PERFORMANCE of VARIOUS COMPUTERS in COMPUTATIONAL CHEMISTRY

Martyn F. Guest,
Computational Science and Engineering Department,
CCLRC Daresbury Laboratory, Daresbury,
Warrington WA4 4AD, Cheshire, UK

September 2003

Contents

ABSTRACT

This report compares the performance of a number of different computer systems using a variety of software from the discipline of computational chemistry. The software includes matrix operations, a variety of chemistry kernels from quantum chemistry and molecular dynamics and a set of twelve quantum chemistry (QC) calculations and six molecular dynamics (MD) simulations. The QC calculations have been carried out using the GAMESS-UK electronic structure code, the MD calculations using the DL_POLY molecular dynamics program.

The comparison involves approximately one hundred and fifty computers, ranging from vector supercomputers such as the NEC SX-5 to scientific workstations from HP/Compaq, IBM, Silicon Graphics and SUN, and both IA32- and IA64-CPUs from Intel and AMD.

1. INTRODUCTION

This report presents a performance evaluation through benchmarking of a number of different computer systems specifically in the area of computational chemistry. This work has been ongoing since 1988, when the intention was to include representative hardware typifying supercomputers, superminis, workstations and the emerging class of parallel, novel architecture machines. Throughout the 1980's the cost effective debate in scientific computing centred on the relative merits of conventional vector supercomputers [1] and so-called *superminis*, machines costing some 10% of supercomputers, and exhibiting some 10% of supercomputer performance [1]. Over the past 8 years the supermini category of computational resource has to a large extent disappeared from both the vocabulary and offerings of most hardware vendors, to be replaced by high-end workstation servers. In contrast to earlier reports in this series, we have now discarded those machines that originally belonged in the supermini bracket (e.g., the Convex C-220 and Convex C-3860, the FPS M64/60 [1] and Alliant FX2808).

Vector supercomputers used in this report include the NEC SX-5 and SX-4, A large number of workstations and workstation servers have been benchmarked, including those from,

- HP/Compaq/DEC. The most recent machines benchmarked include the HP AlphaServer ES45, featuring both 1250 MHz and 1000 MHz A21264C EV68 CPUs, with 16 MByte L2 cache in the former and 8 MByte L2 cache in the latter. Perhaps a more interesting system is the AlphaServer SC based on EV7 technology. Code-named "Marvel", the 1 GHz processor promises significantly enhanced memory bandwidth compared to the EV68. EV67 processors clocked at 833 MHz feature in the AlphaServer ES40 (again with 8 MByte L2 cache) and in the Linux-based UP2000 dual-processor CPU from API (in the present case with 4 MByte L2 DDR cache). The slower 667 MHz EV67 again features in the API UP2000 and in the Compaq PW XP1000, the DS20E AlphaServer, and the ES40 AlphaServer (with 8 MByte L2 cache). A large number of systems housing the A21264 EV6 CPU have been evaluated. These include the DEC Alpha 8400/6-575, the entry-level 466 MHz Compaq AlphaServer DS10, the 500 MHz A21264-based machines (the single CPU XP1000 personal workstation, the dual

processor Compaq DS20/6-500 and quad processor ES40/6-500 AlphaServer), plus the Compaq GS140 with 525 MHz A21264. Note that the DS10 features a 2 MByte L2 cache, in contrast to the 4 MByte cache of the XP1000, DS20/6-500 and ES40/6-500. Also included is the Samsung AlphaPC 264DP-500, which with 2 MByte L2 cache runs Linux, in contrast to the Tru64 OS on the other EV6-based machines. Retired Alpha systems include the AXP Alpha EV4-based 3000 series and EV5-based 500, 600, 2100, PW AU and 8400 series.

- Hewlett Packard, with the most recent PA-RISC based system evaluated being the Model RP7410 featuring the 850 MHz PA8700+. PA8600 and PA8700 CPUs feature in the HP PA-9000/J6000 (552MHz) and HP PA-9000/J6700 (750MHz) respectively. Older PA8500-systems include the PA-9000/785 Model 360 (367MHz), the HP PA-9000/C3000 (400MHz), HP PA-9000/J5000 and PA-9000/N4000 (440MHz) models. Retired systems include the HP model 9000 series with the PA8000 and PA8200 CPUs, the former in the C160 (160MHz), the latter in the 200MHz HP PA-9000/V2200 (the Exemplar-V class), the PA-9000/C200 and in the 236 MHz PA-9000/C240 and PA-9000/V2250.
- IBM, with a wide range of RS6000-based models centred on Power CPU technology. The latest addition to the power series is the power4; clocked at 1.3 GHz, this CPU features in the 8-way IBM pSeries 690Turbo and in the 32-way Regatta H node. Benchmark results from both machine are included in this report, together with those from the 16-way Regatta HPC node (in which one of the dual core CPUs is disabled), and the 1 GHz power4 CPU in the 4-way IBM eServer pSeries 630/6C4. Older Power3 RS6000-based models include the 4-way SP Winterhawk2 (WH2) node and IBM RS/6000 44P-270, both clocked at 375 MHz, the 8-way Nighthawk node, clocked at 222 MHz, and the dual processor IBM RS/6000 43P Model 260 (200 MHz). Retired systems evaluated include those based on Power, Power2 and Power2 Super chip (P2SC) CPUs.
- Silicon Graphics, with desktop and server machines featuring the MIPS range of processors. The most recent R14k-based machines evaluated include the 600 MHz SGI Onyx 300, and the 500 MHz Origin 3800 and dual processor Origin 300. R12k-based machines include the Origin 3800 (400 MHz), Origin 2000 (300 and 400 MHz), the 270 MHz Octane R12k and O2 R12k, and the 400 MHz R12k Octane 2. Systems featuring the R10k include the Power Challenge, Origin200, O2000, Octane and the ill-fated O2; the R10k CPUs include those rated at 175, 195, 225 and 250 MHz. R5k-based machines include the Indy and O2. Retired machines with the R3000-, R4000-, and R8k-based systems include the Challenge, Power Challenge (PChall.), Indy, Indigo and Indigo2, Crimson, and 4D series.
- SUN, with systems based on the SPARC family of processors. The latest UltraSPARC-III Cu-based systems evaluated include the dual 1.056 GHz Sun Blade 2000 and the 8-way Sun Fire V880 with 900 MHz CPUs. Other UltraSPARC-III systems benchmarked include the Sun Blade 1000 Model 1750, with 750 MHz CPU, and SUN Fire 6800/900-Cu. All of these systems feature 8 MByte L2 cache. UltraSPARC-IIi based systems feature the HPC4500 with 400 MHz CPU and Ultra80 (with 450 MHz CPU), both with 4 MByte L2 caches. Retired systems benchmarked include the SPARC-5 and SPARC-10, the HyperSPARC, Ultra-SPARC-1 (Ultra-1/140 and 170) and Ultra-SPARC-2 processors (Ultra-2/200, Ultra-2/300, Ultra30/300 and Enterprise HPC4500, 336MHz).

During the 1990s, workstations based on proprietary RISC CPUs repeatedly demonstrated their cost-effectiveness against vector supercomputers in many scientific applications. Throughout this time, the performance of the family of Intel x86 processors became increasingly competitive, so much so that recent reports in this series have witnessed the IA32 CPUs challenging the leading CPUs from IBM, SGI, Sun, Compaq and HP. A wide variety of both Intel and AMD CPUs feature in our benchmarking. These include Intel's Pentium-based CPUs, with the Pentium Pro (200 MHz), Pentium MMX (233 MHz), the Pentium II (266, 300, 400, 450 MHz), and Pentium III CPUs (500, 550, 650, 733, 750, 800, 866 and 1000 MHz). The Pentium III has now been surpassed by its

successor, the Pentium 4 - systems benchmarked include those based on the 1.4, 1.5 GHz and the dual processor 2.0 GHz Xeon CPUs. In addition to Intel's IA32 products, we have also benchmarked a number of CPUs from AMD. The most recent systems evaluated comprise the MP range of dual processor products, with the MP2400+ (2000 MHz CPUs), MP2000+ (1667 MHz) and MP1800+ (1533 MHz) CPUs. Older AMD systems feature the the K7 Athlon CPUs, clocked at 500, 600, 650, 850, 1000, 1200 and 1400 MHz.

Much has been made of the potential of Intel's new 64-bit IA64 processor in scientific and technical computing. While the first of Intel's IPF products, the Itanium 1 CPU, has arguably under delivered, we include here benchmarks based on both the 733 and 800 MHz CPUs. The former appears in an RX4610 server from Hewlett Packard, a 4-way system with 733 MHz CPUs, featuring 2 MB L3 cache and running the HPUX OS. The 800 MHz Itanium CPU with 4 MB L3 cache also appears in a 4-way system, now running the Linux OS with Intel's 64-bit compilers. The release in 2002 of the second generation Itanium processor from Intel, the Itanium 2 (or McKinley) processor has addressed many of the shortcomings evident in its predecessor. Included here are benchmarks from a number of systems featuring the processor, including those from HP (running both the HPUX and Linux operating system), plus a system with the so-called Tiger board from Intel. Systems from HP include the 4-way RX5670 and 2-way RX2600, both featuring 1 GHz CPUs and 4 MByte of L3 cache; the RX5670 is Linux-based, the RX2600 HPUX-based. The corresponding 900 MHz single-CPU Linux system is the ZX6000, with 1.5 MByte L3 cache, running the Linux OS. The system featuring the Intel Tiger board is a 4-way, 1 GHz machine (4 MB L3 cache) running the Linux OS.

