NAS Parallel Benchmark (Version 1.0) Results 11-96

Subhash Saini[1] and David H. Bailey[2]

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Numerical Aerospace Simulation Program
NASA Ames Research Center
Mail Stop T 27A-1
Moffett Field, CA 94035-1000, USA
email: saini@nas.nasa.gov

Abstract

The NAS Parallel Benchmarks have been developed at NASA Ames Research Center to study the performance of parallel supercomputers. The eight benchmark problems are specified in a ‘‘pencil and paper’’ fashion. In other words, the complete details of the problem to be solved are given in a technical document, and except for a few restrictions, benchmarkers are free to select the language constructs and implementation techniques best suited for a particular system. These results represent the best results that have been reported to us by the vendors for the specific systems listed. In this report[3], we present new NPB (Version 1.0) performance results for the following systems:

- DEC Alpha Server 8400 5/440,
- Fujitsu VPP Series (VX, VPP300, and VPP700),
- HP/Convex Exemplar SPP2000,
- IBM RS/6000 SP P2SC node (120 MHz)
- NEC SX-4/32,
- SGI/CRAY T3E,
- SGI Origin200
- SGI Origin2000

We also report High Performance Fortran (HPF) based NPB results for IBM SP2 Wide Nodes, HP/Convex Exemplar SPP2000, and SGI/CRAY T3D. These results have been submitted by Applied Parallel Research (APR) and Portland Group Inc. (PGI). We also present sustained performance per dollar for Class B LU, SP and BT benchmarks.

1. Subhash Saini is an employe of MRJ Inc. This work is supported by NASA Ames Research Center through contract NAS 2-14303.
2. David H. Bailey is an employee of NASA Ames Research Center.
3. URL: http://www.nas.nasa.gov/NAS/NPB/

1: Introduction

The Numerical Aerodynamic Simulation (NAS) Program, located at NASA Ames Research Center, is a pathfinder in high-performance computing for NASA and is dedicated to advancing the science of computational aerodynamics. One key goal of the NAS organization is to demonstrate by the year 2000 an operational computing system capable of simulating an entire aerospace vehicle system in one to several hours. It is currently projected that the solution of this Grand Challenge problem will require a system that can perform scientific computations at a sustained rate of approximately 1000 times faster than 1990 generation supercomputers. Such a computer system will most likely employ hundreds or even thousands of powerful RISC processors operating in parallel.

In order to objectively measure the performance of various highly parallel computer systems and to compare them with conventional supercomputers, NAS has developed the NAS Parallel Benchmarks (NPB 1.0) [1, 2]. Note that the NPB 1.0 are distinct from the NAS High Speed Processor (HSP) benchmarks and procurements. The HSP benchmarks are used for evaluating production supercomputers for procurements in the NAS organization, whereas the NPB 1.0 are used for studying highly parallel processor (HPP) systems in general.

2: NAS Parallel Benchmarks

The NPB 1.0 consist of a set of eight benchmark problems, each of which focuses on some important aspect of highly parallel supercomputing for aerophysics applications. Some extension of Fortran or C is required for implementations, and reasonable limits are placed on the use of assembly code and the like. Otherwise, programmers are free to utilize language constructs that maximize performance on the particular system being studied. The choice of data structures, processor allocation, and memory usage are generally left open to the discretion of the implementer.

The eight problems consist of five kernels and three simulated computational fluid dynamics (CFD) applications. The five kernels comprise relatively compact problems, each emphasizing a particular type of numerical computation. Compared with the simulated CFD applications, they can be implemented fairly readily and provide insight as to the general levels of performance that can be expected on these specific types of numerical computations.

The simulated CFD applications, on the other hand, usually require more effort to implement, but they are more representative of the types of actual data movement and computation required in state-of-the-art CFD application codes. For example, in an isolated kernel, a certain data structure may be very efficient on a certain system; and yet, this data structure may be inappropriate if incorporated into a larger application. By comparison, the simulated CFD applications require data structures and implementation techniques that are more typical of real CFD applications.

(Space does not permit a complete description of these benchmark problems. A more detailed description of these benchmarks, together with the rules and restrictions associated with them, is given in reference 2.)

There are now three standard sizes for the NAS Parallel Benchmarks: Class A, Class B and Class C size problems. The nominal benchmark sizes for Class A, Class B and Class C problems are shown in Table 1. These tables also give the standard floating-point operation (flop) counts for Class A and Class B. We recommend that those wishing to compute performance rates in millions of floating point operations per second (Mflop/s) use these standard flop counts. Table 1 contains Mflop/s rates calculated in this manner for the current fastest implementation on one processor of CRAY Y-MP for Class A and on one processor of CRAY C90 for Class B. Note, however, that in this report, performance rates are *not* cited in Mflop/s; instead we present, the wall clock times (and, the equivalent performance ratios). We suggest that these, not Mflop/s, be examined when comparing different systems and implementations.

With the exception of the IS benchmark, these standard flop counts were determined by using the hardware performance monitor on the CRAY Y-MP or CRAY C90, and we believe that they are close to the minimal counts required for these problems. In the case of the IS benchmark, which does not involve floating-point operations, we selected a value approximately equal to the number of integer operations required, in order to permit the computation of performance rates analogous to Mflop/s rates. We reserve the right to change these standard flop counts in the future, if necessary.

The NAS organization reserves the right to verify any NPB results that are submitted to us. We may, for example, attempt to run the submitter's code on another system of the same configuration as that used by the submitter. In those instances where we are unable to reproduce the vendor's supplied results (allowing a 5% tolerance), our policy is to alert the submitter of the discrepancy and allow submitter to resolve the discrepancy in the next release of this report. If the discrepancy is not resolved to our satisfaction, then our own observed results and not the submitter's results will be reported.

3: NAS Parallel Benchmark Results

In the following section, each of the eight benchmarks will be briefly described, and then the best performance results we have received to date for each computer system will be given in Tables 2 through 10 and Tables 14-18. These tables include run times and performance ratios. The performance ratios compare individual timings with the current best time for that benchmark achieved on one processor of CRAY Y-MP for Class A and on one processor of CRAY C90 for Class B. The run times in each case are elapsed time measured in accordance with the specifications of NPB rules. This report includes a number of new results including previously unpublished - DEC Alpha Server 8400 5/440, Fujitsu VPP Series (VX, VPP300, VPP700), HP/Convex Exemplar SPP2000, IBM RS/6000 SP P2SC node (120 MHz), NEC SX-4/32, SGI/CRAY T3E, SGI Origin200 and SGI Origin2000

3.1: Kernels

The results for five kernels (EP, MG, CG, FT, and IS) are given below in the following section:

3.1.1: The Embarrassingly Parallel (EP) Benchmark

The first of the five kernel benchmarks is an *embarrassingly parallel* problem. In this benchmark, two-dimensional statistics are accumulated from a large number of Gaussian pseudo-random numbers, which are generated according to a particular scheme that is well-suited for parallel computation. This problem is typical of many *Monte Carlo* applications. Since it requires almost no communication, in some sense this benchmark provides an estimate of the upper achievable limits for floating-point performance on a particular system. Results for EP benchmark are given in Table 2.

3.1.2: Multigrid (MG) Benchmark

The second kernel benchmark is a simplified multigrid kernel, which solves a 3-D Poisson PDE. This problem is simplified in the sense that it has constant rather than variable coefficients as in a more realistic application. This code is a good test of both short and long distance highly structured communication. The Class B problem uses the same size grid as of Class A but a greater number of inner loop iterations. Results for this benchmark are shown in Table 3.

3.1.3: Conjugate Gradient (CG) Benchmark

In this benchmark, a conjugate gradient method is used to compute an approximation to the smallest eigenvalue of a large, sparse, symmetric positive definite matrix. This kernel is typical of unstructured grid computations in that it tests irregular long-distance communication and employs sparse matrix-vector multiplication. Results are shown in Table 4.

3.1.4: 3-D FFT PDE (FT) Benchmark

In this benchmark a 3-D partial differential equation is solved using FFTs. This kernel performs the essence of many *spectral methods*. It is a good test of long-distance communication performance. The rules of the NPB specify that assembly-coded, library routines may be used to perform matrix multiplication and one-dimensional, two-dimensional, or three-dimensional FFTs. Thus this benchmark is somewhat unique in that computational library routines may be legally employed. Results are shown in Table 5.

3.1.5: Integer Sort (IS) Benchmark

This benchmark tests a sorting operation that is important in *particle method* codes. This type of application is similar to particle-in-cell applications of physics, wherein particles are assigned to cells and may drift out. The sorting operation is used to reassign particles to the appropriate cells. This benchmark tests both integer computation speed and communication performance. This problem is unique in that floating point arithmetic is not involved. Significant data communication, however, is required. Results are shown in Table 6.

3.2: Simulated CFD Application Benchmarks

The three simulated CFD application benchmarks are intended to accurately represent the principal computational and data movement requirements of modern CFD applications.

3.2.1: LU Simulated CFD Application (LU) Benchmark

The first of these is the so-called the lower-upper diagonal (LU) benchmark. It does not perform a LU factorization but instead employs a symmetric successive over-relaxation (SSOR) numerical scheme to solve a regular-sparse, block *5x5* lower and upper triangular system. This problem represents the computations associated with a newer class of implicit CFD algorithms, typified at NASA Ames by the code *INS3D-LU*. This problem exhibits a somewhat limited amount of parallelism compared to the next two benchmarks. A complete solution of the LU benchmark requires 250 iterations. Results are given in Table 7.

3.2.2: SP Simulated CFD Application (SP) Benchmark

The second simulated CFD application is called the scalar pentadiagonal (SP) benchmark. In this benchmark, multiple independent systems of nondiagonally dominant, scalar pentadiagonal equations are solved. A complete solution of the SP benchmark requires 400 iteration. Results are given in Table 8.

3.2.3: BT Simulated CFD Application (BT) Benchmark

The third simulated CFD application is called the block tridiagonal (BT) benchmark. In this benchmark, multiple independent systems of non-diagonally dominant, block tridiagonal equations with a *5x5* block size are solved.

SP and BT are representative of computations associated with the implicit operators of CFD codes such as *ARC3D* at NASA Ames. SP and BT are similar in many respects, but there is a fundamental difference with respect to the communication to computation ratio. Timings are cited as complete run times, in seconds, as with the other benchmarks. For the BT benchmark, 200 iterations are required. Results of BT benchmark are given in Table 9.

3.3 NPB 1.0 Class C Results

In Table 10 are given the Class C NPB 1.0 results for EP, MG, CG, FT, LU, SP and BT benchmarks on CRAY T3E.

4: Sustained Performance Per Dollar

One aspect of the relative performance of these systems has not been addressed so far, namely the differences in price between these systems. One should not be too surprised that the CRAY C90 system, for example, exhibits superior performance rates on these benchmarks, since its current list price is much greater than that of the other systems tested.

One way to compensate for these price differences is to compute sustained performance per million dollars, *i.e.* the performance ratio figures shown in Tables 2 through 9 divided by the list price in millions. Some figures of this type are shown in Tables 11-13 for Class B LU, SP, and BT benchmarks, respectively. The table includes the list price of the minimal system (in terms of memory per node and number of processors) required to run the full Class B size NPB as implemented by the vendor. These prices were provided by the vendors and include any associated software costs, i.e. operating system, compilers, scientific libraries as required, *etc.* but do not include maintenance. Note that some vendors' standard configurations may include substantially more hardware than required for the benchmark.

5 High Performance Fortran Based NPB

High Performance Fortran (HPF), the high-level language for parallel Fortran programming, is based on Fortran 90. HPF was defined by an informal standards committee known as the High Performance Fortran Forum (HPFF) in 1993, and modeled on TMC's CM Fortran language. Several HPF features have since been incorporated into the draft ANSI/ISO Fortran 95, the next formal revision of the Fortran standard.

