**1500** 4200	6000 .
134 226	Intel XP/A4	University of South Carolina USA /1992	Academic	56	**1500** 4200	6000 .
135 229	IBM ES 9000-900	Cornell Theory Center Ithaca USA / .	Academic	6	**1457** 2664	. .
136 230	IBM ES 9000-900	UCLA Los Angeles USA / .	Academic	6	**1457** 2664	. .
137 232	Cray CRAY-2s/4-128	Lawrence Livermore National Laboratory NERSC USA /1988	Research Energy	4	**1406** 1952	. .
138 233	Cray CRAY-2s/4-128	NASA/Langley Research Center Hampton USA /1989	Research	4	**1406** 1952	. .
139 234	Cray CRAY-2s/4-128	NCSA Urbana-Champaign USA /1988	Academic	4	**1406** 1952	. .
140 235	Cray CRAY-2/4-256	Air Force/Phillips Lab USA /1987	Research Aerospace	4	**1406** 1951	. .

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N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
141 236	Cray CRAY-2/4-512	Arabian American Oil Company USA /1992	Industry Geophysics	4	**1406** 1951	. .
142 238	Cray CRAY-2/4-128	Cray Research Eagan USA / .	Vendor	4	**1406** 1951	. .
143 242	Cray CRAY-2/4-512	Minnesota Supercomputer Center USA /1988	Academic	4	**1406** 1951	. .
144 244	Cray CRAY-2/4-512	US Air Force/National Test Facility USA /1990	Classified	4	**1406** 1951	. .
145 246	Intel iPSC/860	Caltech Pasadena USA /1990	Academic	64	**1400** 2560	9000 3500
146 248	Intel iPSC/860	McDonnell Douglas USA /1991	Industry Aerospace	64	**1400** 2560	9000 3500
147 249	Intel iPSC/860	SERC USA /1990	Research	64	**1400** 2560	9000 3500
148 250	Intel iPSC/860	Sandia National Labs Albuquerque USA /1991	Research	64	**1400** 2560	9000 3500
149 251	Intel iPSC/860	Superconducting Supercollider Lab USA /1990	Research	64	**1400** 2560	9000 3500
150 252	Intel iPSC/860	UCSD/San Diego Supercomputer Center San Diego USA /1990	Academic	64	**1400** 2560	9000 3500
151 253	Intel iPSC/860	Westinghouse Electric USA /1992	Industry Energy	64	**1400** 2560	9000 3500
152 254	KSR KSR1-48	North Carolina Supercomputer Center USA /1992	Academic	48	**1350** 1920	. .
153 265	Cray Y-MP8E/4128	Boeing Seattle USA / .	Industry Aerospace	4	**1159** 1333	. .
154 267	Cray Y-MP8I/464	Chrysler Motors Company USA /1992	Industry Automotive	4	**1159** 1333	. .
155 271	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
156 272	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
157 275	Cray Y-MP8/464	EXXON USA /1992	Industry Geophysics	4	**1159** 1333	. .
158 278	Cray Y-MP4/432	Florida State University Tallahassee USA /1990	Academic	4	**1159** 1333	. .
159 280	Cray Y-MP4E/464	Lockheed Aeronautical Systems Company USA /1992	Industry Aerospace	4	**1159** 1333	. .
160 281	Cray Y-MP8I/4128	Lockheed Aeronautical Systems Company USA /1993	Industry Aerospace	4	**1159** 1333	. .

TOP500 Supercomputer Sites — USA

N USA World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
161 284	Cray Y-MP8I/4128	Merck Co USA /1993	Industry Chemistry	4	**1159** 1333	. .
162 286	Cray Y-MP4/464	NCSA Urbana-Champaign USA /1990	Academic	4	**1159** 1333	. .
163 287	Cray Y-MP8/464	North Carolina Supercomputer Center USA /1991	Academic	4	**1159** 1333	. .
164 297	Cray Y-MP M98/41024	University of Alaska Fairbanks USA /1992	Academic	4	**1114** 1333	. .
165 298	Fujitsu VPX220/10	GECO-PRAKLA Houston USA /1993	Industry Geophysics	1	**1048** 1250	. .
166 302	TMC CM-5/16	Goverment USA /1993	Classified	16	**980** 2048	6528 3008
167 305	TMC CM-5/16	NCSA USA /1993	Academic	16	**980** 2048	6528 3008
168 306	TMC CM-5/16	Pittsburgh Supercomputing Center Pittsburgh USA / .	Academic	16	**980** 2048	6528 3008
169 307	TMC CM-5/16	Thinking Machines USA /1993	Vendor	16	**980** 2048	6528 3008
170 308	TMC CM-5/16	West Virginia University USA / .	Academic	16	**980** 2048	6528 3008
171 313	NCube nCUBE2	Rockwell USA /1992	Industry Aerospace	512	**958** 1200	15200 2240
172 328	KSR KSR1-32	University of Houston USA /1992	Academic	32	**893** 1280	6144 896
173 330	KSR KSR1-32	University of Toronto Toronto Canada /1993	Academic	32	**893** 1280	6144 896
174 339	Cray Y-MP4/332	Arco Oil and Gas Company USA /1992	Industry Geophysics	3	**881** 999	. .
175 343	Cray Y-MP4/332	Du Pont De Nemours Company USA /1990	Industry Chemistry	3	**881** 999	. .
176 346	Cray Y-MP4E/364	Mobil / Technical Center Tulsa USA /1993	Industry Geophysics	3	**881** 999	. .
177 348	Cray Y-MP4/332	Shell USA USA /1992	Industry Geophysics	3	**881** 999	. .
178 350	Cray Y-MP M98/31024	General Motors/Research Environment Staff USA /1993	Industry Automotive	3	**855** 999	. .
179 366	Cray X-MP EA/432	BP Exploration Inc./U.S. USA /1990	Industry Geophysics	4	**822** 940	. .
180 367	Cray X-MP/48	Battelle Software Seattle USA / .	Industry Energy	4	**822** 940	. .

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
181 368	Cray X-MP/4	Chevron La Habra USA / .	Industry Geophysics	4	**822** 940	. .
182 370	Cray X-MP/416	Cray Research Eagan USA / .	Vendor	4	**822** 940	. .
183 372	Cray X-MP/416	Lawrence Livermore National Laboratory Livermore USA /1987	Research	4	**822** 940	. .
184 373	Cray X-MP EA/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
185 374	Cray X-MP EA/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
186 375	Cray X-MP EA/464	MIT Cambridge USA / .	Research	4	**822** 940	. .
187 377	Cray X-MP EA/464	Minnesota Supercomputer Center USA /1992	Academic	4	**822** 940	. .
188 378	Cray X-MP/416	NASA/Marshall Space Flight Center USA /1988	Research Aerospace	4	**822** 940	. .
189 380	Convex C3880	CONVEX Dallas USA /1992	Vendor	8	**795** 960	. .
190 383	Convex C3880	Ford Dearborn USA /1992	Industry Automotive	8	**795** 960	. .
191 384	Convex C3880	NCSA Urbana-Champaign USA /1992	Academic	8	**795** 960	. .
192 386	Convex C3880	UNOCAL USA /1992	Industry	8	**795** 960	. .
193 390	MasPar MP-2208	Arizona State University USA /1993	Academic	8192	**766** 1200	9386 1374
194 391	Cray S-MP/MCP784	Canon USA / .	Industry	84	**742** 3360	. .
195 392	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
196 393	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
197 394	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
198 395	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
199 396	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
200 397	Cray S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .

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N USA World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
201 398	Cray CRAY-2s/2-128	Eli Lilly and Company USA /1990	Industry Chemistry	2	**741** 976	. .
202 399	Cray CRAY-2s/2-128	US Air Force/National Test Facility USA /1988	Classified	2	**741** 976	. .
203 400	Cray S-MP/MCP756	CNR-Napoli USA / .		56	**678** 2210	. .
204 401	Cray S-MP/MCP256	Cray Research Eagan USA / .	Vendor	56	**678** 2210	. .
205 402	Cray S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
206 403	Cray S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
207 407	IBM 9076-001 SP1	Halliburton USA /1993	Academic	8	**664** 1000	10000 1662
208 409	IBM 9076-001 SP1	NCAR USA /1993	Research	8	**664** 1000	10000 1662
209 412	Intel iPSC/860	Fermi National Accelerator Laboratory Batavia USA / .	Research	32	**640** 1280	6000 2500
210 419	Convex C3860	MIT Cambridge USA /1993	Research	6	**615** 720	. .
211 424	Cray Y-MP8/2128	Air Force/Eglin Air Force Base USA /1990	Classified	2	**604** 666	. .
212 425	Cray Y-MP2E/232	Apple Computer Inc. USA /1991	Industry Electronics	2	**604** 666	. .
213 428	Cray Y-MP2E/232	CONOCO Inc. USA /1991	Industry Geophysics	2	**604** 666	. .
214 432	Cray Y-MP2/232	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
215 433	Cray Y-MP8/21024	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
216 442	Cray Y-MP2E/232	Grumman Aerospace Corporation USA /1991	Industry Aerospace	2	**604** 666	. .
217 446	Cray Y-MP8/264	Los Alamos National Laboratory Los Alamos USA /1990	Research Energy	2	**604** 666	. .
218 447	Cray Y-MP2E/264	Marion Merrell Dow Inc USA /1992	Industry Chemistry	2	**604** 666	. .
219 450	Cray Y-MP2/216	NBS USA /1991	Research Weather	2	**604** 666	. .
220 451	Cray Y-MP2	National Center for Atmospheric Research Boulder USA / .	Research Weather	2	**604** 666	. .

TOP500 Supercomputer Sites — USA

N *USA* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
221 452	Cray Y-MP2E/216	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	2	**604** 666	. .
222 454	Cray Y-MP2E/232	Pennsylvania State University USA /1993	Academic	2	**604** 666	. .
223 455	Cray Y-MP2/232	Phillips Petroleum Company USA /1992	Industry Geophysics	2	**604** 666	. .
224 457	Cray Y-MP2/264	Sandia National Labs Livermore USA / .	Research Energy	2	**604** 666	. .
225 458	Cray Y-MP2E/264	TEXACO USA /1991	Industry Geophysics	2	**604** 666	. .
226 459	Cray Y-MP2/216	Texas AM University USA /1993	Academic	2	**604** 666	. .
227 460	Cray Y-MP2E/264	The Scripps Research Institute USA /1992	Industry Chemistry	2	**604** 666	. .
228 462	Cray Y-MP2E/232	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	2	**604** 666	. .
229 464	Cray Y-MP2/216	University of Nevada at Las Vegas USA /1990	Academic	2	**604** 666	. .
230 465	Cray Y-MP2/232	University of Rochester - Laboratory for Laser E. USA /1991	Academic	2	**604** 666	. .
231 472	Cray Y-MP M92/2256	ATT Bell Laboratories USA /1992	Industry Electronics	2	**550** 666	. .
232 473	Cray Y-MP M92/21024	Minnesota Supercomputer Center USA /1992	Academic	2	**550** 666	. .
233 478	IBM 3090-600S	Utah Supercomputing Institute USA / .	Academic	6	**540** 828	. .
234 481	Convex C3850	NASA/Johnson Space Center Houston USA /1992	Research	5	**522** 600	. .
235 485	MasPar MP-1216	ATT USA /1991	Industry Electronics	16384	**473** 550	11264 1280
236 486	MasPar MP-1216	Bellcore USA /1990	Industry	16384	**473** 550	11264 1280
237 487	MasPar MP-1216	Chevron La Habra USA / .	Industry Geophysics	16384	**473** 550	11264 1280
238 488	MasPar MP-1216	Harvard University Cambridge USA / .	Academic	16384	**473** 550	11264 1280
239 489	MasPar MP-1216	Iowa State University USA /1990	Academic	16384	**473** 550	11264 1280
240 490	MasPar MP-1216	NASA/Goddard Space Flight Center Greenbelt USA /1990	Research Aerospace	16384	**473** 550	11264 1280
241 491	MasPar MP-1216	Purdue University West Laffayette USA /1991	Academic	16384	**473** 550	11264 1280

7

Supercomputing in Japan

Sverre Jarp

7.1 Introduction

Japan with 125 million people, half of the population and one twenty-fifth the geographical size of the United States, has over the last few decades become an economic giant. In correspondence to its economic ambition the country has established itself both as a large producer and consumer of supercomputing systems. As a result, the country finds itself well represented in the TOP500.

Not only can the Japanese point to (by far) the single most powerful computer system on the list, the so-called Numeric Wind Tunnel installed by the National Aerospace Lab, but also to an accumulated R_{max} that is only exceeded by the US and is almost twice that of Europe, in spite of Europe's three-fold number of inhabitants. Although it is true that Japan has fewer installed systems than Europe, this simply means that the Japanese systems are much more powerful on average than the European ones.

In order to review today's TOP500 installations it is extremely relevant to look at the development of the Japanese computing industry in a historical perspective.

About 30 years ago, Japan was entirely dependent on American computing equipment (mainly made by IBM). To reduce their dependency on foreign systems, the Japanese employed a scheme of strong governmental support for reproducing other companies' computer designs and began to build up their own computer industry. For about two decades they were largely content to produce mainframes that imitated the IBM/370 systems, selling them in the local market with a Japanese MVS (Multiple Virtual Systems) look-alike operating system, or as plug-compatible machines abroad.

In recent years we have seen several changes in this scenario:

- First of all the Japanese companies now dominate the domestic market by providing an impressive 80% of all computer equipment. Japanese hardware technology is now state-of-the-art. Japanese software is behind the Western counterparts but Western packages are instead being ported to Japanese hardware systems.

- All the large Japanese manufacturers have expanded beyond mainframes into supercomputers and can today claim to have the fastest supercomputers on the market. With the exception of Fujitsu in Europe (through Siemens) and in Australia, the Japanese have not, however, been particularly successful at exporting their systems. The switch to Unix should help make the systems move acceptable abroad, but until now, we are mainly witnessing domestic use of large Japanese supercomputers.

7.2 'Japan Inc.' and Supercomputers

In order to develop its high-end computing technology, the Japanese have definitely been relying on of the characteristics of the Japanese society, namely loyalty. The government has worked together with the academic community (mainly the large Japanese universities) and industry to nurture the development of high end systems and the necessary infrastructure. Fully developed systems have ended up in the computer centres of the largest universities for production use and applications development.

MITI (Ministry of International Trade and Industry) has managed to get the large companies to line up behind national development projects such as the VLSI project, the 5th generation project, the Supercomputer Project (described below), the Image processing (Ga-As) project and now the 6th generation: the Real World Computing Project.

In the High Speed Computing System for Scientific and Technological Uses Project, six large electronics companies participated, and Fujitsu, NEC, and Hitachi shared the task of assembling a 10 Gigaflop supercomputer. Such projects explain in part why the resulting supercomputers from the various vendors share many common design points.

Although Mitsubishi, Oki and Toshiba also participated in the above mentioned project, only NEC, Fujitsu, and Hitachi have continued to develop and commercialise supercomputers. All three companies are very large (in terms of annual sales) and they are all extremely active in the semi-conductor field and telecommunications, as well as in the field of general purpose computers and more recently supercomputers.

7.3 Supercomputer Evolution

In the beginning there were only a couple of Cray-1s installed in Japan, and until 1983 there were no Japanese-produced supercomputers. The first models were announced in 1983. Naturally there had been prototypes earlier (like the Fujitsu F230-75 APU produced in two copies in 1978) but Fujitsu's VP-200 and Hitachi's S-810 were the first officially announced versions. NEC announced its SX series slightly later.

The last decade has completely changed the scene. About three generations of machines have been produced by each of the domestic manufacturers and model improvements have also been offered during the life-span of those machines. During the last ten years about 300 supercomputer systems have been shipped and installed in Japan, and a whole infrastructure of supercomputing has been established. All major universities have supercomputers, many of the large industrial companies and research centres as well.

7.4
Basic Design of Japanese supercomputers

Based on the success of the Cray-1 and the CDC Cyber 205, the Japanese decided in the late seventies to start producing their own vector-based supercomputers which were initially oriented towards parallel pipelines featuring multiple floating-point units always governed by one control processor. With the advent of the latest generation of systems these supercomputers have added the dimension of multiprocessing and even distributed memory parallel processing. The change logically follows from the fact that only computing problems with long vectors and the right mix of floating-point instructions could expect to move towards peak performance in the early versions of these supercomputers.

Multiprocessing adds a dimension of versatility to the hardware, but the price to pay is added complexity in the software requiring the basic operating system, the compilers, the libraries, and the applications to be made aware of this architectural feature. The complexity becomes even greater in Fujitsu's latest Vector-Parallel system which tries to combine the established advantages of vector supercomputing with the more adventurous dimension of distributed memory parallel processors.

7.5 NEC's SX family

In 1984 the company announced the SX-1 and SX-2 and started delivery in 1985. The first two SX-2 systems were domestic deliveries to Osaka University and the Institute for Computational Fluid Dynamics (ICFD). The SX-2 had multiple pipelines with one set of add and multiply floating point units each. With a cycle time of 6 nanoseconds, each pipelined floating-point unit could peak at 167 Mflop/s. With four pipelines per unit and two floating-point units, the peak performance was about 1.3 Gflop/s. Due to limited memory bandwidth and other issues the sustained performance in benchmark tests was typically less than half the peak value. The SX-1 had a slightly higher cycle time (7 ns) than the SX-2. In addition it had only half the number of pipelines. The maximum execution rate was 570 Mflop/s.

At the end of 1987, NEC improved its supercomputer family with the A-series which gave improvements to the memory and I/O bandwidth. The top model, the SX-2A, had the same theoretical peak performance as the SX-2. Several low-range models were also announced but today none of these systems can qualify for the TOP500.

In 1989 NEC announced a rather aggressive new model, the SX-3, with several important changes. The vector cycle time was brought down to 2.9 ns, the number of pipelines was doubled, but most significantly NEC added multiprocessing capability to its new series. The new top of the range featured four independent arithmetic processors (each with a scalar and a vector processing unit); and NEC pushed its performance by more than one order of magnitude to an impressive peak of 22 Gflop/s (from 1.33 on the SX-2A). The combination of these features put the SX-3 at the top of the list of now the most powerful vector processors in the world. The total memory bandwidth was subdivided into two halves which in turn featured two vector load and one vector store paths per pipeline set as well as one scalar load and one scalar store paths. This gave a total memory bandwidths to the vector units of about 66 GB/s. Like its predecessors, the SX-3 was therefore unable to offer the memory bandwidth needed to sustain peak performance unless most operands were contained in the vector registers.

In 1992 NEC announced the SX-3R with a couple of improvements compared to the first version. The clock was further reduced to 2.5 ns, so that the peak performance increased to 6.4 Gflop/s per processor.

7.6 Fujitsu's VP series

In 1977 Fujitsu produced the first supercomputer prototype called the F230-75 APU that was a pipelined vector processor added to a scalar processor. This attached processor was installed in the Japanese Atomic Energy Commission (JAERI) and the National Aeronautic Lab (NAL).

In 1983 the company came out with the VP-200 and VP-100 systems, which later spun off the low-end VP-50 and VP-30 systems. In 1986 came the VP-400 (with twice as many pipelines as the VP-200) and as of mid-1987 the whole family became the E-series with the addition of an extra (multiply-add) pipelined floating point unit that boosted the performance potential by 50%. Thanks to the flexible range of systems in this generation (VP-30E to VP-400E), and other reasons such as good marketing and a broad range of applications, Fujitsu has became the largest domestic supplier with over 80 systems installed, many of which are well below the cut-off limit in the TOP500.

Available since 1990, the VP-2000 family can offer a peak performance of 5 Gflop/s thanks to a vector cycle time of 3.2 ns. The family was initially announced with four vector performance levels (model 2100, 2200, 2400, and 2600) where each level could have either one of two scalar processors. but the VP-2400/40 doubled this limit offering a peak vector performance similar to the VP-2600. Most of these models are now represented in the Japanese TOP500.

Previous machines had been heavily criticised for the lack of memory throughput. The VP-400 series had only one load/store path to memory that peaked at 4.57 GB/s. This was improved in the VP-2000 series by doubling the paths so that each pipeline set can do two load/store operations per cycle giving a total transfer rate of 20 GB/s. Fujitsu recently decided to use the label, VPX-2x0, for the VP-2x00 systems adapted to their Unix system. Keio Daigaku (university) now runs such a system.

The VPP-500 series

In 1993 Fujitsu surprised the world by announcing a Vector Parallel Processor (VPP) series that was designed for reaching well into the range of hundreds of Gflop/s. At the core of the system is a combined Ga-As/Bi-CMOS processor, based largely on the original design of the VP-200. By using the most advanced hardware technology available the processor chips have a gate delay as low as 60 ps in the Ga-As chips. The resulting cycle time is 9.5 ns. The processor has four independent pipelines each capable of executing two Multiply-Add instructions in parallel resulting in a peak speed of 1.7 Gflop/s per processor. Each processor board is equipped with 256 Megabytes of central memory.

The most striking part of the VPP-500 is the capability to interconnect up to 222 processors via a cross-bar network via two independent (read/write) connections, each operating at 400 MB/s. The total memory can be addressed via virtual shared memory primitives. The system is meant to be front-ended by a VP-2x00 system that handles input/output and permanent file store, and job queue logistics.

As mentioned in the introduction, an early version of this system called the Numeric Wind Tunnel, was developed together with NAL. This early version of the VPP-500 (with 140 processors) is today the fastest supercomputer in the world and stands out at the beginning of the TOP500 due to a R_{max} value that is twice that of the TMC CM-5/1024 installed at Los Alamos.

7.7 Hitachi's Supercomputers

Hitachi has been producing supercomputers since 1983 but differs from the two other manufacturers by not exporting them. For this reason, their supercomputers are less well known in the West than the ones made by NEC and Fujitsu. After having gone through two generations of supercomputers, the S-810 series started in 1983 and the S-820 series in 1988, Hitachi leapfrogged NEC in 1992 by announcing the most powerful vector supercomputer ever.

The top S-820 model consisted of one processor that operated at 4 ns and contained 4 vector pipelines with four pipelines and two independent floating-point units. This corresponded to a peak performance of 2 Gflop/s. Already in these systems Hitachi put great emphasis on a fast memory although this meant limiting its size to a maximum of 512 MB. The memory bandwidth (2 words per pipe per vector cycle, giving a peak rate of 16 GB/s) was a respectable achievement, but it was not enough to keep all functional units busy.

The S-3800 was announced two years ago and is comparable to NEC's SX- 3R in its features. It has up to four scalar processors with a vector processing unit each. These vector units have in turn up to four independent pipelines and two floating point units that can each perform a multiply/add operation per cycle. With a cycle time of 2.0 ns, the whole system achieves a peak performance level of 32 Gflop/s.

The S-3600 systems (there are four of them in the TOP500) can be seen as the design of the S-820 recast in more modern technology. The system consists of a single scalar processor with an attached vector processor. The 4 models in the range correspond to a successive reduction of the number of pipelines and floating point units installed.

7.8 Cray in Japan

Cray has operated in Japan since 1980. Fourteen years later, over 30 systems are in use, mainly in commercial organisations. Cray successively installed Cray-1, X-MP, and Cray-2 systems but by now most of the Cray customers in Japan have moved to more modern Y-MP models. Relatively few systems have the largest possible configuration and quite a few entry level systems with only one or two processors have been sold. There could be two reasons for this. One might be the fact that Cray's prices are considered high, especially given that the systems must be purchased (most domestic systems are leased) with little or no discount. The other explanation might be that the prime need of the Japanese is to get access to applications that run only on the Cray, without a need for the maximum CPU capacity. A clear need for application access is, for instance, demonstrated by the Japanese car manufacturers that have acquired Cray systems to run PAM-crash for car crash simulation.

In spite of the relatively small penetration of Cray systems in Japan, they are nevertheless considered as prestigious systems for several reasons. The Cray computers are architecturally very well balanced, UNICOS is seen as a very mature supercomputer operating system and most importantly, a large number of applications (more than 600) exist for the Cray.

With the Cray Y-MP/8 now installed at the Institute of Fluid Science at the Tohoku University, and the recent announcement of the upgrade to a C90/916 at MITI's AIST (Agency of Industrial Science and Technology) Lab in Tsukuba and the first Cray T3D installation which will take place at the Power Reactor and Nuclear Fuel Development Corporation outside Tokyo, Cray is beginning to get a stronger foothold in the academic research segment.

7.9 Other Foreign Vendors in Japan

IBM is strangely enough completely absent from the Japanese part of the TOP500 in spite of its long presence in the Japanese market and its installed base of several hundreds IBM/3090 or ES/9000 systems. As opposed to its efforts in Europe IBM have not in Japan had an equivalent to the EASI programme which ensured vector processor installations in many European installations.

Thinking Machine Corporation is the other American supercomputer company (in addition to Cray) that has had the best penetration in Japan's TOP500. Eight installations are represented, mainly in the academic community and beyond the end of this list there are also some smaller systems.

Kendall Square Research is present in Japan with two systems acquired by Canon's Supercomputer Division which grew out of the acquisition of the Japanese Floating Point System (FPS) subsidiary some years ago. One of the two systems has been sold to the Advanced Telecommunications Research Institute (ATR) and the other one is kept by Canon for benchmarking and system tests. Canon also markets Cray computers and operate a dual processor Y-MP/4E for the same purposes.

nCube Corporation is present in Mitsubishi Electric with an nCube/2 with 512 processors. There are several other smaller nCube systems in Japan, including one in ATR (whose usage is discussed later on). Large Intel systems have been acquired by the Real World Computing Project and by Hiroshima University and similarly to TMC there are also several smaller systems installed.

7.10 Japanese Involvement with Unix

The Japanese supercomputers originally grew out of the mainframe families. The corresponding operating systems did the same, and since the Japanese domestic operating systems were all inspired by IBM's MVS, these mainframe systems also invaded the supercomputers. With the latest series of high-end computers the Japanese manufacturers have announced a serious stake in Unix. Fujitsu has had a version of UTS (UTS/M), which it obtained from Amdahl in 1985, available on its mainframes since 1986 (native since 1987). With the announcement of the VP-2000 series Fujitsu has announced a consolidated Unix offering for both environments, 'UXP/M', which is based on System V, release 4 and being shipped since 1992. NEC also announced its version of Unix, Super-UX, for its supercomputers, and started shipping in the first half of 1991. Hitachi announced its new system, Hi-UX, with the introduction of the S-3800 and S-3600 systems and they have now started shipping. Japanese Cray systems are almost exclusively running Unicos which is considered the most mature Unix-based supercomputer operating system.