Individual nodes of a variety of Massively Parallel Processors (MPP) include the CRAY T3D, T3E/900 and T3E/1200, the IBM SP2 with both power2-based TN2 and P2SC (120 and 160 MHz) and power3 Nighthawk (222 MHz) and Winterhawk2 (WH2) (375 MHz) CPUs, and the Hitachi SR2201. Figures for the Intel iPSC/860, the KSR-2 from Kendall Square Research, and transputer and i860-based Meiko Computing Surfaces may be found in reference 3.

Machines featuring in this exercise, together with associated configurations, are given in the Appendix. We should stress from the outset that our access to much of the hardware evaluated herein has been at best short lived, and has often involved the temporary loan or donation of machines as part of one of the hardware evaluation exercises run at the Daresbury Laboratory. In many cases these machines were not optimally configured in terms of either memory, or high speed disk, and consideration of the results presented here should be viewed in that light.

Following an introductory evaluation of hardware based on the SPEC Benchmarks (section 2), we present in Sections 3, 4, and 5 results using a variety of chemistry-oriented software. This 64-bit floating point precision FORTRAN-based code may be classified into three distinct categories, each designed to provide a pointer to the relative hardware capabilities in the discipline of computational chemistry;

1. The first category (the MATRIX Benchmark, section 3) reflects the dependence of many of the algorithms in the area of electronic structure calculations on matrix operations, and includes both matrix multiplication and matrix diagonalization. Note that the MATRIX Benchmark has now been extended to include the treatment of larger matrices, designed to exercise both memory bandwidth and cache more rigorously and, in common with many other standard benchmarks, to reflect the limited run times of the original benchmark (hereafter referred to as MATRIX-89) whereby modern CPU's completed the tasks in just a few seconds. We refer to this extended MATRIX Benchmark as MATRIX-97 (see section 3 below).
2. The second category (the Computational Chemistry Kernels, section 4) includes four chemistry `kernels', each comprising less than a 1000 lines of FORTRAN code, and intended to be

representative of the typical calculations undertaken in the area of computational chemistry. Described in more detail in section 4, these kernels include direct-SCF, molecular dynamics (MD), quantum monte carlo (QMC), and a Jacobi eigen solver (JACOBI);

3. Finally, we include complete quantum chemistry and molecular simulation applications (section 5). The QC calculations use the GAMESS-UK electronic structure program [4]. Twelve typical applications are included, featuring both conventional Hartree Fock self-consistent field (SCF) and direct SCF, complete active Space SCF (CASSCF) and multiconfiguration SCF (MCSCF), configuration interaction calculations, both direct-CI and conventional table-driven MRD-CI, Moller Plesset perturbation theory (MP2), and both SCF and MP2 analytic 2nd derivatives. In the same way that the MATRIX benchmarks have been extended to include the treatment of larger matrices, we have recently extended the GAMESS-UK benchmark to handle larger more representative calculations. We refer to this extended GAMESS-UK benchmark as GAMESS-UK-97 (see section 5.1 below), and to the original benchmark as GAMESS-UK-89. The MD calculations use the DL_POLY simulation package [5] with six typical MD calculations.

2. The SPEC BENCHMARKS

One of the most useful indicator of CPU performance is provided by the SPEC (``Standard Performance Evaluation Corporation'') benchmarks. This benchmark suite contains non-tuned application-based code to measure processor speed for both integer (SPECint) and floating point (SPECfp) arithmetic. While earlier versions of the suite (e.g. SPECmark89) had certain well-advertized flaws, SPECfp95 and SPECint95, and their successors, SPECfp2000 and SPECint2000, have become industry standards in measuring primarily the performance of a system's processor, memory architecture, operating system and compiler.

A SPEC FAQ describing the SPEC benchmark suite and the SPEC consortium is periodically posted to comp.benchmarks, and can be found on the WWW at

http://www.specbench.org/spec/faq

An excellent summary of the SPEC benchmarks that was periodically updated is available via anonymous ftp from ftp.cs.toronto.edu in the file /pub/spectable. This posting terminated in December 2000 with the arrival of SPEC2000. More SPEC-related information is available at the SPEC WWW site,

http://www.specbench.org

and at the Performance Database Web site,

http://performance.netlib.org/performance/html/spec.html#specsite.

2.1 SPEC CPU2000 Benchmarks

The next generation of SPEC benchmarks, SPEC CPU2000,

http://www.specbench.org/osg/cpu2000/results/cpu2000.html

has recently replaced SPEC95. CFP2000 is derived from the results of fourteen floating-point

benchmarks compiled with aggressive optimization. It is the geometric mean of fourteen normalized ratios (one for each floating-point benchmark). CINT2000 is derived from the results of twelve integer benchmarks compiled with aggressive optimization. It is the geometric mean of twelve normalized ratios (one for each integer benchmark). Note that the level of optimization is not mandated. While highly aggressive optimization is permitted, results derived from benchmarks compiled with conservative optimization (as in SPECfp_base2000) can be submitted.

It is perhaps worthwhile at the outset to consider the potential shortcomings of using single processor benchmarks, such as SPECfp2000 or SPECfp2000_base, on the current generation of SMP-based clusters. The nature of the associated cache hierarchy and memory architecture need to be considered, both arguing for a consideration of not only the SPECfp values, but also the related RATE benchmarks (SPECfp_rate). The complex cache hierarchy of systems such as the 8-way IBM 690Turbo means in practice that with 7 of the 8 CPUs disabled (according to the SPECfp2000 rules), a given single processor benchmark is actually running in an environment comprising the total L3 cache associated with the 8-way MCM i.e. 128 MByte. Since many of the SPECfp2000 benchmarks have a total memory requirement of this order of magnitude, the recorded level of performance arguably bears little resemblance to what might be seen if, for example, all 8 CPUS were running the same job. A second effect is that of the memory architecture of the SMP node in question; in many instances the effective memory bandwidth available to a given job will decline significantly as more of the CPUs are involved in processing. The impact of this effect will be critically dependent on the nature and bandwidth demands exhibited by the application. The impact of L3 cache utilisation and memory architecture may be partially quantified by considering the associated SPECfp2000_rate figures for such systems. Both effects should be considered when considering all the single CPU results presented in this paper.

The current set of CPU2000 results are given in Tables 1 (SPECfp2000) and 2 (SPECfp_base2000) (with the baseline system the Ultra 10 333MHz). In each case we have normalised the values relative to those of the HP RX2600 Itanium2/1000 (SPECfp2000, 1301; SPECfp_base2000, 1174).

An examination of the SPECfp2000 values of Table 1 demonstrates the impact created by the release of Intel's Itanium2 processor (McKinley), with 8 of the leading 13 systems featuring the 1 GHz and 900 MHz CPUs. Other processors featuring in the 10 highest ranked systems include the Alpha EV68 1.25 GHz CPU (in the HP AlphaServer ES45 68/1250), IBM's power4 CPU, clocked at 1.45 GHz (the pSeries 650/6M2) and 1.3 GHz (the pSeries 655/651 and pSeries 690Turbo), and the 1.35 GHz SPARC64 GP CPU (in the Fujitsu PrimePower900). Considering the two leading systems of Table 1, we note:

1. Two sets of values are typically given for the Itanium2-based systems from HP - the RX5670, RX2600 (1 GHz) and ZX6000 (900 MHz) - corresponding to execution under HPUX using HP's f90 compiler (tagged "H" in the tables), and to execution under Linux running Intel's efc compiler ("L"). While the HPUX-based figures were initially higher than those based on efc, the improvements in version 7.0 of the Intel compiler have reversed this trend with, for example, SPECfp2000 ratings for the RX5670 of 1431 (L) and 1305 (f90). We would expect this situation to remain fluid as new releases of both compilers are made available. It is noticeable that (i) no SPECint2000 figures have yet been published using efc, and (ii) that efc-based figures are all SPECfp_base figures; no optimised SPECfp2000 ratings have been published to date. SPECfp2000 ratings for the Itanium2 processors lie in the range 1431(the 1GHz HP RX5670 with 3 MB L3 cache) to 1086 (the 900 MHz HP ZX2000 with 1.5 MB L3 cache). These may be contrasted with figures for the older Itanium1 systems ranging from 703 (Dell Poweredge 7150, 800 MHz with 4MB L3 cache) to 623 (HP i2000, 733 MHz, with 2 MB L3 cache). Note again that both values are in fact SPECfp2000_base and not SPECfp2000.

2. The 1.45 GHz power4-based IBM pSeries 650/6M2 exhibits effectively the same SPECfp2000 rating (1295) as the 1.3 GHz systems, the 655/651 and 690Turbo (1281 and 1266). The 650/6M2 outperforms the 1.1 GHz p-series 655/651 and 1 GHz pSeries 630/6E4 by factors of 1.17 and 1.46, and the the power3-based systems, the 450 MHz 44P-170 and 375 MHz 44P-270, by factors of 2.99 and 3.43 respectively.
3. With a SPECfp2000 rating of 1365, the AlphaServer ES45 Model 68/1250 (A21264C) outperforms the DS25 68/1000 (985) and ES45/1000 (960) by factors of 1.35 and 1.39. These factors are greater than the clock speed ratio of 1.25, caused in large part by the increased cache on the 68/1250 (16 vs. 8 MByte). Comparisons with older Compaq systems reveal performance factors of 1.76 and 2.43 against the 833 MHz Compaq ES40 (777) and 667 MHz A21264A-based ES40 (562). These factors are again significantly somewhat greater than the clock speed ratios of 1.50 and 1.87.

While the top 50 systems exhibit greater than 58% of the performance of the HP RX5670/Itanium2 (i.e. SPECfp2000 figures higher than 827), only 6 distinct CPUs are involved in these systems, namely Intel's IA64 Itanium2 and IA32 Pentium 4 Xeon processors, AMD's Athlon CPUs, the Alpha A21264C, Sun's UltraSPARC III Cu processor and finally the SPARC64 GP from Fujitsu.