HPF allows users to write a single parallel program that can execute on a serial machine, a shared-memory parallel machine, or a distributed-memory parallel machine. HPF eliminates the complex, error-prone task of explicitly specifying how, where, and when to pass messages between processors on distributed-memory machines, or when to synchronize processors on shared-memory machines. HPF is designed in a way that allows the programmer to code an application at a high level, and then selectively optimize portions of the code by dropping into message-passing or calling tuned library routines as “extrinsics”.

Compilers supporting High Performance Fortran features first appeared in late 1994 and early 1995 from Applied Parallel Research (APR) Digital Equipment Corporation, and The Portland Group (PGI). IBM introduced an HPF compiler for the IBM RS/6000 SP in April of 1996. Over the past year, these implementations have shown steady improvement in terms of both features and performance. NAS is working toward a standard set of HPF NPBs which can be used as a measure of both HPF compilers and hardware systems. In advance of that release we have chosen to publish here results achieved using versions of the HPF NPBs developed outside of NAS and submitted by APR and PGI. These results can be compared to the MPI results in NPB 2.2 [4] and the other NPB 1.0 results supplied here to provide perspective on performance currently obtainable using HPF versus MPI or versus hand-tuned implementations such as those supplied by the hardware vendors.

For more details on HPF, see reference 3 and references therein. HPF NPB results appear in Tables 14-18.

References

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[3] S. Saini, “NAS Experiences of Porting CM Fortran Codes to HPF on IBM SP2 and SGI Power Challenge”, pp. 873-880, in *The Proceedings of IEEE 10th International Parallel Processing Symposium (IPPS)*, Honolulu, Hawaii, April 15-19, 1996.

[4] David Bailey, Tim Harris, William Saphir, Rob van der Wijngaart, Alex Woo, and Maurice Yarrow, “The NAS Parallel Benchmarks 2.0”, Report NAS-95-020, December, 1995.

Table 1: NAS Parallel Benchmarks Problem Size.

Benchmark Name	Abb.	Class A			Class B			Class C
		Nominal Size	**Operation Count ($x\ 10^9$)**	**Mflop/s CRAY Y-MP/1**	**Nominal Size**	**Operation Count ($x10^9$)**	**Mflop/s CRAY C90/1**	**Nominal Size**
Embarrassingly Parallel	EP	2^{28}	26.68	211	2^{30}	100.9	689	2^{32}
Multigrid	MG	256^3	3.905	176	256^3	18.81	557	512^3
Conjugate Gradient	CG	$14x10^3$	1.508	127	$75x10^3$	54.89	447	1.5×10^5
3-D FFT PDE	FT	256^2x128	5.631	196	$512x256^2$	71.37	645	512^3
Integer Sort	IS	$2^{23}x2^{19}$	0.7812	68	$2^{25}x2^{21}$	3.150	244	2^{27}
LU Simulated CFD Appl.	LU	64^3	64.57	194	102^3	319.6	711	162^3
SP Simulated CFD Appl.	SP	64^3	102.0	216	102^3	447.1	648	162^3
BT Simulated CFD Appl.	BT	64^3	181.3	229	102^3	721.5	705	162^3

Table 2: Results of the Embarrassingly Parallel (EP) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to CRAY Y-MP/1	Time in seconds	Ratio to CRAY C90/1
BBN TC2000	Dec 91	64	284.0	0.44	NA	NA
Convex Exemplar SPP1000	Mar 95	1	376.8	0.33	NA	NA
		8	48.1	2.62	191.0	0.77
		16	24.3	5.19	96.0	1.53
		32	11.8	10.69	48.0	3.05
		64	6.1	20.68	24.5	5.98
HP/Convex Exemplar SPP2000	Nov 96	1	160.9	0.78	NA	NA
		4	41.2	3.06	NA	NA
		8	20.7	6.10	NA	NA
		16	10.5	12.02	NA	NA
CRAY C90	Feb 95	1	36.62	3.45	146.41	1.0
		2	18.42	6.85	73.66	1.99
		4	9.15	13.79	36.78	3.98
		8	4.61	27.37	18.37	7.97
		16	2.36	53.46	9.35	15.66
CRAY J916	Feb 95	1	169.44	0.74	675.71	0.22
		2	86.70	1.46	340.13	0.43
		4	43.09	2.93	170.15	0.86
		8	21.54	5.86	85.49	1.71
		16	10.78	11.70	43.16	3.39
CRAY T3D	Feb 95	16	22.74	5.55	91.83	1.59
		32	11.37	11.10	45.92	3.19
		64	5.68	22.21	22.95	6.38
		128	2.87	43.96	11.47	12.76
		256	1.44	87.62	5.74	25.51
		512	0.72	175.24	2.87	51.01
		1024	0.55	229.40	2.19	66.85
CRAY T3E	Nov 96	2	56.2	2.25	224.5	0.65
		4	28.1	4.49	112.2	1.31
		8	14.1	8.95	56.1	2.61
		16	7.0	18.02	28.1	5.21
		32	3.5	36.05	14.0	10.46
		64	1.8	70.09	7.0	20.92
		128	0.9	140.19	3.5	41.83
		256	0.4	315.43	1.8	81.34

Table 2: Results of the Embarrassingly Parallel (EP) benchmark.

CRAY T916	July 95	1 2 4 8	18.56 9.54 4.77 2.42	6.80 13.23 26.45 52.14	76.13 38.11 19.12 9.65	1.92 3.84 7.66 15.17
CRAY Y-MP	Aug 92	1 8	126.17 15.87	1.0 7.95	NA NA	NA NA
DEC Alpha Server 8400 5/300 (300 MHz)	Oct 95	1 4 8 16	155.6 77.97 39.1 19.71	0.81 1.61 3.23 6.40	622.22 311.9 156.69 78.43	0.24 0.47 0.93 1.87
DEC Alpha Server 8400 5/440 (437 MHz)	Nov 96	1 2 4 8 12	94.6328 47.3750 23.8125 12.1016 8.4609	1.33 2.66 5.30 10.43 14.91	378.3750 189.2344 94.8594 47.6172 33.1172	0.39 0.77 1.54 3.07 4.42
Fujitsu VPP500	Aug 94	1 2 4 8 16 32 64	44.25 22.3411 11.24 5.67 2.87 1.46 0.75	2.85 5.65 11.23 22.26 43.96 86.42 168.23	176.64 88.7866 44.52 22.36 11.26 5.68 2.88	0.83 1.65 3.29 6.5 13.00 25.78 50.84
Fujitsu VX	Nov 96	1 2 4	30.3312 15.3105 7.3720	4.16 8.24 17.11	120.9485 57.6907 30.4367	1.21 2.54 4.81
Fujitsu VPP300	Nov 96	1 2 4 8 16	30.3312 15.3105 7.3720 3.9217 1.9962	4.16 8.24 17.11 32.17 63.20	120.9485 57.6907 30.4367 14.6048 7.7563	1.21 2.54 4.81 10.02 18.88
Fujitsu VPP700	Nov 96	1 2 4 6 16 32	30.3312 15.3105 7.3720 3.9217 1.9962 1.0265	4.16 8.24 17.11 32.17 63.20 122.91	120.9485 57.6907 30.4367 14.6048 7.7563 3.7444	1.21 2.54 4.81 10.02 18.88 39.10
IBM RS/6000 SP Wide-node1 (67 MHz)	Mar 95	8 16 32 64 128	19.91 9.95 4.98 2.49 1.25	6.34 12.69 25.34 50.67 100.94	79.75 39.89 19.9 9.95 4.99	1.84 3.67 7.36 14.71 29.34

Table 2: Results of the Embarrassingly Parallel (EP) benchmark.

IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8 16 32 64	NA NA NA NA	NA NA NA NA	39.84 20.04 10.02 5.02	3.68 7.31 14.61 29.17
IBM RS/6000 SP Thin-node2 (67 MHz)	Mar 95	8 16 32 64 128	20.82 10.42 5.23 2.62 1.31	6.06 12.11 24.12 48.16 96.31	82.94 41.47 20.75 10.37 5.19	1.77 3.53 7.06 14.12 28.21
Intel iPSC/860	May 92	32 64 128	102.7 51.4 25.7	1.23 2.46 4.91	NA NA NA	NA NA NA
Intel Paragon OSF R 1.2	Jan 95	64 128 256 512 1024	15.29 7.67 3.87 2.23 1.15	8.25 16.45 32.60 56.58 109.71	61.04 30.57 15.37 8.93 4.45	2.40 4.79 9.53 16.40 32.90
Intel Paragon (SunMos turbo)	Jan 95	64 128 256 512 1024	7.80 3.93 2.00 1.12 .59	16.18 32.10 63.09 112.65 213.85	31.15 15.60 7.82 3.98 2.05	4.70 9.39 18.62 36.79 71.42
Intel Paragon MP OSF R1.3	Jan 95	64 128 256 512	8.02 4.17 2.26 1.28	15.73 30.26 55.83 95.57	31.42 15.88 8.11 4.23	4.66 9.22 18.05 34.61
Intel Paragon MP (SunMos turbo)	Nov 95	64 128 256 512	5.75 2.94 1.54 0.87	21.94 42.92 81.93 145.02	22.70 11.40 5.78 2.98	6.45 12.84 25.34 49.13
Kendall Square KSR1	Oct 93	16 32 64 128	101.9 51.4 26.0 12.8	1.23 2.45 4.85 9.86	NA NA NA NA	NA NA NA NA
Kendall Square KSR2	Feb 94 May 94	32 64	24.8 13.0	5.09 9.71	NA 46.6	NA 3.14
Kyoto/Matsushita ADENART	Feb 94	256	32.9	3.83	NA	NA

Table 2: Results of the Embarrassingly Parallel (EP) benchmark.

MasPar MP-1	Aug 92	4K 16K	248.0 69.3	0.51 1.82	NA NA	NA NA
MasPar MP-2	Nov 92	16K	22.4	5.63	NA	NA
Meiko CS-1	Aug 92	16	116.8	1.08	NA	NA
Meiko CS-2	Oct 94	16 32 64 96 128	39.39 20.45 11.00 7.84 6.29	3.20 6.16 11.46 16.07 20.06	152.81 77.20 39.48 26.84 21.16	0.96 1.90 3.71 5.45 6.92
nCUBE-2S	Mar 94	64 128 256 512 1024	83.8 41.93 20.97 10.50 5.25	1.51 3.01 6.02 12.02 24.03	336.3 168.2 84.1 42.1 21.0	0.44 0.87 1.74 3.48 6.97
NEC SX-3	Oct 94	1	21.27	5.93	NA	NA
NEC SX-4/32	Nov 96	1 2 4 8 16 32	NA NA NA NA NA NA	NA NA NA NA NA NA	89.56 44.79 22.417 11.224 5.658 2.944	1.63 3.27 6.53 13.04 25.87 49.73
Silicon Graphics Power Challenge XL (75 MHz)	Oct 94	1 4 8 16	242.95 61.44 30.77 15.48	0.52 2.05 4.10 8.15	973.62 245.74 122.98 61.79	0.15 0.60 1.19 2.37
SGI Power Challenge XL (90 MHz)	May 95	1 2 4 8 16	169.10 87.46 43.87 21.98 11.05	0.75 1.44 2.88 5.74 11.42	676.78 352.31 176.52 87.80 44.22	0.22 0.42 0.83 1.67 3.31
SGI Origin200 (180 MHz)	Nov 96	1 2 4	110.47 56.68 29.43	1.14 2.23 4.29	442.77 224.93 114.87	0.33 0.65 1.27

Table 2: Results of the Embarrassingly Parallel (EP) benchmark.

SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 31 32	101.93 51.70 25.83 13.00 6.68 NA 3.55	1.24 2.44 4.88 9.71 18.89 NA 35.54	408.25 207.22 103.44 52.06 26.71 NA 14.17	0.36 0.71 1.42 2.81 5.48 NA 10.33
Thinking Machines CM-2	Oct 91	8K 16K 32K 64K	126.6 63.9 33.7 18.8	1.00 1.97 3.74 6.71	NA NA NA NA	NA NA NA NA
Thinking Machines CM-200	Oct 91	8K 16K 32K 64K	76.9 39.2 20.7 10.9	1.64 3.22 6.10 11.58	NA NA NA NA	NA NA NA NA
Thinking Machines CM-5	Nov 92	16 32 64 128 256 512	42.4 21.5 10.9 5.4 2.7 1.4	2.98 5.87 11.58 23.36 46.73 90.12	NA NA NA NA NA NA	NA NA NA NA NA NA
Thinking Machines CM-5E	Sep 95	16 32	27.2 13.6	4.64 9.28	108.5 54.3	1.35 2.70
Thinking Machines CM-500	Sept 95	64 128 256	6.9 3.6 2.0	18.29 35.04 63.09	27.1 13.7 7.0	5.40 10.69 20.92

Table 3: Results of the Multigrid (MG) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to CRAY Y-MP/1	Time in seconds	Ratio to CRAY C90/1
Convex Exemplar SPP1000	Mar 95	1	208.0	0.11	NA	NA
		8	29.9	0.74	150.4	0.22
		16	17.3	1.28	85.1	0.40
		32	11.0	2.02	52.7	0.64
		64	NA	NA	39.6	0.85
HP/Convex Exemplar SPP2000	Nov. 96	1	28.1	0.79	NA	NA
		4	8.0	2.78	NA	NA
		8	5.3	4.19	NA	NA
		16	4.3	5.17	NA	NA
CRAY C90	Feb 95	1	7.27	3.06	33.78	1.00
		2	3.71	5.99	17.24	1.96
		4	1.92	11.58	8.89	3.80
		8	1.10	20.20	4.59	7.36
		16	0.71	31.30	3.43	9.85
CRAY EL	Aug 92	1	89.19	0.25	NA	NA
		4	27.94	0.80	NA	NA
		8	22.30	0.95	NA	NA
CRAY J916	Feb 95	1	39.08	0.57	184.88	0.18
		2	20.52	1.09	94.71	0.36
		4	10.75	2.07	48.69	0.69
		8	5.88	3.78	26.60	1.27
		16	3.82	2.06	16.12	2.10
CRAY T3D	Feb 95	16	13.78	1.61	66.58	0.51
		32	6.40	3.47	30.10	1.11
		64	2.61	8.51	12.56	2.69
		128	1.36	16.34	6.57	5.14
		256	0.74	30.03	3.37	10.02
		512	0.39	56.97	1.74	19.41
		1024	0.25	88.88	1.15	29.38
CRAY T3E	Nov 96	2	NA	NA	NA	NA
		4	11.2	1.98	52.7	0.64
		8	5.6	3.97	26.4	1.28
		16	2.8	7.94	13.4	2.52
		32	1.5	14.81	7.0	4.83
		64	0.8	27.78	3.8	8.89
		128	0.4	55.55	2.0	16.89
		256	0.2	111.1	1.1	30.71

Table 3: Results of the Multigrid (MG) benchmark.

CRAY T916	July 95	1 2 4 8	4.43 2.28 1.27 0.99	5.02 9.75 17.50 22.44	20.30 10.50 5.54 4.06	1.66 3.22 6.10 8.32
CRAY Y-MP	Aug 92	1 8	22.22 2.96	1.00 7.51	NA NA	NA NA
Fujitsu VPP500	Mar 95	4 8 16 32	1.44 0.75 0.42 0.26	15.43 29.63 52.90 85.46	6.81 3.59 2.01 1.26	4.96 9.41 16.81 26.81
Fujitsu VX	Nov 96	4	1.38	16.10	6.58	5.13
Fujitsu VPP300	Nov 96	4 8 16	1.38 0.75 0.41	6.10 29.63 54.20	6.58 3.59 1.95	5.13 9.41 17.32
Fujitsu VPP700	Nov 96	4 8 16 32	1.38 0.75 0.41 0.25	6.10 29.63 54.20 88.88	6.58 3.59 1.95 1.30	5.13 9.41 17.32 25.98
IBM SP-1	Mar 94	8 16 32 64	17.50 9.49 5.10 2.89	1.27 2.34 4.36 7.69	82.03 44.57 24.37 13.86	0.41 0.76 1.39 2.44
IBM RS/6000 SP Wide-node1 (67 MHz)	Oct 94	8 16 32 64 128	6.04 3.17 1.69 0.95 0.53	3.68 7.01 13.15 23.39 41.92	27.92 14.58 7.72 4.36 2.46	1.21 2.32 4.38 7.75 13.73
IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8 16 32 64	NA NA NA NA	NA NA NA NA	17.00 9.02 4.91 2.91	1.99 3.75 6.88 11.61
IBM RS/6000 SP Thin-node2 (67 MHz)	Feb 95	8 16 32 64 128	7.18 3.74 1.99 1.12 0.63	3.09 5.94 11.17 19.84 35.27	32.73 17.13 9.14 5.20 2.95	1.04 1.97 3.96 6.50 11.45
Intel iPSC/860	Aug 92	128	8.6	2.58	NA	NA

Table 3: Results of the Multigrid (MG) benchmark.

Intel Paragon MP (OSF1.3)	Jan 95	64 128 256	6.1 3.53 2.48	3.64 6.29 8.96	28.7 15.9 10.4	1.18 2.12 3.24
Intel Paragon (SunMos)	Jan 95	64 128 256 512	7.72 4.05 2.35 1.75	2.88 5.49 9.46 12.70	36.9 19.5 11.4 8.51	0.92 1.73 2.96 3.97
Intel Paragon (SunMos Turbo)	Nov 95	64 128 256 512	5.85 3.17 1.87 1.46	3.8 7.01 11.88 15.22	27.9 15.2 9.05 7.01	1.21 2.22 3.73 4.82
Intel Paragon MP SunMos Turbo	Jan 95	64 128 256 512	4.83 2.78 1.67 1.37	4.60 7.99 13.31 16.22	23.3 13.4 8.12 6.72	1.45 2.52 4.16 5.03
Kendall Square KSR1	Feb 94	32 64 128	19.7 10.3 5.6	1.13 2.16 3.97	NA NA NA	NA NA NA
Kendall Square KSR2	Feb 94 May 94	32 64	10.3 5.7	2.20 3.90	NA 26.1	NA 1.29
MasPar MP-1	Aug 92	16K	12.0	1.86	NA	NA
MasPar MP-2	Nov 92	16K	4.36	5.09	NA	NA
Meiko CS-1	Aug 92	16	42.8	0.52	NA	NA
Meiko CS-2	Oct 94	16 64 128	7.60 2.35 1.43	2.93 9.83 15.54	35.46 10.76 6.55	0.95 3.14 5.16
NEC SX-3	Oct 94	1	2.80	7.94	13.16	2.57
NEC SX-4/32	Nov 96	1 2 4 8 16 32	NA NA NA NA NA NA	NA NA NA NA NA NA	19.28 9.76 5.00 2.63 1.46 0.95	1.75 3.46 6.76 12.84 23.14 35.56

Table 3: Results of the Multigrid (MG) benchmark.

nCUBE-2S	Mar 94	64 128 512 1024	37.6 19.2 5.3 2.8	0.59 1.16 4.19 7.94	NA NA NA NA	NA NA NA NA
SGI Power Challenge 90 MHz	Oct 95	1 2 4 8 16	37.97 20.03 10.63 6.55 5.71	0.59 1.11 2.09 3.39 3.89	176.22 93.30 49.45 30.43 26.30	0.19 0.36 0.68 1.11 1.28
SGI Origin200 (180 MHz)	Nov 96	1 2 4	34.69 21.77 12.89	0.64 1.02 1.72	245.09 151.04 77.05	0.14 0.22 0.44
SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 31 32	30.14 17.75 10.67 6.00 3.34 NA 2.12	0.74 1.25 2.08 3.70 6.65 NA 10.48	194.88 113.79 56.19 28.41 15.03 NA 8.61	0.17 0.30 0.60 1.19 2.25 NA 3.92
Thinking Machines CM-2	Dec 91	16K 32K 64K	45.8 26.0 14.1	0.49 0.85 1.58	NA NA NA	NA NA NA
Thinking Machines CM-200	Dec 91	16K 32K	30.2 17.2	0.74 1.29	NA NA	NA NA
Thinking Machines CM-5	Aug 93	32 64 128	19.5 10.9 6.1	1.14 2.03 3.64	NA NA NA	NA NA NA
Thinking Machines CM-5E	Sep 95	16 32	7.7 3.8	2.89 5.85	36.1 18.7	0.94 1.81
Thinking Machines CM-500	Sep 95	64 128 256	2.2 1.41 0.91	10.1 15.76 24.42	10.6 6.2 3.9	3.19 5.49 8.67

Table 4: Results of the Conjugate Gradient (CG) benchmark.

Computer System	Date Received	.Number Processor	Class A		Class B	
			Time in seconds	Ratio to CRAY Y-MP/1	Time in seconds	Ratio to CRAY C90/1
BBN TC2000	Dec 91	40	51.4	0.23	NA	NA
Convex Exemplar SPP1000	Mar 95	1	202.9	0.06	NA	NA
		8	22.2	0.54	NA	NA
		16	8.94	1.33	837.0	0.15
		32	4.30	2.77	485.4	0.25
		64	NA	NA	292.1	0.42
HP/Convex Exemplar SPP2000	Nov 96	1	37.7	0.32	NA	NA
		4	9.8	1.22	NA	NA
		8	5.0	2.38	NA	NA
		16	2.7	4.41	NA	NA
CRAY C90	Feb 95	1	3.43	3.48	122.90	1.00
		2	1.79	6.66	63.11	1.95
		4	0.95	12.55	33.25	3.70
		8	0.53	22.49	18.11	6.79
		16	0.34	35.06	10.61	11.58
CRAY EL	Sep 93	1	45.24	0.26	NA	NA
		4	14.29	0.83	NA	NA
		8	10.14	1.18	NA	NA
CRAY J916	July 95	1	15.93	0.75	532.03	0.23
		2	8.42	1.42	293.24	0.42
		4	4.42	2.70	150.92	0.81
		8	2.61	4.57	80.67	1.52
		16	1.68	7.10	42.86	2.87
CRAY T3D	Feb 95	16	14.37	0.83	570.11	0.22
		32	7.44	1.60	291.30	0.42
		64	3.93	3.03	158.81	0.77
		128	2.11	5.65	82.07	1.50
		256	1.21	9.85	47.15	2.61
		512	0.72	16.56	27.34	4.50
		1024	0.58	20.55	16.58	7.41

Table 4: Results of the Conjugate Gradient (CG) benchmark.