7.11 Application software

It is always easy to concentrate on MIPS and flop/s (as indeed we do in this list), but it should always be remembered that the satisfactory use of supercomputers as effective tools is mostly dependent on a sophisticated software environment for application development and execution. To this extent, the Japanese users have been forced to look beyond the domestic suppliers to the American ones, such as Cray and TMC, for a well-established application portfolio founded on a solid operating system basis and surrounded by mature library implementations, debuggers, profilers, and visualisation software. The ease of portability created by the adoption of Unix as a base should slowly make the playground more even, but so far, Cray and other American companies have maintained a solid lead over the Japanese counterparts.

In order to correct the situation NEC, Fujitsu and Hitachi have established competence centres and collaborations in the United States. Collaborations with European and Australian sites, installing Japanese hardware, is commonly based on agreements of software development for the application areas that correspond to the customer concerned.

In certain cases there may be political pressure to stop applications being ported to Japanese platforms. This is the case today with PAM-crash which is a vital applications package for automobile crash simulation and certification.

7.12 Japanese Supercomputer Installations

The Japanese supercomputer installations, including the low-end Fujitsu VP-systems, are believed by now to exceed 200. The TOP500, limited to R_{max} values exceeding 472 Mflop/s, contains 106 of them. In the following summary they are discussed by reviewing the following main categories: Universities, Government Research Institutes, Automobile Industry, and Electronics Industry.

Universities

The seven major National (previously 'Imperial') Universities were amongst the first sites to install Japanese supercomputers. A consolidated effort of collaboration with the three Japanese manufacturers was initiated and one observes that Tokyo and Hokkaido Universities have since the beginning been faithful to Hitachi, Nagoya, Kyushu and Kyoto Universities to Fujitsu, and Osaka and Tohoku Universities to NEC.

All these Universities have relatively large computer systems by Japanese standards. The three Fujitsu-influenced Universities all have VP-2600 systems. Tokyo University enjoys a top of the range Hitachi S3800/480 whereas Hokkaido still employs a S-820/80 installed in 1989. Osaka has a uniprocessor NEC SX-3 in use and Tohoku is about to get an upgrade to a top-of-the-range NEC SX-3/44R installed as part of the governmental supercomputer deployment program. It should also be noted that the Research Institute for Iron, Steel and other Metals at Tohoku University will be getting a three-processor Hitachi S-3800.

Nevertheless the well-publicised installation of a Cray Y-MP/8 at the Institute of Fluid Science in Tohoku in 1992 signalled a more flexible attitude that has continued since then. Based on this new acquisition strategy a TMC CM-5/32 is now installed in Tokyo University's Medical Lab and a CM-5/16 in Kyushu University. Additionally the Chemical Research Lab at Kyoto University possesses a Cray Y-MP/2E.

Although in a somewhat more modest way, seven other universities are present in the TOP500. The Nihon and Senshu Universities employ Hitachi S-820/80 systems. Tokai University possesses a uni-processor NEC SX-3, Aoyama Gakuin University a NEC SX-2 whereas Meiji University now has a Fujitsu VP-2200 as a replacement for the ETA 10-P system originally in use. The installation of a 30 processor VPP-500 at the University of Tsukuba will be the first installation of this new Fujitsu computer generation at a Japanese University .

Hiroshima University has an Intel XP/A4 installed but details of its use are not known.

The role of the university supercomputer installations in Japan is similar to what is seen in the Western world, i.e. provision of services to the University faculties and possible partnerships for the development of new applications software in collaboration with the computer vendors thanks the in-house easy access to academic resources.

Governmental Research Laboratories

The list of governmental Research Lab employing large supercomputers is quite impressive and is extending itself further thanks to the new governmental initiative for supercomputer deployment.

As already mentioned, the National Aerospace Laboratory is the un-contested leader of the TOP500 with its 140-processor 'Numeric Wind Tunnel'. NAL is also equipped with one VP-2600 and is about to receive a second one (as an upgrade from a VP-400E). It will also deviate slightly from its Fujitsu-only past by acquiring a Cray Y/M92 and an Intel Paragon XP/330. The enormous computing capacity installed in this Lab can be seen as commensurate to Japan's ambitions in space exploration in the future.

JAERI, the Japan Atomic Energy Research Institute, operates two VP-2600 systems as well as one NEC SX-3/41R. This institute, which is linked to Japan's peaceful nuclear reactor program, is blessed with a computing capacity in correspondence with the importance of its mission. In the same context should be mentioned the two VP-2600 computers installed in at the Power Reactor and Nuclear Fuel Development Corporation which is now slated to get the first Cray T3D system in Japan.

Several of the Japanese Research Labs, operate relative large NEC supercomputers. The National Institute of Fusion Science employs a brand- new SX-3/24R in its research and The National Institute for Environmental Studies employs a SX-3/14. The National Institute for Molecular Science in Okazaki operates a Hitachi S-820 today and is scheduled to receive a three processor SX-3R later this fiscal year.

The Advanced Telecommunications Research Institute In the Kansai Science City has taken a leading role in the deployment of parallel computing technology. It acquired a CM/2 in 1990 for use in its

Auditory and Visual Perception Research Lab. The Institute has become one of the leaders in deploying Massively Parallel systems in Japan due to its huge needs for s development and execution of parallel algorithms linked to speech recognition, visualisation and other related human-oriented interface systems. It has more recently added a CM-5/64 and is in the process of installing a KSR-1/96.

A Hitachi S-820 system can be found in the National Laboratory for High- Energy Physics (KEK) in Tsukuba where the vector processing capacity to demanded by the computational requirements of their theoretical physicists. The Disaster Prevention Research Institute possesses a Cray Y-MP/2E for its earthquake simulation programs. The National Space Observatory outside Tokyo continues to exploit a VP-200 that was installed in 1989, whereas the Institute of Space and Astronomical Science who has been using a VP-200E since 1988 should receive a 7-processor VPP-500 in this.

Quite an interesting deviation from Japan's traditional faithfulness to domestic suppliers is seen in the list of computers in use in the Japanese 6th generation computer project, now called the Real World Computing Project. RWCP has equipped itself with a 64-processor CM-5 as well as a 66-processor XP/S5 from Intel that will be used for assisting the construction of a large parallel processing system especially designed for this project Equally interesting is the announcement of two DEC-MPP (Maspar) installations in this fiscal year; one will be installed at the National Cancer Research Institute in Tokyo and the other at the Institute for Agrobiological Resources in Tsukuba. Both systems will have 16,384 processors.

Automobile Manufacturers

The Japanese automobile industry has been unique in its investment in foreign large supercomputers, namely Cray systems. This is a direct result of the necessity to deploy software packages such as PAM-crash in automobile crash simulation and certification, but the Cray systems have also been appreciated for their good system balance. At the top of the automobile manufacturers' list we find Mitsubishi Motor Company with a Y-MP/C92A and a Y-MP4 followed by Nissan Motors and Toyota each with a six-processor Y-MP8. Honda Research possesses a three-processor Y-MP. Mazda Motor Corporation has installed two Y-MP/2E systems and Isuzu Motor and Daihatsu have each installed one of these more affordable Cray computers. In the list of non-Cray supercomputers installed in the car industry, a variety of domestic systems can be observed. Suzuki Motor Corporation uses a S-820/60, Mazda has a NEC SX-2A, Toyota Motors outside Nagoya is using a VP-2200 and Toyota Central Research Lab has installed a SX-3/14R front- ended by an IBM 3090. Hino Motor possesses an entry-level SX-3. NEC's dominance in this list is probably explained by the availability of the Radius application package as an alternative to PAM-crash. In addition to pure car manufacturing companies one also finds Toyo Rubber Tyre Company with a recent S-3600/160 and Sumitomo Rubber Industries with an entry-level SX-3.

Electronics Manufacturers

The complexity of modern electronics equipment (including computers !) have brought supercomputers to all the large Japanese electronics manufacturers. The long list of in-house supercomputers in use by NEC, Fujitsu and Hitachi will not be discussed in detail, but it is relevant to focus a bit on the other corporations that have taken supercomputers in use for circuit simulation, CAD/CAM and many other applications. It is worth noting the large diversity of computer vendors inside the electronics sector, although Cray seems once again to have a leading edge The variety is either due to a larger availability of adequate simulation packages from all the vendors or a correspondingly higher degree of in-house developed software making the choice of a given hardware platform less critical.

Sharp and SONY have both acquired a Fujitsu VP-2200 for their product development and research whereas Sanyo Electric uses a NEC uniprocessor SX-3 Toshiba is using a four-processor Cray Y-MP8, Mitsubishi Electric uses a three-processor Y-MP4, Nippon Denso (Electric Equipment) has settled for a two-processor version, whereas Matsushita Electric possesses a fully equipped Y-MP/4E as well as the only Japanese nCube system included in the TOP500.

NTT is still using the Cray-2 acquired in 1988, but its X/MP-22, in faithful use since 1987 has been discontinued. The Cray-2 is being used in high-speed communications tests based on HIPPI and FDDI with a 2.4 Gigabit per second optical link.

7.13 Future Outlook

The Japanese will undoubtedly continue to be well represented in the list of the most powerful computer installations in the world. With an increasing acceptance of supercomputing, both in academic circles and industry, a large number, probably as many as 30 new systems, can be expected, either as replacement of smaller systems or as brand-new installations. Massively parallel systems are in use in several places and with the growing maturity of the software for such systems, we can foresee that these systems will start replacing some of the traditional vector supercomputers. The Japanese vendors will expand beyond the early prototypes of their own MPP machines, such as Cenju-3 and AP-1000, but it is expected to take several years before they can offer commercial products that can compete effectively with the American vendors, such as Thinking Machine Corporation, Intel and others. IBM can also be expected to gain ground in the traditional supercomputing market with its SP1/SP2 parallel systems.

The major unknown factor could be the element of right-sizing. Although beyond the scope of this report, most of the Japanese manufacturers are now selling RISC-based workstations and servers, and combined with a strong presence of the main American RISC vendors, this is bound to influence the long-term computing scenario in Japan in a similar way to what has been seen in the Western countries.

Given that application availability is one of the prime requirements of the Japanese end users, the ratio of downsized system installations will depend on application partfolio, which is thought to favour the RISC-based systems.

In all cases, Japan as the economic giant it has now become, will surely not stand back when addressing the computing needs of its industries, research centres and academic communities.

Figure 7.1:
Systems installed for the different manufacturers in Japan

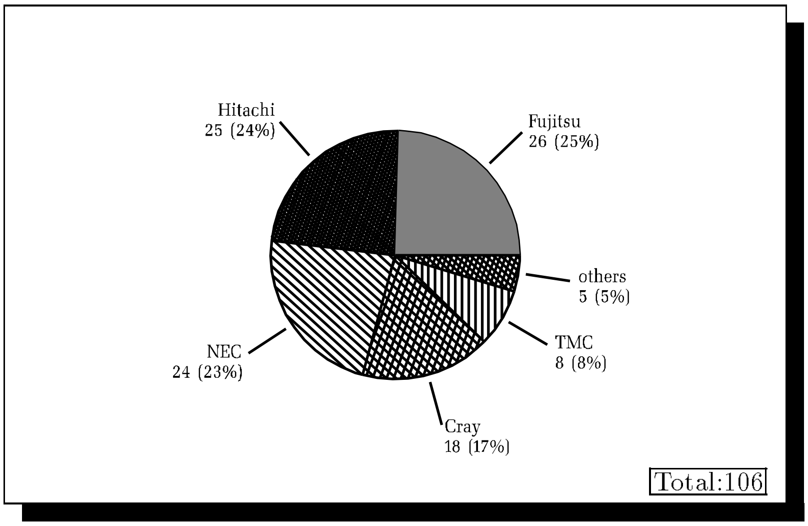
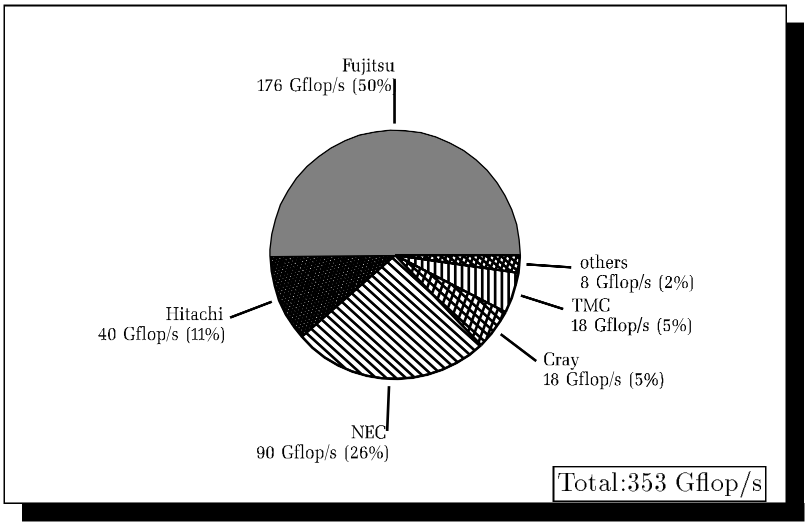


Figure 7.2:
R_{max} installed for the different manufacturers in Japan



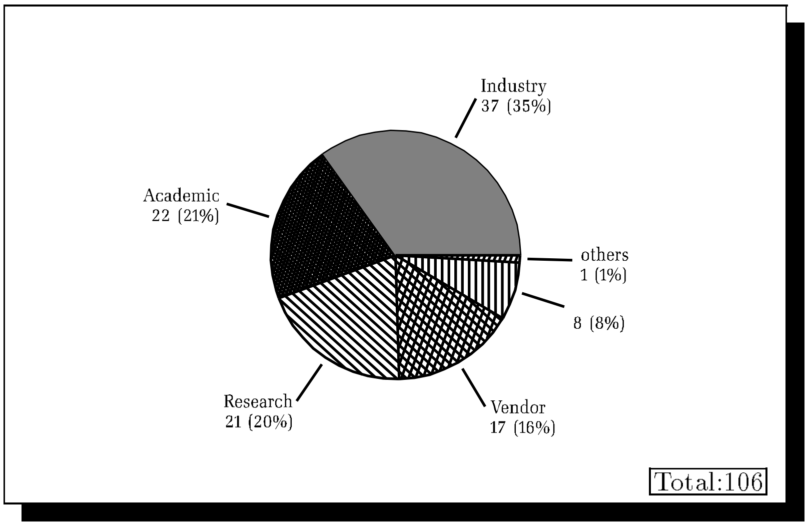


Figure 7.3:
Systems installed for the different application areas in Japan

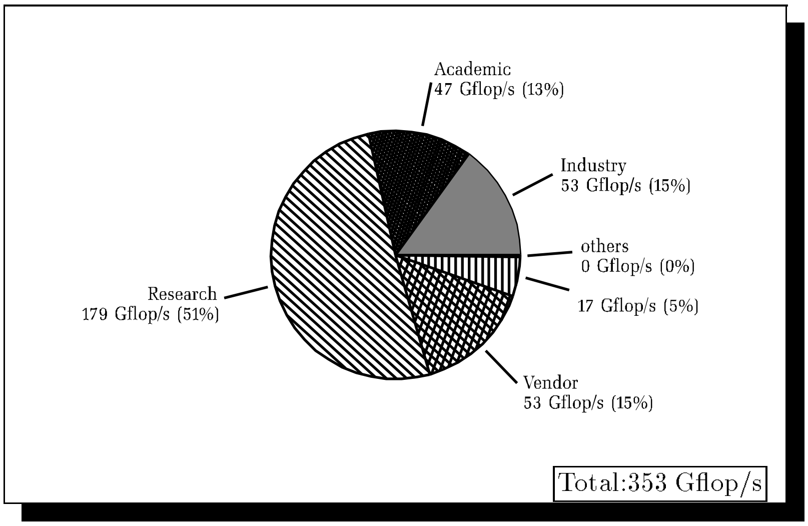


Figure 7.4:
R_{max} installed for the different application areas in Japan

TOP500 Supercomputer Sites — Japan

N Japan World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	Rmax Rpeak [Mflop/s]	N_{max} $N_{1/2}$
1 1	Fujitsu Numerical Wind Tunnel	NAL/Fujitsu Japan /1993	Research Aerospace	140	**124500** 236000	31920 11950
2 6	NEC SX-3/44R	NEC Fuchu Plant Japan /1990	Vendor	4	**23200** 26000	6400 830
3 29	NEC SX-3/24R	National Institute of Fusion Science (NIFS) Japan /1993	Research	2	**11600** 13000	4352 516
4 30	NEC SX-3/24	NEC Daito Supercomputer Center Japan /1991	Vendor	2	**10000** 11000	4352 500
5 42	Hitachi S-3800/480	Tokyo University Tokyo Japan /1993	Academic	4	**7016** 32000	. .
6 50	NEC SX-3/41R	Japan Atomic Energy Research Japan /1992	Research	4	**5800** 6400	3584 414
7 51	NEC SX-3/14R	Osaka University Osaka Japan /1993	Academic	1	**5800** 6400	2816 282
8 52	NEC SX-3/14R	Toyota Central Research Japan /1992	Industry Automotive	1	**5800** 6400	2816 282
9 58	NEC SX-3/14	IBM Japan Tokyo Japan /1991	Industry Electronics	1	**5000** 5500	3072 384
10 60	NEC SX-3/14	National Institute of Environmental Studies Japan /1992	Research Environment	1	**5000** 5500	3072 384
11 64	Fujitsu VP2600/10	Fuji Heavy Japan /1990	Industry Heavy Ind.	1	**4009** 5000	. .
12 65	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
13 66	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
14 67	Fujitsu VP2600/20	Kyoto University Kyoto Japan /1990	Academic	1	**4009** 5000	. .
15 68	Fujitsu VP2600/10	Kyushu University Kyushu Japan /1992	Academic	1	**4009** 5000	. .
16 69	Fujitsu VP2600/10	NAL (Space Technology) Japan /1990	Research	1	**4009** 5000	. .
17 70	Fujitsu VP2600/10	Nagoya University Nagoya Japan /1991	Academic	1	**4009** 5000	. .
18 71	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
19 72	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
20 73	Fujitsu VP2600/10	Taisei Construction Japan /1992	Industry Construction	1	**4009** 5000	. .

TOP500 Supercomputer Sites — Japan

N *Japan* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 79	TMC CM-5/64	ATR Kyoto Japan / .		64	**3800** 8192	13056 6016
22 84	TMC CM-5/64	Japanese AIST Hokuriku Japan /1993		64	**3800** 8192	13056 6016
23 85	TMC CM-5/64	Real World Computing (RWCP) Tokyo Japan /1992		64	**3800** 8192	13056 6016
24 94	NEC SX-3/12R	NEC Scientific Information (NSIS) Japan /1992	Research	1	**2900** 3200	2048 174
25 95	NEC SX-3/21R	Obayashi Corporation Japan /1992	Industry	2	**2900** 3200	2560 257
26 141	Cray Y-MP8/8128	Tohoku University, Institute of Fluid Science Aramaki Japan /1992	Academic	8	**2144** 2667	. .
27 158	Intel XP/S5	Real World Computing (RWC) Tokyo Japan /1993		66	**2000** 3300	8000 .
28 161	TMC CM-5/32	CRIEPI Japan /1993		32	**1900** 4096	9216 4096
29 175	TMC CM-5/32	Tokyo University, Medical Lab Tokyo Japan /1993	Academic	32	**1900** 4096	9216 4096
30 184	KSR KSR1-64	Canon Japan /1993	Industry	64	**1838** 2560	9216 1536
31 185	KSR KSR1-64	Canon Japan /1993	Industry	64	**1838** 2560	9216 1536
32 193	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	. .
33 194	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	. .
34 195	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	. .
35 196	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	. .
36 197	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1990	Vendor	1	**1817** 3000	. .
37 198	Hitachi S-820/80	Hitachi Ltd. SSD Japan /1989	Vendor	1	**1817** 3000	. .
38 199	Hitachi S-820/80	Hokkaido University Sapporo Japan /1989	Academic	1	**1817** 3000	. .
39 200	Hitachi S-820/80	Institute of Molecular Science Japan /1988	Research	1	**1817** 3000	. .
40 201	Hitachi S-820/80	Nat. Lab. for High Energy Physics Japan /1988	Research	1	**1817** 3000	. .

TOP500 Supercomputer Sites — Japan

N *Japan* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41 202	Hitachi S-820/80	Nihon University Japan /1993	Academic	1	**1817** 3000	. .
42 203	Hitachi S-820/80	Senshu University Japan / .	Academic	1	**1817** 3000	. .
43 206	Cray Y-MP C92A/2128	Mitsubishi Motors Company Kawasaki Japan /1993	Industry Automotive	2	**1703** 1905	. .
44 207	Fujitsu VP2400/20	Computer Technology Integrated (CTI) Japan /1991	Industry	1	**1688** 2000	. .
45 208	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	. .
46 209	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	. .
47 212	Cray Y-MP8/664	Nissan Motor Kanagawa Japan /1990	Academic	6	**1651** 2000	. .
48 214	Cray Y-MP8/632	Toyota Motor Company Japan /1991	Industry Automotive	6	**1651** 2000	. .
49 219	Intel XP/A4	Hiroshima University Japan /1993	Academic	56	**1500** 4200	6000 .
50 243	Cray CRAY-2/4-256	NTT Japan /1987	Industry Electronics	4	**1406** 1951	. .
51 255	TMC CM-2/16k	ATR Japan /1990		512	**1300** 3500	. .
52 258	TMC CM-2/16k	ICFD Japan /1991	Research	512	**1300** 3500	. .
53 260	NEC SX-3/11	Sanyo Electric Moriguchi City Japan /1991	Industry Electronics	1	**1300** 1370	2816 192
54 261	NEC SX-3/11	Tokai University Tokai Japan /1992	Academic	1	**1300** 1370	2816 192
55 283	Cray Y-MP4E/464	Matsushita Electric Osaka Japan /1992	Academic	4	**1159** 1333	. .
56 285	Cray Y-MP4/464	Mitsubishi Motors Company Okazaki Japan /1992	Industry Automotive	4	**1159** 1333	. .
57 291	Cray Y-MP8/4128	Toshiba Kanagawa Japan /1990	Academic	4	**1159** 1333	. .
58 299	Fujitsu VPX220/10	Keio Daigaku University Japan /1992	Academic	1	**1048** 1250	. .
59 303	TMC CM-5/16	Kyushu University Kyushu Japan / .	Academic	16	**980** 2048	6528 3008
60 312	NCube nCUBE2	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	512	**958** 1200	15200 2240

TOP500 Supercomputer Sites — Japan

N *Japan* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
61 314	Hitachi S-820/60	Defence Agency Land Japan /1989	Classified	1	**905** 1500	. .
62 315	Hitachi S-820/60	Hitachi Ltd. Adv. Res. Lab Japan /1993	Vendor	1	**905** 1500	. .
63 316	Hitachi S-820/60	Hitachi Ltd. Cent. Res. Lab. Japan /1992	Vendor	1	**905** 1500	. .
64 317	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
65 318	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
66 319	Hitachi S-820/60	Hitachi Ltd. STRD Japan /1991	Vendor	1	**905** 1500	. .
67 320	Hitachi S-820/60	Kajima Corporation Japan /1990	Industry Construction	1	**905** 1500	. .
68 321	Hitachi S-820/60	Suzuki Motor Japan /1989	Industry Automotive	1	**905** 1500	. .
69 322	Hitachi S-820/60	Yamaichi Information Systems Japan /1989	Research Economics	1	**905** 1500	. .
70 331	NEC SX-2	Aoyama Gakuin University Japan /1988	Academic	1	**885** 1333	. .
71 332	NEC SX-2	Institute Laser Eng Osaka Univ. Osaka Japan /1985	Academic	1	**885** 1333	. .
72 333	NEC SX-2	Institute of Computational Fluid Dynamics Japan /1987	Research	1	**885** 1333	. .
73 334	NEC SX-2A	Mazda Motor Corporation Yokohama Japan /1989	Industry Automotive	1	**885** 1333	. .
74 335	NEC SX-2	NEC Fuchu Plant Japan /1987	Vendor	1	**885** 1333	. .
75 336	NEC SX-2	NEC Scientific Information (NSIS) Japan /1985	Research	1	**885** 1333	. .
76 337	NEC SX-2	Sumitomo Metal Industries Japan /1988	Industry	1	**885** 1333	. .
77 338	NEC SX-2	Tohoku University Tohoku Japan /1988	Academic	1	**885** 1333	. .
78 344	Cray Y-MP8/364	Honda Research and Development Company Tokyo Japan /1990	Industry Automotive	3	**881** 999	. .
79 345	Cray Y-MP4/364	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	3	**881** 999	. .
80 351	Hitachi S-3600/160	Hitachi Zosen Corp. Japan /1992	Vendor	1	**851** 1000	. .