The 12 systems following the HP ZX6000 (900MHz Itanium2) exhibit SPECfp2000 ratings in excess of 1000; these include include 7 based on Intel's Pentium 4 Xeon, two based on IBM's power4 systems plus three HP/Compaq 1224 MHz AlphaServer systems. The Xeon systems are clocked at 3.06 GHz (SPECfp2000, 1091-1103), 2.8 GHz (1048-1060), 2.67 GHz (1024-1036) and 2.53 GHz (1005). IBM's power4-based systems include the the 1.1 GHz pSeries 655/651 (1103) and pSeries 670 (1075) while the three HP 1224 MHz AlphaServer systems (the GS60/180/320) exhibit identical SPECfp ratings of 1014).

Twenty of the next 24 entries feature either the Pentium 4 or AMD Athlon IA32 CPUs, with 18 systems from Intel and two from AMD. SPECfp2000 figures for Intel's Pentium 4 Xeon in this range vary from 827 (1.7 GHz) to 990 (2.53 GHz), while the AMD systems exhibit values of 831 (2166 MHz, XP 2700+) and 843 (2250 MHz, XP 2800+). The only non IA-32 CPUs in this range are the Compaq AlphaServer ES45 Model 68/1000 (960), the IBM eServer pSeries 630/6E4 1000MHz (886) and the 1050 MHz UltraSPARC III Cu CPU in the Sun Blade Model 2050 (827).

All other CPUs exhibit SPECfp2000 ratings of less than 827 i.e. are a at least a factor 1.75 times slower than the 1 GHz HP RX5670/Itanium2. Other figures worth noting on the leading machines from other vendors include:

- 785 for the 1015 MHz Cu in the Sun Fire 280R, and 731 for the 900MHz UltraSPARC III Cu CPU in the Sun Blade 1000 Model 1900. The release of the Cu CPU has coincided with a major enhancement in the SPEC ratings from Sun. The above rating is to be compared with the figure of just 410 for the 900MHz UltraSPARC III CPU in the same system. Based on the figure of 827, the 1050 MHz CPU is outperformed by the HP RX5670 Itanium2 by a factor of 1.7, but still presents a significant performance enhancement over the older UltraSPARC-II based systems. A comparison with the Sun Enterprise 450/480MHz (291) reveals a factor (2.84) significantly greater than the clock speed ratio (2.2).
- 674 for the 875 MHz PA8700+ in Hewlett Packards HP 9000 Model C3750 (47% of the HP RX5670/Itanium). The HP 9000 Model C3750 is ranked at position 96 in the SPECfp2000 list.
- 656 for the dual-processor 2.00 GHz CPU (Asus A7M266-D Motherboard in the MP2400+).
- 529 for the MIPS R14k/600 MHz CPU and 463 for the R14k/500 MHz CPU, both in SGI's Origin 3200. The SGI Origin 3200 / 600MHz R14k is ranked at position 154 in the SPECfp2000 list.
- 456 and 440 for the 1.4 GHz and 1.26 GHz Pentium III respectively in Dell's Precision

PowerEdge 1500SC WorkStation. Clearly the PentiumIII is no longer competitive with its Pentium 4 successor, a factor of 2.5 slower than the 3.06 GHz Pentium 4.
- 434 for the 450 MHz RS/6000 power3 CPU in IBM's RS/6000 44P-170, and 382 for the 375 MHz CPU in the IBM RS/6000 SP-375MHz T/W.

Normalised ratings for the leading CPUs from each vendor based on the HP RX2600/Itanium2 1GHz (HPUX,f90) and the values of Table 1 are as follows:

1. 110% - HP RX5670 and RX2600/Itanium2 1GHz CPUs running the (Linux/efc) environment;
2. 105% - HP/Compaq AlphaServer ES45 68/1250;
3. 100% - IBM eServer pSeries 650/6M2 1450 MHz;
4. 65% - AMD AMD ASUS A7N8X XP 2800+/2250 MHz;
5. 64% - Sun Blade Model 2050/1050 MHz Cu;
6. 54% - 800 MHz Itanium1 (4MB L3, 48% with 2MB L3);
7. 52% - HP 9000 Model HP 9000 Model C3750 / PA8700+/875;
8. 41% - SGI Origin 3200/R14k-600 and 36% for the Origin 3200/R14k-500; and,
9. 35% - Dell PowerEdge 1500SC (1.4 GHz Pentium III).

In terms of leading CPUS from each vendor, the poorest performer would appear to be the current offerings from SGI. Thus the 600 MHz CPU in SGI Onyx 300/R14k-600 is a factor of 2.7 times slower than the HP RX5670/Itanium2, the 500 MHz CPU a factor of 3.1 times slower. The leading 30 entries of Table 1 feature six systems from Compaq, three from Sun, and one from both IBM and Hewlett Packard. Eighteen systems feature Intel's Pentium 4 CPU and two Intel's Itanium CPU.

An examination of the SPECfp2000_base values of Table 2 shows a somewhat different picture. While the Itanium2-based systems from HP remain and power4-based systems from IBM remain the leading CPUs, the HP/Compaq AlphaServer ES45/1250 now exhibits effectively the same rating (1019) as the 2.66 GHz Pentium 4 Xeon systems from Dell (SPECfp2000_base, 1024), lying 19th in the SPECfp2000_base table. In similar fashion the HP/Compaq AlphaServer ES25 and ES45 68/1000 which lie 28th and 32nd in the SPECfp2000 ratings, now occupy lower positions (45th and 50th), being outperformed by a number of Pentium 4 (2.2 GHz) and AMD Athlon CPUs.

SPECfp2000_base figures for Intel's Pentium 4 Xeon range from 581 (1.4 GHz) to 1092 (3.06 GHz). The only systems that do not feature an Intel-based CPU appearing in the top 30 SPECfp2000_base entries are from IBM (the 5 IBM power4 IBM pSeries, 1017 - 1221), the HP/Compaq AlphaServer ES45 68/1250 (1019), plus the 1350 MHz Fujitsu PrimePower900 (1004).

Finally, we would point out a number of issues around the present benchmarks and their potential relationship to the SPEC benchmarks:

- Some issues need to be considered when comparing the SPECfp2000 ratings with the results of the present benchmarking exercise. Many of the published figures rely on utilities that were not available in the current benchmarking exercise e.g., "spike", and it may be more meaningful in such cases to draw comparisons with the corresponding SPECfp_base values.
- When considering the present benchmarking results, there are several factors we wish to consider in assessing the usefulness of the SPEC ratings;
  - Do the SPECfp values provide a reliable metric for evaluating the capabilities of hardware in computational chemistry? If so, we would expect to find a close mapping of the ratios for the various chemistry benchmarks onto the SPECfp ratios;
  - Does any particular CPU consistently ``underperform'' based on the SPECfp criteria? - this would manifest itself as the ratios from the chemistry benchmarks falling below the SPECfp ratios e.g., the impact of the memory problems of the SGI O2-R12k and R10k [6] impacting on the benchmarks.
  - As discussed above, we should consider the potential shortcomings of using single

processor benchmarks such as SPECfp2000 on the current generation of SMP hardware. The only way to quantify this effect is to generate the associated "rate" figures for the machine in question. We note at this stage that the current set of SPECfp2000_rate figures are given in Table 3; these will be discussed later in this document.

We will attempt to address these issues below.

2.2 SPEC CPU95 Benchmarks

With an increasing number of vendors publishing CPU2000 results for new systems, we clearly had a problem in terms of relating older machines, for which only SPECfp95 results are available, with these newer systems. In practice we have discontinued our analysis based on the older CPU95 metric, but have attempted to generate extrapolated CPU2000 values for these older machines based on a comparison of those processor families where both CPU95 and CPU2000 values were available.

We note for completeness that SPECfp95 was derived from the results of ten floating-point benchmarks compiled with aggressive optimization. It is the geometric mean of ten normalized ratios (one for each floating-point benchmark). SPECint95 was derived from the results of eight integer benchmarks compiled with aggressive optimization. It is the geometric mean of eight normalized ratios (one for each integer benchmark) Note that the level of optimization is not mandated. While highly aggressive optimization was permitted, results derived from benchmarks compiled with conservative optimization (as in SPECfp_base) were often submitted.

SPECfp95 and SPECint95 results for many of the CPUs discussed in this paper are available in previous versions of thie report.

3. The MATRIX-89 and MATRIX-97 Benchmarks

Previous versions of this report presented timings from both the older MATRIX-89 and extended MATRIX-97 Benchmarks. We now present only the detailed timings from the latter (see Tables 4-8) given the limited run times of the original benchmark.

3.1 Whetstone Benchmark

A comparison of the single processor Whetstone performance on a variety of machines, including workstations, both IA32 and IA64 commodity CPUs, vector CPUs and a variety of MPP processors is given in Table 4 (MATRIX-97). Data provided includes the Mflop performance on a variety of floating point vector loops (V_L =1024), together with the total CPU time to execute the benchmark, and the MWIPS performance. The primary aim of this benchmark is to provide a performance measure of both floating point (FP) and integer arithmetic; thus while trends in the V_L Mflop ratings are of interest, only a small part of the total CPU time is actually involved in these operations. The wide variety of standard functions exercised (abs, sqrt, exp, alog, sin, cos, atan etc.) consume a far larger fraction of the reported times; note the latter provide a close mapping onto the measured rate of instruction processing (MWIPS, million whetstones instructions per second). Note also that the MATRIX-97 benchmark was generated from the original MATRIX-89 code by increasing the outer loop variable, i2, by an order of magnitude.