CRAY T3E	Nov 96	1	NA	NA	802.3	0.15
		2	NA	NA	404.5	0.30
		8	6.5	1.83	205.6	0.60
		16	2.9	4.11	107.1	1.15
		32	1.6	7.45	59.3	2.07
		64	0.9	13.24	33.8	3.64
		128	0.6	19.87	22.9	5.37
		256	0.4	29.80	22.2	5.54
CRAY T916	July 95	1	1.95	6.11	73.98	1.66
		4	1.10	10.84	37.79	3.25
		8	0.58	20.55	19.65	6.25
		16	0.38	31.37	11.43	10.75
CRAY Y-MP	Aug 92	1	11.92	1.00	NA	NA
		8	2.38	5.01	NA	NA
Fujitsu VPP500	Aug 94	1	5.68	2.10	NA	NA
		2	3.06	3.90	104.51	1.18
		4	1.72	6.93	55.40	2.22
		8	1.04	11.46	31.80	3.86
		15	NA	NA	20.85	5.89
		16	0.80	14.90	NA	NA
		30	NA	NA	15.21	8.08
Fujitsu VX	Nov 96	1	5.8703	2.03	NA	NA
		2	3.1802	3.75	104.1408	1.18
		4	1.8185	6.55	57.8277	2.13
Fujitsu VPP300	Nov 96	1	5.8703	2.03	NA	NA
		2	3.1802	3.75	104.1408	1.18
		4	1.8185	6.55	57.8277	2.13
		8	1.0656	11.19	32.0605	3.83
		15	NA	NA	19.7696	6.22
		16	0.7514	15.86	NA	NA
Fujitsu VPP700	Nov 96	1	5.8703	2.03	NA	NA
		2	3.1802	3.75	104.1408	1.18
		4	1.8185	6.55	57.8277	2.13
		8	1.0656	11.19	32.0605	3.83
		15	NA	NA	19.7696	6.22
		16	0.7514	15.8	NA	NA
		30	NA	NA	13.4585	9.13
		35	0.6726	17.72	NA	NA

Table 4: Results of the Conjugate Gradient (CG) benchmark.

IBM SP-1	Feb 94	8 16 32 64	21.37 12.82 7.98 4.72	0.56 0.93 1.49 2.53	NA 638.2 362.9 193.4	NA 0.19 0.34 0.64
IBM RS/6000 SP Wide-node1 (67 MHz)	Mar 94	8 16 32 64 128	4.91 3.09 2.09 1.6 1.38	2.43 3.86 5.70 7.45 8.64	156.21 88.4 52.53 33.79 25.44	0.79 1.39 2.34 3.64 4.83
IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8 16 32 64	NA NA NA NA	NA NA NA NA	115.88 62.21 36.22 22.71	1.06 1.98 3.39 5.41
IBM RS/6000 SP Thin-node2 (67 MHz)	Mar 95	8 16 32 64 128	5.60 3.48 2.34 1.72 1.48	2.13 3.43 5.09 6.93 8.05	234.46 120.23 67.16 38.52 28.50	0.52 1.02 1.83 3.19 4.31
Intel iPSC/860	Sep 93	128	7.0	1.70	NA	NA
Intel Paragon (OSF1.2)	Mar 94	64 128 256 512	4.10 3.30 2.83 NA	2.91 3.61 4.21 NA	NA 132.5 70.0 47.6	NA 0.93 1.76 2.58
Intel Paragon (SunMos)	Nov 95	64 128 256 512	3.59 2.76 2.44 NA	3.32 4.31 4.89 NA	NA 125.4 63.6 40.5	NA 0.98 1.93 3.03
Kendall Square KSR1	Feb 94	32 64	19.0 13.4	0.63 0.89	NA NA	NA NA
Kendall Square KSR2	Feb 94	32 64	9.8 6.1	1.22 1.95	NA 182.0	NA 0.67
MasPar MP-1	Aug 92	4K 16K	64.5 14.6	0.18 0.82	NA NA	NA NA
MasPar MP-2	Nov 92	16K	11.0	1.08	NA	NA
Meiko CS-1	Aug 92	16	67.5	0.18	NA	NA
Meiko CS-2	Oct 94	16 32	7.18 5.60	1.66 2.13	248.30 156.50	0.49 0.79

Table 4: Results of the Conjugate Gradient (CG) benchmark.

nCUBE-2S	Mar 94	64	29.6	0.40	NA	NA
		128	16.9	0.7 1	NA	NA
		256	9.6	1.24	NA	NA
		512	6.2	1.92	NA	NA
		1024	4.1	2.91	NA	NA
NEC SX-4/32	Nov 96	1	NA	NA	81.77	1.50
		2	NA	NA	45.12	2.72
		4	NA	NA	26.31	4.67
Silicon Graphics	Oct 94	1	39.0	0.31	NA	NA
Power Challenge XL		2	16.9	0.71	NA	NA
(75 MHz)		4	7.2	1.66	NA	NA
		8	4.5	2.65	NA	NA
		16	3.5	3.41	NA	NA
SGI	May 95	1	35.14	0.34	NA	NA
Power Challenge		2	19.58	0.61	NA	NA
(90 MHz)		4	8.79	1.35	NA	NA
	Oct 95	8	4.03	2.96	NA	NA
		16	2.54	4.69	NA	NA
SGI Origin200	Nov 96	1	31.38	0.38	1731.18	0.07
(180 MHz)		2	18.67	0.64	1002.32	0.12
		4	9.76	1,22	624.62	0.20
SGI Origin2000	Nov 96	1	26.89	0.44	1538.71	0.08
(195 MHz)		2	14.37	0.83	851.82	0.14
		4	6.23	1.91	490.76	0.25
		8	3.02	3.95	283.19	0.43
		16	2.04	5.84	156.57	0.78
		31	NA	NA	79.65	1.54
Thinking Machines	Mar 92	8K	25.6	0.47	NA	NA
CM-2		16K	14.1	0.85	NA	NA
		32K	8.8	1.35	NA	NA
Thinking Machines	Aug 93	32	20.7	0.58	NA	NA
CM-5		64	10.6	1.12	NA	NA
		128	6.2	1.92	NA	NA
Thinking Machines	Sep 95	16	13.5	0.88	454	0.27
CM-5E		32	8.0	1.49	251	0.49
Thinking Machines	Sep 95	64	5.4	2.21	149	0.82
CM-500		128	3.9	3.06	91	1.35
		256	3.4	3.51	62	1.98

Table 5: Results of the 3-D FFT PDE (FT) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to CRAY Y-MP/1	Time in seconds	Ratio to CRAY C90/1
Convex Exemplar SPP1000	Mar 95	1	178.6	0.16	NA	NA
		8	25.5	1.13	375.4	0.29
		16	20.5	1.40	NA	NA
		32	13.9	2.07	NA	NA
CRAY C90	Feb 95	1	8.95	3.21	110.60	1.00
		2	4.53	6.35	55.75	1.98
		4	2.29	12.56	27.95	3.96
		8	1.29	22.30	14.12	7.83
		16	0.80	35.96	7.65	14.46
CRAY EL	May 93	1	105.1	0.27	NA	NA
		4	27.9	1.03	NA	NA
		8	18.5	1.56	NA	NA
CRAY J916	July 95	1	42.84	0.67	530.06	0.21
		2	22.08	1.30	267.92	0.41
		4	11.21	2.57	134.92	0.82
		8	5.80	4.97	70.51	1.57
		16	3.41	8.44	38.06	2.91
CRAY T3D	Feb 95	16	11.80	2.44	NA	NA
		32	5.90	4.87	NA	NA
		64	2.99	9.62	40.57	2.73
		128	1.52	18.93	20.68	5.35
		256	0.77	37.36	10.77	10.27
		512	0.51	56.41	6.44	17.17
		1024	0.32	89.91	3.76	29.41
CRAY T3E	Nov 96	2	28.9	1.00	NA	NA
		4	14.4	2.00	NA	NA
		8	7.3	3.94	86.2	1.28
		16	3.7	7.78	43.1	2.57
		32	1.9	15.14	21.8	5.07
		64	1.0	28.77	11.0	10.05
		128	0.5	57.54	5.5	20.11
		256	0.2	143.85	2.8	39.5

Table 5: Results of the 3-D FFT PDE (FT) benchmark.

CRAY T916	July 95	1 2 4 8	5.23 2.67 1.40 0.98	5.50 10.78 20.55 29.36	64.81 32.39 16.65 9.48	1.71 3.41 6.64 11.67
CRAY Y-MP	Aug 92	1 8	28.77 4.19	1.0 6.87	NA NA	NA NA
Fujitsu VPP500	Sept 95	1 2 4 8 16 32 64	11.25 5.67 2.88 1.44 0.75 0.40 0.24	2.56 5.07 9.99 19.98 38.36 71.93 119.88	NA NA 31.21 15.92 7.94 4.07 2.18	NA NA 3.54 6.95 13.91 27.17 50.73
Fujitsu VX	Nov 96	1 2 4	6.3272 4.3788 2.2557	4.55 6.57 12.75	NA 49.6885 24.5128	NA 2.23 4.51
Fujitsu VPP300	Nov 96	1 2 4 8 16	6.3272 4.3788 2.2557 1.1491 0.6005	4.55 6.57 12.75 25.04 47.91	NA 49.6885 24.5128 12.3758 6.3013	NA 2.23 4.51 8.94 17.55
Fujitsu VPP700	Nov 96	1 2 4 8 16 32	6.3272 4.3788 2.2557 1.1491 0.6005 0.3345	4.55 6.57 12.75 25.04 47.91 86.01	NA 49.6885 24.5128 12.3758 6.3013 3.2577	NA 2.23 4.51 8.94 17.55 33.95
IBM SP-1	Feb 94	8 16 32 64	43.68 22.86 12.08 6.46	0.66 1.26 2.38 4.45	NA 286.5 143.2 74.5	NA 0.39 0.77 1.49
IBM RS/6000 SP Wide-node1 (67 MHz)	Oct 94	8 16 32 64 128	13.31 7.17 3.96 2.19 1.23	2.16 4.01 7.27 13.4 23.39	NA 91.8 47.23 26.05 14.52	NA 1.20 2.34 4.25 7.62

Table 5: Results of the 3-D FFT PDE (FT) benchmark.

IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8	NA	NA	83.24	1.33
		16	NA	NA	40.52	2.73
		32	NA	NA	21.07	5.25
		64	NA	NA	15.07	7.34
IBM RS/6000 SP Thin-node2 (67 MHz)	Mar 95	8	14.78	1.95	NA	NA
		16	8.09	3.56	101.03	1.09
		32	4.31	6.68	51.38	2.15
		64	2.39	12.04	28.02	3.95
		128	1.30	22.13	15.68	7.05
Intel iPSC/860	Dec 91	64	20.9	1.38	NA	NA
	Apr 92	128	9.7	2.97	NA	NA
Intel Paragon OSF R 1.2	Nov 95	16	24.7	1.16	NA	NA
		32	12.99	2.21	NA	NA
		64	6.83	4.21	83.6	1.32
		128	3.85	7.47	42.07	2.63
		256	3.46	8.32	25.93	4.27
Intel Paragon SunMos	Nov 95	16	20.46	1.41	NA	NA
		32	10.54	2.73	NA	NA
		64	5.47	5.26	60.9	1.82
		128	3.13	9.19	32.15	3.44
		256	2.82	10.20	18.66	5.93
		512	NA	NA	16.17	6.84
Intel Paragon MP R1.3	Nov 95	16	17.6	1.63	NA	NA
		32	9.52	3.02	NA	NA
		64	5.16	5.58	60.9	1.82
		128	2.93	9.82	31.0	3.57
		256	2.73	10.54	19.87	5.57
Intel Paragon MP SunMos Turbo	Nov 95	64	3.87	7.43	41.8	2.65
		128	2.38	12.09	22.76	4.86
		256	2.20	13.08	14.2	7.79
		512	1.92	14.98	12.4	8.92
Kendall Square KSR1	Feb 94	32	16.2	1.78	NA	NA
		64	9.2	3.13	NA	NA
Kendall Square KSR2	Feb 94	32	9.0	3.20	NA	NA
	May 94	64	6.5	4.43	124.0	0.89
Kyoto/Matsushita ADENART	Feb 94	256	72.7	0.4	NA	NA

Table 5: Results of the 3-D FFT PDE (FT) benchmark.