TOP500 Supercomputer Sites — Japan

N *Japan* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
81	Hitachi	Toyo Tire Rubber	Industry	1	**851**	.
352	S-3600/160	Japan /1993			1000	.
82	Fujitsu	Kawasaki Heavy Industry	Industry	1	**842**	.
355	VP2200/10	Japan /1990	Heavy Ind.		1000	.
83	Fujitsu	Kawasaki Steel	Industry	1	**842**	.
356	VP2200/10	Japan /1991	Heavy Ind.		1000	.
84	Fujitsu	Meiji University	Academic	1	**842**	.
357	VP2200/10	Japan /1990			1000	.
85	Fujitsu	Nikko Securities	Industry	1	**842**	.
358	VP2200/10	Japan /1991	finance		1000	.
86	Fujitsu	Nippon Steel	Industry	1	**842**	.
359	VP2200/10	Japan /1992	Heavy Ind.		1000	.
87	Fujitsu	Sharp	Industry	1	**842**	.
360	VP2200/10	Japan /1990	Electronics		1000	.
88	Fujitsu	Sony	Industry	1	**842**	.
361	VP2200/10	Japan /1990			1000	.
89	Fujitsu	Toyota Motor Company	Industry	1	**842**	.
362	VP2200/20	Japan /1991	Automotive		1000	.
90	Fujitsu	NAL		1	**794**	.
388	VP-400E	Japan /1987			1714	.
91	NEC	Sumitomo Rubber Industries	Industry	1	**780**	2304
389	SX-3/1LR	Japan /1992	Chemistry		800	112
92	NEC	Hino Motor	Industry	1	**670**	2048
404	SX-3/1L	Japan /1992	Automotive		680	128
93	NEC	Kajima Construction	Industry	1	**670**	2048
405	SX-3/1L	Japan /1991			680	128
94	NEC	Komatsu MFG	Industry	1	**670**	2048
406	SX-3/1L	Japan /1991			680	128
95	Cray	Canon Sales	Industry	2	**604**	.
430	Y-MP4E/232	Tokyo Japan /1992			666	.
96	Cray	Daihatsu Motor Company	Industry	2	**604**	.
435	Y-MP2E/232	Japan /1992	Automotive		666	.
97	Cray	Disaster Prevention Research	Research	2	**604**	.
436	Y-MP2E/264	Japan /1992			666	.
98	Cray	Isuzu Motor	Industry	2	**604**	.
444	Y-MP2E/232	Tokyo Japan /1991	Automotive		666	.
99	Cray	Kyoto University, Chemical Research	Academic	2	**604**	.
445	Y-MP2E/264	Kyoto Japan /1992			666	.
100	Cray	Mazda Motor Corporation	Industry	2	**604**	.
448	Y-MP2E/232	Yokohama Japan /1991	Automotive		666	.

TOP500 Supercomputer Sites — Japan

N *Japan* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
101 449	Cray Y-MP2E/216	Mazda Motor Corporation Yokohama Japan /1992	Industry Automotive	2	**604** 666	. .
102 453	Cray Y-MP8/232	Nippon Denso Japan /1991		2	**604** 666	. .
103 495	Fujitsu VP-200E	MOE Nobeyama Observatory Japan /1989	Research	1	**472** 857	. .
104 496	Fujitsu VP-200E	MOE Space Science Research Japan /1987	Research	1	**472** 857	. .
105 497	Fujitsu VP-200E	Nat. Space Observatory Japan /1986	Research	1	**472** 857	. .
106 498	Fujitsu VP-200E	National Fusion Research Japan /1988	Research	1	**472** 857	. .

Mannheim/Tennessee November 11,1993

8

High Performance Computing in Europe

Hans-Werner Meuer

Ad Emmen

Geerd-R. Hoffmann

Erich Strohmaier

Abstract

In this paper we discuss the situation in Europe in the field of high-performance computing, based on the latest TOP500 statistics (chapter 2). We present the sublist of 133 supercomputers installed in Europe and discuss the number of systems installed with respect to the different manufacturers and the different countries.

8.1 General Situation

If we restrict our view to the 133 supercomputers in Europe, Germany is with the number of installed systems (44%) as well as installed performance (39%) clearly ahead of France with 39% of the systems and 17% performance and ahead of Great Britain with 15% systems and 22% performance (Fig. 8.1 and 8.2), followed by Benelux, Scandinavia, Switzerland/Austria and Italy.

Compared to any measure–economic strength, population–Germany has relatively more systems and Italy has fewer systems than the average for Europe. The abundance of systems in Germany, may partially be explained by the presence of Siemens Nixdorf which does the marketing and sales for the Fujitsu and KSR machines.

The discrepancies between the number of installed machines and installed R_{max} in the different European countries, is mainly due to the good performance of parallel machines for the algorithm that underlies the R_{max} calculation. Large parallel machines are more commonly found in the UK and in France. In Germany there are a larger number of smaller parallel machines, notably the KSR systems.

Note that the total R_{max} performance of all machines installed in Europe equals the sum of the R_{max} performance of the numbers 1 and 2 on the world list.

Figure 8.1:
Systems installed in the Europe
—countries—

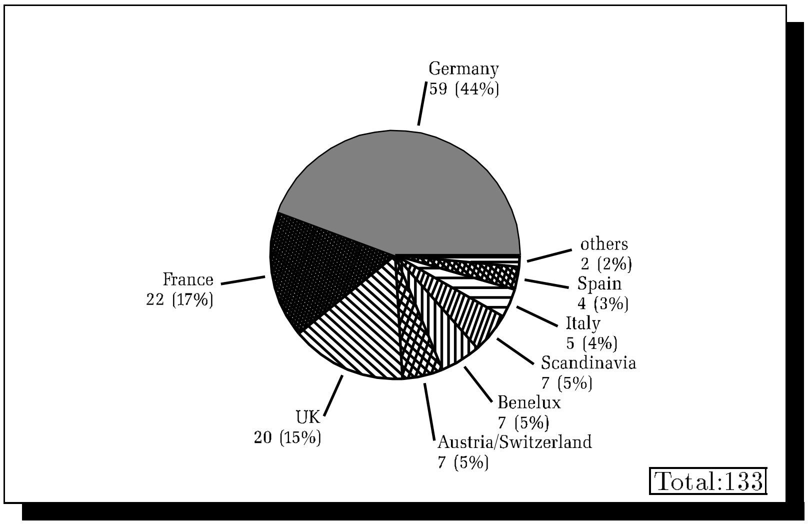
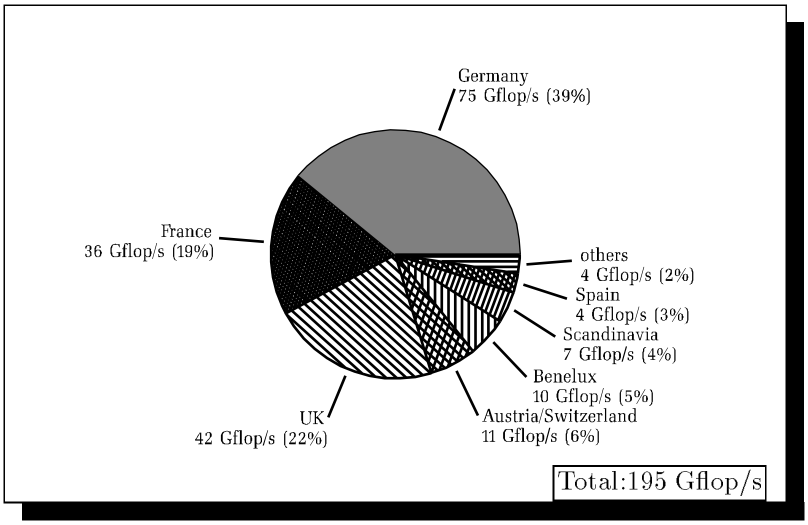


Figure 8.2:
R_{max} installed in the Europe
—countries—



Broken down into manufacturers (Fig. 8.3 and 8.4) it is noticeable that the European companies Meiko (UK) with 2% and Parsytec (Germany) with 3% of installed systems play a minor part at present even in Europe. Market leader in Europe again is Cray Research far ahead with 42% of the systems and 39% of installed performance, followed by SNI with 11% of installed systems and 12% of installed performance. SNI profits from its extremely strong position in Germany where it comes shortly behind Cray Research. Third in Europe—and therefore also market leader of MPP systems—comes TMC (10% installed systems but 16% installed performance), almost head on with SNI. Forth and fifth are Intel and Kendall Square Research, both are American based MPP manufacturers with 8% respectively 6% of installed systems and 9% resp. 4% installed performance. Kendall Square Research had a very good start in Europe and was able to

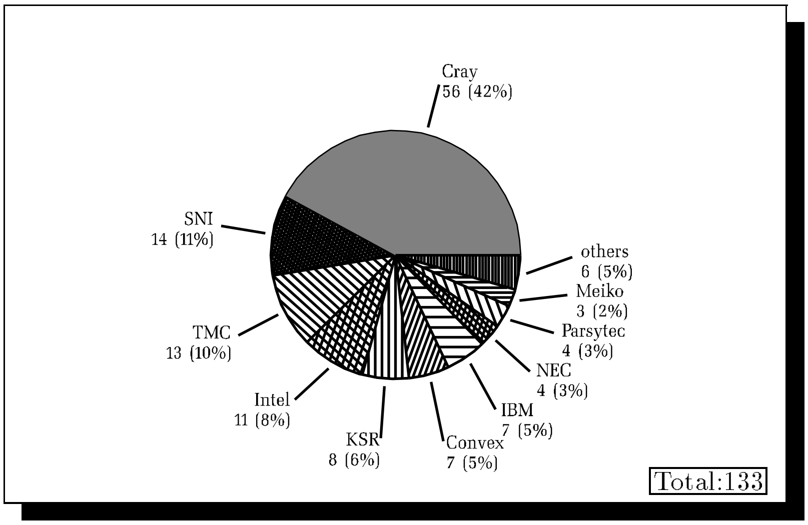


Figure 8.3:
Systems installed in the Europe
—manufacturers—

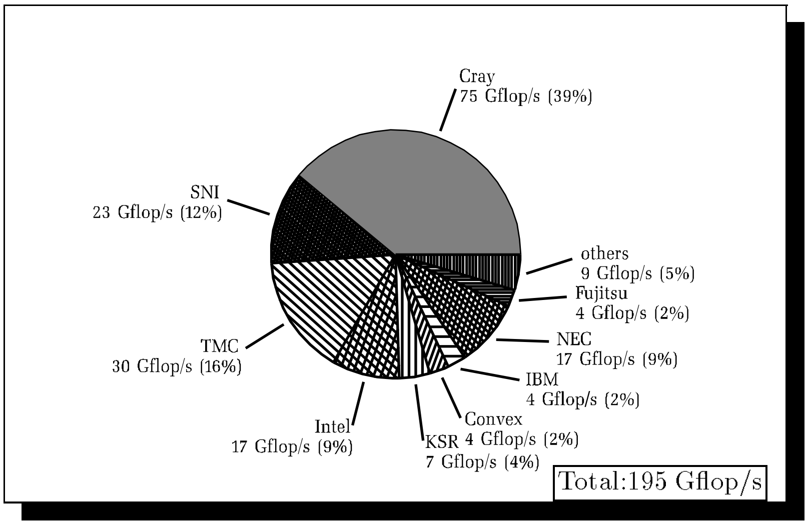


Figure 8.4:
R_{max} installed in the Europe
—manufacturers—

win several universities for their installations. The cooperation with SNI since December 1992 is meant to improve this already good position.

Convex is a very good example that the era for mini-supercomputers is over; this is also true for Europe. Our first TOP500 of July 1993 still showed that Convex was much stronger represented in Europe with 10% of installed systems than it was worldwide. Not even half a year later this was reduced to 5% and moves now visibly closer to their worldwide 3% mark and thus disappears into unimportance. It is high time that an important decision with the already announced MPP system (Convex SPP1000/XA series with HP PA-RISC-nodes) is made for the future.

Looking at the application fields (Fig. 8.5 and 8.6) the predominance in the area of universities and major research institutions with 40% respectively 35% of the installed systems in Europe is clearly visible; compared to USA/Canada with 28% resp. 31% of this installation base, in Japan it is only 21% resp. 20%. But this should not deceive that Japan's research sectors have the most powerful supercomputers with 51% of the installed Japanese supercomputer performance; Europe has 48% of installed performance, USA/Canada have 42% in this segment.

In Europe the industry is rather weakly represented with 20% of installed supercomputers and only 13% of installed performance. Again, it seems to be a worldwide trend that the industry does not have the most powerful supercomputers. In comparison USA/Canada have 28% of the supercomputers in this hotly battled for marketsegment, but also with less powerful systems as the 12% of the installed performance show. In Japan 35% of the installed supercomputers are found in the industry but also with only a modest 15% of installed performance.

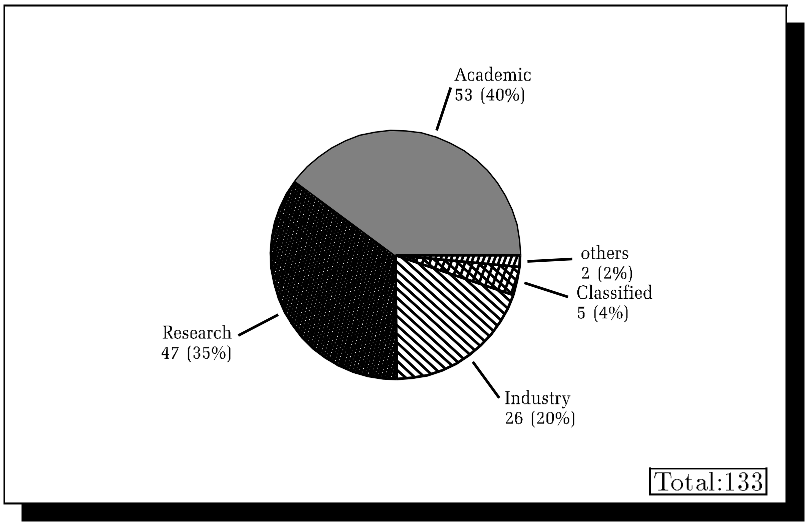


Figure 8.5:
Systems installed in the Europe
—application areas—

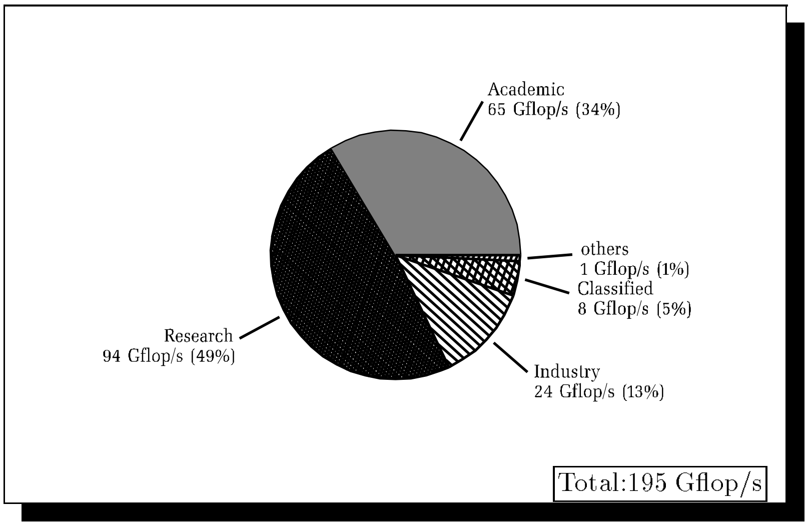


Figure 8.6:
R_{max} installed in the Europe
—application areas—

TOP500 Supercomputer Sites — Europe

N *Europe* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 18	Cray Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650
2 37	TMC CM-5/128	Institut de Physique du Globe de Paris (IPG) Paris France /1992	Research	128	**7700** 16000	18432 8192
3 49	NEC SX-3/14R	German Aerospace Laboratory (DLR) Goettingen Germany /1993	Research Aerospace	1	**5800** 6400	2816 282
4 59	NEC SX-3/22	National Aerospace Laboratory (NLR) Nordoostpolder Netherlands/1992	Research Aerospace	2	**5000** 5500	3072 384
5 61	NEC SX-3/22	Swiss Scientific Computing Center Manno Switzerland/1991	Research	2	**5000** 5500	3072 384
6 74	SNI S600/20	Universitaet Aachen Aachen Germany /1991	Academic	1	**4009** 5000	. .
7 75	SNI S600/20	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	1	**4009** 5000	. .
8 83	TMC CM-5/64	GMD Birlinghoven Germany /1993	Research	64	**3800** 8192	13056 6016
9 87	SNI S400/40	Universitaet Darmstadt Darmstadt Germany /1991	Academic	2	**3624** 5000	10239 .
10 88	SNI S400/40	Universitaet Hannover Hannover Germany /1991	Academic	2	**3624** 5000	10239 .
11 92	Cray Y-MP C98/4256	Direction de la Meteorologie Nationale Toulouse France /1993	Research Weather	4	**3275** 3810	. .
12 96	TMC CM-2/32k	AMK Bonn Germany /1990	Classified	1024	**2600** 7000	. .
13 98	Intel iPSC/860	Grant Tensor UK /1991	Industry Geophysics	128	**2600** 5120	12000 4500
14 105	Intel iPSC/860	ONERA Chatillon France /1991	Research Aerospace	128	**2600** 5120	12000 4500
15 110	TMC CM-200/16k	INRIA - Sophia Antipolis Rennes France /1992	Research	512	**2400** 5000	14848 5632
16 112	TMC CM-200/16k	University of Edinburgh Edinburgh UK / .	Research	512	**2400** 5000	14848 5632
17 122	Cray Y-MP8/864	Government Communications Headquarters Benhall UK / .	Classified	8	**2144** 2667	. .
18 123	Cray Y-MP8/832	KFA Juelich Germany /1989	Research	8	**2144** 2667	. .
19 126	Cray Y-MP8/8128	Leibniz Rechenzentrum Muenchen Germany /1992	Academic	8	**2144** 2667	. .
20 139	Cray Y-MP8I/8128	Rutherford Appleton Laboratory UK /1992	Research	8	**2144** 2667	. .

TOP500 Supercomputer Sites — Europe

N *Europe* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 143	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
22 144	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
23 146	Fujitsu VPX240/10	CESGA Sant. de Compostella Spain /1992	Academic	1	**2110** 2500	. .
24 149	SNI S400/10	IFP (Institute Francais du Petrole) Rueil-Malmaison France /1992	Academic Geophysics	1	**2110** 2500	. .
25 150	Fujitsu VPX240/10	University of Manchester Manchester UK /1993	Academic	1	**2110** 2500	. .
26 154	Intel XP/S5	KFA Juelich Germany /1992	Research	66	**2000** 3300	8000 .
27 159	Intel XP/S5-32	Universitaet Stuttgart Stuttgart Germany /1992	Academic	66	**2000** 3300	8000 .
28 163	TMC CM-5/32	Compagnie Generale de Geophysique (CGG) Massy France /1993	Industry Geophysics	32	**1900** 4096	9216 4096
29 170	TMC CM-5/32	RUG (Rijksuniversiteit Groningen) Groningen Netherlands/1993	Academic	32	**1900** 4096	9216 4096
30 171	TMC CM-5/32	Site Experimental Hyperparallelisme (SEH/ETCA) Arcueil France / .	Research	32	**1900** 4096	9216 4096
31 176	TMC CM-5/32	Universitaet Wuppertal Wuppertal Germany /1992	Academic	32	**1900** 4096	9216 4096
32 187	KSR KSR1-64	Government UK /1992	Classified	64	**1838** 2560	9216 1536
33 205	Cray Y-MP C94A/2128	Instituto National de Meteorologia (INM) Spain /1993	Research Weather	2	**1703** 1905	. .
34 217	DEC DECmpp SX 200	University of Bergen Bergen Norway / .	Academic	16384	**1600** 2400	11264 1920
35 220	Intel XP/A4E	IRISA Rennes France /1993	Research Aerospace	56	**1500** 4200	6000 .
36 223	Intel XP/A4E	Technische Universitaet Graz Graz Austria /1993	Academic	56	**1500** 4200	6000 .
37 227	Intel XP/A4	University of Trondheim Norway /1992	Academic	56	**1500** 4200	6000 .
38 228	IBM ES 9000-900	CERN Geneva Switzerland/ .	Research	6	**1457** 2664	. .
39 231	Cray CRAY-2s/4-128	DKRZ Hamburg Germany /1988	Research Weather	4	**1406** 1952	. .
40 237	Cray CRAY-2/4-256	Commissariat a l'Energie Atomique Grenoble France /1989	Research Energy	4	**1406** 1951	. .

TOP500 Supercomputer Sites — Europe

N Europe World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41 239	Cray CRAY-2/4-256	Defense Research Agency Farnborough UK /1990	Classified	4	**1406** 1951	. .
42 240	Cray CRAY-2/4-256	Direction de la Meteorologie Nationale Toulouse France /1989	Research Weather	4	**1406** 1951	. .
43 241	Cray CRAY-2/4-256	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1990	Academic	4	**1406** 1951	. .
44 245	Cray CRAY-2/4-256	Universitaet Stuttgart Stuttgart Germany /1986	Research	4	**1406** 1951	. .
45 247	Intel iPSC/860	Daresbury Laboratory Warrington UK / .	Research	64	**1400** 2560	9000 3500
46 257	TMC CM-2/16k	GMD Birlinghoven Germany /1990	Research	512	**1300** 3500	. .
47 259	Meiko CS/i860/64	University of Edinburgh Edinburgh UK /1990	Academic	64	**1300** 2500	8500 3500
48 262	NEC SX-3/11	Universitaet Koeln Koeln Germany /1990	Academic	1	**1300** 1370	2816 192
49 263	TMC CM-200/8k	Uni-C Copenhagen Denmark /1992	Academic	256	**1200** 2500	10752 4096
50 264	Cray Y-MP8/4128	BMW AG Muenchen Germany /1992	Industry Automotive	4	**1159** 1333	. .
51 266	Cray Y-MP8/464	CINECA Bologna Italy /1992	Academic	4	**1159** 1333	. .
52 268	Cray Y-MP4E/464	Citroen Peugeot Velizy France /1992	Industry Automotive	4	**1159** 1333	. .
53 269	Cray Y-MP4E/464	Compagnie Generale de Geophysique (CGG) Fletham UK /1993	Industry Geophysics	4	**1159** 1333	. .
54 270	Cray Y-MP4/432	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**1159** 1333	. .
55 273	Cray Y-MP8/432	Defense Research Agency Ford Halstead UK /1990	Research	4	**1159** 1333	. .
56 274	Cray Y-MP4/432	Deutscher Wetterdienst Offenbach Germany /1990	Research Weather	4	**1159** 1333	. .
57 276	Cray Y-MP4/464	Eidgenoessische Technische Hochschule Zuerich Switzerland/1992	Academic	4	**1159** 1333	. .
58 277	Cray Y-MP8/4128	Electricite de France Clamart France /1990	Industry Energy	4	**1159** 1333	. .
59 282	Cray Y-MP4E/464	MPI Garching Germany /1991	Research	4	**1159** 1333	. .
60 288	Cray Y-MP8/4128	ONERA Chatillon France /1991	Research Aerospace	4	**1159** 1333	. .

TOP500 Supercomputer Sites — Europe

N Europe World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
61 289	Cray Y-MP4/464	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	4	**1159** 1333	. .
62 293	Cray Y-MP4E/464	Universitaet Kaiserslautern Kiel Germany /1993	Academic	4	**1159** 1333	. .
63 294	Cray Y-MP4/464	University of Trondheim Norway /1992	Academic	4	**1159** 1333	. .
64 295	Cray Y-MP8/464	VW (Volkswagen AG) Wolfsburg Germany /1993	Industry Automotive	4	**1159** 1333	. .
65 296	Cray Y-MP M94/4256	KFA Juelich Germany /1993	Research	4	**1114** 1333	. .
66 300	SNI S200/10	Schering Berlin Germany /1991	Industry Chemistry	1	**1048** 1250	. .
67 301	SNI S200/20	Siemens Muenchen Germany /1991	Industry Electronics	1	**1048** 1250	. .
68 309	Parsytec GCel 3/1024	Universitaet Koeln/DLR Koeln Germany /1992	Academic	1024	**971** 1540	15999 2073
69 310	Parsytec GCel 3/1024	Universitaet Paderborn Paderborn Germany /1992	Academic	1024	**971** 1540	15999 2073
70 311	Meiko CS/i860/42	Ensign Geophysics Weybridge UK /1987	Academic	42	**970** 1700	. .
71 323	KSR KSR1-32	GWDG Goettingen Germany /1992	Academic	32	**893** 1280	6144 896
72 324	KSR KSR1-32	INRIA - Sophia Antipolis Rennes France /1992	Research	32	**893** 1280	6144 896
73 325	KSR KSR1-32	Leibniz Rechenzentrum Muenchen Germany /1993	Academic	32	**893** 1280	6144 896
74 326	KSR KSR1-32	Siemens Nixdorf Muenchen Germany /1993	Vendor	32	**893** 1280	6144 896
75 327	KSR KSR1-32	Universitaet Mannheim Mannheim Germany /1992	Academic	32	**893** 1280	6144 896
76 329	KSR KSR1-32	University of Manchester Manchester UK /1992	Academic	32	**893** 1280	6144 896
77 340	Cray Y-MP4E/364	British Aerospace PLC Farnborough UK /1991	Industry Aerospace	3	**881** 999	. .
78 342	Cray Y-MP4E/364	DKRZ Hamburg Germany /1991	Research Weather	3	**881** 999	. .
79 347	Cray Y-MP4E/364	Renault Rueil-Malmaison France /1992	Industry Automotive	3	**881** 999	. .
80 349	Cray Y-MP4/364	debis Stuttgart Germany /1991	Industry Automotive	3	**881** 999	. .

TOP500 Supercomputer Sites — Europe

N *Europe* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
81 363	SNI S200/10 (4ns)	Universitaet Frankfurt Frankfurt Germany /1991	Academic	1	**842** 1000	. .
82 364	Meiko CS/i860/32	DRA Malvern Weybridge UK /1990	Research	32	**825** 1300	7000 3000
83 365	Cray X-MP/416	AMK Bonn Germany /1990	Classified	4	**822** 940	. .
84 369	Cray X-MP/416	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**822** 940	. .
85 371	Cray X-MP EA/464	Finish State Computer Centre Espoo Finland /1990	Academic	4	**822** 940	. .
86 376	Cray X-MP/416	Michelin Clermont-Ferrand France /1992	Industry Automotive	4	**822** 940	. .
87 379	Cray X-MP/416	Swedish National Supercomputer Centre Linkoping Sweden /1991	Academic	4	**822** 940	. .
88 381	Convex C3880	DKRZ Hamburg Germany /1993	Research Weather	8	**795** 960	. .
89 382	Convex C3880	Danish Meteorological Institute Copenhagen Denmark /1992	Research	8	**795** 960	. .
90 385	Convex C3880	SICAN Hannover Germany /1993	Industry	8	**795** 960	. .
91 387	SNI VP400EX	KFK Karlsruhe Germany /1990	Research	1	**794** 1714	. .
92 410	TMC CM-2/8k	Universitaet Wuppertal Wuppertal Germany /1990	Academic	256	**650** 1750	. .
93 411	TMC CM-2/8k	University of Parma Parma Italy / .	Academic	256	**650** 1750	. .
94 413	Intel iPSC/860	GSF Neuherberg Germany /1990	Research	32	**640** 1280	6000 2500
95 414	Intel iPSC/860	KFA Juelich Germany /1991	Research	32	**640** 1280	6000 2500
96 415	Intel iPSC/860	Universitaet Saarbruecken Saarbruecken Germany /1990	Academic	32	**640** 1280	6000 2500
97 416	Convex M3860/8	CIRA Capua Italy /1993		6	**615** 720	. .
98 417	Convex C3860	GRS (Gesellschaft fuer Reaktorsicherheit) Muenchen Germany /1993	Research	6	**615** 720	. .
99 418	Convex C3860	Josef Stefan Institut Ljubljana Slovenia /1993	Research	6	**615** 720	. .
100 420	Convex C3860	Universitaet Tuebingen Tuebingen Germany /1992	Academic	6	**615** 720	. .