This benchmark was originally designed to monitor the performance of vector supercomputers, and

an examination of Table 4 reveals that the NEC SX-5 continues to outperform all other machines, factors of 1.9 and 2.4 times the speed of the SX-4 and FUJITSU VPP-300 respectively. The SX-5 is seen to outperform the fastest of the RISC CPUs, the 1250 MHz EV68/21264C, by a factor of 1.9. Prior to analysing the results of Table 4, we would suggest that the value of the Whetstone benchmark in truly reflecting the overall performance of a given CPU is now limited. It is clear that the simple loop constructs invoked do not exercise the memory bandwidth, while many of the vector-loop timings derived through repeated iteration of the same loop construct are overcome by "clever" compilers who perform only a single execution of the loops (e.g. the null N8 entries for the SGI machines and the relatively "good" performance of machines such as the SGI O2 R5k).

The fastest RISC CPUs are the 1250 MHz EV68/21264C and the 1.3 GHz power4 CPU from IBM, with the Compaq Marvel EV7/1000 somewhat faster than the Compaq Alpha ES45/1000 and IBM pSeries 630/1000. The leading six systems are followed by the (HPUX-f90)-based RX2600 Itanium2/1000, a factor of 1.46 times slower than the Compaq Alpha ES45/1250, and the SGI Onyx 300/R14k-600 and AMD MP2400+/2000 (pgi), factors of 1.51 and 1.58 times slower than the ES45/1250. Following the MP2400+ are the two R14k-500 based systems from SGI, the O300 and O3800, together with the AMD MP2000+/1667. The Compaq Alpha ES40/833 and Pentium 4/2000 (ifc) follow, achieving only 50% of the performance of the ES45/1250. Similar timings are found for the (Linux/efc)-based Itanium2 systems, the HP RX5670 and Intel tiger; the HPUX-f90 executable is clearly outperforming that based on Intel's efc compiler on this benchmark (by a factor of 1.4).

In terms of systems, the benchmark is dominated by the Alpha ES45 and IBM's power4, with a significant presence of both the MIPS R14k and AMD Athlon-based systems. Of the leading fifteen machines, four are Alpha-based from HP/Compaq, while three appear from IBM, AMD and SGI; only a single Itanium2 based system is present, together with the Pentium 4/2000 (ifc). The 1250 MHz EV68 outperforms the leading PA-RISC system, the HP PA-9000/RP7410-875 , by a factor of 2.6, and the leading UltraSPARC-III CPU in the SUN Fire 6800/900-Cu, by a factor of three.

SGI's MIPS-based machines perform surprisingly well, with the 600 MHz R14k in the SGI Onyx 300 outperforming the 500 MHz R14k in the O300 and O3800 by factors of 1.19 and 1.23, and the 400 MHz R12k in the Octane2 and O3800 by a factor of 1.49. Clearly the Benchmark performance is reflecting closely the relative clock speeds. The same behaviour is seen in the ES45 timings, with the ES45/1250 outperforming the ES45/1000 by a factor of 1.25, although higher factors are seen when comparing with the EV67 processor family. The ES45/1250 outperforms the Compaq Alpha ES40/833 and DS20E/667 by factors of 1.94 and 2.42, to be compared with the clock speed ratios of 1.50 and 1.87 respectively.

The performance of a number of processor families, notably the Itanium2, PA-RISC and UltraSPARCIII-Cu are far below that expected based on the published SPECfp2000 ratings, with the Compaq Alpha ES45/1250 outperforming the HP RX2600 Itanium2/1000, the HP PA-9000/RP7410-875 and SUN Blade 2000/1056-Cu by factors of 2.04, 2.62 and 3.01. Corresponding SPECfp2000 ratios are 1.05, 2.02, and 1.67.

Finally, we note that the performance of the IA32 AMD- and Pentium III-based machines is significantly better than expected based solely on the SPECfp ratings. The optimum performance is seen from the AMD MP2400+/2000 (pgi) which performs on a par with Itanium2-based systems, outperforming the Pentium 4/2000 (ifc) by a factor of 1.26 and the PentiumIII/1000 by a factor of 2.43. The MP2400+/2000 is a factor of 1.55 slower than the Compaq Alpha ES45/1250, this figure to be compared with the corresponding SPECfp ratio of 2.08.

Note that in many of the IA32-based benchmarks reported here, we have used both the Absoft and

Portland Group Fortran compilers (pgf77 and pgf90), in addition to the GNU public domain g77. Earlier benchmarks conducted using the g77 compiler suggested markedly inferior performance to that based on code from the commercial compilers e.g. an improvement factor of 1.61 when using pgf77 compared to using the GNU project Fortran Compiler (g77, v0.5.21). Use of pgf77 on a 400 MHz PentiumII gave performance comparable to the SUN Ultra/2-300. In similar fashion, use of the g77 and a variety of C-compilers on the Pentium pro produced inferior figures to those based on code from the Intel reference compiler, some 2-3 times slower than the figures of Table 4.

This situation changed with the later releases of g77 (version 2.95 0728), where a significant effort has been investigated in improving the optimisation capabilities. Thus the pgf77/g77 improvement ratio of 1.61 noted above was reduced to just 1.12 on the PentiumIII/800, although the higher figure of 1.4 is found on the AMD Athlon K7/850. Release 3.2 of the PGI compilers re-addressed this balance somewhat, with an average pgf77/g77 improvement factor of 1.25 for the PentiumIII/1000, 866, 800, 750 and 733, and the higher figure of 1.48 for the AMD K7/1400, MP1800+/1533 and MP2000+/1667. The optimum compiler, however, on this benchmark code is clearly Intel's ifc; the ifc-compiled Whetstone code on the Pentium 4/2000 outperforms the pgi- and g77-based code by factors of 1.27 and 2.38 respectively.

Turning to the older Whetstone-89 Benchmark results, we see that the overall conclusions derived from the MATRIX-97 benchmark are little altered. The main difference is that the dominant position of the Compaq Alpha ES45/1250 is less marked in the larger benchmark, with, for example, the ES45/1250 vs. IBM Regatta-HPC/1300 factor of 1.48 in Whetstone-89 decreasing to 1.05 in Whetstone-97. Considering the more dated hardware, we find that the IBM/RS6000-SP/375 outperforms the Cray T3E/1200E by a decreased factor of 1.7 (versus the Whetstone-97 factor of 2.0), and (ii) the IBM RS/6000 43P is outperformed by the SGI 195 MHz R10k-based machines.

3.2 Sparse Matrix Multiply Benchmark

The matrix multiply operation (MMO) is central to the efficient operation of modern QC codes on vector processors [1], it being possible both to extract near peak performance for this kernel and to formulate many QC steps around this operation. A comparison of the single processor sparse MMO performance on a variety of machines, is given in Table 5. In this benchmark a series of MMOs (R = A X B) involving matrices of increasing order were performed, with each MMO conducted a number of times, this number being inversely proportional to the order of the matrices,

In the MATRIX-89 benchmark, the matrices were of order 10, 20, 30, ...,100, with the summed CPU time metric referring to 100 MMOs of order 10 matrices, 90 of order 20 matrices, and so on up to 10 MMOs for matrices of order 100. The order of the matrices involved in the MATRIX-97 benchmark were increased by a factor of five compared to MATRIX-89, with the CPU times of Table 5 referring to 10 MMOs of order 50, 9 MMOs of order 100 etc., up to a single MMO for matrices of order 500. Figures are presented for both `full' (0% sparse) and 50%-sparse B matrices, with the performance figures referring to code written entirely in Fortran.

The MATRIX-97 results of Table 5 suggests that the leading CPU is the 1.3 GHz MHz power4 from IBM, with the Regatta-HPC/1300 and pSeries 690Turbo outperforming the 1Gz Itanium2/1000 of the HP RX2600 by factor of 1.5, and that of the HP RX5670 and Intel Tiger by a factor of 1.7. Indeed the optimal Itanium2-based system is marginally outperformed by the IBM pSeries 630/1000. The leading six systems are followed by the Compaq Alpha ES45/1250, the HP ZX6000 Itanium2/900, and the pwr3-based IBM RS/6000 44P-270 and HP PA-9000/J6700-750, factors of 2.2, 2.6 and 2.7 slower than the IBM Regatta-HPC/1300.

The performance of the leading systems from SUN and SGI, together with the IA32-based systems, are not compelling. The SGI Onyx 300/R14k-600 and SUN Blade 2000/1056-Cu are factors of 2.8 and 3.9 times slower than the IBM Regatta-HPC/1300. The leading IA32-based systems, the Pentium 4/2000 (ifc) and AMD MP2400+/2000 (g77) are factors of 4.0 and 5.8 times slower.