MasPar MP-1	Aug 92	16K	18.3	1.57	NA	NA
MasPar MP-2	Nov 92	16K	8.0	3.60	NA	NA
Meiko CS-1	Aug 92	16	170.0	0.17	NA	NA
Meiko CS-2	Oct 94	16 32 64	12.67 7.17 4.53	2.27 4.01 6.35	NA 82.71 48.04	NA 1.34 2.30
nCUBE-2S	Mar 94	64 128 256 512 1024	62.8 32.9 16.0 8.4 4.1	0.46 0.87 1.8 3.43 7.02	NA NA NA NA NA	NA NA NA NA NA
NEC SX-3	Oct 94	1	2.79	10.31	37.52	2.95
NEC SX-4/32	Nov 96	1 2 4 8 16 32	NA NA NA NA NA NA	NA NA NA NA NA NA	56.57 28.14 14.79 8.03 4.74 3.14	1.96 3.93 7.48 13.77 23.33 35.22
Silicon Graphics Power Challenge XL (75 MHz)	Oct 94	1 2 4 8 16	61.17 35.53 19.98 12.57 11.18	0.47 0.81 1.44 2.29 2.57	761.67 414.52 223.97 130.15 110.37	0.15 0.27 0.49 0.85 1.00
SGI Power Challenge (90 MHz)	May 95	1 2 4 8 16	51.89 27.49 16.64 10.47 9.23	0.55 1.05 1.73 2.75 3.12	642.3 331.5 181.4 110.6 93.9	0.17 0.33 0.61 1.00 1.18
SGI Origin200 (180 MHz)	Nov 96	1 2 4	66.56 35.51 18.61	0.43 0.81 1.55	NA NA NA	NA NA NA

Table 5: Results of the 3-D FFT PDE (FT) benchmark.

SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 32	55.43 29.53 15.56 8.05 4.55 3.16	0.52 0.97 1.85 3.57 6.32 9.10	810.41 419.72 215.95 108.42 54.88 28.66	0.14 0.26 0.51 1.02 2.02 3.85
Thinking Machines CM-2	Dec 91	16K 32K 64K	37.0 18.2 11.4	0.78 1.58 2.52	NA NA NA	NA NA NA
Thinking Machines CM-200	Dec 91	8K	45.6	0.63	NA	NA
Thinking Machines CM-5	Aug 93	32 64 128	14.9 7.9 6.6	1.93 3.64 4.36	NA NA NA	NA NA NA
Thinking Machines CM-5E	Sep 95 Feb 94	16 32 64 128	12.8 6.7 3.9 2.9	2.25 4.29 7.38 9.92	160 82.0 46.0 34.0	0.69 1.35 2.40 3.25
Thinking Machines CM-500	Sep 95	64 128 256	3.5 1.96 1.33	8.22 14.67 21.63	41.9 22.5 13.2	2.64 4.92 8.38

Table 6: Results of the Integer Sort (IS) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to Cray Y-MP/1	Time in seconds	Ratio to Cray C90/1
Convex Exemplar SPP1000	Mar 95	1	83.2	0.14	NA	NA
		8	10.1	1.13	43.5	0.30
HP/Convex Exemplar SPP2000	Nov 96	1	30.6	0.37	NA	NA
		4	7.04	1.63	NA	NA
		8	3.49	3.28	NA	NA
		16	2.21	5.19	NA	NA
CRAY C90	Feb 95	1	3.33	3.44	12.92	1.0
		2	1.64	6.99	6.50	1.99
		4	0.85	13.48	3.30	3.92
		8	0.46	24.91	1.73	7.47
		16	0.27	42.44	0.98	13.18
CRAY EL	Sep 93	1	43.76	0.26	NA	NA
		4	12.99	0.88	NA	NA
		8	8.45	1.35	NA	NA
CRAY J916	July 95	1	13.75	0.83	54.41	0.24
		2	7.02	1.63	27.96	0.46
		4	3.81	3.00	13.93	0.93
		8	2.21	5.19	7.60	1.70
		16	1.63	7.03	4.91	2.63
CRAY T3D	Feb 95	16	7.07	1.62	NA	NA
		32	3.89	2.95	16.57	0.78
		64	2.09	5.48	8.74	1.48
		128	1.05	10.91	4.56	2.83
		256	0.55	20.84	2.36	5.47
		512	0.31	36.97	1.33	9.71
		1024	0.44	26.05	1.22	10.59

Table 6: Results of the Integer Sort (IS) benchmark.

CRAY T3E	Nov 96	2 4 8 16 32 64 128 256	16.9 8.1 4.0 2.2 1.2 0.6 0.3 0.2	0.68 1.42 2.87 5.21 9.55 19.10 38.20 57.30	NA 38.9 18.6 9.8 5.1 2.9 1.6 0.8	NA 0.33 0.69 1.32 2.53 4.46 8.08 16.15
CRAY T916	July 95	1 2 4 8	2.02 1.02 0.52 0.38	5.67 11.24 22.04 30.16	7.44 3.74 1.92 1.41	1.74 3.45 6.73 9.16
CRAY Y-MP	Aug 92	1 8	11.46 1.85	1.00 6.19	NA NA	NA NA
Fujitsu VPP500	Apr 94	1 2 4 8	2.189 1.574 1.098 0.917	5.24 7.28 10.44 12.50	NA NA 3.70 3.03	NA NA 3.49 4.26
Fujitsu VX	Nov 96	1 2 4	2.3968 1.8038 1.2519	4.78 6.35 9.15	9.1964 6.0875 4.1363	1.41 2.12 3.12
Fujitsu VPP300	Nov 96	1 2 4 8 16	2.3968 1.8038 1.2519 1.1249 1.0204	4.78 6.35 9.15 10.19 11.23	9.1964 6.0875 4.1363 3.1959 2.7231	1.41 2.12 3.12 4.04 4.74
Fujitsu VPP700	Nov 96	1 2 4 8 16 32	2.3968 1.8038 1.2519 1.1249 1.0204 0.9839	4.78 6.35 9.15 10.19 11.23 11.64	9.1964 6.0875 4.1363 3.1959 2.7231 2.7211	1.41 2.12 3.12 4.04 4.74 4.75
IBM SP-1	Feb 94	8 16 32 64	16.81 8.85 5.04 3.06	0.68 1.29 2.27 3.75	NA 37.3 20.1 11.2	NA 0.35 0.64 1.15

Table 6: Results of the Integer Sort (IS) benchmark.

IBM RS/6000 SP Wide-node1 (67 MHz)	Mar 95	8 16 32 64 128	4.93 2.65 1.54 0.89 0.59	2.32 4.32 7.44 12.88 19.42	19.75 10.60 5.92 3.41 1.98	0.65 1.22 2.18 3.79 6.53
IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8 16 32 64	NA NA NA NA	NA NA NA NA	11.16 5.85 3.20 1.75	1.16 2.21 4.04 7.38
IBM RS/6000 SP Thin-node2 (67 MHz)	Feb 95	8 16 32 64 128	5.16 2.89 1.66 0.91 0.61	2.22 3.97 6.90 12.59 18.79	20.79 11.46 6.37 3.58 2.05	0.62 1.13 2.03 3.61 6.30
Intel iPSC/860	May 92	32 64 128	25.7 17.3 13.6	0.45 0.66 0.84	NA NA NA	NA NA NA
Intel Paragon (OSF1.2)	Mar 94	32 64 128 256 512	7.81 4.34 2.41 NA NA	1.47 2.64 4.76 NA NA	NA 17.33 9.52 5.94 4.69	NA 0.75 1.36 2.18 2.75
Intel Paragon (SunMos)	Mar 94	32 64 128	5.48 3.77 2.29	2.09 3.04 5.00	NA 11.98 7.22	NA 1.08 1.79
Kendall Square KSR1	Feb 94	32 64	10.8 6.6	1.06 1.74	NA NA	NA NA
Kendall Square KSR2	Feb 94 May 94	32 64	7.0 3.9	1.64 2.94	NA 20.3	NA 0.64
Kyoto/Matsushita ADENART	Feb 94	256	46.6	0.25	NA	NA
MasPar MP-1	Jan 93	16K	11.5	1.00	NA	NA
MasPar MP-2	Jan 93	16K	7.7	1.49	NA	NA
Meiko CS-1	Aug 92	16	62.7	0.18	NA	NA

Table 6: Results of the Integer Sort (IS) benchmark.

nCUBE-2S	Mar 94	64 128 256 512 1024	23.2 12.0 6.1 3.2 1.7	0.49 0.96 1.88 3.58 6.74	NA 47.5 NA 12.5 6.5	NA 0.27 NA 1.03 1.99
NEC SX-4/32	Nov 96	1 2 4 8 16	NA NA NA NA NA	NA NA NA NA NA	6.77 3.50 1.877 1.139 0.896	1.91 3.69 6.88 11.34 14.42
SGI Power Challenge (90 MHz)	Oct 95	1 2 4 8	20.0 11.9 7.1 5.0	0.57 0.96 1.61 2.29	NA NA NA NA	NA NA NA NA
SGI Origin200 (180 MHz)	Nov 96	1 2 4	17.26 9.18 4.89	0.66 1.25 2.34	235.05 154.28 79.18	0.055 0.084 0.16
SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 32	13.66 7.07 3.80 2.14 1.34 1.21	0.84 1.62 3.02 5.36 8.55 9.47	104.48 54.36 27.25 15.09 8.89 5.76	0.12 0.24 0.47 0.86 1.45 2.24
Thinking Machines CM-200	Dec 91	64K	5.7	2.01	NA	NA
Thinking Machines CM-5	Aug 93	32 64 128	43.1 24.2 12.0	0.27 0.47 0.96	NA NA	NA NA NA
Thinking Machines CM-5E	Sep 95 Feb 94	16 32 64 128	11.9 6.1 3.1 1.66	0.96 1.88 3.70 6.90	NA 31.4 16.4 8.4	NA 0.41 0.79 1.54
Thinking Machines CM-500	Sep 95	64 128 256	3.16 1.67 1.16	3.63 6.86 9.88	16.1 8.2 4.3	0.80 1.58 3.0

Table 7: Results of the LU CFD Application (LU)benchmark.
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Computer System	Date Received	No. Proc.	Class A		Class B	
			Time in seconds	Ratio to Cray YMP/1	Time in seconds	Ratio to Cray C90/1
BBN TC2000	Dec 91	62	3032.0	0.11	NA	NA
Convex Exemplar SPP1000	Mar 95	1	2668	0.13	NA	NA
		8	331	1.00	1492	0.30
		16	196	1.70	827	0.54
		32	126	2.65	465.9	0.9
CRAY C90	Feb 95	1	119.78	2.78	449.54	1.00
		2	62.29	5.35	231.98	1.94
		4	32.20	10.36	121.26	3.71
		8	17.15	19.45	63.03	7.13
		16	10.17	32.79	37.93	11.85
CRAY EL	Aug 92	1	1449.0	0.23	NA	NA
		4	522.3	0.64	NA	NA
		8	351.6	0.95	NA	NA
CRAY J916	July 95	1	492.83	0.68	1994.05	0.23
		2	254.94	1.31	1024.74	0.44
		4	135.07	2.47	526.29	0.85
		8	72.73	4.51	286.17	1.57
		16	47.59	7.01	170.26	2.64
CRAY T3D	Feb 95	16	205.69	1.62	844.53	0.53
		32	106.89	3.12	451.18	1.00
		64	55.32	6.03	233.45	1.93
		128	28.71	11.62	120.53	3.73
		256	15.94	20.92	65.06	6.9
		512	9.02	36.97	36.39	12.35
		1024	7.09	47.04	20.77	21.64