TOP500 Supercomputer Sites — Europe

N *Europe* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
101 421	Cray Y-MP4/264	AEA Technology Harwell UK /1993	Research Energy	2	**604** 666	. .
102 422	Cray Y-MP4E/264	AGIP Milano Italy /1993	Industry Geophysics	2	**604** 666	. .
103 426	Cray Y-MP2E/264	Audi AG Ingolstadt Germany /1992	Industry Automotive	2	**604** 666	. .
104 427	Cray Y-MP2E/232	Bundesanstalt fuer Wasserbau Hamburg Germany /1992	Research Geophysics	2	**604** 666	. .
105 431	Cray Y-MP2E/232	Centro de Supercomputacion de Catalunya Barcelona Spain /1992	Academic	2	**604** 666	. .
106 434	Cray Y-MP2/232	DLR Oberpfaffenhofen Germany /1990	Research	2	**604** 666	. .
107 437	Cray Y-MP2E/232	EDS/ Adam Opel AG Ruesselsheim Germany /1992	Industry auot	2	**604** 666	. .
108 438	Cray Y-MP2E/232	ELF Aquitaine Pau France /1992	Industry Geophysics	2	**604** 666	. .
109 439	Cray Y-MP4E/264	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1992	Academic	2	**604** 666	. .
110 440	Cray Y-MP4/264	Electricite de France Clamart France /1992	Industry Energy	2	**604** 666	. .
111 441	Cray Y-MP4/216	Fiat Torino Italy /1991	Industry Automotive	2	**604** 666	. .
112 443	Cray Y-MP2E/232	Institute Mediterraneen de Technologie Marseille France /1991	Academic	2	**604** 666	. .
113 456	Cray Y-MP4/216	Rolls-Royce PLC UK /1990	Industry Aerospace	2	**604** 666	. .
114 463	Cray Y-MP2E/264	Universitaet Stuttgart Stuttgart Germany /1993	Academic	2	**604** 666	. .
115 466	Cray Y-MP2E/264	debis Muenchen Germany /1993	Industry	2	**604** 666	. .
116 468	SNI S100/10	GEOVOR Traben Trabach Germany /1991	Industry Weather	1	**556** 625	. .
117 469	SNI S100/10	Technische Universitaet Wien Wien Austria /1992	Academic	1	**556** 625	. .
118 470	SNI S100/10	Universitaet Hamburg Hamnburg Germany /1992	Academic	1	**556** 625	. .
119 471	KSR KSR1-20	AWI (Alfred Wegener Institut) Bremerhaven Germany /1993	Research	20	**550** 800	. .
120 474	IBM 3090-600J	Centro de Supercomputacion de Catalunya Barcelona Spain / .	Academic	6	**540** 828	. .

TOP500 Supercomputer Sites — Europe

N *Europe* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
121 475	IBM 3090-600J	GSI Darmstadt Germany /1987	Academic	6	**540** 828	. .
122 476	IBM 3090-600J	TU Braunschweig Braunschweig Germany / .	Academic	6	**540** 828	. .
123 477	IBM 3090-600E	University of Leuven Belgium / .	Academic	6	**540** 828	. .
124 479	IBM ES 9000-720	DESY Hamburg Germany / .	Research	6	**540** 828	. .
125 480	IBM ES 9000-720	SARA/IC3A (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	6	**540** 828	. .
126 482	Cray S-MP/MCP728	CWI/Centrum voor Wiskunde en Informatica Amsterdam Netherlands/1992	Research	28	**508** 1120	. .
127 483	Parsytec GCel 3/512	Athens HPC Lab, Athen Greece /1993	Research	512	**485** 770	. .
128 484	Parsytec GCel 3/512	SARA/IC3A (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1993	Academic	512	**485** 770	. .
129 492	DEC DECmpp SX 100	Thompson LER Rennes France / .	Industry Electronics	16384	**473** 550	11264 1280
130 493	MasPar MP-1216	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	16384	**473** 550	11264 1280
131 494	MasPar MP-1216	Universitaet Stuttgart Stuttgart Germany /1991	Academic	16384	**473** 550	11264 1280
132 499	SNI VP200EX	Universitaet Bremen Bremen Germany /1991	Academic	1	**472** 857	. .
133 500	SNI VP200EX	Universitaet Dresden Dresden Germany /1991	Academic	1	**472** 857	. .

8.2 Germany

History

The first two Cray 1 Run Systems had been installed in 1980 at the MPI for Plasma Physics in Munich and at the German Aerospace Agency DLR. Since then supercomputers have continuously been used in Germany. Big machines have often been found very early in Germany. The Cray 2 with serial number 6 for example was installed at the University of Stuttgart in 1986. The situation in Germany is special because Siemens Nixdorf has quite successfully been selling Fujitsu VPs in Germany since 1985. They have never manufactured a supercomputer by themselves and in the meantime they are also marketing and selling the KSR systems in Germany.

#14 in Germany

Present Situation

At present we see 59 systems in the TOP500. But the first one of them is only at position 49 in the world and position 3 in Europe. This already shows a lack of big MPP systems in Germany. The ratio of the installed vector systems to MPP systems is quite similar to the world average. But the installed MPP systems are typical low and midrange systems installed as experimental systems. That is why the percentage of the overall installed performance in Germany (5.2%) is, by a factor of two, lower than the percentage of systems (12%). Until now there is no big MPP production system in use in Germany.

Manufacturers

Looking at the distribution concerning the manufacturers (Fig. 8.7 and 8.8) we see Cray Research leading with 19 systems (33%), followed by SNI with 12 systems (20%), the latter being manufactured by Fujitsu. The KSR systems sold by SNI are counted separately. This percentage of SNI/Fujitsu Systems is unusually high. SNI almost only sold systems in Germany. Only one system in France and

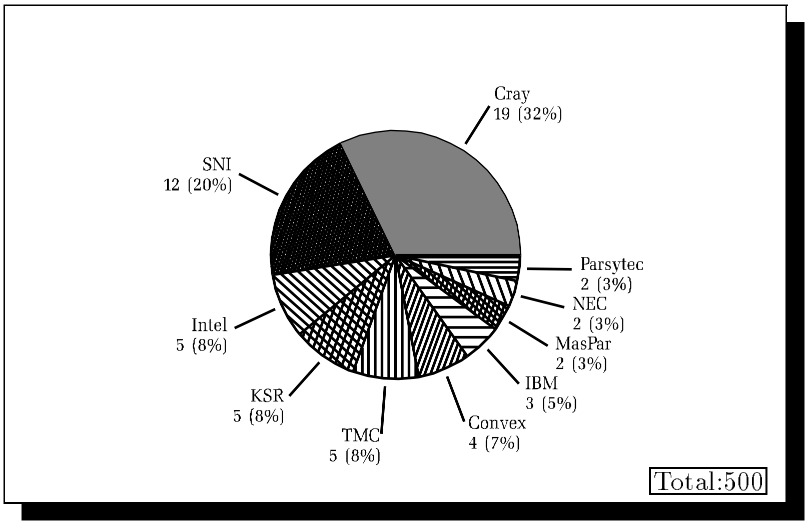


Figure 8.7:
Systems installed in Germany

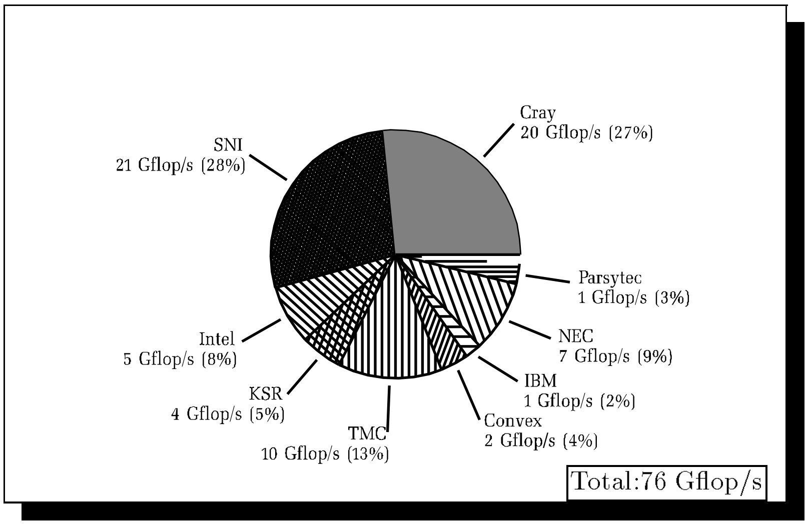


Figure 8.8:
R_{max} installed in Germany

one in Austria are present in the TOP500. But the management at SNI believes that such a strong position in the home market is not enough, for an own supercomputer development to pay off. Including the five KSR systems, four of which are sold by SNI, SNI is almost equal with Cray Research. With regards to the installed performance SNI is in lead of Cray. This is mainly because of the big LINPACK performance of the top VP systems compared to the usual YMP8 systems presently installed in Germany. With the first C90 systems coming soon this will change. But on the other hand there will also be two VPP500 systems in Germany shortly.

While Thinking Machines seems to be slightly underrepresented, especially in the big computing centers, Convex seems to have quite a good position in Germany. Intel sold two systems to big computing centers along with smaller ones at universities and shows a market share similar to the one worldwide. Parsytec, the only German supercomputer manufacturer, was only able to position four systems in the TOP500, two of them installed in Germany. They waited quite a long time for the Inmos T9000 chip to come and are currently switching to the Power PC 601 chip as the central processor. The GCeL systems in the TOP500 are based on nodes with the older T805 chip. So the weak position of Parsytec hides the fact that those four systems have 1024 or 512 nodes, which are quite respectful numbers. By the way, both systems in Germany are installed in the state of Northrhine-Westphalia where the company is located.

Looking at the distribution of the lander (Fig. 8.9 and 8.10) we see Northrhine-Westphalia ahead with 14 systems followed by Bavaria with 11 and Baden-Württemberg with 10 systems. This does not come as a surprise since these are the biggest lander in Germany. In the lander of the former Democratic Republic we find only one system in the TOP500 which is at position 500. This shows the big need for those lander to catch up when it comes to supercomputers.

Looking at the installations at university computing centers we see a great amount of VP systems especially in some of the lander of Germany, where there are almost only VP systems like in Hessen. Also all big VP systems are installed at university centers. Most of the MPP systems are also installed at universities, but not only in the computing centers but also at institutes.

# of Germany
KFA: #8, 10, 22, 40
LRZ: #9, 28
DKRZ: #13, 31, 35

The big governmental research centers like KFA in Jülich , LRZ in Munich and the Climate Computing Center in Hamburg all have Cray systems installed as main production machines. The Climate Computing Center in Hamburg will be the first German site to install a Cray C90 system in May '94. Only the German Aerospace agency (DLR) recently switched from a Cray system to a NEC SX3 which is the most powerful system in Germany at the moment.

DLR: #1, 25, 46

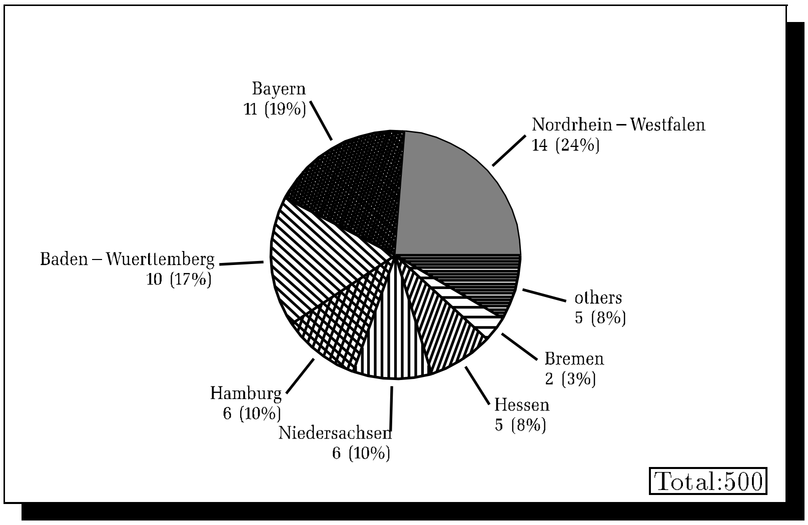


Figure 8.9:
Systems installed in German lander

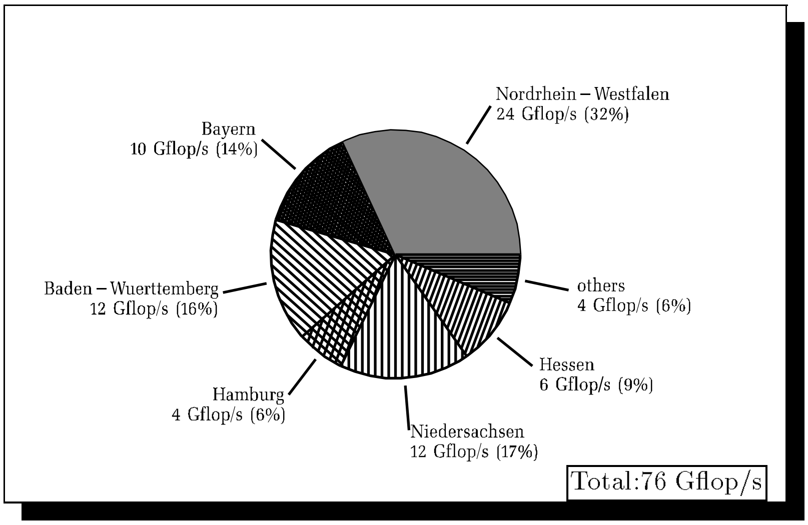


Figure 8.10:
R_{max} installed in German lander

Looking at the industry you find almost nothing but Cray systems or Convex systems installed. Especially all the automotive vendors have installed Cray systems. There are also a few VP systems at industrial sites especially in the chemical industry and in the electronic industry. But the last one is an installation at Siemens, not to be mixed up with Siemens Nixdorf. This system is used for chip design and that is why we do not count it as a vendor system but as an industrial site.

Autom.:#17, 21, 32, 44, 47, 49
Chemical: #23
Electronic: #24

All in all, Germany has quite a good position in Europe, with regards to the number of installed systems, but can easily fall behind in the development of the MPP sector.

TOP500 Supercomputer Sites — Germany

N Germa World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 49	NEC SX-3/14R	German Aerospace Laboratory (DLR) Goettingen Germany /1993	Research Aerospace	1	**5800** 6400	2816 282
2 74	SNI S600/20	Universitaet Aachen Aachen Germany /1991	Academic	1	**4009** 5000	. .
3 75	SNI S600/20	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	1	**4009** 5000	. .
4 83	TMC CM-5/64	GMD Birlinghoven Germany /1993	Research	64	**3800** 8192	13056 6016
5 87	SNI S400/40	Universitaet Darmstadt Darmstadt Germany /1991	Academic	2	**3624** 5000	10239 .
6 88	SNI S400/40	Universitaet Hannover Hannover Germany /1991	Academic	2	**3624** 5000	10239 .
7 96	TMC CM-2/32k	AMK Bonn Germany /1990	Classified	1024	**2600** 7000	. .
8 123	Cray Y-MP8/832	KFA Juelich Germany /1989	Research	8	**2144** 2667	. .
9 126	Cray Y-MP8/8128	Leibniz Rechenzentrum Muenchen Germany /1992	Academic	8	**2144** 2667	. .
10 154	Intel XP/S5	KFA Juelich Germany /1992	Research	66	**2000** 3300	8000 .
11 159	Intel XP/S5-32	Universitaet Stuttgart Stuttgart Germany /1992	Academic	66	**2000** 3300	8000 .
12 176	TMC CM-5/32	Universitaet Wuppertal Wuppertal Germany /1992	Academic	32	**1900** 4096	9216 4096
13 231	Cray CRAY-2s/4-128	DKRZ Hamburg Germany /1988	Research Weather	4	**1406** 1952	. .
14 245	Cray CRAY-2/4-256	Universitaet Stuttgart Stuttgart Germany /1986	Research	4	**1406** 1951	. .
15 257	TMC CM-2/16k	GMD Birlinghoven Germany /1990	Research	512	**1300** 3500	. .
16 262	NEC SX-3/11	Universitaet Koeln Koeln Germany /1990	Academic	1	**1300** 1370	2816 192
17 264	Cray Y-MP8/4128	BMW AG Muenchen Germany /1992	Industry Automotive	4	**1159** 1333	. .
18 274	Cray Y-MP4/432	Deutscher Wetterdienst Offenbach Germany /1990	Research Weather	4	**1159** 1333	. .
19 282	Cray Y-MP4E/464	MPI Garching Germany /1991	Research	4	**1159** 1333	. .
20 293	Cray Y-MP4E/464	Universitaet Kaiserslautern Kiel Germany /1993	Academic	4	**1159** 1333	. .

TOP500 Supercomputer Sites — Germany

N Germa World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 295	Cray Y-MP8/464	VW (Volkswagen AG) Wolfsburg Germany /1993	Industry Automotive	4	**1159** 1333	. .
22 296	Cray Y-MP M94/4256	KFA Juelich Germany /1993	Research	4	**1114** 1333	. .
23 300	SNI S200/10	Schering Berlin Germany /1991	Industry Chemistry	1	**1048** 1250	. .
24 301	SNI S200/20	Siemens Muenchen Germany /1991	Industry Electronics	1	**1048** 1250	. .
25 309	Parsytec GCel 3/1024	Universitaet Koeln/DLR Koeln Germany /1992	Academic	1024	**971** 1540	15999 2073
26 310	Parsytec GCel 3/1024	Universitaet Paderborn Paderborn Germany /1992	Academic	1024	**971** 1540	15999 2073
27 323	KSR KSR1-32	GWDG Goettingen Germany /1992	Academic	32	**893** 1280	6144 896
28 325	KSR KSR1-32	Leibniz Rechenzentrum Muenchen Germany /1993	Academic	32	**893** 1280	6144 896
29 326	KSR KSR1-32	Siemens Nixdorf Muenchen Germany /1993	Vendor	32	**893** 1280	6144 896
30 327	KSR KSR1-32	Universitaet Mannheim Mannheim Germany /1992	Academic	32	**893** 1280	6144 896
31 342	Cray Y-MP4E/364	DKRZ Hamburg Germany /1991	Research Weather	3	**881** 999	. .
32 349	Cray Y-MP4/364	debis Stuttgart Germany /1991	Industry Automotive	3	**881** 999	. .
33 363	SNI S200/10 (4ns)	Universitaet Frankfurt Frankfurt Germany /1991	Academic	1	**842** 1000	. .
34 365	Cray X-MP/416	AMK Bonn Germany /1990	Classified	4	**822** 940	. .
35 381	Convex C3880	DKRZ Hamburg Germany /1993	Research Weather	8	**795** 960	. .
36 385	Convex C3880	SICAN Hannover Germany /1993	Industry	8	**795** 960	. .
37 387	SNI VP400EX	KFK Karlsruhe Germany /1990	Research	1	**794** 1714	. .
38 410	TMC CM-2/8k	Universitaet Wuppertal Wuppertal Germany /1990	Academic	256	**650** 1750	. .
39 413	Intel iPSC/860	GSF Neuherberg Germany /1990	Research	32	**640** 1280	6000 2500
40 414	Intel iPSC/860	KFA Juelich Germany /1991	Research	32	**640** 1280	6000 2500

TOP500 Supercomputer Sites — Germany

N *Germa* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41 415	Intel iPSC/860	Universitaet Saarbruecken Saarbruecken Germany /1990	Academic	32	**640** 1280	6000 2500
42 417	Convex C3860	GRS (Gesellschaft fuer Reaktorsicherheit) Muenchen Germany /1993	Research	6	**615** 720	. .
43 420	Convex C3860	Universitaet Tuebingen Tuebingen Germany /1992	Academic	6	**615** 720	. .
44 426	Cray Y-MP2E/264	Audi AG Ingolstadt Germany /1992	Industry Automotive	2	**604** 666	. .
45 427	Cray Y-MP2E/232	Bundesanstalt fuer Wasserbau Hamburg Germany /1992	Research Geophysics	2	**604** 666	. .
46 434	Cray Y-MP2/232	DLR Oberpfaffenhofen Germany /1990	Research	2	**604** 666	. .
47 437	Cray Y-MP2E/232	EDS/ Adam Opel AG Ruesselsheim Germany /1992	Industry auot	2	**604** 666	. .
48 463	Cray Y-MP2E/264	Universitaet Stuttgart Stuttgart Germany /1993	Academic	2	**604** 666	. .
49 466	Cray Y-MP2E/264	debis Muenchen Germany /1993	Industry	2	**604** 666	. .
50 468	SNI S100/10	GEOVOR Traben Trabach Germany /1991	Industry Weather	1	**556** 625	. .
51 470	SNI S100/10	Universitaet Hamburg Hamnburg Germany /1992	Academic	1	**556** 625	. .
52 471	KSR KSR1-20	AWI (Alfred Wegener Institut) Bremerhaven Germany /1993	Research	20	**550** 800	. .
53 475	IBM 3090-600J	GSI Darmstadt Germany /1987	Academic	6	**540** 828	. .
54 476	IBM 3090-600J	TU Braunschweig Braunschweig Germany / .	Academic	6	**540** 828	. .
55 479	IBM ES 9000-720	DESY Hamburg Germany / .	Research	6	**540** 828	. .
56 493	MasPar MP-1216	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	16384	**473** 550	11264 1280
57 494	MasPar MP-1216	Universitaet Stuttgart Stuttgart Germany /1991	Academic	16384	**473** 550	11264 1280
58 499	SNI VP200EX	Universitaet Bremen Bremen Germany /1991	Academic	1	**472** 857	. .
59 500	SNI VP200EX	Universitaet Dresden Dresden Germany /1991	Academic	1	**472** 857	. .

8.3 United Kingdom

In this section we look at the supercomputer situation in the UK and review the history and current use of this type of machines. The different application areas the supercomputers are used in are described and the trend to parallel systems is shown.

History

From the early days of computers, the United Kingdom (UK) has always played a major role in the exploitation of supercomputers. Initially, the UK built its own computers—just remember the Atlas—, then it imported them for research and academic use. Examples of this trend were the CDC 7600 at Manchester and London.

When vector supercomputers were introduced by Cray Inc. and Control Data Corp. in the late 70s, again, the UK was in the forefront of use of these machines in Europe: the first Cray machine in Europe was installed at ECMWF, the first Cyber 205 at the British Meteorological Office. The first European subsidiary of Cray Inc. was founded in the UK.

This trend, however, stopped during the late 80s. Except for ECMWF and the British Meteorological Office who were still able to exploit the top performing supercomputers like the CRAY X and Y series and the ETA-10, only smaller systems were bought by the others users.

Today, there is only one UK entry left in the first 90 entries of the TOP500, and this is owned by ECMWF, an international organisation. The first UK research site (RAL) is only at place 139.

The reasons for this relative decline are manifold, but the political priorities with regard to education and government funded research play a major role.

Current situation

At present, the UK has 20 supercomputers listed in the 1993 TOP500 (Table 8.3). As stated earlier, one of them, the Cray C90 at ECMWF, cannot really be counted, because it belongs to an international organisation funded by 18 European countries. Of the remaining 19 sites, seven installations support academic research, five are dedicated to classified work and three are specialised research centers. This leaves only four systems for industrial use.

The size of the machines is relatively small, only nine entries are among the TOP200 and none in the TOP50. The percentage of massively parallel systems is relatively high: eight systems belong to this category. However, the highest number of processors is reached with

#3 in UK
#2

512 at Edinburgh (TMC CM-200), followed by 128 at Grant Tensor (Intel iPSC/860). The remaining machines are small compared to the largest possible configurations. The total installed capacity measured in R_{max} (28.7 Gflop/s without ECMWF) is less than 10% of the capacity of Japan and is only twice that of Australia (see Fig. 5.2 and 8.2).

In summary, the UK has still the third largest installed base of supercomputers in Europe, but is less than half the size of Germany both in numbers and installed capacity and has also been overtaken by France (see Fig. 8.1).

Outlook

Even though the UK has recently witnessed the purchase of a number of supercomputers for academic and research use, e.g. a CRAY C90 for the British Meteorological Office and a CRAY T3D with 256 processors for the University of Edinburgh, the trend of use of supercomputers in the UK, nevertheless, seems to be unbroken. The move away from traditional supercomputers to RISC based scaleable computing is continuing, with emphasis on low cost, high performance computing.