We note the following when Comparing CPUs from a given vendor;

- Surprisingly, the Hewlett Packard 875 MHz PA8750-based RP7410-875 is outperformed by the PA-9000/J6700-750, in marked contrast to the MATRIX-89 results (see below). The J6700-750 outperforms the PA8600-based HP PA-9000/J6000-552 by a factor of 1.88 and the HP PA-9000/J5000-440 by a factor of 2.24, both factors far higher than the MHz ratios of 1.36 and 1.70. The J5000 is slightly faster than the other PA8500-based machines (the N4000 and C3000) and the PA8200 HP PA-9000/C240.
- The 1.3 GHz power4 CPU in the IBM Regatta-HPC/1300 is only marginally faster than the dual-core CPU of the pSeries 690Turbo, an effect attributable to a later version of the xlf compiler used for the pSeries 690Turbo benchmark. The Regatta-HPC/1300 outperforms the 375 MHz power3 CPU in the RS/6000-SP/375 and 200 MHz power3 RS/6000-43P by factors of 2.5 and 4.6, both factors significantly less than the corresponding clock speed ratios of 3.5 and 6.5.
- The HP/Compaq EV68-based 1250 and 1000 MHz CPUs in the Alphaserver ES45s perform according to clock speed with the 1250 MHz CPU ES45 a factor of 1.23 faster than the ES45/1000. The performance of the Marvel EV7/1000 is disappointing, slightly slower than the EV68 ES45/1000. The leading EV67-based Alpha, the Compaq Alpha ES40/833, is a factor of 1.35 slower than the ES45/1250, compared to the clock speed ratio of 1.50. Within the EV67-based ES40 family, machines perform exactly according to clock speed, with the 833 MHz ES40 a factor of 1.24 faster than the ES40/6-667. The latter outperforms the leading EV6-based solutions (DS20/6-500, XP1000/6-500) by a factor of 1.45, and the 8400/5-625 by a factor of 3.1. Considering the EV5-based machines, we see that the latter CPU, together with the Alpha PW/600AU, outperforms the Alpha 500/5-500, Alpha PW/433AU, Alpha 500/5-400, and Alpha 600/5-333 by factors of 1.2, 1.8, 2.0, and 1.8 respectively.
- While the SUN Blade 2000/1056-Cu outperforms the 900 MHz SUN Fire V880/900-Cu by a factor of 1.14, in line with clock speed, it is a factor of 1.9 times faster than the SUN Fire 6800/900-Cu and outperforms the SUN Blade 1000/M1750 by a factor of 1.21. The 2000/1056-Cu outperforms the UltraSPARC-II based SUN Ultra80/450 by a factor of 3.4; this figure is significantly greater than that expected based on clock speed (2.35), pointing to improvements in compiler and to the enhanced memory bandwidth of the UltraSPARC-III machine.
- Finally, we see that the 600 MHz MIPS R14k of the SGI Onyx 300 outperforms the 500 MHz-based CPUs in the O300 and O3800 by factors of 1.11 and 1.36, to be compared with the MHz ratio of 1.2. In the SGI Origin 3800 family, the 500 MHz R14k outperforms the 400 MHz R12k by a factor of 1.16, but appears to perform no better than the 400 MHz R12k of the SGI Origin 2000. The latter outperforms the 300 MHz-based Origin by a factor of 1.42, with the 300 MHz R12k machine faster by factors of 1.4 and 1.9 than the 250 MHz R10k Origin 2000 and the O2000/195.

We note that increasing the dimension of the matrices from MATRIX-89 to MATRIX-97 leads to some significant reordering in ranking of the systems, with the performance of a number of machines clearly degrading in the larger benchmark. This degradation is found in all the IA32 hardware from Intel and AMD (see below). Similar degradation is found in the PA8700+ HP RP7410-875 and the PA8600- and PA8500-based HP machines (J6000 and J5000, N4000 and C3000), the API UP2000/833 and /667, and the CRAY T3E/1200 and T3E/900. The HP PA-9000/RP7410-875 is 1.78

times slower than the IBM pSeries 690Turbo in MATRIX-89 and 2.81 times slower in MATRIX-97. The HP PA-9000/J6000 and EV67-based UP2000/833 exhibit identical MATRIX-89 performance to the IBM RS/6000-SP/375, and yet are seen to be factors of 2.0 and 2.3 times slower in MATRIX-97. In contrast both R14k (Onyx 300 and Origin 3800) and R12k-based SGI Origins (300 and 400 MHz) show enhanced performance in the larger benchmark. The CRAY T3E/1200 is faster than the DEC Alpha 8400/5-625 (by a factor of 1.7) in MATRIX-89, but shows identical performance in MATRIX-97. Most spectacular however are the SGI O2 R12k/270 and O2 R10k/175. The memory bandwidth problems of these machines [6] are clearly exercised by the MATRIX-97 benchmark in a way not shown by MATRIX-89. Thus the O2 R12k/270 is seen to be a factor of 6.1 times slower than the SGI Octane/R12k-270 from the MATRIX-97 results of Table 5, compared to the identical run times of MATRIX-89. Similarly, the MATRIX-97 timing for the O2 R10k/175 is seen to be 3.8 times slower than the 195 MHz Octane, to be compared with the MATRIX-89 factor of just 1.2.

The performance of the Intel and AMD IA32 CPUs is consistent with expectations based on SPECfp for the smaller MATRIX-89 benchmarks, but degrades significantly on moving to the larger MATRIX-97. Thus the G77-based timings for the AMD MP2400+/2000, MP2000+/1667 and MP1800+/1533 are found to be slower than the IBM pSeries 690Turbo by factors of 2.44, 2.78 and 3.00 in the MATRIX-89 benchmarks. These factors increase substantially for the larger MATRIX-97, to 5.59, 6.18 and 5.76 respectively. Similarly the ifc-compiled Pentium 4/2000 is ranked 5th in the MATRIX-89 benchmarks, 1.78 times slower than the IBM pSeries 690Turbo; it slips to rank 23 in MATRIX-97, now 3.82 times slower than the 690Turbo. This degradation on MATRIX-97 is less marked with the Pentium 4 due to the enhanced memory bandwidth compared to the Pentium III; thus the Pentium 4/2000 is 2.62 times faster than the Pentium III/1000 in the MATRIX-89 benchmark, and 3.76 times faster in MATRIX-97.

The enlarged dimensions of MATRIX-97 are seen to benefit in predictable fashion the vector machines; the NEC SX-5 is now 2.25 times faster than the IBM pSeries 690Turbo, to be compared with the MATRIX-89 benchmark when the pSeries 690Turbo outperformed the SX-5, by a factor of 2.1.

One additional feature of the MMO benchmark not apparent in Table 5 is the significantly enhanced performance found on all machines when comparing assembly language MMO to Fortran MMO. Historically this has often involved the user having to code key routines in assembly language, for few vendors initially provided optimized mathematical libraries; improvement factors of 3.2 (CRAY X-MP), 4.2 (IBM 3090/VF), and 3.4 (FPS-M64/60) have previously been reported with assembly language implementations of the sparse MMO routine, MXMB. Optimized BLAS libraries are now commonplace on all workstation platforms. These factors increase substantially in the MATRIX-97 benchmark, when efficient strip-mining with the larger matrices is paramount. The following improvement factors against the 0% sparsity timings of Table 5 are found when using the BLAS dgemm:

1. 1.8, 2.0, 2.4, 4.6 and 9.3 on the SGI O300/R14k-500, Onyx 300/R14k-600, Origin 3800/R14k-500, O2 R5k/300 and O2 R12k/270;
2. 3.2 and 3.3 on the Compaq Alpha ES45/1000 and Alpha ES45/1250, and 2.9 on the Compaq Marvel EV7/1000
3. 2.1 and 2.4 on the IBM RS/6000-SP/375 and IBM pSeries 690Turbo;
4. 4.3 on the CRAY T3E/1200;
5. 3.6, 4.3, 5.0, 5.7 and 6.6 on the HP PA-9000/J6700-750, HP RP7410-875, PA-9000/J6000-552, PA-9000/N4000 and HP PA-9000/785 C360; and
6. 4.3, 4.5 and 7.3 on the SUN Blade 2000/1056-Cu, SUN Fire V880/900-Cu and 6800/900-Cu.
7. 3.6 on the HP RX2600 Itanium2/1000 (HPUX/f90), 3.9 on the HP RX5670 and Intel Tiger, and 4.9 on the HP ZX6000 Itanium2/900.

8. Significantly higher factors are found on the IA32-based hardware: 8.6, 7.9 and 6.8 on the AMD MP2400+/2000, AMD MP2000+/1667 and AMD MP1800+/1533; 5.9 on the Pentium 4/2000 (ifc) and 6.6 on the Pentium III/1000-CM.

3.3 Matrix Multiply Benchmark II - Similarity Transformations

The second matrix multiplication benchmark is designed in part to show the importance of well-optimized library software in the goal of cost-effective performance. This benchmark involves performing a series of similarity transforms (Q*HQ) using both a scalar and vector algorithm. The scalar code collapses the matrix transposition and multiplications to yield an algorithm with fewer FLOPS than the vector code, which adopts a brute force approach by explicitly performing the transposition and two matrix multiplications. In the latter case we utilize the BLAS library routine DGEMM (where available) for performing the requisite MMOs, in the former case the dot product BLAS routine, DDOT. In the MATRIX-89 benchmark, the matrices were of order 10, 20, 30, ...,150, the summed CPU time metric referring to 150 transforms of order 10 matrices, 140 of order 20 matrices, and so on up to 10 transforms for matrices of order 150. The order of the matrices involved in the MATRIX-97 benchmark were doubled compared to MATRIX-89, with the CPU times of Table 6 referring to 300 transforms of order 20, 280 transforms of order 40 etc., up to 20 transforms for matrices or order 300. Again, given the small execution times of the MATRIX-89 benchmark, we focus the discussion below on the MATRIX-97 results.

Considering the MATRIX-97 scalar algorithm, we find the HP RX2600 Itanium2/1000 to be the leading system, outperforming the IBM Regatta-HPC/1300, Compaq Alpha ES45/1250 and IBM pSeries 690Turbo by factors of 1.26, 1.45 and 1.55 respectively. These four systems are closely followed by the HP PA-9000/RP7410-875 and Compaq Alpha ES45/1000, factors of 1.66 and 1.81 slower than the HP RX2600. The HPUX/f90 environment on the Itanium2 is clearly outperforming the corresponding Linux/efc environment, for the next two systems, the HP RX5670 and Intel Tiger Itanium2/1000 are factors of ca. 1.85 slower than the HP RX2600. The Compaq Marvel EV7/1000 follows, exhibiting comparable performance to the Intel Tiger, and marginally faster than the HP PA-9000/J6700-750. The top ten systems lie within a performance factor of two of the HP RX2600 Itanium2/1000, and are followed by the SUN Blade 2000/1056-Cu, IBM pSeries 630/1000 and the HP ZX6000 Itanium2/900.