CRAY T3E	Nov 96	2 4 8 16 32 64 128 256	356.4 179.2 90.2 46.9 24.0 12.9 7.1 4.2	0.94 1.86 3.70 7.11 13.90 25.85 46.97 79.41	1497.4 728.9 365.8 185.1 95.9 51.5 29.5 16.8	0.30 0.62 1.23 2.43 4.69 8.73 15.24 26.76
CRAY T916	July 95	1 2 4 8 16	82.67 46.91 23.68 15.74 NA	4.03 7.11 14.08 21.19 NA	293.38 149.33 77.95 43.13 28.26	1.53 3.01 5.77 10.42 15.91
CRAY Y-MP	Aug 92	1 8	333.5 49.5	1.00 6.74	NA NA	NA NA
DEC Alpha Server 8400 5/300 (300 MHz)	Oct 95	1 2 4 8 12	528.6 301.77 158.78 91.72 79.13	0.63 1.11 2.10 3.64 4.21	2304.9 1350.0 691.8 376.23 296.19	0.20 0.33 0.65 1.19 1.51
DEC Alpha Server 8400 5/440 (437 MHz)	Nov 96	1 2 4 8	378.61 219.41 115.83 67.965	0.88 1.52 2.88 4.91	1684.47 987.54 500.12 271.32	0.27 0.46 0.90 1.66
Fujitsu VPP500	Oct 95	1 2 3 4 6 8 16 17 34	101.960 61.409 NA 35.789 NA 21.041 13.944 NA NA	3.27 5.43 NA 9.31 NA 15.85 23.92 NA NA	414.82 242.23 175.20 NA 97.851 NA NA 43.644 28.095	1.08 1.86 2.57 NA 4.59 NA NA 10.30 16.00
Fujitsu VX	Nov 96	1 2 3 4	77.732 50.880 NA 30.500	4.29 6.55 NA 10.93	297.94 190.00 138.34 NA	1.51 2.37 3.25 NA

Fujitsu VPP300	Nov 96	1	77.732	4.29	297.94	1.51
		2	50.880	6.55	190.00	2.37
		3	NA	NA	138.34	3.25
		4	30.500	10.93	NA	NA
		6	NA	NA	78.026	5.76
		8	18.444	18.08	NA	NA
		16	12.553	26.57	NA	NA
Fujitsu VPP700	Nov 96	1	77.732	4.29	297.94	1.51
		2	50.880	6.55	190.00	2.37
		3	NA	NA	138.34	3.25
		4	30.500	10.93	NA	NA
		6	NA	NA	78.026	5.76
		8	18.444	18.08	NA	NA
		16	12.553	26.57	NA	NA
		17	NA	NA	36.736	12.24
		32	10.063	33.14	NA	NA
IBM SP-1	Feb 94	8	291.4	1.14	NA	NA
		16	172.9	1.93	604.8	0.74
		32	101.8	3.28	348.1	1.29
		64	63.2	5.28	207.5	2.17
IBM RS/6000 SP Wide-node1 (67 MHz)	Mar 95	8	112.5	2.96	429.8	1.05
		16	64.6	5.16	234.4	1.92
		32	36.5	9.14	129.7	3.47
		64	22.7	14.69	76.8	5.85
		128	15.2	21.94	47.8	9.4
IBM RS/6000 SP Wide-node2 (77 MHz)	Oct 95	1	501.5	0.67	2066.6	0.22
		8	80.81	4.13	311.53	1.44
		16	48.36	6.90	171.79	2.62
		32	29.41	11.34	98.04	4.59
		64	19.20	17.37	59.45	7.56
IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8	NA	NA	236.64	1.90
		16	NA	NA	126.77	3.55
		32	NA	NA	73.16	6.14
		64	NA	NA	42.89	10.48
IBM RS/6000 SP Thin-node1 (67 MHz)	Mar 95	8	120.8	2.76	477.3	0.94
		16	70.9	4.70	255.4	1.76
		32	40.1	8.32	141.3	3.18
		64	24.5	13.61	82.9	5.42
		128	15.9	20.97	51.2	8.78
Intel iPSC/860	Mar 91	64	690.8	0.48	NA	NA
		128	442.5	0.75	NA	NA

Intel Paragon (OSF1.2)	Jul 94	64 128 256 512	190.0 118.0 75.0 NA	1.76 2.83 4.45 NA	675.0 406.0 254.0 175.0	0.67 1.11 1.77 2.57
Kendall Square KSR1	Feb 94	32 64 128	341.0 199.0 155.0	0.98 1.68 2.15	NA NA NA	NA NA NA
Kendall Square KSR2	Feb 94 May 94	32 64	172.0 102.0	1.93 3.27	NA 424.0	NA 1.06
MasPar MP-1	Aug 92	4K	1580.0	0.21	NA	NA
MasPar MP-2	Nov 92	4K	463.5	0.72	NA	NA
Meiko CS-1	Aug 92	16	2937.0	0.11	NA	NA
nCUBE-2S	Mar 94	64 128 256 512 1024	1322.0 712.5 389.1 226.1 134.1	0.25 0.47 0.86 1.48 2.49	NA NA NA NA NA	NA NA NA NA NA
NEC SX-4/32	Nov 96	1 2 4 8 16 17 32	NA NA NA NA NA NA NA	NA NA NA NA NA NA NA	291.06 148.29 77.246 43.087 27.151 25.294 20.909	1.54 3.03 5.82 10.43 16.56 17.77 21.50
Silicon Graphics Power Challenge XL (75 MHz)	Oct 94	1 4 8 16	604.0 231.8 111.7 65.3	0.55 1.44 2.99 5.11	2617.9 1010.5 550.2 308.1	0.17 0.44 0.82 1.46
SGI Power Challenge - XL (90 MHz)	Oct 94	1 2 4 8 16	549.02 356.73 188.33 101.00 65.90	0.61 0.93 1.77 3.30 5.06	2439.90 1500.30 774.93 419.90 292.02	0.18 0.30 0.58 1.07 1.54
SGI Origin200 (180 MHz)	Nov 96	1 2 4	397.30 206.52 114.39	0.84 1.61 2.92	1873.60 958.01 519.32	0.24 0.47 0.87

SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 25 31	351.35 181.39 97.52 50.56 29.91 NA 18.93	0.95 1.84 3.42 6.60 11.15 NA 17.62	1522.30 777.43 401.80 221.32 130.41 89.75 NA	0.30 0.58 1.12 2.03 3.45 5.01 NA
Thinking Machines CM-2	Mar 91	8K 16K 32K	1307.0 850.0 546.0	0.26 0.39 0.61	NA NA NA	NA NA NA
Thinking Machines CM-5	Aug 93	32 64 128	418.0 272.0 171.0	0.80 1.23 1.95	NA NA NA	NA NA NA
Thinking Machines CM-5E	Sep 95 Feb 94	16 32 64 128	256 143 97.0 65.0	1.30 2.33 3.44 5.13	957 533 367.0 318.0	0.47 0.84 1.22 1.41
Thinking Machines CM-500	Sep 95	64 128 256	90 61 43	3.71 5.47 7.76	336 247 149	1.34 1.82 3.02

Table 8: Results of the SP simulated CFD application (SP) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to Cray YMP/1	Time in seconds	Ratio to Cray C90/1
BBN TC2000	Dec 91	112	880.0	0.54	NA	NA
Convex Exemplar SPP1000	Mar 95	1	2533	0.19	NA	NA
		8	345	1.37	1584	0.44
		16	228	2.07	1068	0.65
		32	144	3.27	697.4	0.99
		64	102	4.62	449.5	1.5
HP/Convex Exemplar SPP2000	Nov 96	1	770.9	0.61	NA	NA
		4	198.6	2.37	NA	NA
		8	101.6	4.64	NA	NA
		16	56.6	8.33	NA	NA
CRAY C90	Feb 95	1	174.50	2.70	689.60	1.00
		2	87.32	5.40	345.57	2.00
		4	44.75	10.54	175.85	3.92
		8	22.74	20.73	90.80	7.59
		16	12.82	36.78	52.22	13.21
CRAY EL	Aug 92	1	2025.7	0.23	NA	NA
		4	601.9	0.78	NA	NA
		8	488.4	0.97	NA	NA
CRAY J916	July 95	1	870.47	0.54	3728.69	0.18
		2	436.91	1.08	1927.50	0.36
		4	226.66	2.08	941.08	0.73
		8	118.30	3.99	521.73	1.32
		16	77.54	6.08	316.58	2.18
CRAY T3D	Feb 95	16	202.11	2.33	818.07	0.84
		32	104.10	4.53	463.62	1.49
		64	53.26	8.85	233.52	2.95
		128	27.54	17.12	130.45	5.29
		256	14.71	32.05	74.89	9.21
		512	8.91	52.92	42.63	16.18
		1024	5.41	87.15	25.23	27.33

Table 8: Results of the SP simulated CFD application (SP) benchmark.

CRAY T3E	Nov 96	2 4 8 16 32 64 128 256	621.9 313.0 157.5 79.8 39.2 20.4 11.2 6.0	0.76 1.51 3.00 5.91 12.03 23.11 42.10 78.58	2427.7 1230.5 611.7 312.9 162.7 85.5 48.1 26.9	0.28 0.56 1.13 2.20 4.24 8.07 14.34 25.64
CRAY T916	Jul 95	1 2 4 8 16	112.37 56.46 30.42 18.69 NA	4.20 8.35 15.50 25.23 NA	427.56 214.63 113.02 60.61 40.59	1.61 3.21 6.10 11.38 16.99
CRAY Y-MP	Aug 92	1 8	471.5 64.6	1.01 7.30	NA NA	NA NA
DEC Alpha Server 8400 5/300 (300 MHz)	Mar 95	1 4 8 12	749.61 199.17 118.04 102.75	0.63 2.37 3.99 4.59	3448.10 904.45 452.13 364.54	0.20 0.76 1.53 1.89
DEC Alpha Server 8400 5/440 (437 MHz)	Nov 96	1 2 4 8	575.80 290.83 153.89 91.430	0.82 1.62 3.06 5.16	2569.5 1294.9 661.45 363.35	0.27 0.53 1.04 1.90
Fujitsu VPP500	Mar 95	1 2 4 6 8 16 17 32 34 51 64	99.309 61.588 32.114 NA 16.399 8.5761 NA 4.5355 NA NA 2.5483	4.75 7.66 14.68 NA 28.75 54.98 NA 103.96 NA NA 185.03	404.08 241.23 127.48 83.710 64.930 NA 30.474 NA 15.674 10.654 NA	1.71 2.86 5.41 8.24 10.62 NA 22.63 NA 44.0 64.73 NA
Fujitsu VX	Nov 96	1 2 4	80.504 60.436 31.324	5.86 7.80 15.05	331.36 219.11 114.41	2.08 3.15 6.03

Table 8: Results of the SP simulated CFD application (SP) benchmark.