TOP500 Supercomputer Sites — UK

N *UK* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 18	Cray Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650
2 98	Intel iPSC/860	Grant Tensor UK /1991	Industry Geophysics	128	**2600** 5120	12000 4500
3 112	TMC CM-200/16k	University of Edinburgh Edinburgh UK / .	Research	512	**2400** 5000	14848 5632
4 122	Cray Y-MP8/864	Government Communications Headquarters Benhall UK / .	Classified	8	**2144** 2667	. .
5 139	Cray Y-MP8I/8128	Rutherford Appleton Laboratory UK /1992	Research	8	**2144** 2667	. .
6 143	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
7 144	Cray Y-MP8/864	United Kingdom Meteorological Office Bracknell UK /1991	Research Weather	8	**2144** 2667	. .
8 150	Fujitsu VPX240/10	University of Manchester Manchester UK /1993	Academic	1	**2110** 2500	. .
9 187	KSR KSR1-64	Government UK /1992	Classified	64	**1838** 2560	9216 1536
10 239	Cray CRAY-2/4-256	Defense Research Agency Farnborough UK /1990	Classified	4	**1406** 1951	. .
11 247	Intel iPSC/860	Daresbury Laboratory Warrington UK / .	Research	64	**1400** 2560	9000 3500
12 259	Meiko CS/i860/64	University of Edinburgh Edinburgh UK /1990	Academic	64	**1300** 2500	8500 3500
13 269	Cray Y-MP4E/464	Compagnie Generale de Geophysique (CGG) Fletham UK /1993	Industry Geophysics	4	**1159** 1333	. .
14 273	Cray Y-MP8/432	Defense Research Agency Ford Halstead UK /1990	Research	4	**1159** 1333	. .
15 311	Meiko CS/i860/42	Ensign Geophysics Weybridge UK /1987	Academic	42	**970** 1700	. .
16 329	KSR KSR1-32	University of Manchester Manchester UK /1992	Academic	32	**893** 1280	6144 896
17 340	Cray Y-MP4E/364	British Aerospace PLC Farnborough UK /1991	Industry Aerospace	3	**881** 999	. .
18 364	Meiko CS/i860/32	DRA Malvern Weybridge UK /1990	Research	32	**825** 1300	7000 3000
19 421	Cray Y-MP4/264	AEA Technology Harwell UK /1993	Research Energy	2	**604** 666	. .
20 456	Cray Y-MP4/216	Rolls-Royce PLC UK /1990	Industry Aerospace	2	**604** 666	. .

8.4 France

Once, there was an equality 'Supercomputer=Cray'. This TOP500 shows this is not true anymore. Except for one country where Cray still holds most of the ground. In France the Cray hegemony is nearly absolute with 60% of the installed machines. Only TMC with four installations has a significant market share of over 20% double that of the figure for whole Europe. The TMC machines together account for nearly 40% of the installed R_{max} power in France.

The research institutes are the biggest supercomputer users in number of installations, closely followed ty the industry. Due to the fact that the research institutes house nearly all parallel machines with high R_{max} rates and the largest Cray machine, they together have the major part of the installed R_{max} performance. The French industry is almost exclusively Cray territory with a dominance of 2-4 processor Cray YMP systems.

TOP500 Supercomputer Sites — France

N *France* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 37	TMC CM-5/128	Institut de Physique du Globe de Paris (IPG) Paris France /1992	Research	128	**7700** 16000	18432 8192
2 92	Cray Y-MP C98/4256	Direction de la Meteorologie Nationale Toulouse France /1993	Research Weather	4	**3275** 3810	. .
3 105	Intel iPSC/860	ONERA Chatillon France /1991	Research Aerospace	128	**2600** 5120	12000 4500
4 110	TMC CM-200/16k	INRIA - Sophia Antipolis Rennes France /1992	Research	512	**2400** 5000	14848 5632
5 149	SNI S400/10	IFP (Institute Francais du Petrole) Rueil-Malmaison France /1992	Academic Geophysics	1	**2110** 2500	. .

TOP500 Supercomputer Sites — France

N *France* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
6 163	TMC CM-5/32	Compagnie Generale de Geophysique (CGG) Massy France /1993	Industry Geophysics	32	**1900** 4096	9216 4096
7 171	TMC CM-5/32	Site Experimental Hyperparallelisme (SEH/ETCA) Arcueil France / .	Research	32	**1900** 4096	9216 4096
8 220	Intel XP/A4E	IRISA Rennes France /1993	Research Aerospace	56	**1500** 4200	6000 .
9 237	Cray CRAY-2/4-256	Commissariat a l'Energie Atomique Grenoble France /1989	Research Energy	4	**1406** 1951	. .
10 240	Cray CRAY-2/4-256	Direction de la Meteorologie Nationale Toulouse France /1989	Research Weather	4	**1406** 1951	. .
11 268	Cray Y-MP4E/464	Citroen Peugeot Velizy France /1992	Industry Automotive	4	**1159** 1333	. .
12 270	Cray Y-MP4/432	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**1159** 1333	. .
13 277	Cray Y-MP8/4128	Electricite de France Clamart France /1990	Industry Energy	4	**1159** 1333	. .
14 288	Cray Y-MP8/4128	ONERA Chatillon France /1991	Research Aerospace	4	**1159** 1333	. .
15 324	KSR KSR1-32	INRIA - Sophia Antipolis Rennes France /1992	Research	32	**893** 1280	6144 896
16 347	Cray Y-MP4E/364	Renault Rueil-Malmaison France /1992	Industry Automotive	3	**881** 999	. .
17 369	Cray X-MP/416	Compagnie Generale de Geophysique (CGG) Massy France /1992	Industry Geophysics	4	**822** 940	. .
18 376	Cray X-MP/416	Michelin Clermont-Ferrand France /1992	Industry Automotive	4	**822** 940	. .
19 438	Cray Y-MP2E/232	ELF Aquitaine Pau France /1992	Industry Geophysics	2	**604** 666	. .
20 440	Cray Y-MP4/264	Electricite de France Clamart France /1992	Industry Energy	2	**604** 666	. .
21 443	Cray Y-MP2E/232	Institute Mediterraneen de Technologie Marseille France /1991	Academic	2	**604** 666	. .
22 492	DEC DECmpp SX 100	Thompson LER Rennes France / .	Industry Electronics	16384	**473** 550	11264 1280

8.5 Benelux

In the Benelux, Belgium, The Netherlands and Luxembourg, six of the installed machines have entered the TOP500. Among them is the second most powerful European vector computer in the list: the NEC SX-3 machine of the NLR. The number of machines is to small to draw any statistical conclusions from. Nevertheless, machines in three classes are available:

IBM VF

1. The oldies: vector mainframes from the IBM vector computer type. These machines where placed as part of the EASINET initiative: a network of the then most powerful IBM vector mainframes in Europe. Probably, we will not see them back in the next TOP500. The machine in Amsterdam will be downsized, so certainly will fall of the list.

Vector MPs

2. The work horses: two vector multiprocessors, the NEC SX-3 and the Dutch national supercomputer, a Cray YMP figure high in the list. In The Netherlands, these two machines are the two computers on which the real high-performance computing is performed.

MPPs

3. The parallel machines of different brands: There is not a real big parallel machine yet. The parallel machines are used to explore parallelization and to acquire experience.

All machines, but one, are in The Netherlands. In fact, most machines are located in one building in Amsterdam: in the Scientific Center Watergraafsmeer, SARA houses three supercomputers (Cray YMP, IBM 9000, and Parsytec) and the neighbouring CWI has a Cray SMP.

Belgium is clearly lagging behind in large machines. One reason is that preferably machines have to be mirrored in the French and Dutch speaking parts of the country. If you divide a supercomputer in two, the parts may not be big enough to enter the TOP500 list!

TOP500 Supercomputer Sites — Benelux

N *Benel* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 59	NEC SX-3/22	National Aerospace Laboratory (NLR) Nordoostpolder Netherlands/1992	Research Aerospace	2	**5000** 5500	3072 384
2 170	TMC CM-5/32[1]	RUG (Rijksuniversiteit Groningen) Groningen Netherlands/1993	Academic	32	**1900** 4096	9216 4096
3 289	Cray Y-MP4/464	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	4	**1159** 1333	. .
4 477	IBM 3090-600E	University of Leuven Belgium / .	Academic	6	**540** 828	. .
5 480	IBM ES 9000-720	SARA/IC3A (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	6	**540** 828	. .
6 482	Cray S-MP/MCP728	CWI/Centrum voor Wiskunde en Informatica Amsterdam Netherlands/1992	Research	28	**508** 1120	. .
7 484	Parsytec GCel 3/512	SARA/IC3A (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1993	Academic	512	**485** 770	. .

Mannheim/Tennessee November 11,1993

[1] By the way, the 32-processor machine in Groningen only has 16 processors so should be much lower on the list. TMC smallest model is a 32-node machine, but if you have money for only sixteen, they leave out the other sixteen.

9

The TOP25 Supercomputer Centers

Horst D. Simon

Abstract

In this short note the top 25 supercomputer centers worldwide are introduced. This list of the top 25 centers has been compiled based on the information given in the TOP500 list[4]. First we briefly explain how this list was established. For fifteen of the top twentyfive supercomputer centers we provide a short description of facilities, equipment, and mission.

9.1 Introduction

The TOP500 [4] provides an opportunity to rank the top supercomputer sites worldwide. In the TOP500 report the 500 highest performing supercomputers are listed. The measurement of performance is based on the LINPACK benchmark as reported in [3]. All the information here is based on the TOP500 of November 1993. We use results from this list because it provides the most comprehensive list of supercomputer sites. Also real LINPACK figures are available for all the machines on the list. Some of the limitations of using LINPACK and relying on the TOP500 are discussed in chapter 6.

An alternative "List of the World's Most Powerful Computing Sites" is compiled by Ahrendt [1]. This list is based on the NAS Parallel Benchmarks code BT [2]. There is considerable overlap between these two lists. BT as benchmark generally does not perform as well on highly parallel machines as LINPACK, when compared to vector machines. Also BT results are not always immediately available on new machines, so [1] resorts sometimes to estimates and extrapolations. On the other hand the list [1] is updated more frequently. In general, however, the results and the ranking are fairly consistent. The main point here is that we will give some additional information about the supercomputer sites, beyond just a listing of machines. This provides a general overview and pointers to further reading, on what the most powerful supercomputers on earth are actually used for.

9.2
List of the TOP25 Sites

The Top25 list of supercomputer sites is given in Table 9.1. This list has been established by simply adding the Linpack R_{max} performancein Gflop/s of all supercomputers installed at a given site. Generally under a 'site' we have combined supercomputers, which are installed in the same geographical location, and belong to the same organizational unit. The column 'machines' lists the machines whose performance have been added to reach the total performance for a site. The integers refer to the ranking of these supercomputers on the Top500. The performance column lists the aggregate performance of all the machines at the site in Linpack R_{max}-Gflop/s. An excellent and current overview of the supercomputers in use is [5].

There are several intriguing observations one can make from Table 9.1. In order to qualify as a top supercomputer site, and installation must have at least a full 16 processor Cray C90. Any site with a smaller machine does not not make the list. The typical installation on the list has now one large supercomputer, and a number of smaller machines. The vendors have different configurations consisting of a larger number of small machines.

The list also shows how much U.S. government spending dominates the supercomputing world. All 18 U.S. non-vendor sites directly or indirectly are funded by the U.S. government. There are 13 U.S. government laboratories, and the five U.S. universities receive their support for supercomputers from the NSF, DoD (Minnesota), or a consortium of government agencies (Caltech). However, also the foreign sites are also all falling into the same category, and are government institutions in their countries.

Table 9.1: TOP25 Supercomputer Centers

	Institution	Country	Machines	R_{max} [Gflop/s]
1	National Aerospace Lab. (NAL), Tokyo	Japan	1, 69, 388	129.3
2	Los Alamos National Laboratory	U.S.	2, 31, 32, 127–129, 446	86.3
3	U.S. Government, Classified	U.S.	19, 20 ,21, 22	54.8
4	Minnesota Supercomputer Center	U.S.	3, 43, 56, 242, 377, 473	45.0
5	NCSA, Univ. of Illinois	U.S.	4, 33, 234, 286, 305, 384	44.5
6	NASA Ames Research Center	U.S.	25, 40, 45, 48, 103, 130	39.2
7	National Security Agency	U.S.	5	30.4
8	Cray Research	U.S.	14, 116–118, 204, 210, 238 271, 272, 370, 401, 432, 433	29.9
9	NEC Fuchu Plant	Japan	6, 335	24.1
10	Lawrence Livermore National Laboratory	U.S.	24, 113, 124, 125, 232, 372	22.4
11	Oak Ridge National Laboratory	U.S.	9, 106, 156, 188	21.6
12	Sandia National Labs, Albuquerque	U.S.	8, 140, 182, 250	20.6
13	Atmospheric Env. Serv., Dorval	Canada	7	20.0
14	Calif. Institute of Technology	U.S.	13, 183, 218, 246	18.6
15	US Naval Research Laboratory	U.S.	12, 111	17.5
16	Thinking Machines Corp.	U.S.	11, 307	16.1
17	DOE/Bettis Atomic Power Laboratory	U.S.	16, 119	15.8
	DOE/Knolls Atomic Power Laboratory	U.S.	17, 120	15.8
19	UCSD/San Diego Supercomputer Center	U.S.	28, 142, 252	15.4
20	Hitachi Ltd.	Japan	193–197, 208, 209, 315–319	15.2
21	U.S. Government, classified	U.S.	10	15.1
22	Pittsburgh Supercomputing Center	U.S.	26, 306	14.7
23	US Naval Ocean. Commd, Bay St. Louis	U.S.	27, 452	14.3
24	Japan Atomic Energy Research	Japan	50, 65, 66	13.8
25	DOD/CEWES Vicksburg, Miss.	U.S.	15	13.7
	ECMWF, Reading, UK	UK	18	13.7
	KIST/System Engineering Res. Inst.	Korea	23	13.7
Total			101 Systems	781.5
Percentage			20.2%	53.2%

9.3 Background Information about some of the TOP25 sites

Wherever available some short summary of the mission and the environment of the first fifteen of the Top25 sites will be given below. If not noted otherwise, this information was gathered from home pages of these sites on the world wide web (WWW). With the availability of Mosaic many of the supercomputer sites have created such home pages. In order to facilitate browsing the net, URLs for site home pages are given.

National Aerospace Laboratory Numerical Wind Tunnel, Tokyo, Japan - 129.3 Gflop/s

The following information is from [6] and [8]:

"The 140 processor NWT represents, on paper, one of the worlds most powerful computers. Each processor has a peak performance of 1.7 Gflop/s, allowing a potential peak performance of 236 Gflop/s. NWT is situated in a room that also contains a Fujitsu VP2600, itself a powerful 5 Gflop/s (peak) supercomputer, but which functions as a front end for the NWT."

"NAL was established in 1955 to promote aeronautical engineering technology and belongs to the Science and Technology Agency. ... The numerical windtunnel (NWT) is a parallel computer system of distributed memory architecture composed of vector processors. NWT consists of 140 Processing Elements (PE), two Control Processors(CP) and Crossbar Network. That is, each PE itself is a vector supercomputer similar to VP400. Each PE has 256 MBytes of memory and peak performance of 1.7 Gflop/s. PE has Vector Unit, Scalar Unit and Data Mover which communicates with other PE's. PE is 50% faster than the standard VP400 and same size of memory. CP has 128 MB of memory. CP manages NWT and communicates with VP2600 through SSU. CP's do not execute real computation of CFD code. The cross-bar network has 421 MByte/s x 2 x 142 performance between each processors. The total performance of NWT is 236 Gflop/s and 35 GB main memory.

The specific feature of NWT is that it only pursues the efficiency and performance of CFD codes. The architecture is intended to satisfy to get maximum efficiency in this target only. Each PE itself can execute a large scale CFD computation with fewer data exchange with other PE's. Commercial MPP type machine has deficiency in this aspect as each load is small granularity. Commercial machines may not be able to concentrate into CFD purpose only even if they become available early this year. Only special order can realize this kind of development."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1 1	Fujitsu Numerical Wind Tunnel	NAL/Fujitsu Japan /1993	Research Aerospace	140	**124500** 236000	31920 11950

Los Alamos National Laboratory - 86.3 Gflop/s

The following information is from the home page of the Advanced Computing Laboratory (ACL)
(URL `http://www.acl.lanl.gov/Home.html`).
General information about Los Alamos National Laboratory is available under URL `http://www.lanl.gov:/welcome.html`.

"In December, 1991 Los Alamos National Laboratory was named as one of two national high performance computing research center (HPCRC) sites by the Department of Energy's (DOE) HPCC Program. The Advanced Computing Laboratory (ACL) at LANL is the foundation upon which this center is being built. The goal of the ACL as an HPCRC is to promote technology transfer in advanced computing to industry, academia, and other national laboratories through the operation of an experimental computational laboratory. The ACL will support an advanced environment for computational scientists working together in interdisciplinary teams to solve today's Grand Challenges, forming the building blocks of tomorrow's computing environment and educating others in the tools of the trade. Together, the Grand Challenge problems, the GRAnd Challenge Computing Environment (GRACCE), and the ACL form the nucleus of the HPCRC."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
2 2	TMC CM-5/1024	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	1024	**59700** 131000	52224 24064
2 31	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
2 32	TMC CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
2 127	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
2 128	Cray Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
2 129	Cray Y-MP8/864	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
2 446	Cray Y-MP8/264	Los Alamos National Laboratory Los Alamos USA /1990	Research Energy	2	**604** 666	. .

U.S. Government, Classified - 54.8 Gflop/s

Although in general nothing is known about this center, this classified installation is supposedly located in Texas. It contains at least 4 Cray C90's which are networked in a unique way for solving a single computational task.

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
3 19	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
3 20	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
3 21	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
3 22	Cray Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650

Minnesota Supercomputer Center - 45.0 Gflop/s

Resources at the University of Minnesota include supercomputers at the Minnesota Supercomputer Center and at the Army High Performance Computing Research Center (AHPCRC). "AHPCRC is a university led research and educational consortium. Consortium members include the University of Minnesota as prime contractor and Howard, Jackson State, and Purdue Universities. The AHPCRC is funded by the Army Research Office's Division of Mathematical and Computer Sciences. The AHPCRC mission is to advance the state of the art in heterogeneous and networked high performance computing, to educate Army researchers and the next generation of engineers and scientists in new techniques in high performance computing, and to promote technology transfer and encourage joint research and development projects which include both university and Army researchers (`URL http://www.arc.umn.edu/html/ahpcrc.html`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
4 3	TMC CM-5/544	Minnesota Supercomputer Center USA / .	Academic	544	**30400** 70000	36864 16384
4 43	Cray Y-MP C916/8256	Minnesota Supercomputer Center USA / .	Academic	8	**6850** 7619	. .
4 56	TMC CM-200/32k	Minnesota Supercomputer Center USA / .	Academic	1024	**5000** 10000	21504 8192
4 242	Cray CRAY-2/4-512	Minnesota Supercomputer Center USA /1988	Academic	4	**1406** 1951	. .
4 377	Cray X-MP EA/464	Minnesota Supercomputer Center USA /1992	Academic	4	**822** 940	. .
4 473	Cray Y-MP M92/21024	Minnesota Supercomputer Center USA /1992	Academic	2	**550** 666	. .

NCSA, Univ. of Illinois - 44.5 Gflop/s

"Established in February 1985 with a National Science Foundation (NSF) grant, the National Center for Supercomputing Applications (NCSA) opened to the national research community in January 1986. The state of Illinois, the University of Illinois at Urbana-Champaign (UIUC), corporate partners, and other federal agencies supply additional funding. The center has provided high-performance computing and communications (HPCC) resources for over 6,000 users at more than 380 universities and corporations (URL `http://www.ncsa.uiuc.edu/General/NCSAHome.html`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
5 4	TMC CM-5/512	NCSA Urbana-Champaign USA / .	Academic	512	**30400** 66000	36864 16384
5 33	TMC CM-200/64k	NCSA USA / .	Academic	2048	**9800** 20000	29696 11264
5 234	Cray CRAY-2s/4-128	NCSA Urbana-Champaign USA /1988	Academic	4	**1406** 1952	. .
5 286	Cray Y-MP4/464	NCSA Urbana-Champaign USA /1990	Academic	4	**1159** 1333	. .
5 305	TMC CM-5/16	NCSA USA /1993	Academic	16	**980** 2048	6528 3008
5 384	Convex C3880	NCSA Urbana-Champaign USA /1992	Academic	8	**795** 960	. .

NASA Ames Research Center - 39.2 Gflop/s

"The Numerical Aerodynamic Simulation (NAS) program was started in 1984 to support the NASA charter to maintain 'the role of the United States as a leader in aeronautical technology'. The NAS vision is to provide the nation's aerospace research and development community by the year 2000 a high-performance, operational computing system capable of simulating an entire aerospace vehicle system within a computing time ranging from one to several hours. The major objectives of the NAS program are:

1. Act as pathfinder in advanced, large scale computational capability through systematic incorporation of state-of-the-art improvements in computer hardware and software technologies.

2. Provide a national computational capability, available to NASA, DoD, industry, other government agencies and universities, as a necessary element in insuring continuing leadership in computational fluid dynamics and related computational aerospace disciplines.

3. Provide a strong research tool for the Office of Aeronautics. "

For more details see `URL http://www.nas.nasa.gov/home.html`.

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
6 25	Cray Y-MP C916/16256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	16	**13700** 15238	10000 650
6 40	TMC CM-5/128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	128	**7700** 16000	18432 8192
6 45	Cray Y-MP C98/8128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**6850** 7619	. .
6 48	Intel XP/S15	NASA/Ames Research Center/NAS Moffett Field USA /1992	Research	208	**6200** 10400	. .
6 103	Intel iPSC/860	NASA/Ames Research Center/NAS Moffett Field USA /1990	Research	128	**2600** 5120	12000 4500
6 130	Cray Y-MP8/8256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	8	**2144** 2667	. .

National Security Agency - 30.4 Gflop/s

"The goal of NSA's HPCC Program is to accelerate the development and application of the highest performance computing and communications technologies to meet national security requirements and to contribute to collective progress in the Federal HPCC Program. In support of this goal, NSA develops algorithms and architectural simulators and testbeds that contribute to a balanced environment of workstations, vector supercomputers, massively parallel computer architectures, and high speed networks. It sponsors and participates in basic and applied research and development of gigabit networking technology. NSA develops network security and information security techniques and testbeds appropriate for high speed in-house networking and for interconnection with public networks. It also develops software and hardware technology for highly parallel architectures scalable to sustained teraops performance, and it investigates or develops new technologies in materials science, superconductivity, ultra-high-speed switching and interconnection techniques, networking, and mass storage systems fundamental to increased performance objectives of high performance computing programs (URL `http://www.hpcc.gov/blue94/section.4.6.html`).

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
7 5	TMC CM-5/512	National Security Agency USA / .	Classified	512	**30400** 66000	36864 16384

Cray Research - 29.9 Gflop/s

The following general information is from a Cray Research press release: "Founded on April 6 ,1972, Cray Research Inc. continues its mission to lead in the development and marketing of supercomputers.

As of June 30, 1993, the company employed 4,978 people. Its principal manufacturing and development facilities are in Chippewa Falls, Wisconsin, with additional operations in San Diego, California, and Beaverton, Oregon. Software development, marketing support and corporate headquarters are located in the St. Paul/Minneapolis area. The company maintains sales and support offices throughout the United States and in 21 other countries.

The company continues to target at least 15 percent of its revenue toward research and development. This helps ensure that Cray Research is on the cutting edge of advanced scientific computing."

N Center World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
8 14	Cray Y-MP C916/16256	Cray Research Eagan USA / .	Vendor	16	**13700** 15238	10000 650
8 116	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
8 117	Cray Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
8 118	Cray Y-MP8/832	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
8 204	Cray Y-MP M98	Cray Research Eagan USA / .	Vendor	8	**1733** 2667	. .
8 210	Cray Y-MP8/664	Cray Research Eagan USA / .	Vendor	6	**1651** 2000	. .
8 238	Cray CRAY-2/4-128	Cray Research Eagan USA / .	Vendor	4	**1406** 1951	. .
8 271	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
8 272	Cray Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
8 370	Cray X-MP/416	Cray Research Eagan USA / .	Vendor	4	**822** 940	. .
8 401	Cray S-MP/MCP256	Cray Research Eagan USA / .	Vendor	56	**678** 2210	. .
8 432	Cray Y-MP2/232	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
8 433	Cray Y-MP8/21024	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .

NEC Fuchu Plant - 24.1 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
9 6	NEC SX-3/44R	NEC Fuchu Plant Japan /1990	Vendor	4	**23200** 26000	6400 830
9 335	NEC SX-2	NEC Fuchu Plant Japan /1987	Vendor	1	**885** 1333	. .

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Lawrence Livermore National Laboratory - 22.4 Gflop/s

"Lawrence Livermore National Laboratory (LLNL), managed by the University of California for the U.S. Department of Energy, has achieved 40 years of excellence in creating and applying science and technology to meet vital national needs. LLNL is a major national resource whose mission areas have been expanded by the federal government to address a broad spectrum of evolving national needs, including national security, energy, the environment, health and biomedicine, economic competitiveness, and science and math education (URL `http://www.llnl.gov/`)." There are two major computing facilities at LLNL: Livermore Computing and the National Energy Research Supercomputer Center (NERSC).

"The Livermore Computing organization has been a leader in the development of High Performance computing since the Lawrence Livermore National Laboratory (LLNL) was founded in 1952. During the Cold War, Livermore Computing concentrated on supporting the development of our nation's nuclear deterrent, designing early supercomputers, like the LARC (Livermore Advanced Research Computer), and developing the first time-sharing system in the 1960s and 1970s, large archival storage systems in the 1970s and 1980s, and distributed systems in the 1980s and 1990s (URL `http://www.llnl.gov/liv_comp/lc.html`)."

"The National Energy Research Supercomputer Center (NERSC), located at the Lawrence Livermore National Laboratory (LLNL), is the principal supplier of production high-performance computing and networking services to the nationwide energy research community. The programs directly supported by NERSC in the Department of Energy's Office of Energy Research include the Office of Scientific Computing, Fusion Energy, Basic Energy Sciences, High Energy and Nuclear Physics, and Health and Environmental Research. Scientists funded by these programs access the supercomputing resources at NERSC via the Energy Sciences network (ESnet) (URL `http://www.nersc.gov/`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
10 24	Cray Y-MP C916/16256	Lawrence Livermore National Laboratory NERSC USA /1992	Research Energy	16	**13700** 15238	10000 650
10 113	Cray CRAY-2s/8-128	Lawrence Livermore National Laboratory NERSC USA /1990	Research Energy	8	**2171** 3902	. .
10 124	Cray Y-MP8/8128	Lawrence Livermore National Laboratory Livermore USA /1991	Research	8	**2144** 2667	. .
10 125	Cray Y-MP8/864	Lawrence Livermore National Laboratory Livermore USA /1992	Research	8	**2144** 2667	. .
10 232	Cray CRAY-2s/4-128	Lawrence Livermore National Laboratory NERSC USA /1988	Research Energy	4	**1406** 1952	. .
10 372	Cray X-MP/416	Lawrence Livermore National Laboratory Livermore USA /1987	Research	4	**822** 940	. .