The weakest CPU families on the scalar algorithm are evidently the MIPS-based systems, with the SGI Onyx 300/R14k-600 a factor of 3.2 times slower than the RX2600, and the IA32 processors, where the Pentium 4/2533 (g77), Pentium 4/2000 (ifc) and AMD MP2400+/2000 (pgi) are factors of 2.1, 3.4 and 6.2 times slower. As in the FORTRAN MMO benchmarks, the latter systems show a marked decline in relative performance compared to the smaller MATRIX-89 benchmarks.

The PGI-compiled performance of the scalar code on the Pentium III and 4, together with the AMD processors is disappointing, with the g77-generated code typically faster. The K7/600 and K7/500 appear to be exceedingly poor, a factor of 1.5 times slower than the g77-generated code. This effect is also seen on the PentiumIII/550, but is less marked using the current release of PGI on the Pentium 4/2000 (a factor of 1.2), while the PGI-based code on the AMD MP2400+/2000 outperforms G77, albeit by a small factor. Intel's ifc compiler does somewhat better, with the ifc-based code outperforming the pgi code by a factor of 1.3 on the Pentium 4/2000. Considering the commodity CPUs, we find the Pentium 4/2000 (ifc) to be factors of 1.9 and 2.0 times faster than the AMD MP2400+/2000 and MP2000+/1667 (pgi), and 3.45 times faster than the Pentium III/1000.

The recognized memory bandwidth problems of the R12k- and R10k-based SGI O2s are less

apparent on this benchmark. The O2/R12k-270 is a factor of 1.4 slower than the Octane/R12k-270, while the O2/R10k-175 performs on a par with the SGI Octane/R10k-175. Finally, we note that the leading workstation CPU, the HP RX2600 Itanium2/1000, outperforms the vector-based NEC SX5 a factor of 4.3.

Turning to the vector algorithm results of Table 6, we immediately note significant reordering compared to the scalar case. All recent CPUs exhibit enhanced performance on the vector code, with this improvement a measure of the quality and optimisation of the underlying BLAS library routines. The vector algorithm timings on many of the systems of Table 6 lead to an improved factor of two or more over the scalar algorithm . The largest improvements are found in the Linux/efc-based Itanium1 and Itanium2/1000 IA64 systems (IBM Itanium/800-4M L3, 2.88; the Intel Tiger Itanium2, 3.00 and HP RX5670, 2.81) and the IA32 AMD (MP2400+/2000, 2.83; AMD MP2000+/1667, 2.67; AMD MP1800+/1533, 2.93), and Intel Pentium III systems (Pentium III/1000-CM, 2.51; Pentium III/750-CM, 2.69). Smaller improvement factors are found on the proprietary RISC CPUS, ranging from 2.14 - 2.29 on the HP PA-RISC systems (the PA-9000/RP7410-875 and PA-9000/J6000-552 respectively), through 1.55 - 1.62 on the UltraSPARCIII-based systems (SUN Blade 2000/1056-Cu and SUN Fire V880/900-Cu), to 1.46 on the HP/Compaq Alphaserver ES45 systems (the ES45/1250 and ES45/1000. The higher factors found on the IA32 systems stems from use of the ATLAS blas library [15]. The most dramatic effect here is seen with the vector hardware; an improvement factor of 15 for the NEC SX5 vector algorithm leads to the machine outperforming all other CPUs, a factor of 1.8 times faster than the HP RX2600 Itanium2/1000.

Considering the final order of CPUs of Table 6, we see again that the HP RX2600 Itanium2/1000 outperforms the Linux/efc-based Itanium2 systems, the Intel Tiger and HP RX5670, by factors of 1.12-1.18, and the IBM Regatta-HPC/1300 and IBM pSeries 690Turbo by factors of 1.25-1.28. THE PA-RISC systems from HP do well on the vector-based algorithm. While the HP PA-9000/RP7410-875 and PA-9000/J6700-750 are 1.40-1.52 times slower than the HP RX2600 Itanium2, they outperform the HP ZX6000 Itanium2/900, IBM pSeries 630/1000 and the HP Itanium1/733-2M L3. The performance of the HP/Compaq Alphaserver ES45 systems is not impressive, with the ES45/1250 and ES45/1000 factors of 1.77 and 2.23 times slower than the HP RX2600 Itanium2. This is perhaps not surprising given the limited improvement factors found when using the dxml-based DGEMM routine.

Following the Compaq Alpha ES45/1250 we find the IBM Itanium/800-4M L3, HP PA-9000/J6000-552, Compaq Alpha ES45/1000 and Pentium 4/2533 (pgi), factors of between 2.0 - 2.25 slower than the HP RX2600 Itanium2/1000. The four systems after the Pentium 4/2533 (pgi) include the SUN Blade 2000/1056-Cu and Compaq Marvel EV7/1000, with similar run times, and the SUN Fire V880/900-Cu and Compaq Alpha ES40/833. The leading system from SGI, the Onyx 300/R14k-600, is significantly slower, exhibiting comparable performance to the Pentium 4/2000 (ifc), and 3.3 times slower than the RX2600 Itanium2/1000.

Considering the fastest of the IA32 commodity CPUs, we find that the Pentium 4/2533 (pgi) outperforms the Pentium 4/2000 (ifc) and AMD MP2400+/2000 by factors of 1.5 and 1.7, and the Pentium III/1000 by a factor of 3.7. The Pentium 4/2533 is itself outperformed by the HP RX2600 Itanium2/1000 by a factor of 2.23.

Turning now to the smaller MATRIX-89 benchmark, we note a number of significant changes compared to the MATRIX-97 results that are attributable in no small part to the quality of compiler / maths libraries in use at the time of the benchmarks:

- While the position of the pwr4- and Itanium2-based systems remains unchanged in the vector

benchmark, a number of systems do exhibit a relative degradation in performance in the larger benchmark. Most noticeable is the PA-RISC system from HP, the PA-9000/RP7410-875, which moves from 2nd to 6th in the performance rankings, together with the entire family of IA32 processors. The performance of the both AMD and Intel Pentium-based systems are significantly inferior to that obtained in MATRIX-89. The pgi-compiled AMD MP2400+/2000, MP2000+/1667 and MP1800+/1533 occupy positions 12, 19 and 20 in the MATRIX-89 performance table. The corresponding positions in MATRIX-97 are 33, 44 and 39 respectively. Similarly the pgi-based results for the Pentium 4 systems show the Pentium 4/2533 and Pentium 4/2000 to occupy positions 10 and 33 in MATRIX-89; the corresponding MATRIX-97 rankings are 15 and 38. The HP RX2600 Itanium2/1000 outperforms the Pentium 4/2533 by a factor of 1.56 in MATRIX-89 and 2.25 in MATRIX-97. Similarly the Pentium III/1000 is a factor of 4.51 slower than the HP RX2600 Itanium2 in the smaller benchmark, and a factor of 8.33 slower in MATRIX-97.

- This decline is even more marked in the scalar algorithm where the AMD MP2400+/2000 is a factor of 1.4 slower than the RX2600 Itanium2 in MATRIX-89, but a factor of 6.8 slower in MATRIX-97. This decline is less marked with the Pentium 4. Thus the Pentium 4/2533 and 2000 (ifc) are factors of 1.3 and 1.4 slower than the RX2600 Itanium2 in the MATRIX-89 scalar benchmark, factors that increase to 2.1 and 3.4 in MATRIX-97.
- Systems that show a modest improvement in the larger benchmarks relative to the HP RX2600 Itanium2/1000 include the SUN Blade 2000/1056-Cu and UN Fire V880/900-Cu (2.4 and 2.6 times slower on the vector algorithm compared to the factors of 2.6 and 2.9 in MATRIX-89),
- Interesting comparisons are seen in the scalar results found on the HP hardware under study. While the HP PA-9000/J6000-552, N4000 and J5000 remain impressive in the vector algorithm, the performance of the scalar algorithm on the J6000 is markedly superior to that found on both the N4000 and J5000 (by a factor of more than two). This is undoubtedly due to quality of the f90 compiler, HP F90 2.4, available on the J6000, compared to earlier versions used on the N4000, J5000 and V2250. This effect, whereby the "scalar" performance appeared to be three times slower than the "vector", is almost certainly a consequence of the code quality generated by the compiler in use under HPUX 11.0. Results for all three machines were generated using this compiler, while the HP PA-9000/C3000 "scalar" figures that show a 50% improvement in performance were generated using the older f77 compiler available under HPUX 10.20.
- The performance of the Alpha-based hardware on the vector algorithm is variable, and is very much a function of the version of dxml in use at the time. Results on the Alpha ES45/1250 and ES45/1000 show improvements factors of 1.47 against the scalar algorithm, those on the Marvel EV7/1000 a factor of 1.42. Results on the ES40/833, DS20E/667 and DS20/500 show better improvements against the scalar algorithm with vector/scalar ratios of 1.76, 1.77 and 1.71 respectively. Benchmarks conducted prior to this demonstrated noticeably inferior performance to that obtained in MATRIX-89. These CPUs exhibited typical vector/scalar enhancements of just 1.11 (Compaq PW XP1000/500) and 1.15 (DS20/6-500), and are outperformed by e.g., the SUN Ultra80/450 and HPC4500/400, and perform only marginally better than the SGI O2000/R12k-300, in marked contrast to the MATRIX-89 results.
- All of the MIPS-based SGI machines exhibit comparable performance in MATRIX-97 and MATRIX-89 benchmarks. Thus SGI Onyx 300/R14k-600 is a factor of 3.1 slower than the HP RX2600 Itanium2/1000 in the MATRIX-89 vector benchmark, and a factor of 3.3 slower in MATRIX-97. One not unexpected result is that for the SGI O2 R12k/270 and O2 R10k/175, although the degradation in performance for the SGI O2 R12k is less marked (8.4 vs. 11.5) than that noted when using the FORTRAN MMO code above.