Fujitsu VPP300	Nov 96	1	80.504	5.86	331.36	2.08
		2	60.436	7.80	219.11	3.15
		4	31.324	15.05	114.41	6.03
		6	NA	NA	78.381	8.80
		8	16.054	29.37	58.781	11.73
		16	8.2465	57.18	NA	NA
Fujitsu VPP700	Nov 96	1	80.504	5.86	331.36	2.08
		2	60.436	7.80	219.11	3.15
		4	31.324	15.05	114.41	6.03
		6	NA	NA	78.381	8.80
		8	16.054	29.37	58.781	11.73
		16	8.2465	57.18	NA	NA
		17	NA	NA	27.860	24.75
		32	4.5311	104.06	NA	NA
		34	NA	NA	14.621	47.17
IBM SP-1	Feb 94	8	441.6	1.07	NA	NA
		16	268.7	1.75	941.2	0.73
		32	165.0	2.86	522.4	1.32
		64	100.4	4.69	302.3	2.28
IBM RS/6000 SP Wide-node1 (67 MHz)	Mar 95	8	143.8	3.28	589.3	1.17
		16	83.2	5.67	300.6	2.29
		32	48.7	9.68	163.8	4.21
		64	30.1	15.66	91.7	7.52
		128	18.7	25.21	54.8	12.58
IBM RS/6000 SP Wide-node2 (77 MHz)	Oct 95	1	711.8	0.66	3087.0	0.22
		8	114.15	4.13	453.66	1.52
		16	69.32	6.80	248.51	2.77
		32	43.20	10.91	142.88	4.83
		64	26.46	17.82	80.17	8.60
IBM RS/6000 SP P2SC node (120 MHz)	Nov 96	8	NA	NA	359.81	1.92
		16	NA	NA	182.30	3.78
		32	NA	NA	107.16	6.44
		64	NA	NA	58.35	11.82
IBM RS/6000 SP Thin-node2 (67 MHz)	Mar 95	8	161.1	2.93	640.9	1.08
		16	93.3	5.05	342.3	2.01
		32	53.6	8.80	184.4	3.74
		64	32.7	14.42	101.6	6.79
		128	20.6	22.89	59.9	11.51

Table 8: Results of the SP simulated CFD application (SP) benchmark.

Intel iPSC/860	Jul 94 Aug 92	64 128	640.0 449.5	0.74 1.05	NA NA	NA NA
Intel Paragon (OSF1.2)	Jul 94	64 102 128 204 256 324 400 484	226.0 NA 143.0 NA 97.0 89.0 NA NA	2.09 NA 3.30 NA 4.86 5.30 NA NA	960.0 610.0 NA 387.0 301.0 262.0 246.0 209.0	0.72 1.13 NA 1.78 2.29 2.63 2.80 3.30
Kendall Square KSR1	Feb 94	32 64 128	418.0 257.0 160.0	1.13 1.83 2.95	NA NA NA	NA NA NA
Kendall Square KSR2	Feb 94 May 94	32 64	221.0 131.0	2.13 3.59	NA 495.0	NA 1.39
Kyoto/Matsushita ADENART	Feb 94	256	209.9	2.24	NA	NA
MasPar MP-1	Aug 92	4K	1772	0.27	NA	NA
MasPar MP-2	Nov 92	4K	615	0.77	NA	NA
Meiko CS-1	Aug 92	16	2975	0.16	NA	NA
nCUBE-2S	Mar 94	64 128 256 512 1024	1243.2 717.4 387.3 208.6 120.9	0.38 0.66 1.22 2.26 3.90	NA NA NA NA NA	NA NA NA NA NA
NEC SX-3	Oct 94	1	75.72	6.23	495.0	1.39
NEC SX-4/32	Nov 96	1 2 4 8 16 17 26 32	NA NA NA NA NA NA NA NA	NA NA NA NA NA NA NA NA	398.77 199.08 99.984 52.353 28.823 24.697 17.410 17.130	1.73 3.46 6.90 13.17 23.93 27.92 39.61 40.26

Table 8: Results of the SP simulated CFD application (SP) benchmark.

Silicon Graphics Power Challenge XL (75 MHz)	Oct 94	1	858.3	0.55	3719.5	0.19
		4	225.8	2.09	947.6	0.73
		8	119.5	3.95	491.4	1.40
		16	67.2	7.02	313.1	2.20
SGI Power Challenge - XL (90 MHz)	May 95	1	757.00	0.62	3343.90	0.21
		2	387.90	1.22	1685.30	0.41
		4	200.44	2.35	853.35	0.81
		8	106.43	4.43	445.38	1.55
		16	63.18	7.46	294.22	2.34
SGI Origin200 (180 MHz)	Nov 96	1	768.25	0.61	4036.90	0.17
		2	408.32	1.15	2259.90	0.31
		4	222.04	2.12	1229.30	0.56
SGI Origin2000 (195 MHz)	Nov 96	1	675.28	0.70	3068.70	0.22
		2	346.02	1.36	1628.00	0.42
		4	187.86	2.51	803.64	0.86
		8	97.97	4.81	423.61	1.63
		16	52.01	9.07	234.99	2.94
		25	NA	NA	140.48	4.91
		31	30.47	15.47	NA	NA
Thinking Machines CM-2	Dec 91	16K	1444.0	0.33	NA	NA
		32K	917.0	0.51	NA	NA
		64K	640.0	0.74	NA	NA
Thinking Machines CM-5		32	289.0	1.63	NA	NA
		64	170.0	2.77	NA	NA
		128	119.0	3.96	NA	NA
Thinking Machines CM-5E	Sep 95	16	268	1.76	1580	0.44
		32	144	3.27	771	0.89
	Feb 94	64	104.0	4.53	595.0	1.16
		128	61.0	7.73	320.0	2.16
Thinking Machines CM-500	Sep 95	64	85	5.55	405	1.70
		128	51	9.25	236	2.92
		256	34	13.87	140	4.93

Table 9: Results of the BT simulated CFD application (BT) benchmark.

Computer System	Date Received	Number Processor	Class A		Class B	
			Time in seconds	Ratio to CRAY Y-MP/1	Time in seconds	Ratio CRAY C90/1
BBN TC2000	Dec 91	112	1378.0	0.58	NA	NA
Convex Exemplar SPP1000	Mar 95	1	2825	0.28	NA	NA
		8	366	2.17	1675	0.61
		16	211	3.76	984	1.04
		32	125	6.34	559.8	1.82
		64	78	10.16	338.2	3.03
HP/Convex Exemplar SPP2000	Nov 96	1	829.4	0.96	NA	NA
		4	212.9	3.72	NA	NA
		8	107.2	7.39	NA	NA
		16	55.3	14.33	NA	NA
CRAY C90	Feb 95	1	276.80	2.86	1023.4	1.00
		2	139.44	5.68	519.46	1.97
		4	72.11	10.99	265.20	3.86
		8	36.99	21.42	138.16	7.41
		16	20.30	39.03	78.80	12.99
CRAY EL	May 93	1	3832.8	0.21	NA	NA
		4	1090.2	0.73	NA	NA
		8	764.1	1.04	NA	NA
CRAY J916	July 95	1	1202.53	0.66	5356.59	0.19
		2	608.83	1.30	2789.74	0.37
		4	317.62	2.49	1414.43	0.72
		8	168.46	4.70	765.60	1.34
		16	98.80	8.02	426.91	2.40
CRAY T3D	Feb 95	16	230.41	3.44	918.04	1.11
		32	115.53	6.85	476.97	2.15
		64	59.01	13.43	252.86	4.04
		128	29.96	26.44	128.21	7.98
		256	15.89	49.87	68.38	15.0
		512	8.39	94.45	38.01	26.92
		1024	4.56	173.77	20.45	50.04

Table 9: Results of the BT simulated CFD application (BT) benchmark.

CRAY T3E	Nov 96	2	677.9	1.17	2988.7	0.34
		4	339.8	2.33	1480.7	0.69
		8	172.5	4.59	735.6	1.39
		16	88.6	8.94	370.3	2.76
		32	44.6	17.77	192.2	5.32
		64	22.7	34.91	99.9	10.24
		128	11.9	66.59	54.5	18.78
		256	6.2	127.81	29.3	34.93
CRAY T916	July 95	1	193.19	4.10	649.10	1.58
		2	100.10	7.92	332.38	3.08
		4	53.23	14.89	169.27	6.05
		8	30.66	25.84	92.43	11.07
		16			64.06	15.98
CRAY Y-MP	Aug 92	1	792.4	1.00	NA	NA
		8	114.0	6.95	NA	NA
DEC Alpha Server 8400 5/300 (300 MHz)	Oct 95	1	1048.7	0.76	4076.50	0.25
		2	527.04	1.50	2525.00	0.41
		4	271.13	2.92	1278.60	0.80
		8	146.91	5.39	649.53	1.58
		12	103.47	7.66	458.21	2.23
DEC Alpha Server 8400 5/440 (437 MHz)	Nov 96	1	747.75	1.06	3390.4	0.30
		2	376.03	2.11	1727.7	0.59
		4	192.67	4.11	881.90	1.16
		8	103.54	7.65	454.39	2.25
Fujitsu VPP500	Mar 95	1	142.42	5.56	NA	NA
		2	75.17	10.54	NA	NA
		4	39.14	20.25	NA	NA
		8	19.82	39.98	NA	NA
		16	9.99	79.32	NA	NA
		17	NA	NA	37.26	27.47
		32	5.09	155.68	NA	NA
		34	NA	NA	18.82	54.38
		51	NA	NA	12.61	81.16
		64	2.66	297.90	NA	NA
Fujitsu VX	Nov 96	1	129.40	6.12	487.29	2.10
		2	68.510	11.57	258.20	3.96
		4	35.518	22.31	175.09	5.84

Table 9: Results of the BT simulated CFD application (BT) benchmark.

Fujitsu VPP300	Nov 96	1	129.40	6.12	487.29	2.10
		2	68.510	11.57	258.20	3.96
		3	NA	NA	175.09	5.84
		4	35.518	22.31	NA	NA
		6	NA	NA	88.541	11.56
		8	18.088	43.81	NA	NA
		16	9.2841	85.35	NA	NA
Fujitsu VPP700	Nov 96	1	129.40	6.12	487.29	2.10
		2	68.510	11.57	258.20	3.96
		3	NA	NA	175.09	5.84
		4	35.518	22.31	NA	NA
		6	NA	NA	88.541	11.56
		8	18.088	43.81	NA	NA
		16	9.2841	85.35	NA	NA
		17	NA	NA	31.634	32.35
		32	4.9286	160.78	NA	NA
		34	NA	NA	16.824	60.83
IBM SP-1	Aug 94	8	443.9	1.79	NA	NA
		16	249.2	3.18	987.4	1.04
		32	143.0	5.54	511.2	2.00
		64	83.1	9.54	274.6	3.73
IBM RS/6000 SP	Mar 95	8	206.7	3.83	862.8	1.19
Wide-node1 (67 MHz)		16	112.9	7.02	440.6	2.32
		32	61.8	12.82	226.8	4.51
		64	34.7	22.84	119.1	8.59
		128	20.1	39.42	67.0	15.27
IBM RS/6000 SP	Oct 95	1	1130.7	0.70	4775.7	0.21
Wide-node2 (77 MHz)		8	170.74	4.64	708.47	1.44
		16	95.48	8.30	375.76	2.72
		32	51.34	15.44	197.91	5.17
		64	29.01	27.31	105.19	9.73
IBM RS/6000 SP	Nov 96	8	NA	NA	504.58	2.03
P2SC node (120 MHz)		16	NA	NA	263.77	3.88
		32	NA	NA	143.77	7.12
		64	NA	NA	76.49	13.38
IBM RS/6000 SP	Feb 95	8	216.6	3.66	889.8	1.15
Thin-node2 (67 MHz)		16	118.0	6.72	459.2	2.23
		32	64.9	12.21	237.2	4.31
		64	36.3	21.83	124.8	8.20
		128	20.8	38.10	69.6	14.70

Table 9: Results of the BT simulated CFD application (BT) benchmark.