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Oak Ridge National Laboratory - 21.6 Gflop/s

"The Center for Computational Sciences (CCS) at Oak Ridge National Laboratory (ORNL) provides state-of-the-art resources for Grand Challenge computing and serves as a centerpiece for computational science at ORNL. The CCS is the ORNL focal point for the U.S. High Performance Computing and Communications (HPCC) Program, with responsibilities also extending to educational initiatives. The CCS is home to one of the two High Performance Computing Research Centers established by the United States Department of Energy (DOE). The CCS is a focus for collaborations with academia, industry, and other federal laboratories. Through these efforts, the Center extends its impact far beyond the boundaries of the Oak Ridge campus. The most extensive of these cooperative ventures is the Partnership in Computational Science (PICS) Consortium supported by the DOE's Office of Scientific Computing (OSC). The three national laboratories and six universities of the PICS collaborate on a variety of Grand Challenges and other research projects. In addition to ORNL and PICS, the CCS provides computational resources to the DOE's Advanced Mathematics and Model Physics (CHAMMP) program, as an essential component of its global climate modeling program, and to a number of other Grand Challenge programs (Quantum Chromodynamics, Quantum Structure of Matter, Numerical Tokamak, Computational Biology, Computational Chemistry). Resources are also provided to a number of other organizations or programs involved in systems evaluation (e.g., NASA, ARPA, other universities and federal labs) to assist scientists and engineers in evaluating current architectures and systems with an eye to superior capabilities in the future (`URL http://gopher.ccs.ornl.gov/HomePage.html`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
11 9	Intel XP/S35	Oak Ridge National Laboratory Oak Ridge USA /1992	Research	512	**15200** 26000	23000 9000
11 106	Intel iPSC/860	Oak Ridge National Laboratory Oak Ridge USA /1989	Research	128	**2600** 5120	12000 4500
11 156	Intel XP/S5	Oak Ridge National Laboratory Oak Ridge USA / .	Research	66	**2000** 3300	8000 .
11 188	KSR KSR1-64	Oak Ridge National Laboratory Oak Ridge USA /1991	Research	64	**1838** 2560	9216 1536

Sandia National Labs, Albuquerque - 20.6 Gflop/s

"The Department of Energy's Sandia National Laboratories is one of the nation's largest and most diverse research and development facilities. It employs more than 8,000 people at two locations in New Mexico and California. One of Sandia's strengths is in computational and experimental mechanics where several advanced code development efforts are in progress. These codes are run on state-of-the-art vector and massively parallel computer systems at Sandia. They support internal customers with analysis capabilities and the codes are also distributed to external customers. In addition, Sandia makes use of commercial and externally developed codes when applicable." The highly parallel supercomputers are located at Sandia's Massively Parallel Computing Research Laboratory (MPCRL) in Albuquerque, NM
(URL `http://tesuque.cs.sandia.gov/MPCRL/MPCRL_home_page.html`).

N Center World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
12 8	Intel XP/S135	Sandia National Labs Albuquerque USA /1993	Research	1840	**15200** 92000	23000 9000
12 140	Cray Y-MP8/864	Sandia National Labs Albuquerque USA / .	Research	8	**2144** 2667	. .
12 182	NCube nCUBE2	Sandia National Labs Albuquerque USA / .	Research	1024	**1900** 2400	21376 3193
12 250	Intel iPSC/860	Sandia National Labs Albuquerque USA /1991	Research	64	**1400** 2560	9000 3500

Atmospheric Env. Serv., Dorval, Canada - 20.0 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
13 7	NEC SX-3/44	Atmospheric Environment Service (AES) Dorval Canada /1991	Research Weather	4	**20000** 22000	6144 832

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Calif. Institute of Technology - 18.6 Gflop/s

"The Caltech Concurrent Supercomputing Facilities (CCSF) is located on the campus of the California Institute of Technology which supports and maintains a variety of massively parallel supercomputers for the Concurrent Supercomputing Consortium (CSCC). The CSCC is an alliance of twelve institutions – universities, research laboratories, government agencies, and industry – that pool their resources to gain access to unique computational facilities and to exchange technical information, share expertise, and collaborate on high-performance computing issues.

Major scientific applications that are being pursued include: computationally intensive astronomical data analysis (such as searches for binary radio pulsars and gamma-ray pulsars); computational neuroscience (using simulations to explore nervous system function and to develop a version of the GENESIS neural network simulation package that takes advantage of parallel computers); volumetric data rendering of medical instrument data, electron-molecule collisions in low-temperature plasmas; calculation of chemical reaction cross sections and rate constants from first quantum principles; 3-D simulations of mantle convections and the Earth's True Polar Wander; calculation of the nucleon-nucleon interaction; and computational fluid dynamics, including the numerical simulation of turbulent and unsteady separated fluid flows. In addition, Caltech researchers are developing numerical algorithms as well as new programming languages such as PCN (a crPC collaboration) and CC++ for use on parallel computers (`URL http://ccsf.caltech.edu`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
14 13	Intel Delta	Caltech Pasadena USA / .	Academic	512	**13900** 20480	25000 7500
14 183	KSR KSR1-64	Caltech Pasadena USA /1992	Academic	64	**1838** 2560	9216 1536
14 218	Intel XP/A4	Caltech Pasadena USA /1993	Academic	56	**1500** 4200	6000 .
14 246	Intel iPSC/860	Caltech Pasadena USA /1990	Academic	64	**1400** 2560	9000 3500

US Naval Research Laboratory - 17.5 Gflop/s

"NRL is the Navy's corporate research and development laboratory, created in 1923 by Congress for the Department of the Navy on the advice of Thomas Edison. The Laboratory has over 4000 personnel (over 1500 full-time scientists, engineers and SES employees - more than half of these PhDs, currently including a Nobel Laureate), who address basic research issues concerning the Navy's environment of sea, sky, and space. Investigations have ranged widely from monitoring the sun's behavior, to analyzing marine atmospheric conditions, to measuring parameters of the deep oceans, to exploring the outermost regions of space. Detection and communication capabilities have benefited by research that has exploited new portions of the electromagnetic spectrum, extended ranges to outer space, and provided means of transferring information reliably and securely, even through massive jamming. Submarine habitability, lubricants, shipbuilding, aircraft materials, and fire fighting along with the study of sound in the sea and the advancement of radar technology have been steadfast concerns. New and emerging areas include the study of biological and chemical processes and nanoelectronics.

The Center for Computational Sciences (CCS) is a newly formed NRL organization within the Information Technology Division. The mission of the CCS is to provide the Navy community with access to state-of-the-art high performance computing and communications (HPCC) capabilities and provide production computational services. Contained within the CCS is the Navy's cutting edge research in massively parallel computing (MPP) and high speed wide area networking (URL `http://www.cmf.nrl.navy.mil/home.html`)."

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
15 12	TMC CM-5/256	US Naval Research Laboratory USA /1992	Research	256	**15100** 33000	26112 12032
15 111	TMC CM-200/16k	US Naval Research Laboratory USA /1987	Research	512	**2400** 5000	14848 5632

Thinking Machines Corp. - 16.1 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
16 11	TMC CM-5/256	Thinking Machines USA /1993	Vendor	256	**15100** 33000	26112 12032
16 307	TMC CM-5/16	Thinking Machines USA /1993	Vendor	16	**980** 2048	6528 3008

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DOE/Bettis Atomic Power Laboratory - 15.8 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
17 16	Cray Y-MP C916/16256	DOE/Bettis Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
17 119	Cray Y-MP8/864	DOE/Bettis Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .

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DOE/Knolls Atomic Power Laboratory - 15.8 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
17 17	Cray Y-MP C916/16256	DOE/Knolls Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
17 120	Cray Y-MP8/864	DOE/Knolls Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .

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UCSD/San Diego Supercomputer Center - 15.4 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
19 28	Intel XP/S30	UCSD/San Diego Supercomputer Center San Diego USA /1993	Academic	400	**11900** 20000	. .
19 142	Cray Y-MP8/864	UCSD/San Diego Supercomputer Center San Diego USA /1989	Academic	8	**2144** 2667	. .
19 252	Intel iPSC/860	UCSD/San Diego Supercomputer Center San Diego USA /1990	Academic	64	**1400** 2560	9000 3500

Hitachi Ltd. - 15.2 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
20 193	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	5000 .
20 194	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1988	Vendor	1	**1817** 3000	5000 .
20 195	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	5000 .
20 196	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1989	Vendor	1	**1817** 3000	5000 .
20 197	Hitachi S-820/80	Hitachi Ltd. GPCD Japan /1990	Vendor	1	**1817** 3000	5000 .
20 208	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	1000 .
20 209	Hitachi S-3600/180	Hitachi Ltd. GPCD Japan /1993	Vendor	1	**1672** 2000	1000 .
20 315	Hitachi S-820/60	Hitachi Ltd. Adv. Res. Lab Japan /1993	Vendor	1	**905** 1500	. .
20 316	Hitachi S-820/60	Hitachi Ltd. Cent. Res. Lab. Japan /1992	Vendor	1	**905** 1500	. .
20 317	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
20 318	Hitachi S-820/60	Hitachi Ltd. SICD Japan /1991	Vendor	1	**905** 1500	. .
20 319	Hitachi S-820/60	Hitachi Ltd. STRD Japan /1991	Vendor	1	**905** 1500	. .

U.S. Government, classified - 15.1 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21 10	TMC CM-5/256	Goverment USA /1993	Classified	256	**15100** 33000	26112 12032

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Pittsburgh Supercomputing Center - 14.7 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
22 26	Cray Y-MP C916/16256	Pittsburgh Supercomputing Center Pittsburgh USA /1992	Academic	16	**13700** 15238	10000 650
22 306	TMC CM-5/16	Pittsburgh Supercomputing Center Pittsburgh USA / .	Academic	16	**980** 2048	6528 3008

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US Naval Ocean. Commd, Bay St. Louis - 14.3 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
23 27	Cray Y-MP C916	US Naval Oceanographic Command Bay Saint Louis USA / .	Research Weather	16	**13700** 15238	10000 650
23 452	Cray Y-MP2E/216	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	2	**604** 666	. .

Japan Atomic Energy Research - 13.8 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
24 50	NEC SX-3/41R	Japan Atomic Energy Research Japan /1992	Research	4	**5800** 6400	3584 414
24 65	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
24 66	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .

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DOD/CEWES Vicksburg, Miss. - 13.7 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**R_{max}** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
25 15	Cray Y-MP C916/16256	DOD/CEWES Vicksburg USA /1993	Research Mechanics	16	**13700** 15238	10000 650

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ECMWF, Reading, UK - 13.7 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
25 18	Cray Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650

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KIST/System Engineering Res. Inst., Korea - 13.7 Gflop/s

N *Center* *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	$\mathbf{R_{max}}$ R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
25 23	Cray Y-MP C916	KIST/System Engineering Research Institute Korea /1993	Academic	16	**13700** 15238	10000 650

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A

TOP500 Supercomputer Sites—June 1993

Jack J. Dongarra
Hans-Werner Meuer
Erich Strohmaier

Abstract

To provide a better basis for statistics on high-performance computers, we list the sites that have the 500 most powerful computer systems installed. The best LINPACK benchmark performance achieved is used as a performance measure in ranking the computers.

A.1 Introduction and Objectives

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.

Statistical lists of supercomputers are not new. Every year since 1986 Hans Meuer [1] has published system counts of the major vector computer manufacturers, based principally on those at the Mannheim Supercomputer Seminar. Statistics based merely on the name of the manufacturer are no longer useful, however.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.

To provide this new statistical foundation, we have decided to assemble and maintain a list of the 500 most powerful computer sys-

[1]This chapter is a reprint of the Technical Report RUM 33/93, Computing Center, University of Mannheim, June 30, 1993

tems. Our list has been compiled with the help of high-performance computer experts, computational scientists, manufacturers, and the Internet community in general who responded to a questionnaire we sent out; we thank all the contributors for their cooperation. We have also used parts of statistical lists published by others for different purposes [2] [3].

In the present list (which we call the TOP500), we list computer ranked by their performance on the LINPACK Benchmark. While we make every attempt to verify the results obtained from users and vendors, errors are bound to exist and should be brought to our attention. We intend to update this list quarterly and, in this way, to keep track with the evolution of computers. Hence, we welcome any comments and information; please send electronic mail to *top500@rz.uni-mannheim.de*.

A.2 The Linpack Benchmark

As a yardstick of performance we are using the 'best' performance as measured by the LINPACK Benchmark [5]. LINPACK was chosen because it is widely used and performance numbers are available for almost all relevant systems.

The LINPACK Benchmark was introduced by Jack Dongarra. A detailed description as well as a list of performance results on a wide variety of machines is available from *netlib* by sending electronic mail to *netlib@ornl.gov* and by typing the message *send performance from benchmark*.

The problem used in the LINPACK Benchmark is to solve a dense system of linear equations. For the TOP500 list, 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.

By measuring the actual performance for different problem sizes n, a user can get not only the maximal achieved performance R_{max} for the problem size N_{max} but also the problem size $N_{1/2}$ where half of the performance R_{max} is achieved. These numbers together with the theoretical peak performance R_{peak} are the numbers given in the TOP500 list. 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.

A.3
The TOP500 List

Table A.1 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:

N_{world}	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	
# Proc.	Number of processors
$\mathbf{R_{max}}$	Maximal LINPACK performance achieved
R_{peak}	Theoretical peak performance
N_{max}	Problemsize for achieving R_{max}
$N_{1/2}$	Problemsize for achieving half of R_{max}

If R_{max} from Table 3 of the LINPACK Report [5] is not available, we use the TPP performance given in Table 1 [5] for solving a system of 1000 equations. 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 (e.g., Hitachi S3800/480, KSR1-256, bigger models of Paragon XPS), the performance of the next smaller system measured is used.

In Table A.1, the computers are ordered first by their R_{max} value. In the case of equal performances (R_{max} value) for different computers, we have chosen to order by R_{peak}. For sites that have the same computer, the order is alphabeticly.

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
1	Thinking Machines CM-5/1024	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	1024	**59700** 131000	52224 24064
2	Thinking Machines CM-5/1024	National Security Agency USA / .	Classified	1024	**59700** 131000	52224 24064
3	Thinking Machines CM-5/544	Minnesota Supercomputer Center USA / .	Academic	544	**30400** 70000	36864 16384
4	Thinking Machines CM-5/512	NCSA Urbana-Champaign USA / .	Academic	512	**30400** 66000	36864 16384
5	NEC SX-3/44R	NEC Fuchu Plant Japan /1990	Vendor	4	**23200** 26000	6400 830
6	NEC SX-3/44	Atmospheric Environment Service (AES) Dorval Canada /1991	Research Weather	4	**20000** 22000	6144 832
7	Thinking Machines CM-5/256	US Naval Research Laboratory USA /1992	Research	256	**15100** 33000	26112 12032
8	Intel Delta	Caltech Pasadena USA / .	Academic	512	**13900** 20000	25000 7500
9	Cray Research Y-MP C916/16256	Cray Research Eagan USA / .	Vendor	16	**13700** 15238	10000 650
10	Cray Research Y-MP C916/16256	DOE/Bettis Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
11	Cray Research Y-MP C916/16256	DOE/Knolls Atomic Power Laboratory USA /1993	Research	16	**13700** 15238	10000 650
12	Cray Research Y-MP C916/16128	ECMWF Reading UK /1993	Research Weather	16	**13700** 15238	10000 650
13	Cray Research Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
14	Cray Research Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
15	Cray Research Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
16	Cray Research Y-MP C916/161024	Government USA /1992	Classified	16	**13700** 15238	10000 650
17	Cray Research Y-MP C916/16256	Lawrence Livermore National Laboratory NERSC USA /1992	Research Energy	16	**13700** 15238	10000 650
18	Cray Research Y-MP C916/16256	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	16	**13700** 15238	10000 650
19	Cray Research Y-MP C916/16256	Pittsburgh Supercomputing Center Pittsburgh USA /1992	Academic	16	**13700** 15238	10000 650
20	Cray Research Y-MP C916/16512	US Army Waterways Experiment Station Vicksburg USA /1993	Research Mechanics	16	**13700** 15238	10000 650

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
21	Cray Research Y-MP C916	US Naval Oceanographic Command Bay Saint Louis USA / .	Research Weather	16	**13700** 15238	10000 650
22	NEC SX-3/24R	National Institute of Fusion Science (NIFS) Japan /1993	Research	2	**11600** 13000	4352 516
23	NEC SX-3/24	NEC Daito Supercomputer Center Japan /1991	Vendor	2	**10000** 11000	4352 500
24	Thinking Machines CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
25	Thinking Machines CM-200/64k	Los Alamos National Laboratory Los Alamos USA / .	Research Energy	2048	**9800** 20000	29696 11264
26	Thinking Machines CM-5/128	Institut de Physique du Globe de Paris (IPG) Paris France /1992	Research	128	**7700** 16000	18432 8192
27	Thinking Machines CM-5/128	MIT Cambridge USA / .	Research	128	**7700** 16000	18432 8192
28	Thinking Machines CM-5/128	NASA/Ames Research Center/NAS Moffett Field USA /1993	Research	128	**7700** 16000	18432 8192
29	Thinking Machines CM-5/128	Schlumberger Well Services USA /1992	Industry Geophysics	128	**7700** 16000	18432 8192
30	Cray Research Y-MP C916/8256	Ford Motor Company Dearborn USA /1992	Industry Automotive	8	**6850** 7619	. .
31	Cray Research Y-MP C916/8256	Minnesota Supercomputer Center USA / .	Academic	8	**6850** 7619	. .
32	Cray Research Y-MP C916/8256	NASA/Ames Research Center/CCF Moffett Field USA /1993	Research Aerospace	8	**6850** 7619	. .
33	Cray Research Y-MP C916/8128	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	8	**6850** 7619	. .
34	NEC SX-3/41R	Japan Atomic Energy Research Japan /1992	Research	4	**5800** 6400	3584 414
35	NEC SX-3/14R	Osaka University Osaka Japan /1993	Academic	1	**5800** 6400	2816 282
36	NEC SX-3/14R	Toyota Central Research Japan /1992	Industry Automotive	1	**5800** 6400	2816 282
37	Hitachi S-3800/480	Tokyo University Tokyo Japan /1993	Academic	4	**5715** 32000	. .
38	Thinking Machines CM-2/64k	Brandeis University USA / .	Academic	2048	**5200** 14000	26624 11000
39	Thinking Machines CM-2/64k	Florida State University Tallahassee USA / .	Academic	2048	**5200** 14000	26624 11000
40	Thinking Machines CM-200/32k	Minnesota Supercomputer Center USA / .	Academic	1024	**5000** 10000	21504 8192

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
41	NEC SX-3/22	Houston Advanced Research Center Houston USA / .	Research	2	**5000** 5500	3072 384
42	NEC SX-3/14	IBM Japan Tokyo Japan /1991	Industry Electronics	1	**5000** 5500	3072 384
43	NEC SX-3/22	National Aerospace Laboratory (NLR) Netherlands/1992	Research Aerospace	2	**5000** 5500	3072 384
44	NEC SX-3/14	National Institute of Environmental Studies Japan /1992	Research Environment	1	**5000** 5500	3072 384
45	NEC SX-3/22	Swiss Scientific Computing Center Manno Switzerland/1991	Research	2	**5000** 5500	3072 384
46	Fujitsu VP2600/10	Fuji Heavy Japan /1990	Industry Heavy Ind.	1	**4009** 5000	. .
47	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
48	Fujitsu VP2600/10	Japan Atomic Energy Research Japan /1991	Research	1	**4009** 5000	. .
49	Fujitsu VP2600/20	Kyoto University Kyoto Japan /1990	Academic	1	**4009** 5000	. .
50	Fujitsu VP2600/10	Kyushu University Kyushu Japan /1992	Academic	1	**4009** 5000	. .
51	Fujitsu VP2600/10	NAL (Space Technology) Japan /1990	Research	1	**4009** 5000	. .
52	Fujitsu VP2600/10	Nagoya University Nagoya Japan /1991	Academic	1	**4009** 5000	. .
53	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
54	Fujitsu VP2600/10	Reactor Nuclear Fuel Development Japan /1991	Research	1	**4009** 5000	. .
55	Fujitsu VP2600/10	Taisei Construction Japan /1992	Industry Construction	1	**4009** 5000	. .
56	Siemens-Nixdorf S600/20	Universitaet Aachen Aachen Germany /1991	Academic	1	**4009** 5000	. .
57	Siemens-Nixdorf S600/20	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	1	**4009** 5000	. .
58	Thinking Machines CM-5/64	ATR Kyoto Japan / .		64	**3800** 8000	13056 6016
59	Thinking Machines CM-5/64	Boston University Boston USA / .	Academic	64	**3800** 8000	13056 6016
60	Thinking Machines CM-5/64	GMD Birlinghoven Germany /1993	Research	64	**3800** 8000	13056 6016

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
61	Thinking Machines CM-5/64	Japanese AIST Hokuriku Japan /1993		64	**3800** 8000	13056 6016
62	Thinking Machines CM-5/64	Mobil / Technical Center Tulsa USA /1992	Industry Geophysics	64	**3800** 8000	13056 6016
63	Thinking Machines CM-5/64	Real World Computing (RWCP) Tokyo Japan /1992		64	**3800** 8000	13056 6016
64	Thinking Machines CM-5/64	University of Wisconsin USA / .	Academic	64	**3800** 8000	13056 6016
65	Siemens-Nixdorf S400/40	Universitaet Darmstadt Darmstadt Germany /1991	Academic	2	**3624** 5000	10239 .
66	Siemens-Nixdorf S400/40	Universitaet Hannover Hannover Germany /1991	Academic	2	**3624** 5000	10239 .
67	KSR KSR1-256	KSR Boston USA /1992	Vendor	256	**3380** 10240	10240 1824
68	KSR KSR1-256	US Army Research Laboratory Aberdeen USA /1993	Research	256	**3380** 10240	10240 1824
69	KSR KSR1-128	Cornell Theory Center Ithaca USA /1992	Academic	128	**3380** 5120	10240 1824
70	Intel XP/S15	Intel SSD Development Centers USA /1993	Vendor	208	**3300** 10400	10000 .
71	Intel XP/S15	NASA/Ames Research Center/NAS Moffett Field USA /1992	Research	208	**3300** 10400	10000 .
72	Intel XP/S10	Intel SSD Development Centers USA /1992	Vendor	140	**3300** 7000	10000 .
73	NEC SX-3/12R	Institute of Space Science (INPE) Brazil /1993	Research Weather	1	**2900** 3200	2048 174
74	NEC SX-3/12R	NEC Scientific Information (NSIS) Japan /1992	Research	1	**2900** 3200	2048 174
75	NEC SX-3/21R	Obayashi Corporation Japan /1992	Industry	2	**2900** 3200	2560 257
76	Thinking Machines CM-2/32k	AMK Bonn Germany /1990	Classified	1024	**2600** 7000	. .
77	Intel iPSC/860	Alliant Techsystems Inc. USA /1990	Industry Biochemistry	128	**2600** 5000	12000 4500
78	Intel iPSC/860	Grant Tensor UK /1991	Industry Geophysics	128	**2600** 5000	12000 4500
79	Intel iPSC/860	Grant Tensor USA /1991	Industry Geophysics	128	**2600** 5000	12000 4500
80	Intel iPSC/860	Grant Tensor Houston USA /1992	Industry Geophysics	128	**2600** 5000	12000 4500

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
81	Intel iPSC/860	Honeywell USA /1990	Industry	128	**2600** 5000	12000 4500
82	Intel iPSC/860	Lockheed Advanced Development Palmdale USA /1992	Industry Aerospace	128	**2600** 5000	12000 4500
83	Intel iPSC/860	NASA/Ames Research Center/NAS Moffett Field USA /1990	Research	128	**2600** 5000	12000 4500
84	Intel iPSC/860	NIH Frederick USA /1990	Research	128	**2600** 5000	12000 4500
85	Intel iPSC/860	ONERA France /1991	Research Aerospace	128	**2600** 5000	12000 4500
86	Intel iPSC/860	Oak Ridge National Laboratory Oak Ridge USA /1989	Research	128	**2600** 5000	12000 4500
87	Thinking Machines CM-200/16k	INRIA - Sophia Antipolis Rennes France /1992	Research	512	**2400** 5000	14848 5632
88	Thinking Machines CM-200/16k	US Naval Research Laboratory USA /1987	Research	512	**2400** 5000	14848 5632
89	Thinking Machines CM-200/16k	University of Edinburgh Edinburgh UK / .	Research	512	**2400** 5000	14848 5632
90	Cray Research CRAY-2s/8-128	Lawrence Livermore National Laboratory NERSC USA /1990	Research Energy	8	**2171** 3902	. .
91	Cray Research Y-MP8E/8256	Arabian American Oil Company USA /1991	Industry Geophysics	8	**2144** 2667	. .
92	Cray Research Y-MP8/864	Atomic Weapons Establishment USA /1990	Classified	8	**2144** 2667	. .
93	Cray Research Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
94	Cray Research Y-MP8/8128	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
95	Cray Research Y-MP8/832	Cray Research Eagan USA / .	Vendor	8	**2144** 2667	. .
96	Cray Research Y-MP8/864	DOE/Bettis Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .
97	Cray Research Y-MP8/864	DOE/Knolls Atomic Power Laboratory USA /1990	Research	8	**2144** 2667	. .
98	Cray Research Y-MP8/8256	DOE/National Security Agency USA / .	Classified	8	**2144** 2667	. .
99	Cray Research Y-MP8/864	Government Communications Headquarters Benhall UK / .	Classified	8	**2144** 2667	. .
100	Cray Research Y-MP8/832	KFA Juelich Germany /1989	Research	8	**2144** 2667	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
101	Cray Research Y-MP8/8128	Lawrence Livermore National Laboratory Livermore USA /1991	Research	8	**2144** 2667	. .
102	Cray Research Y-MP8/864	Lawrence Livermore National Laboratory Livermore USA /1992	Research	8	**2144** 2667	. .
103	Cray Research Y-MP8/864	Leibniz Rechenzentrum Muenchen Germany /1992	Academic	8	**2144** 2667	. .
104	Cray Research Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
105	Cray Research Y-MP8/8128	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
106	Cray Research Y-MP8/864	Los Alamos National Laboratory Los Alamos USA /1992	Research Energy	8	**2144** 2667	. .
107	Cray Research Y-MP8/864	NASA/Goddard Space Flight Center Greenbelt USA /1993	Research Weather	8	**2144** 2667	. .
108	Cray Research Y-MP8E/8256	NASA/Langley Research Center Hampton USA /1992	Research	8	**2144** 2667	. .
109	Cray Research Y-MP8/8128	NASA/Lewis Research Center USA /1991	Research	8	**2144** 2667	. .
110	Cray Research Y-MP8/832	NOAA USA /1990	Research Weather	8	**2144** 2667	. .
111	Cray Research Y-MP8/832	NOAA/GFDL USA /1990	Research Weather	8	**2144** 2667	. .
112	Cray Research Y-MP8/8128	National Cancer Institute USA /1991	Research Chemistry	8	**2144** 2667	. .
113	Cray Research Y-MP8/864	National Center for Atmospheric Research Boulder USA /1990	Research Weather	8	**2144** 2667	. .
114	Cray Research Y-MP8E/8128	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	8	**2144** 2667	. .
115	Cray Research Y-MP8/864	Ohio Supercomputer Center Columbus USA /1989	Academic	8	**2144** 2667	. .
116	Cray Research Y-MP8/864	Sandia National Labs Albuquerque USA / .	Research	8	**2144** 2667	. .
117	Cray Research Y-MP8/8128	Tohoku University, Institute of Fluid Science Aramaki Japan /1992	Academic	8	**2144** 2667	. .
118	Cray Research Y-MP8/864	UCSD/San Diego Supercomputer Center San Diego USA /1989	Academic	8	**2144** 2667	. .
119	Cray Research Y-MP8I/8128	UK Atlas Supercomputing Center UK / .	Research	8	**2144** 2667	. .
120	Cray Research Y-MP8/864	United Kingdom Meteorological Office UK /1991	Research Weather	8	**2144** 2667	. .