The enlarged dimensions of MATRIX-97 are again seen to benefit the vector machines in predictable fashion; the NEC SX-5 is now 1.8 times faster than the HP RX2600 Itanium2/1000, to be compared

with the MATRIX-89 benchmark figure of just 1.1.

3.4 Diagonalization Benchmark

Tables 10 and 11 present the results of a matrix diagonalization benchmark intended to supplement the previous analysis conducted by Dunning and co-workers [7]. We consider a similar benchmark, based on diagonalizing a series of real symmetric matrices, using 64-bit floating point arithmetic. Again the CPU time was measured for the diagonalization of each size matrix, with the summed times used as the benchmark execution time. Results include the compiler options used on the depicted hardware.

In the MATRIX-89 benchmark, the matrices were of order 10, 20, 30,..., 100, the summed CPU times of Table 10 referring to 100 diagonalizations of order 10 matrices, 90 of order 20 matrices, and so on up to 10 diagonalizations for matrices of order 100. The order of the matrices involved in the MATRIX-97 benchmark were increased compared to MATRIX-89, with the CPU times of Table 11 referring to three diagonalisations for matrices of order 50, 100, 150, 200, 250 and 300.

While the previous analysis was restricted to the EISPACK RS routine, we consider below the performance of eight diagonalization routines available in various mathematical libraries and quantum chemistry codes:

1. EIGRS, an unoptimized FORTRAN version of the library routine RS (available in SCILIB on the CRAY) from the IMSL library of routines [8].
2. F02ABF from the NAG library [9].
3. HQRII [10], as implemented in the semiempirical MOPAC program [11].
4. GIVENS, adapted from the QCPE program exchange (number 62.1).
5. SDIAG2, as implemented in the MUNICH system of programs.
6. JACOBI, from the ATMOL system of programs [12].
7. JACO, the diagonalization routine from the direct-SCF program DISCO [13].
8. ERDUW, as taken from the Berkeley System of Quantum Chemistry codes.

The first four routines are all based on the Householder QR method, whilst the last four use the Jacobi method. Note that the only optimization performed involved inserting calls to the BLAS for two-dimensional rotations (DROT) and vector interchange (DSWAP).

The reported MATRIX-89 timings of Table 10 again illustrate the limited value of the benchmark bearing in mind the exceedingly small run times associated with the leading CPUs. The timings do suggest however that the 833 MHz and 667 MHz Compaq/API Alpha EV67 CPUs, together with the AMD Athlon K7 (1.4 and 1.2 GHz) are dominant, providing the leading 6 machines of Table 10. The PC-based machines perform commendably, with the AMD Athlon K7/1000 and Pentium 4/1500 exhibiting identical run times, fractionally slower than the API UP2000 6/667, The Pentium 4/1400 and Pentium III/1000 are marginally slower, performing on a par with the HP PA-9000/J6000-552.

The thirteen leading machines are followed by the SGI Origin 3800/R14k-500 and five EV6-based CPUs, with the IBM RS/6000-SP/375, IBM RS/6000 44P-270, and PA8500-based CPUs from Hewlett Packard exhibiting performance comparable to the slowest of these, the Compaq Alpha DS10/466. The PC-based machines continue to impress, with the AMD Athlon K7/850 and Pentium III/866 exhibiting the same benchmark time as the EV6-based Compaq Alpha ES40/6-500. The leading CPU from SUN, the SUN Blade 1000/M1750, shows similar performance to the R12k-400 CPUs from SGI (the SGI O3800/R12k-400 and Octane2/R12k-400), approximately the same speed

as a number of coppermine Pentium III CPUs (733 and 800 Mhz). The SUN Blade 1000/M1750 appear at positions 36 in Table 10. The timings do suggest that a large number of machines exhibit comparable performance, with the fastest 36 CPUs only separated by a factor of two in performance.

This benchmark tends to be dominated by the slowest of the diagonalization routines in use, JACO, which typically accounts for > 40% of the total CPU time. Significantly the leading 55 workstations are now seen to outperform the NEC SX-5.

Turning to the MATRIX-97 results of Table 11, we again see that increasing the dimension of the matrices produces some reordering compared to the smaller dimensioned MATRIX-89, although this effect is less pronounced than that found in the MMO benchmarks. While the Compaq Alpha ES40/6-833 remains the optimal machine, the PA8600- and PA8500-based HP machines show enhanced performance. The HP PA-9000/J6000-552 now outperforms the API UP2000 6/833 and Alpha DS20E/667, while the N4000 and J5000 exhibit benchmark times comparable to that of the Pentium 4/1500, Compaq PW XP1000/667, API UP2000/667 and the Pentium 4/1400. The HP PA-9000/C3000-400, SGI Origin 3800/R14k-500 and IBM RS/6000 44P-270 show similar performance to the Pentium 4/1400, and are marginally faster than the leading EV6-based machines and the 400 MHz R12k-based SGI Octane2 and O2000 (with the DS20/6-500 now 1.37 times slower than the ES40/6-667). The performance of the SUN Blade 1000/M1750 is not impressive here, the improvement factor of 1.25 over the Ultra80/450 (versus the clock speed ratios of 1.67) suggesting compiler-related optimisation problems on the UltraSPARC-III. The SGI O2000/R12k-300 and Ultra80/450 show somewhat enhanced performance, but remain slower than the Compaq Alpha DS10/466, by factors of 1.13 and 1.21 respectively.

The most noticeable deterioration in MATRIX-97 performance is found with all the AMD Athlon K7 CPUs. Thus the K7/1400, which performed on a par with the Compaq Alpha ES40/6-833 in MATRIX-89, is now only half the speed and performs no better than the 400 MHz R12k Origin 2000. The K7/1200, in 5th position in the MATRIX-89 ranking, has slipped to position 29 in MATRIX-97. Both the Athlon K7/1000 and K7/850 exhibit inferior performance to that found in the smaller benchmark, with the Athlon K7/1000 (pgf77) now 2.8 times slower than the Compaq Alpha ES40/6-833, The AMD K7/850 exhibits similar performance to the Pentium III/866 (using pgf77). The corresponding degradation in performance on the larger benchmark is found with the Pentium III/CM-based machines e.g. the Pentium III/1000 and Pentium III/866 are now factors of 2.75 and 2.95 times slower than Compaq Alpha ES40/833, compared to the factors of 1.43 and 1.71 in the smaller benchmark. Interestingly, this degradation is far less drastic for the Pentium 4, with the Pentium 4/1500 factors of 1.28 and 1.52 slower than the Alpha ES40/833 in MATRIX-89 and MATRIX-97 respectively.

Considering the older CPUs of Table 11, we find that the HP PA-9000/C240 and V2250, IBM RS/6000-43P, SGI O2000/250 and SUN HPC4500/400 show almost identical performance (with the 250Mhz R10k-based Origin a factor of just 1.17 times slower than the R12k-based machine). The latter machines are somewhat faster than the DEC Alpha 8400/5-625 and Alpha PW/600AU, which now show performance comparable to the SUN HPC4500/336, HP PA-9000/C200 and HP PA-9000/V2200. Of some note is the significant deterioration in the relative performance of the IBM RS/6000-397. The net effect of this is that the SUN HPC4500/336 and HP PA-9000/C200 now outperform the RS/6000-397 by factors of 1.92 and 1.91; the corresponding factors in the MATRIX-89 benchmark were 1.31 and 1.21. One of the reasons for this can be traced to the problems that the xlf compiler had in optimising the jaco routine; an examination of Table 11 suggests that this routine is consuming 62% of the overall benchmark on the IBM RS/6000-397; excluding this routine, the factors noted above decrease to 1.42 and 1.60. These problems have been addressed in the more recent benchmarks on the IBM RS/6000 44P-270, Other machines to show a deterioration on

performance on the larger benchmark include the Cray T3E/1200 and SGI O2 R5k/300.

Considering the fastest of the commodity CPUs, we find that the AMD Athlon K7/1400 outperforms the Pentium 4/1500 and Pentium III/1000 by factors of 1.3 and 1.4 in MATRIX-89. This ordering is reversed in the more meaningful MATRIX-97, where the Pentium 4/1500 is now a factor of 1.3 and 1.8 times faster than the Athlon K7/1400 and Pentium III/1000.

Considering the parallel MPP and SMP CPUs, we find the IBM RS/6000-SP/375 to be factors of 1.6, 1.9 and 4.0 times faster than the IBM RS/6000-SP/222, HP PA-9000/V2200 and IBM SP2/160Thin, respectively. The decline in the performance of the CRAY T3E/1200 compared to the MATRIX-89 benchmark is evident here, with the T3E now a factor of 4.5 times slower than the RS/6000-SP/375, compared to the factor of 2.3 in the smaller benchmark.

3.5 Relative Performance on Matrix Operations

To summarize the performance of the various workstations on the matrix multiply and diagonalization benchmarks detailed above, we show in Table 12 (MATRIX-89) and Table 13 (MATRIX-97) the performance of each relative to the Compaq Alpha ES40/6-833 (100%). The "Total" is derived by simply averaging the individual figures for the MMO, (Q*HQ) and Diagonalisation benchmarks.