Intel iPSC/860	Aug 92	64	714.7	1.11	NA	NA
		128	414.3	1.91	NA	NA
Intel Paragon	Mar 94	64	235.0	3.37	NA	NA
(OSF1.2)		102	NA	NA	633.0	1.62
		128	129.0	6.14	NA	NA
		204	NA	NA	359.0	2.86
		256	83.0	9.55	NA	NA
		306	NA	NA	257.0	3.98
		408	NA	NA	226.0	4.53
		510	NA	NA	196.0	5.22
		512	63.0	12.58	NA	NA
Intel Paragon	Nov 93	64	224.0	3.54	NA	NA
(SunMos)	Mar 94	102	NA	NA	598.0	1.71
		128	113.0	7.01	NA	NA
		204	NA	NA	324.0	3.16
		306	NA	NA	215.0	4.76
Kendall Square KSR1	Feb 94	32	457	1.74	NA	NA
		64	256	3.1	NA	NA
		128	145	5.46	NA	NA
Kendall Square KSR2	Feb 94	32	225	3.52	NA	NA
	May 94	64	130	6.10	542.0	1.89
Kyoto/Matsushita ADENART	Feb 94	256	314.1	2.52	NA	NA
MasPar MP-1	Aug 92	4K	2396.0	0.33	NA	NA
MasPar MP-2	Nov 92	4K	789.0	1.00	NA	NA
Meiko CS-1	Aug 92	16	2984.0	0.27	NA	NA
Meiko CS-2	Oct 94	8	570.4	1.39	NA	NA
		16	286.6	2.77	NA	NA
		32	149.3	5.31	NA	NA
nCUBE-2S	Mar 94	64	1243.2	0.64	NA	NA
		128	644.7	1.22	NA	NA
	Jul 94	256	336.7	2.35	NA	NA
		512	179.1	4.42	NA	NA
		1024	100.9	7.85	NA	NA
NEC SX-3	Oct 94	1	100.31	7.90	NA	NA

Table 9: Results of the BT simulated CFD application (BT) benchmark.

NEC SX-4/32	Nov 96	1 2 4 8 16 17 26 32	NA NA NA NA NA NA NA NA	NA NA NA NA NA NA NA NA	577.16 288.72 146.59 75.393 40.932 35.574 23.996 24.042	1.77 3.54 6.98 13.57 25.00 28.77 42.65 42.57
Silicon Graphics Power Challenge XL (75 MHz)	Oct 94	1 4 8 16	1330.3 355.9 177.0 91.8	0.60 2.23 4.48 8.63	5698.7 1450.0 775.0 426.0	0.18 0.71 1.32 2.40
SGI Power Challneg XL (90 MHz)	May 95	1 2 4 8 16	1145.20 574.37 298.74 152.65 80.20	0.69 1.38 2.65 5.19 9.88	5089.60 2537.70 1278.60 672.56 391.88	0.20 0.40 0.80 1.52 2.61
SGI Origin200 (180 MHz)	Nov 96	1 2 4	826.53 420.08 222.57	0.96 1.89 3.56	3953.70 2091.50 1069.20	0.26 0.49 0.95
SGI Origin2000 (195 MHz)	Nov 96	1 2 4 8 16 25 31	768.42 388.43 196.13 103.41 55.44 NA 30.05	1.03 2.04 4.04 7.66 14.29 NA 26.37	3437.70 1767.00 904.23 468.77 253.07 151.87 NA	0.30 0.58 1.13 2.18 4.04 6.73 NA
Thinking Machines CM-2	Dec 91	16K 32K 64K	1118.0 634.0 370.0	0.71 1.25 2.14	NA NA NA	NA NA NA
Thinking Machines CM-200	Dec 91	16K 32K	832.0 601.0	0.95 1.32	NA NA	NA NA
Thinking Machines CM-5	May 93	32 64 128	284.0 175.0 119.0	2.79 4.50 6.66	NA NA NA	NA NA NA

Table 9: Results of the BT simulated CFD application (BT) benchmark.

Thinking Machines CM-5E	Sep 95	16	259	3.06	1480	0.69
		32	135	5.87	712	1.44
	Feb 94	64	84.0	9.43	464.0	2.21
		128	48.0	16.50	253.0	4.05
Thinking Machines CM-500	Sep 95	64	75	10.56	370	2.77
		128	43	18.43	209	4.90
		256	27	29.34	114	8.98

Table 10: Results for NPB 1.0 Class C on CRAY T3E.

No. of CPUs	Wall Clock Time in Seconds							
	EP	**MG**	**CG**	**FT**	**IS**	**LU**	**SP**	**BT**
1	NA	NA	NA	NA	NA	NA	NA	NA
4	448.8	NA	NA	NA	NA	NA	NA	NA
8	224.4	NA	NA	NA	NA	NA	NA	NA
16	112.2	NA	272.9	NA	48.9	773.4	1352.7	1806.5
32	56.1	53.0	146.2	93.4	23.8	387.8	661.5	904.3
64	28.1	26.7	78.5	47.2	14.5	195.3	327.0	454.4
128	14.0	13.6	51.7	23.7	7.5	101.5	174.3	230.6
256	7.0	7.1	46.9	12.1	4.0	52.8	93.9	115.4

Table 11: Approximate sustained performance per dollar for Class B LU benchmark.

.

Computer System	# Proc.	Memory	Ratio to C90/1	List Price Million Dollars	Performance per Million Dollars	Date
CRAY T3E	128	64 MB/PE	15.24	5.0	3.05	Nov 96
DEC Alpha Server 8400 5/440 (437 MHz)	8	2 GB	1.66	0.58	2.86	Nov 96
Fujitsu VX	3	2 GB /PE	3.25	1.11	2.93	Nov 96
Fujitsu VPP300	6	512 MB /PE	5.76	1.54	3.74	Nov 96
Fujitsu VPP700	17	512 MB/PE	12.24	5.17	2.37	Nov 96
IBM RS/6000 SP P2SC node (120 MHz)	64	128 MB/PE	10.48	3.52	2.98	Nov 96
NEC SX-4/32	32	4 GB	21.50	10.7	2.0	Nov 96
SGI Origin2000 (195 MHz)	26	2 GB	5.01	0.96	5.21	Nov 96

Table 12: Approximate sustained performance per dollar for Class B SP benchmark.
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Computer System	# Proc	Memory	Ratio to C90/1	List Price Million Dollars	Performance per Million Dollars	Date
CRAY T3E	128	64 MB/PE	14.34	5.0	2.87	Nov 96
DEC Alpha Server 8400 5/440 (437 MHz)	8	2 GB	1.90	0.58	3.28	Nov 96
Fujitsu VX	4	512 MB/PE	6.03	1.0	6.03	Nov 96
Fujitsu VPP300	8	512 MB/PE	11.73	1.99	5.89	Nov 96
Fujitsu VPP700	34	512 MB/PE	47.17	9.98	4.73	Nov 96
IBM RS/6000 SP P2SC node (120 MHz)	64	128 MB/PE	11.82	3.52	3.36	Nov 96
NEC SX-4/32	32	4 GB	40.26	10.7	3.76	Nov 96
SGI Origin2000 (195 MHz)	26	2 GB	4.91	0.96	5.11	Nov 96

Table 13: Approximate sustained performance per dollar for Class B BT benchmark.
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Computer System	# Proc	Memory	Ratio to C90/1	List Price Million Dollars	Performance per Million Dollars	Date
CRAY T3E	128	64 MB/PE	18.78	5.0	3.76	Nov 96
DEC Alpha Server 8400 5/440 (437 MHz)	8	2 GB	2.25	0.58	3.88	Nov 96
Fujitsu VX	3	512 MB/PE	5.84	1.11	5.26	Nov 96
Fujitsu VPP300	6	512 MB/PE	11.56	1.54	7.51	Nov 96
Fujitsu VPP700	34	512 MB/PE	60.83	9.98	6.1	Nov 96
IBM RS/6000 SP P2SC node (120 MHz)	64	128 MB/PE	13.38	3.52	3.80	Nov 96
NEC SX-4/32	32	4 GB	42.57	10.7	3.98	Nov 96
SGI Origin2000 (195 MHz)	26	2 GB	6.73	0.96	7.01	Nov 96

Table 14: Results of the HPF based EP benchmark.

Computer System	Date Received	Number Processor	Time in seconds			
			Class A		Class B	
			APR	PGI	APR	PGI
HP/Convex Exemplar SPP200	Oct 96	1	NA	617	NA	NA
		2	NA	289	NA	NA
		4	NA	145	NA	NA
		8	NA	75	NA	NA
		16	NA	39	NA	NA
IBM SP2 Wide Nodes	Sept 96	1	NA	947	NA	NA
		2	NA	473	NA	1895
		4	NA	237	NA	946
		8	NA	119	NA	474
		16	79	59	NA	237
		32	42	30	NA	119
		64	23	15	NA	59
SGI/CRAY T3D	Sept 96	1	NA	1190	NA	4782
		2	NA	596	NA	2398
		4	NA	302	NA	1190
		8	NA	151	NA	595
		16	86	74	NA	298
		32	43	37	NA	149
		64	22	19	NA	NA

Table 15: Results of the HPF based MG benchmark.

Computer System	Date Received	Number Processor	Time in seconds			
			Class A		Class B	
			APR	PGI	APR	PGI
IBM SP2 Wide Nodes	Sept 96	16 32 64	12 9 7	NA NA NA	NA NA NA	NA NA NA
SGI/CRAY T3D	Sept 96	16 32 64	64 37 25	NA NA NA	NA NA NA	NA NA NA

Table 16: Results of the HPF based FT benchmark.

Computer System	Date Received	Number Processor	Time in seconds			
			Class A		Class B	
			APR	PGI	APR	PGI
IBM SP2 Wide Nodes (67 mHz)	Sept 96	16 32 64	NA NA NA	6.2 3.1 2.6	NA NA NA	NA NA NA
SGI/CRAY T3D	Sept 96	16 32 64 128	NA NA NA NA	27.2 15.6 9.5 5.6	NA NA NA NA	NA NA NA 19.6

Table 17: Results of the HPF based SP benchmark.

Computer System	Date Received	Number Processor	Time in seconds			
			Class A		Class B	
			APR	PGI	APR	PGI
HP/Convex Exemplar SPP200	Oct 96	1	NA	3826	NA	NA
		2	NA	1908	NA	NA
		4	NA	966	NA	NA
		8	NA	504	NA	NA
		16	NA	274	NA	NA
IBM SP2 Wide Nodes (67 MHz)	Sept 96	16	315	237	NA	NA
		32	207	142	NA	NA
		64	130	99	NA	NA
SGI/CRAY T3D	Sept 96	8	NA	1618	NA	NA
		16	803	834	NA	3327
		32	420	425	NA	1950
		64	226	228	NA	1012

Table 18: Results of the HPF based BT benchmark.

Computer System	Date Received	Number Processor	Time in seconds			
			Class A		Class B	
			APR	PGI	APR	PGI
HP/Convex Exemplar SPP200	Oct 96	1	NA	2372	NA	NA
		2	NA	1161	NA	NA
		4	NA	699	NA	NA
		8	NA	335	NA	NA
		16	NA	175	NA	NA
IBM SP2 Wide Nodes (67 MHz)	Sept 96	1	NA	3273	NA	NA
		2	NA	1697	NA	NA
		4	NA	907	NA	3788
		8	NA	469	NA	1963
		16	332	249	NA	1111
		32	184	135	NA	652
		64	109	81	NA	350
SGI/CRAY T3D	Sept 96	8	NA	1669	NA	6795
		16	1044	855	NA	3634
		32	536	438	NA	2119
		64	275	226	NA	1096