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
121	Cray Research Y-MP8/864	United Kingdom Meteorological Office UK /1991	Research Weather	8	**2144** 2667	. .
122	Cray Research Y-MP8/864	University of Texas Austin USA /1990	Academic	8	**2144** 2667	. .
123	Fujitsu VPX240/20	Fujitsu Houston USA / .	Vendor	1	**2110** 2500	. .
124	Fujitsu VPX240/10	High Performance Computing Center Alberta Canada / .	Research	1	**2110** 2500	. .
125	Siemens-Nixdorf S400/10	IFP (Institute Francais du Petrole) Rueil France /1991	Academic Geophysics	1	**2110** 2500	. .
126	Fujitsu VPX240/10	University of Manchester Manchester UK /1993	Academic	1	**2110** 2500	. .
127	Thinking Machines CM-5/32	AMOCO Tulsa USA / .	Industry Geophysics	32	**1900** 4000	9216 4096
128	Thinking Machines CM-5/32	Australian National University Canberra Australia / .	Academic	32	**1900** 4000	9216 4096
129	Thinking Machines CM-5/32	Booz-Allen Hamilton Washington DC USA / .	Industry Consulting	32	**1900** 4000	9216 4096
130	Thinking Machines CM-5/32	Columbia University New York City USA / .	Academic	32	**1900** 4000	9216 4096
131	Thinking Machines CM-5/32	Compagnie Generale de Geophysique (CGG) France /1993	Industry Geophysics	32	**1900** 4000	9216 4096
132	Thinking Machines CM-5/32	Duke University Durham USA / .	Academic	32	**1900** 4000	9216 4096
133	Thinking Machines CM-5/32	Etablissement Technique Central de l'Armement ETCA France /1993	Academic	32	**1900** 4000	9216 4096
134	Thinking Machines CM-5/32	Experimental Hyperparallelism Site France / .	Research	32	**1900** 4000	9216 4096
135	Thinking Machines CM-5/32	JPL Pasadena USA / .	Research	32	**1900** 4000	9216 4096
136	Thinking Machines CM-5/32	National Center for Atmospheric Research Boulder USA / .	Research Weather	32	**1900** 4000	9216 4096
137	Thinking Machines CM-5/32	Oregon State University USA / .	Academic	32	**1900** 4000	9216 4096
138	Thinking Machines CM-5/32	SEH/ETCA France / .		32	**1900** 4000	9216 4096
139	Thinking Machines CM-5/32	Stanford University USA / .	Academic	32	**1900** 4000	9216 4096
140	Thinking Machines CM-5/32	Syracuse University Syracuse USA / .	Academic	32	**1900** 4000	9216 4096

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
141	Thinking Machines CM-5/32	Tokyo University, Medical Lab Tokyo Japan /1993	Academic	32	**1900** 4000	9216 4096
142	Thinking Machines CM-5/32	Universitaet Wuppertal Wuppertal Germany /1992	Academic	32	**1900** 4000	9216 4096
143	Thinking Machines CM-5/32	University of Adelaide Adelaide Australia / .	Academic	32	**1900** 4000	9216 4096
144	Thinking Machines CM-5/32	University of California at Berkeley USA / .	Academic	32	**1900** 4000	9216 4096
145	Thinking Machines CM-5/32	University of Maryland USA / .	Academic	32	**1900** 4000	9216 4096
146	Thinking Machines CM-5/32	University of New South Wales Kensington Australia / .	Academic	32	**1900** 4000	9216 4096
147	Thinking Machines CM-5/32	University of Tennessee Knoxville USA / .	Academic	32	**1900** 4000	9216 4096
148	Intel XP/S5	Boeing Seattle USA /1992	Industry Aerospace	66	**1900** 3300	8000 .
149	Intel XP/S5	Intel SSD Development Centers USA /1993	Vendor	66	**1900** 3300	8000 .
150	Intel XP/S5	KFA Juelich Germany /1992	Research	66	**1900** 3300	8000 .
151	Intel XP/S5-32	NASA/Langley Research Center Hampton USA /1992	Research	66	**1900** 3300	8000 .
152	Intel XP/S5	Oak Ridge National Laboratory Oak Ridge USA / .	Research	66	**1900** 3300	8000 .
153	Intel XP/S5	Prudential Bache Securities New York USA /1993	Industry	66	**1900** 3300	8000 .
154	Intel XP/S5	Real World Computing (RWC) Tokyo Japan /1993		66	**1900** 3300	8000 .
155	Intel XP/S5-32	Universitaet Stuttgart Stuttgart Germany /1992	Academic	66	**1900** 3300	8000 .
156	nCube nCUBE2	Sandia National Labs Albuquerque USA / .	Research	1024	**1900** 2400	21376 3193
157	KSR KSR1-64	Caltech Pasadena USA /1992	Academic	64	**1838** 2560	9216 1536
158	KSR KSR1-64	Government UK /1992	Classified	64	**1838** 2560	9216 1536
159	KSR KSR1-64	Oak Ridge National Laboratory Oak Ridge USA /1991	Research	64	**1838** 2560	9216 1536
160	KSR KSR1-64	University of Colorado USA /1992	Academic	64	**1838** 2560	9216 1536

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
161	KSR KSR1-64	University of Massachusetts Amherst USA /1993	Academic	64	**1838** 2560	9216 1536
162	Cray Research Y-MP M98	Cray Research Eagan USA / .	Vendor	8	**1733** 2667	. .
163	Fujitsu VP2400/10	CESGA Spain /1992	Academic	1	**1688** 2000	. .
164	Fujitsu VP2400/20	Computer Technology Integrated (CTI) Japan /1991	Industry	1	**1688** 2000	. .
165	Hitachi S-820/80	Hokkaido University Sapporo Japan /1989	Academic	1	**1672** 3000	. .
166	Hitachi S-820/80	Institute of Molecular Science Japan /1988	Research	1	**1672** 3000	. .
167	Hitachi S-820/80	Nat. Lab. for High Energy Physics Japan /1988	Research	1	**1672** 3000	. .
168	Hitachi S-820/80	Nihon University Japan /1993	Academic	1	**1672** 3000	. .
169	Hitachi S-820/80	Senshu University Japan / .	Academic	1	**1672** 3000	. .
170	Cray Research Y-MP8/664	Cray Research Eagan USA / .	Vendor	6	**1651** 2000	. .
171	Cray Research Y-MP8/6128	DOE/CEWES USA /1990	Research Weather	6	**1651** 2000	. .
172	Cray Research Y-MP8I/6128	NASA/Marshall Space Flight Center USA /1993	Research Aerospace	6	**1651** 2000	. .
173	Cray Research Y-MP8/664	Nissan Motor Kanagawa Japan /1990	Academic	6	**1651** 2000	. .
174	Cray Research Y-MP8I/632	Tawain Central Weather Bureau Taiwan /1992	Research Weather	6	**1651** 2000	. .
175	Cray Research Y-MP8/632	Toyota Motor Company Japan /1991	Industry Automotive	6	**1651** 2000	. .
176	MasPar MP-2216	Lockheed Missiles and Space Company USA /1993	Industry Aerospace	16384	**1600** 2400	11264 1920
177	MasPar MP-2216	National Cancer Institute USA /1993	Research Chemistry	16384	**1600** 2400	11264 1920
178	dec DECmpp SX 200	University of Bergen Bergen Norway / .	Academic	16384	**1600** 2400	11264 1920
179	KSR KSR1-56	University of Washington Seattle USA /1992	Academic	56	**1590** 2240	. .
180	Intel XP/A4	Caltech Pasadena USA /1993	Academic	56	**1500** 4200	6000 .

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
181	Intel XP/A4	Hiroshima University Japan /1993	Academic	56	**1500** 4200	6000 .
182	Intel XP/A4E	IRISA Rennes France /1993	Research Aerospace	56	**1500** 4200	6000 .
183	Intel XP/A4	Rice University USA /1993	Academic	56	**1500** 4200	6000 .
184	Intel XP/A4	Sandia National Labs Livermore USA /1993	Research Energy	56	**1500** 4200	6000 .
185	Intel XP/A4E	Technische Universitaet Graz Graz Austria /1993	Academic	56	**1500** 4200	6000 .
186	Intel XP/A4	University of Indiana USA /1993	Academic	56	**1500** 4200	6000 .
187	Intel XP/A4	University of Melbourne Australia /1993	Academic	56	**1500** 4200	6000 .
188	Intel XP/A4	University of South Carolina USA /1992	Academic	56	**1500** 4200	6000 .
189	Intel XP/A4	University of Trondheim Norway /1992	Academic	56	**1500** 4200	6000 .
190	Cray Research CRAY-2s/4-128	DKRZ Germany /1988	Research Weather	4	**1406** 1952	. .
191	Cray Research CRAY-2s/4-128	KIST/System Engineering Research Institute Korea /1988	Academic	4	**1406** 1952	. .
192	Cray Research CRAY-2s/4-128	Lawrence Livermore National Laboratory NERSC USA /1988	Research Energy	4	**1406** 1952	. .
193	Cray Research CRAY-2s/4-128	NASA/Langley Research Center Hampton USA /1989	Research	4	**1406** 1952	. .
194	Cray Research CRAY-2s/4-128	NCSA Urbana-Champaign USA /1988	Academic	4	**1406** 1952	. .
195	Cray Research CRAY-2/4-256	Air Force/Phillips Lab USA /1987	Research Aerospace	4	**1406** 1951	. .
196	Cray Research CRAY-2/4-512	Arabian American Oil Company USA /1992	Industry Geophysics	4	**1406** 1951	. .
197	Cray Research CRAY-2/4-256	Commissariat a l'Energie Atomique Grenoble France /1989	Research Energy	4	**1406** 1951	. .
198	Cray Research CRAY-2/4-128	Cray Research Eagan USA / .	Vendor	4	**1406** 1951	. .
199	Cray Research CRAY-2/4-256	Defense Research Agency Farnborough UK /1990	Classified	4	**1406** 1951	. .
200	Cray Research CRAY-2/4-256	Direction de la Meteorologie Nationale France /1989	Research Weather	4	**1406** 1951	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
201	Cray Research CRAY-2/4-256	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1990	Academic	4	**1406** 1951	. .
202	Cray Research CRAY-2/4-512	Minnesota Supercomputer Center USA /1988	Academic	4	**1406** 1951	. .
203	Cray Research CRAY-2/4-256	NASA/Ames Research Center/NAS Moffett Field USA /1991	Classified	4	**1406** 1951	. .
204	Cray Research CRAY-2/4-256	NT T Japan /1987	Industry Electronics	4	**1406** 1951	. .
205	Cray Research CRAY-2/4-512	US Air Force/National Test Facility USA /1990	Classified	4	**1406** 1951	. .
206	Cray Research CRAY-2/4-256	Universitaet Stuttgart Stuttgart Germany /1986	Research	4	**1406** 1951	. .
207	Intel iPSC/860	Caltech Pasadena USA /1990	Academic	64	**1400** 2500	9000 3500
208	Intel iPSC/860	Daresbury Laboratory Warrington UK / .	Research	64	**1400** 2500	9000 3500
209	Intel iPSC/860	McDonnell Douglas USA /1991	Industry Aerospace	64	**1400** 2500	9000 3500
210	Intel iPSC/860	SERC USA /1990	Research	64	**1400** 2500	9000 3500
211	Intel iPSC/860	Sandia National Labs Albuquerque USA /1991	Research	64	**1400** 2500	9000 3500
212	Intel iPSC/860	Superconducting Supercollider Lab USA /1990	Research	64	**1400** 2500	9000 3500
213	Intel iPSC/860	UCSD/San Diego Supercomputer Center San Diego USA /1990	Academic	64	**1400** 2500	9000 3500
214	Intel iPSC/860	Westinghouse Electric USA /1992	Industry Energy	64	**1400** 2500	9000 3500
215	KSR KSR1-48	North Carolina Supercomputer Center USA /1992	Academic	48	**1350** 1920	. .
216	Thinking Machines CM-2/16k	ATR Japan /1990		512	**1300** 3500	. .
217	Thinking Machines CM-2/16k	Australian National University Canberra Australia / .	Academic	512	**1300** 3500	. .
218	Thinking Machines CM-2/16k	GMD Birlinghoven Germany /1990	Research	512	**1300** 3500	. .
219	Thinking Machines CM-2/16k	ICFD Japan /1991	Research	512	**1300** 3500	. .
220	Meiko CS/i860/64	University of Edinburgh Edinburgh UK /1990	Academic	64	**1300** 2500	8500 3500

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
221	NEC SX-3/11	Sanyo Electric Moriguchi City Japan /1991	Industry Electronics	1	**1300** 1370	2816 192
222	NEC SX-3/11	Tokai University Tokai Japan /1992	Academic	1	**1300** 1370	2816 192
223	NEC SX-3/11	Universitaet Koeln Koeln Germany /1990	Academic	1	**1300** 1370	2816 192
224	Cray Research Y-MP8/4128	BMW AG Germany /1992	Industry Automotive	4	**1159** 1333	. .
225	Cray Research Y-MP8E/4128	Boeing Seattle USA / .	Industry Aerospace	4	**1159** 1333	. .
226	Cray Research Y-MP8/464	CINECA Bologna Italy /1992	Academic	4	**1159** 1333	. .
227	Cray Research Y-MP8I/464	Chrysler Motors Company USA /1992	Industry Automotive	4	**1159** 1333	. .
228	Cray Research Y-MP4E/464	Citroen Peugeot Velizy France /1992	Industry Automotive	4	**1159** 1333	. .
229	Cray Research Y-MP4/432	Compagnie Generale de Geophysique (CGG) France /1992	Industry Geophysics	4	**1159** 1333	. .
230	Cray Research Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
231	Cray Research Y-MP4/464	Cray Research Eagan USA / .	Vendor	4	**1159** 1333	. .
232	Cray Research Y-MP8/432	Defense Research Agency Ford Halstead UK /1990	Research	4	**1159** 1333	. .
233	Cray Research Y-MP4/432	Deutscher Wetterdienst Offenbach Germany /1990	Research Weather	4	**1159** 1333	. .
234	Cray Research Y-MP8/432	EXXON USA /1992	Industry Geophysics	4	**1159** 1333	. .
235	Cray Research Y-MP4/464	Eidgenoessische Technische Hochschule Zuerich Switzerland/1992	Academic	4	**1159** 1333	. .
236	Cray Research Y-MP8/4128	Electricite de France Clamart France /1990	Industry Energy	4	**1159** 1333	. .
237	Cray Research Y-MP4/432	Florida State University Tallahassee USA /1990	Academic	4	**1159** 1333	. .
238	Cray Research Y-MP4E/464	MPI Garching Germany /1991	Research	4	**1159** 1333	. .
239	Cray Research Y-MP4E/464	Matsushita Electric Osaka Japan /1992	Academic	4	**1159** 1333	. .
240	Cray Research Y-MP8I/4128	Merck Co USA /1993	Industry Chemistry	4	**1159** 1333	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
241	Cray Research Y-MP4/464	Mitsubishi Motors Company Japan /1992	Industry Automotive	4	**1159** 1333	. .
242	Cray Research Y-MP4/464	NCSA Urbana-Champaign USA /1990	Academic	4	**1159** 1333	. .
243	Cray Research Y-MP8/464	North Carolina Supercomputer Center USA /1991	Academic	4	**1159** 1333	. .
244	Cray Research Y-MP8/4128	ONERA France /1991	Research Aerospace	4	**1159** 1333	. .
245	Cray Research Y-MP4/464	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1990	Academic	4	**1159** 1333	. .
246	Cray Research Y-MP4E/464	Samsung Korea /1991	Industry Electronics	4	**1159** 1333	. .
247	Cray Research Y-MP8/4128	Toshiba Kanagawa Japan /1990	Academic	4	**1159** 1333	. .
248	Cray Research Y-MP4/432	Universidad Nacional Autonoma de Mexico Mexico /1991	Academic	4	**1159** 1333	. .
249	Cray Research Y-MP4/464	University of Trondheim Norway /1992	Academic	4	**1159** 1333	. .
250	Cray Research Y-MP M94/4256	KFA Juelich Germany /1993	Research	4	**1114** 1333	. .
251	Cray Research Y-MP M98/41024	University of Alaska Fairbanks USA /1992	Academic	4	**1114** 1333	. .
252	Fujitsu VPX220/10	GECO-PRAKLA Houston USA /1993	Industry Geophysics	1	**1048** 1250	. .
253	Siemens-Nixdorf S200/10	Schering Germany /1991	Industry Chemistry	1	**1048** 1250	. .
254	Siemens-Nixdorf S200/20	Siemens Muenchen Germany /1991	Industry Electronics	1	**1048** 1250	. .
255	Thinking Machines CM-5/16	Kyushu University Kyushu Japan / .	Academic	16	**980** 2000	6528 3008
256	Thinking Machines CM-5/16	Pittsburgh Supercomputing Center Pittsburgh USA / .	Academic	16	**980** 2000	6528 3008
257	Thinking Machines CM-5/16	RUG (Rijksuniversiteit Groningen) Groningen Netherlands/1993	Academic	16	**980** 2000	6528 3008
258	Thinking Machines CM-5/16	West Virginia University USA / .	Academic	16	**980** 2000	6528 3008
259	Parsytec GCel 3/1024	Universitaet Koeln/DLR Koeln Germany /1992	Academic	1024	**971** 1540	15999 2073
260	Parsytec GCel 3/1024	Universitaet Paderborn Paderborn Germany /1992	Academic	1024	**971** 1540	15999 2073

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
261	Meiko CS/i860/42	Ensign Geophysics Weybridge UK /1987	Academic	42	**970** 1700	. .
262	nCube nCUBE2	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	512	**958** 1200	15200 2240
263	nCube nCUBE2	Rockwell USA /1992	Industry Aerospace	512	**958** 1200	15200 2240
264	KSR KSR1-32	GWDG Goettingen Germany /1992	Academic	32	**893** 1280	6144 896
265	KSR KSR1-32	Georgia Institute of Technology USA /1992	Research	32	**893** 1280	6144 896
266	KSR KSR1-32	Leibniz Rechenzentrum Muenchen Germany /1993	Academic	32	**893** 1280	6144 896
267	KSR KSR1-32	Siemens Nixdorf Muenchen Germany /1993	Vendor	32	**893** 1280	6144 896
268	KSR KSR1-32	Universitaet Mannheim Mannheim Germany /1992	Academic	32	**893** 1280	6144 896
269	KSR KSR1-32	University of Houston USA /1992	Academic	32	**893** 1280	6144 896
270	KSR KSR1-32	University of Manchester Manchester UK /1992	Academic	32	**893** 1280	6144 896
271	KSR KSR1-32	University of Michigan Michigan USA /1992	Academic	32	**893** 1280	6144 896
272	NEC SX-2	Aoyama Gakuin University Japan /1988	Academic	1	**885** 1333	. .
273	NEC SX-2	Institute Laser Eng Osaka Univ. Osaka Japan /1985	Academic	1	**885** 1333	. .
274	NEC SX-2	Institute of Computational Fluid Dynamics Japan /1987	Research	1	**885** 1333	. .
275	NEC SX-2A	Mazda Motor Corporation Yokohama Japan /1989	Industry Automotive	1	**885** 1333	. .
276	NEC SX-2	NEC Fuchu Plant Japan /1987	Vendor	1	**885** 1333	. .
277	NEC SX-2	NEC Scientific Information (NSIS) Japan /1985	Research	1	**885** 1333	. .
278	NEC SX-2	Sumitomo Metal Industries Japan /1988	Industry	1	**885** 1333	. .
279	NEC SX-2	Tohoku University Tohoku Japan /1988	Academic	1	**885** 1333	. .
280	Cray Research Y-MP4/332	Arco Oil and Gas Company USA /1992	Industry Geophysics	3	**881** 999	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
281	Cray Research Y-MP4E/364	British Aerospace PLC UK /1991	Industry Aerospace	3	**881** 999	. .
282	Cray Research Y-MP4E/364	DKRZ Germany /1991	Research Weather	3	**881** 999	. .
283	Cray Research Y-MP4/332	Du Pont De Nemours Company USA /1990	Industry Chemistry	3	**881** 999	. .
284	Cray Research Y-MP8/364	Honda Research and Development Company Tokyo Japan /1990	Industry Automotive	3	**881** 999	. .
285	Cray Research Y-MP4/364	Mitsubishi Electric Corporation Kanagawa Japan /1991	Industry Electronics	3	**881** 999	. .
286	Cray Research Y-MP4E/364	Mobil / Technical Center Tulsa USA /1993	Industry Geophysics	3	**881** 999	. .
287	Cray Research Y-MP4E/364	Renault France /1992	Industry Automotive	3	**881** 999	. .
288	Cray Research Y-MP4/332	Shell USA USA /1992	Industry Geophysics	3	**881** 999	. .
289	Cray Research Y-MP8/364	VW (Volkswagen AG) Wolfsburg Germany /1991	Industry Automotive	3	**881** 999	. .
290	Cray Research Y-MP4/364	debis Stuttgart Germany /1991	Industry Automotive	3	**881** 999	. .
291	Cray Research Y-MP M98/31024	General Motors/Research Environment Staff USA /1993	Industry Automotive	3	**855** 999	. .
292	Fujitsu VP2200/10	ANSTO Australia /1991	Academic	1	**842** 1000	. .
293	Fujitsu VP2200/10	Australian National University Canberra Australia /1991	Academic	1	**842** 1000	. .
294	Fujitsu VP2200/10	Kawasaki Heavy Industry Japan /1990	Industry Heavy Ind.	1	**842** 1000	. .
295	Fujitsu VP2200/10	Kawasaki Steel Japan /1991	Industry Heavy Ind.	1	**842** 1000	. .
296	Fujitsu VP2200/10	Meiji University Japan /1990	Academic	1	**842** 1000	. .
297	Fujitsu VP2200/10	Nikko Securities Japan /1991	Industry finance	1	**842** 1000	. .
298	Fujitsu VP2200/10	Nippon Steel Japan /1992	Industry Heavy Ind.	1	**842** 1000	. .
299	Fujitsu VP2200/10	SONY Japan /1991	Industry	1	**842** 1000	. .
300	Fujitsu VP2200/10	Sharp Japan /1990	Industry Electronics	1	**842** 1000	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
301	Fujitsu VP2200/20	Toyota Motor Company Japan /1991	Industry Automotive	1	**842** 1000	. .
302	Siemens-Nixdorf S200/10 (4ns)	Universitaet Frankfurt Frankfurt Germany /1991	Academic	1	**842** 1000	. .
303	Meiko CS/i860/32	DRA Malvern Weybridge UK /1990	Research	32	**825** 1300	7000 3000
304	Cray Research X-MP/416	AMK Bonn Germany /1990	Classified	4	**822** 940	. .
305	Cray Research X-MPea/432	BP Exploration Inc./U.S. USA /1990	Industry Geophysics	4	**822** 940	. .
306	Cray Research X-MP/48	Battelle Software Seattle USA / .	Industry Energy	4	**822** 940	. .
307	Cray Research X-MPea/432	CSC (Centre for Sientific computing) Espoo Finland /1990	Academic	4	**822** 940	. .
308	Cray Research X-MP/4	Chevron La Habra USA / .	Industry Geophysics	4	**822** 940	. .
309	Cray Research X-MP/416	Compagnie Generale de Geophysique (CGG) France /1992	Industry Geophysics	4	**822** 940	. .
310	Cray Research X-MP/416	Cray Research Eagan USA / .	Vendor	4	**822** 940	. .
311	Cray Research X-MP/416	Lawrence Livermore National Laboratory Livermore USA /1987	Research	4	**822** 940	. .
312	Cray Research X-MPea/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
313	Cray Research X-MPea/464	Lockheed Missiles and Space Company USA /1990	Industry Aerospace	4	**822** 940	. .
314	Cray Research X-MP/4	MIT Cambridge USA / .	Research	4	**822** 940	. .
315	Cray Research X-MP/416	Michelin France /1992	Industry Automotive	4	**822** 940	. .
316	Cray Research X-MPea/464	Minnesota Supercomputer Center USA /1991	Academic	4	**822** 940	. .
317	Cray Research X-MPea/464	Minnesota Supercomputer Center USA /1992	Academic	4	**822** 940	. .
318	Cray Research X-MP/416	NASA/Marshall Space Flight Center USA /1988	Research Aerospace	4	**822** 940	. .
319	Cray Research X-MP/416	Swedish National Supercomputer Centre Sweden /1991	Academic	4	**822** 940	. .
320	Convex C3880	CONVEX Dallas USA /1992	Vendor	8	**795** 960	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
321	Convex C3880	DKRZ Germany /1993	Research Weather	8	**795** 960	. .
322	Convex C3880	DMI Copenhagen Denmark /1992		8	**795** 960	. .
323	Convex C3880	Ford Dearborn USA /1992	Industry Automotive	8	**795** 960	. .
324	Convex C3880	NCSA Urbana-Champaign USA /1992	Academic	8	**795** 960	. .
325	Convex C3880	SICAN Hannover Germany /1993	Industry	8	**795** 960	. .
326	Convex C3880	UNOCAL USA /1992	Industry	8	**795** 960	. .
327	Siemens-Nixdorf VP400EX	KFK Karlsruhe Germany /1990	Research	1	**794** 1714	. .
328	Fujitsu VP-400E	NAL Japan /1987		1	**794** 1714	. .
329	NEC SX-3/1LR	Sumitomo Rubber Industries Japan /1992	Industry Chemistry	1	**780** 800	2304 112
330	MasPar MP-2208	Arizona State University USA /1993	Academic	8192	**766** 1200	9386 1374
331	Cray Research S-MP/MCP784	Canon USA / .	Industry	84	**742** 3360	. .
332	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
333	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
334	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
335	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
336	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
337	Cray Research S-MP/MCP784	Martin Marietta USA / .	Industry Defense	84	**742** 3360	. .
338	Cray Research CRAY-2s/2-128	Eli Lilly and Company USA /1990	Industry Chemistry	2	**741** 976	. .
339	Cray Research CRAY-2s/2-128	US Air Force/National Test Facility USA /1988	Classified	2	**741** 976	. .
340	Cray Research S-MP/MCP756	CNR-Napoli USA / .		56	**678** 2210	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
341	Cray Research S-MP/MCP256	Cray Research Eagan USA / .	Vendor	56	**678** 2210	. .
342	Cray Research S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
343	Cray Research S-MP/MCP756	Special Systems USA / .		56	**678** 2210	. .
344	NEC SX-3/1L	Hino Motor Japan /1992	Industry Automotive	1	**670** 680	2048 128
345	NEC SX-3/1L	Kajima Construction Japan /1991	Industry	1	**670** 680	2048 128
346	NEC SX-3/1L	Komatsu MFG Japan /1991	Industry	1	**670** 680	2048 128
347	Thinking Machines CM-2/8k	Universitaet Wuppertal Wuppertal Germany /1990	Academic	256	**650** 1750	. .
348	Thinking Machines CM-2/8k	University of Parma Parma Italy / .	Academic	256	**650** 1750	. .
349	Intel iPSC/860	Fermi National Accelerator Laboratory Batavia USA / .	Research	32	**640** 1280	6000 2500
350	Intel iPSC/860	GSF Neuherberg Germany /1990	Research	32	**640** 1280	6000 2500
351	Intel iPSC/860	KFA Juelich Germany /1991	Research	32	**640** 1280	6000 2500
352	Intel iPSC/860	Universitaet Saarbruecken Saarbruecken Germany /1990	Academic	32	**640** 1280	6000 2500
353	Convex M3860/8	CIRA Italy /1993		6	**615** 720	. .
354	Convex C3860	GRS (Gesellschaft fuer Reaktorsicherheit) Muenchen Germany /1993	Research	6	**615** 720	. .
355	Convex C3860	Josef Stefan Institut Ljubljana Slovenia /1993	Research	6	**615** 720	. .
356	Convex C3860	MIT Cambridge USA /1993	Research	6	**615** 720	. .
357	Cray Research Y-MP4E/264	AGIP Italy /1993	Industry Geophysics	2	**604** 666	. .
358	Cray Research Y-MP2E/232	Agency for Defense Development Korea /1992	Classified	2	**604** 666	. .
359	Cray Research Y-MP8/2128	Air Force/Eglin Air Force Base USA /1990	Classified	2	**604** 666	. .
360	Cray Research Y-MP2E/232	Apple Computer Inc. USA /1991	Industry Electronics	2	**604** 666	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
361	Cray Research Y-MP2E/232	Audi AG Ingolstadt Germany /1992	Industry Automotive	2	**604** 666	. .
362	Cray Research Y-MP2E/232	Bundesanstalt fuer Wasserbau Germany /1992	Research Geophysics	2	**604** 666	. .
363	Cray Research Y-MP2E/232	Bureau of Meterology Melbourne Australia /1992	Research Weather	2	**604** 666	. .
364	Cray Research Y-MP2E/232	CONOCO Inc. USA /1991	Industry Geophysics	2	**604** 666	. .
365	Cray Research Y-MP4E/264	CSIRO (Commonwealth Scientific) Carlton Australia / .	Research	2	**604** 666	. .
366	Cray Research Y-MP4E/232	Canon Sales Tokyo Japan /1992	Industry	2	**604** 666	. .
367	Cray Research Y-MP2E/232	Centro de Supercomputacion de Catalunya Barcelona Spain /1992	Academic	2	**604** 666	. .
368	Cray Research Y-MP4E/232	Compagnie Generale de Geophysique (CGG) UK /1992	Industry Geophysics	2	**604** 666	. .
369	Cray Research Y-MP2/232	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
370	Cray Research Y-MP8/21024	Cray Research Eagan USA / .	Vendor	2	**604** 666	. .
371	Cray Research Y-MP2/232	DLR Oberpfaffenhofen Germany /1990	Research	2	**604** 666	. .
372	Cray Research Y-MP2E/232	Daihatsu Motor Company Japan /1992	Industry Automotive	2	**604** 666	. .
373	Cray Research Y-MP2E/264	Disaster Prevention Research Japan /1992	Research	2	**604** 666	. .
374	Cray Research Y-MP2E/232	EDS/ Adam Opel AG Ruesselsheim Germany /1992	Industry auot	2	**604** 666	. .
375	Cray Research Y-MP4E/264	Ecole Polytechnique Federale de Lausanne Lausanne Switzerland/1992	Academic	2	**604** 666	. .
376	Cray Research Y-MP4/264	Electricite de France Clamart France /1992	Industry Energy	2	**604** 666	. .
377	Cray Research Y-MP4/216	Fiat Italy /1991	Industry Automotive	2	**604** 666	. .
378	Cray Research Y-MP2E/232	Grumman Aerospace Corporation USA /1991	Industry Aerospace	2	**604** 666	. .
379	Cray Research Y-MP4/264	Harwell Laboratory UK /1993	Research Energy	2	**604** 666	. .
380	Cray Research Y-MP2E/232	Institute Mediterraneen de Technologie Marseille France /1991	Academic	2	**604** 666	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
381	Cray Research Y-MP2E/232	Isuzu Motor Tokyo Japan /1991	Industry Automotive	2	**604** 666	. .
382	Cray Research Y-MP2E/264	Kyoto University, Chemical Research Kyoto Japan /1992	Academic	2	**604** 666	. .
383	Cray Research Y-MP2/216	Lockheed Aeronautical Systems Company USA /1992	Industry Aerospace	2	**604** 666	. .
384	Cray Research Y-MP8/264	Los Alamos National Laboratory Los Alamos USA /1990	Research Energy	2	**604** 666	. .
385	Cray Research Y-MP2E/264	Marion Merrell Dow Inc USA /1992	Industry Chemistry	2	**604** 666	. .
386	Cray Research Y-MP2E/232	Mazda Motor Corporation Yokohama Japan /1991	Industry Automotive	2	**604** 666	. .
387	Cray Research Y-MP2E/216	Mazda Motor Corporation Yokohama Japan /1992	Industry Automotive	2	**604** 666	. .
388	Cray Research Y-MP2/216	NBS USA /1991	Research Weather	2	**604** 666	. .
389	Cray Research Y-MP2	National Center for Atmospheric Research Boulder USA / .	Research Weather	2	**604** 666	. .
390	Cray Research Y-MP2E/216	Navy POPS Supercomputing Facility Saint Louis USA / .	Research Weather	2	**604** 666	. .
391	Cray Research Y-MP8/232	Nippon Denso Japan /1991		2	**604** 666	. .
392	Cray Research Y-MP2E/232	Pennsylvania State University USA /1993	Academic	2	**604** 666	. .
393	Cray Research Y-MP2/232	Phillips Petroleum Company USA /1992	Industry Geophysics	2	**604** 666	. .
394	Cray Research Y-MP4/216	Rolls-Royce PLC UK /1990	Industry Aerospace	2	**604** 666	. .
395	Cray Research Y-MP2/264	Sandia National Labs Livermore USA / .	Research Energy	2	**604** 666	. .
396	Cray Research Y-MP2E/264	TEXACO USA /1991	Industry Geophysics	2	**604** 666	. .
397	Cray Research Y-MP2/216	Texas A M University USA /1993	Academic	2	**604** 666	. .
398	Cray Research Y-MP2E/264	The Scripps Research Institute USA /1992	Industry Chemistry	2	**604** 666	. .
399	Cray Research Y-MP2E/232	UFRGS/Uni. Federal do Rio Grande do Sul Brazil /1992	Academic	2	**604** 666	. .
400	Cray Research Y-MP2E/232	US Navy/Fleet Numerical Oceanography Center Monterey USA /1992	Research Weather	2	**604** 666	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
401	Cray Research Y-MP2/216	University of Nevada at Las Vegas USA /1990	Academic	2	**604** 666	. .
402	Cray Research Y-MP2/232	University of Rochester - Laboratory for Laser E. USA /1991	Academic	2	**604** 666	. .
403	Siemens-Nixdorf S100/10	GEOVOR Traben Trabach Germany /1991	Industry Weather	1	**556** 625	. .
404	Siemens-Nixdorf S100/10	Technische Universitaet Wien Wien Austria /1992	Academic	1	**556** 625	. .
405	Siemens-Nixdorf S100/10	Universitaet Hamburg Germany /1992	Academic	1	**556** 625	. .
406	Cray Research Y-MP M92/2256	AT T Bell Laboratories USA /1992	Industry Electronics	2	**550** 666	. .
407	Cray Research Y-MP M92/21024	Minnesota Supercomputer Center USA /1992	Academic	2	**550** 666	. .
408	Convex C3850	NASA/Johnson Space Center Houston USA /1992	Research	5	**522** 600	. .
409	Convex C3850	Universitaet Tuebingen Tuebingen Germany /1992	Academic	5	**522** 600	. .
410	Cray Research S-MP/MCP728	CWI/Centrum voor Wiskunde en Informatica Amsterdam Netherlands/1992	Research	28	**508** 1120	. .
411	Parsytec GCel 3/512	SARA (Stichting Academisch Rekencentrum) Amsterdam Netherlands/1993	Academic	512	**485** 770	. .
412	MasPar MP-1216	AT T USA /1991	Industry Electronics	16384	**473** 550	11264 1280
413	MasPar MP-1216	Bellcore USA /1990	Industry	16384	**473** 550	11264 1280
414	MasPar MP-1216	Chevron La Habra USA / .	Industry Geophysics	16384	**473** 550	11264 1280
415	MasPar MP-1216	Harvard University Cambridge USA / .	Academic	16384	**473** 550	11264 1280
416	MasPar MP-1216	Iowa State University USA /1990	Academic	16384	**473** 550	11264 1280
417	MasPar MP-1216	NASA/Goddard Space Flight Center Greenbelt USA /1990	Research Aerospace	16384	**473** 550	11264 1280
418	MasPar MP-1216	Purdue University West Laffayette USA /1991	Academic	16384	**473** 550	11264 1280
419	dec DECmpp SX 100	Thompson LER Rennes France / .	Industry Electronics	16384	**473** 550	11264 1280
420	MasPar MP-1216	Universitaet Karlsruhe Karlsruhe Germany /1990	Academic	16384	**473** 550	11264 1280

N World	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	Rmax Rpeak [Mflop/s]	N_{max} $N_{1/2}$
421	MasPar MP-1216	Universitaet Stuttgart Stuttgart Germany /1991	Academic	16384	**473** 550	11264 1280
422	Fujitsu VP-200E	MOE Nobeyama Observatory Japan /1989	Research	1	**472** 857	. .
423	Fujitsu VP-200E	MOE Space Science Research Japan /1987	Research	1	**472** 857	. .
424	Fujitsu VP-200E	Nat. Space Observatory Japan /1986	Research	1	**472** 857	. .
425	Fujitsu VP-200E	National Fusion Research Japan /1988	Research	1	**472** 857	. .
426	Siemens-Nixdorf VP200EX	Universitaet Bremen Germany /1991	Academic	1	**472** 857	. .
427	Siemens-Nixdorf VP200EX	Universitaet Dresden Dresden Germany /1991	Academic	1	**472** 857	. .
428	Meiko CS/i860/16	DRA Malvern Weybridge UK /1990	Research	16	**445** 640	5000 2000
429	Meiko CS/i860/16	Hewlett Packard Corvallis USA /1988	Industry Electronics	16	**445** 640	5000 2000
430	Meiko CS/i860/16	INRIA - Sophia Antipolis France /1991	Research	16	**445** 640	5000 2000
431	Meiko CS/i860/16	Uni-C Copenhagen Denmark /1992	Academic	16	**445** 640	5000 2000
432	Meiko CS/i860/16	University of Edinburgh Edinburgh UK / .	Research	16	**445** 640	5000 2000
433	Meiko CS/i860/16	University of Hong Kong Hong Kong Hong Kong /1993	Academic	16	**445** 640	5000 2000
434	Fujitsu VP2100/10	Fukuoka University Japan /1991	Academic	1	**445** 500	. .
435	Fujitsu VP2100/20	GECO-PRAKLA UK /1991	Industry Geophysics	1	**445** 500	. .
436	Fujitsu VP2100/10	Goyo Kensetu Japan /1991	Industry Construction	1	**445** 500	. .
437	Fujitsu VP2100/10	Ishikawajima Harima Japan /1991	Industry Heavy Ind.	1	**445** 500	. .
438	Fujitsu VP2100/20	Kobe Steel Japan /1992	Industry Heavy Ind.	1	**445** 500	. .
439	Fujitsu VP2100/10	Kozo Keikaku Research Japan /1992	Research	1	**445** 500	. .
440	Fujitsu VP2100/10	Mitsui Toatsu Chemical Japan /1991	Industry Chemistry	1	**445** 500	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
441	Fujitsu VP2100/10	Nippon Kokan Japan /1991		1	**445** 500	. .
442	Fujitsu VP2100/10	Takenaka Komuten Japan /1992		1	**445** 500	. .
443	Fujitsu VP2100/10	Toyoda Oriki Japan /1991		1	**445** 500	. .
444	Fujitsu VP2100/10	Toyota Machinery Japan /1991	Industry Heavy Ind.	1	**445** 500	. .
445	Fujitsu VP2100/10	Toyota Motor Company Japan /1991	Industry Automotive	1	**445** 500	. .
446	Siemens-Nixdorf S100/10 (4ns)	Universitaet Giessen Giessen Germany /1992	Academic	1	**445** 500	. .
447	Siemens-Nixdorf S100/10 (4ns)	Universitaet Kassel Kassel Germany /1992	Academic	1	**445** 500	. .
448	Fujitsu VP2100/10	Waseda University Japan /1990	Academic	1	**445** 500	. .
449	Fujitsu VP2100/10	Yokohama Rubber Japan /1991	Industry Chemistry	1	**445** 500	. .
450	KSR KSR1-16	AWI (Alfred Wegener Institut) Bremerhaven Germany /1993	Research	16	**440** 640	. .
451	KSR KSR1-16	Arithmotechniki Greece /1992	Research	16	**440** 640	. .
452	KSR KSR1-16	INRIA - Sophia Antipolis Rennes France /1992	Research	16	**440** 640	. .
453	MasPar MP-1	NASA/Ames Research Center/CCF Moffett Field USA /1993	Research Aerospace	16384	**440** 550	5504 1180
454	MasPar MP-1	Nippon DEC Japan /1991	Industry Electronics	16384	**440** 550	5504 1180
455	MasPar MP-1	Rikei Technical Center Japan /1990		16384	**440** 550	5504 1180
456	MasPar MP-1	Sumitomo Metal Industries Japan /1991	Industry	16384	**440** 550	5504 1180
457	MasPar MP-1	Tokyo University Tokyo Japan /1991	Academic	16384	**440** 550	5504 1180
458	MasPar MP-1	Toyohashi Technical and Science Univ. Japan /1990	Academic	16384	**440** 550	5504 1180
459	Cray Research X-MP/216	Alabama Supercomputer Center USA /1992	Academic	2	**427** 470	. .
460	Cray Research X-MP/216	Commissariat a l'Energie Atomique Saclay France /1992	Research Energy	2	**427** 470	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
461	Cray Research X-MP/216	DOE/Idaho National Engineering Laboratory USA /1989	Research Energy	2	**427** 470	. .
462	Cray Research X-MP/216	Hydro-Quebec Canada /1991	Industry Energy	2	**427** 470	. .
463	Cray Research X-MP/216	Japanese AIST Hokuriku Japan /1988		2	**427** 470	. .
464	Cray Research X-MP/216	MITI Japan /1988	Research	2	**427** 470	. .
465	Cray Research X-MP/28	NASA/Lewis Research Center USA /1990	Research	2	**427** 470	. .
466	Cray Research X-MP/216	Thomson RCM - Radars Contre-Mesures France /1990	Industry Aerospace	2	**427** 470	. .
467	Cray Research X-MP/22	Toshiba Kanagawa Japan /1985	Academic	2	**427** 470	. .
468	Cray Research X-MP/28	US Naval Underwater Weapons Center USA /1991	Classified	2	**427** 470	. .
469	Cray Research X-MP/216	Universitaet Kiel Kiel Germany /1988	Academic	2	**427** 470	. .
470	Cray Research X-MP/28	University of California at Berkeley USA /1991	Academic	2	**427** 470	. .
471	Cray Research X-MP/216	ZIB/Konrad Zuse-Zentrum fuer Informationstechnik Germany /1992	Academic	2	**427** 470	. .
472	Convex C3840	AEDC USA /1992		4	**425** 480	. .
473	Convex C3840	AEDC USA /1992		4	**425** 480	. .
474	Convex C3840	CSC (Centre for Sientific computing) Helsinki Finland /1992	Academic	4	**425** 480	. .
475	Convex C3840	DGA/Etablissement Technique d'Angers (ETAS) France / .		4	**425** 480	. .
476	Convex M3820/8	DIGICON Houston USA /1992		4	**425** 480	. .
477	Convex C3840	DOD USA /1991	Classified	4	**425** 480	. .
478	Convex C3840	David Taylor Research Center USA /1992	Research	4	**425** 480	. .
479	Convex C3840	EADTB USA /1992		4	**425** 480	. .
480	Convex C3840	EADTB USA /1992		4	**425** 480	. .

N *World*	Manufacturer Computer	Installation Site Location/Year	Field of Application	# Proc.	**Rmax** R_{peak} [Mflop/s]	N_{max} $N_{1/2}$
481	Convex C3840	GSF Muenchen Germany /1992		4	**425** 480	. .
482	Convex C3840	General Electric USA /1992	Industry	4	**425** 480	. .
483	Convex C3840	Gulfstream USA /1993	Industry Aerospace	4	**425** 480	. .
484	Convex C3840	Lockheed USA /1992	Industry Aerospace	4	**425** 480	. .
485	Convex C3840	NCHC Taiwan /1992		4	**425** 480	. .
486	Convex C3840	NSYSU Taiwan /1992		4	**425** 480	. .
487	Convex C3840	SMHI Stockholm Sweden /1992		4	**425** 480	. .
488	Convex C3840	Sharp Japan /1992	Industry	4	**425** 480	. .
489	Convex C3840	TEL Tokyo Japan /1992		4	**425** 480	. .
490	Convex C3840	TUD (Technical University Delft) Delft Netherlands/1992	Academic	4	**425** 480	. .
491	Convex C3840	Universitaet Hamburg-Harburg Hamburg-Harburg Germany /1992	Academic	4	**425** 480	. .
492	Convex C3840	University of Aarhus Denmark /1992	Academic	4	**425** 480	. .
493	NEC SX-1	Kumagaigumi Japan /1989	Academic	1	**422** 630	. .
494	Siemens-Nixdorf VP-200	CIRCE France /1986	Academic	1	**422** 533	. .
495	Fujitsu VP-200	GECO-PRAKLA USA /1990	Industry Geophysics	1	**422** 533	. .
496	Fujitsu VP-200	Inst. f. Space Astronautics Japan /1986	Research	1	**422** 533	. .
497	Fujitsu VP-200	Kao Japan /1991		1	**422** 533	. .
498	Fujitsu VP-200	Kobe Seiko Japan /1989	Industry Heavy Ind.	1	**422** 533	. .
499	Fujitsu VP-200	National Fusion Research Japan /1984	Research	1	**422** 533	. .
500	Siemens-Nixdorf VP-200	debis Muenchen Germany /1985	Industry	1	**422** 533	. .

A.4 Statistics on Manufacturers and Continents

As basic statistics of the complete list, we give the number of systems installed with respect to the different manufacturers in the different countries or continents (Table A.2) as well as the accumulated R_{max} values (Table A.3) and R_{peak} values (Table A.4) for those systems. A comprehensive report of more than 200 pages, based on the data of the TOP500 list, will be published [4].

"This volume"

Table A.2: Number of Systems Installed

TOP500 Statistics — Number of Systems Installed						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		14	2	16	2	34
Cray Research	2	54	20	123	6	205
DEC		2				2
Fujitsu	2	3	41	4		50
Hitachi			6			6
Intel	1	11	2	30		44
KSR		9		12		21
MasPar		2	5	11		18
Meiko		7		1	1	9
nCube			1	2		3
NEC		3	25	2	1	31
Parsytec		3				3
SNI		18				18
TMC	4	14	7	31		56
Total	9	140	109	232	10	**500**

Mannheim June 30, 1993

TOP500 Statistics — Installed R_{max} [Gflop/s]						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		7.7	0.9	8.6	0.9	18.1
Cray Research	1.2	68.6	18.2	318.0	6.6	412.6
DEC		2.1				2.1
Fujitsu	1.7	4.2	58.7	5.7		70.3
Hitachi			14.1			14.1
Intel	1.5	16.8	3.4	72.0		93.7
KSR		7.6		23.2		30.8
MasPar		0.9	2.2	7.7		10.8
Meiko		4.9		0.4	0.4	5.7
nCube			1.0	2.9		3.9
NEC		11.3	90.9	25.0	2.9	130.1
Parsytec		2.4				2.4
SNI		25.5				25.5
TMC	7.0	32.0	16.9	292.0		347.9
Total	11.4	184.0	206.3	755.5	10.8	**1168.0**

Mannheim June 30, 1993

Table A.3: Installed R_{max}

TOP500 Statistics — Installed R_{peak} [Gflop/s]						
Manufacturer	Aus.	Europe	Japan	USA	Oth.	Total
Convex		9.0	1.0	9.9	1.0	20.9
Cray Research	1.3	81.6	21.4	391.0	8.0	503.3
DEC		3.0				3.0
Fujitsu	2.0	5.0	73.8	6.8		87.6
Hitachi			47.0			47.0
Intel	4.2	35.5	7.5	144.0		191.2
KSR		10.9		43.8		54.7
MasPar		1.1	2.8	10.4		14.3
Meiko		8.1		0.6	0.6	9.3
nCube			1.2	3.6		4.8
NEC		12.4	103.0	27.5	3.2	146.1
Parsytec		3.9				3.9
SNI		33.4				33.4
TMC	15.5	70.0	37.0	638.0		760.5
Total	23.0	273.9	294.7	1275.6	12.8	**1880.0**

Mannheim June 30, 1993

Table A.4: Installed R_{peak}

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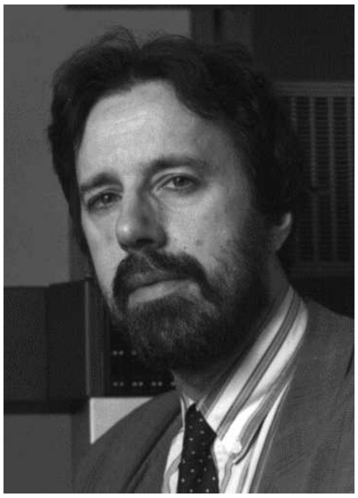

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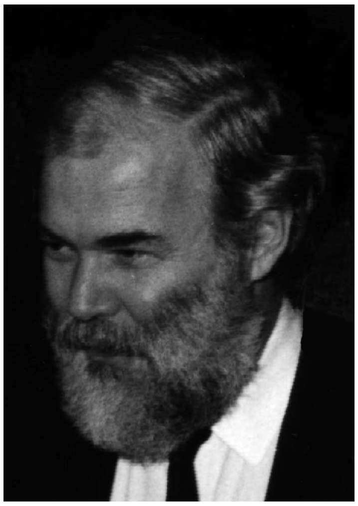
He is editor of several journals and magazins in the field, including 'Supercomputer' and 'Supercomputer European Watch'.

Geerd-R. Hoffmann



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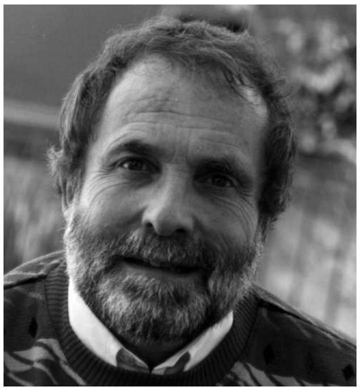

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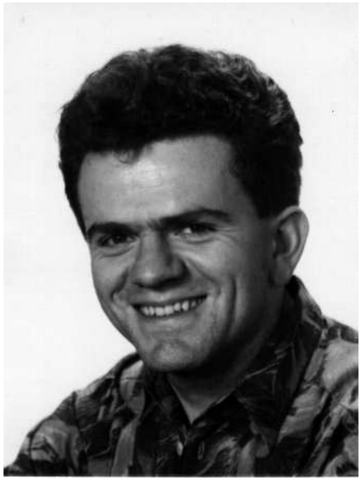

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He is working for about ten years with vector computers and parallel computers with special interest in architectures and performance evaluation.

TOP500 Report 1994

Jack J. Dongarra, Hans-Werner Meuer, and Erich Strohmaier will publish the 1994 version of the TOP500 REPORT in mid January 1995. This REPORT will be based on the TOP500 data as of November 1994. The authors of the 1993 REPORT will also contribute to this version.

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- Analysis of the Supercomputer Situation 1994 worldwide
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