It is clear from the MATRIX-89 "Totals" that the Compaq Alpha ES40/833 (100%), HP PA-9000/J6000-552 (98%) and API UP2000 6/833 (95%) are the leading CPUS with comparable performance. These three machines are closely followed by the leading commodity CPUS, the AMD Athlon K7/1400 (89%) and Pentium 4/1500 (88%). Somewhat further back, with performance between 75-80% of the ES40/6-833, lie a clutch of nine machines, including the Compaq Alpha DS20E/667 and Pentium 4/1400 (80%), the AMD Athlon K7/1200 and IBM RS/6000 44P-270 (79%), the PA8500-based HP PA-9000/J5000 and N4000 and IBM RS/6000-SP/375 (76%), the EV67-based API UP2000/667 (75%) and the PW XP1000/667 (73%). The other EV67-based machine, the Compaq ES40 (70%), lies somewhat ahead of the AMD Athlon K7/1000 (64%).

The next eleven CPUs, with TOTALs in the range 51%-63% are from Compaq, SGI and SUN, including five EV6-based machines, together with the SGI O3800/R14k-500 (63%), The Pentium III/1000 (60%), the HP PA-9000/C3000 (58%), SGI Octane2/R12k-400 (55%), and O2000/R12k-400 and SUN Blade 1000/M1750 (53%). The UltraSPARC-III based SUN Blade is running 1.67 times faster than the Ultra80/450, a figure exactly in line with clock speed. The range of Pentium III coppermine CPUs (650 - 1000 mHz) exhibit performance ratios of between 38-63% of the ES40/833 when using pgf77, and between 33-51% when using G77.

Considering the MPP nodes, we see that the IBM SP/WH2-375 delivers the optimum performance, faster than the IBM RS/6000-SP/222, HP PA-9000/V2200, CRAY T3E/1200, IBM SP2/160Thin, CRAY T3E/900 and Hitachi SR2201 by factors of 1.74, 2.19, 2.30, 2.61, 2.76, and 8.55 respectively. Of the vector machines, the NEC SX-5 is 1.38 times faster than the Compaq Alpha ES40/833, while the NEC SX-4 exhibits similar overall performance to the AMD Athlon K7/1000.

The relative ordering of processors within a given family are found to be broadly in line with clock speeds. Considering the EV5-based CPUs, we find the Alpha machines, the 500/5-500, PW/433AU, 500/5-400, 600/5-333, 8400/5-300, and 2100/5-250 to be slower than the Alpha 8400/5-625 and PW/600AU by factors of 1.37, 1.37, 1.47, 1.75, 1.93 and 2.33 respectively. For the Ultra, the SUN Ultra80/450, SUN HPC4500/400, SUN HPC4500/336, Ultra30/300 and Ultra-2/200 are slower than

the SUN Blade 1000/M1750 by factors of 1.66, 1.83, 1.96, 2.30 and 3.53 respectively.

Turning to the enlarged, and more representative, MATRIX-97 benchmarks, the relative TOTALs are, with a couple of notable exceptions, seen to be reasonably close to those of Table 12. Considering those machines that exhibit enhanced performance relative to MATRIX-89 when compared to the Compaq Alpha ES40/833, we see that the IBM power3-based machines exhibit increased TOTAL %'s of 86% (+10%, IBM Power3 IBM SP/WH2-375) and 47% (+10%, IBM RS/6000-43P Model 260). The IBM SP/WH2-375 now outperforms both HP PA-9000/J5000 and Compaq Alpha ES40/6-667. The relative performance of both SUN and SGI machines are also seen to increase compared to the MATRIX-89 figures, with the SGI O3800/R14k-500 and SUN Blade 1000/M1750 TOTAL ratios increasing to 67% and 63% respectively compared to the MATRIX-89 values of 63% and 53%. Corresponding TOTALs for the SGI O3800/R12k-400, O2000/R12k-400 and SUN Ultra80/450 are 57%, 59% and 36%, compared to the MATRIX-89 values of 52%, 53% and 32%.

Many machines exhibit slower relative performance on the MATRIX-97 benchmarks. Most notable is the collapse in performance of the AMD Athlon K7, with the K7/1400, K7/1200 and K7/1000 MATRIX-89 ratios of 89%, 79% and 64% reduced to 43%, 42% and 29% respectively in MATRIX-97 i.e. effectively halved. Other notable performance declines are found in the API UP2000/6-833 (from 95 to 73%) and UP2000/6-667 (from 75 to 57%), and in the Pentium 4 (with the 4/1500 and 4/1400 ratios declining from 88 to 65%, and from 80 to 61% respectively). Other examples include (i) the HP machines, PA-9000/J6000-552 (98 to 88%), PA-9000/J5000-440 (76 to 70%) and PA-9000/N4000-440 (76 to 67%), and (ii) the AlphaPC 264DP-500, CRAY T3E/1200 and T3E/900, SGI O2 R12k/270, R10k/175 and O2 R5k/180.

As noted above, the performance of the PC-based hardware lies somewhat ahead of expectations based on SPECfp for the smaller MATRIX-89 benchmarks, but degrades significantly on moving to the larger MATRIX-97. Thus the AMD Athlon K7/1400, K7/1200, and K7/1000 are seen to be slower than the Compaq Alpha ES40/833 by factors of just 1.12, 1.27 and 1.56 in the MATRIX-89 benchmarks. These factors increase substantially for the larger MATRIX-97, to 2.33, 2.38, and 3.45 respectively. The corresponding factors for the Pentium 4/1500 and 1400 increase from 1.14 and 1.25 in MATRIX-89 to 1.53 and 1.64 in MATRIX-97. The same effect is found for the Pentium III CPUs, with the Pentium III/1000, Pentium III/866 and Pentium III/800 factors of 1.67, 1.96 and 2.17 in MATRIX-89 increasing to 3.45, 4.00, and 4.00 in MATRIX-97. The corresponding SPECfp_2000 and SPECfp_base2000 factors for the Compaq Alpha ES40/833 relative to the Athlon K7/1400 are 1.71 and 1.36. Of further note is the poor performance of the Pentium III/800; while outperforming the 550 MHz by a factor of 1.47 on the smaller benchmarks (in line with clock speed), it is no faster on MATRIX-97, a clear indication of the limited cache and memory bandwidth on the VC820 motherboard.

The IBM SP/WH2-375 is now 4.0 times faster than the CRAY T3E/1200, compared to the factor of 2.3 in the MATRIX-89 benchmarks.

We would also point to the following:

- The 833 MHz EV67 in the Compaq Alpha ES40/6-833 outperforms the 667 MHz CPU in the DS20E/6-667 by a factor of 1.25, the 500 MHz EV6 in the Compaq Alpha DS20/6-500 by a factor of 1.60, and the 625 MHz EV5 in the DEC Alpha 8400/5-625 by a factor of 3.57.
- The 500 MHz R14k of the SGI O3800 exhibits a speed up of 1.14 against the 400 MHz R12k of the SGI O2000, 1.56 against the 300 MHz R12k O2000, 2.03 against the 250 MHz R10k Origin, and a speed up of 2.68 against the 195 MHz-based processors.

- The enhanced BLAS library on the HP PA-9000/V2200 under HPUX B11 would seem to account for the 200 MHz CPU outperforming the more powerful 236 MHz CPU in the HP PA-9000/C240.
- The 375 MHz power3 processor of the IBM SP/WH2-375 outperforms the 200 MHz power3 in the RS/6000-43P Model 260 by a factor of 1.81, the P2SC/160 processor (IBM RS/6000-397) by a factor of 3.2 and the P2SC/120 MHz processor (IBM SP2/Thin) by a factor of 4.1.
- The CRAY T3E/1200 node is seen to be only 1.10 times faster than the T3E/900, less than that expected from clock speed.

4. COMPUTATIONAL CHEMISTRY KERNELS

One of the crucial requirements in evaluating the increasingly broad range of hardware platforms, whether these be parallel machines (true MIMD message-passing machines, workstation clusters, shared-memory multiprocessors etc), or simply the lastest workstation, is the availability of portable benchmarking codes that are representative of the application area under consideration. In an attempt to provide such capabilities in computational chemistry, we have described previously four representative codes, each of which is less than 1000 lines of FORTRAN, and is sufficiently portable that migration to any hardware platform can typically be achieved in a matter of hours. In this report we limit our discussion to the performance of these codes on a variety of single CPUs.

The benchmarking kernels comprise the following programs that are realistic models of actual chemical applications or algorithms;

1. SELF CONSISTENT FIELD (SCF); This Self Consistent Field (SCF) electronic structure kernel uses distributed primitive 1s gaussian functions as a basis (thus emulating use of s,p,... functions) and computes integrals to essentially full accuracy. It is a direct SCF code, with an atomic density used for a starting guess. There are two available problem sizes, corresponding to 60 basis functions Be_4 and 240 basis functions (Be_{16}). The timings of Table 14 refer to the former.
2. MOLECULAR DYNAMICS (MD); This program bounces a few thousand argon atoms around in a box with periodic boundary conditions. Pairwise interactions (Leonard-Jones) are used with a simple integration of the Newtonian equations of motion.
3. MONTE CARLO (QMC); This code evaluates the energy of the simplest explicitly correlated electronic wavefunction for the He atom ground state using a variational monte-carlo method without importance sampling.
4. JACOBI ITERATIVE LINEAR EQUATION SOLVER (JACOBI); Uses a naive jacobi iterative algorithm to solve a linear equation. All the time is spent in a large matrix vector product.

Total CPU timings for the SCF, MD and QMC benchmarks are presented in Table 14, together with the Mflop ratings from the JACOBI benchmark. Historically, these results have presented a somewhat confusing picture, with the detailed processor ordering very much a function of the particular chemistry kernel under examination. It would now appear, with the possible exception of the JACOBI benchmark, that the 833 MHz EV67-based Compaq and API machines (the ES40/6-833 and API UP20000) and the Athlon AMD K7/1400 are the leading CPUs in these kernel benchmarks, followed by the SGI O3800/R14k-500, the 667 MHz EV67 machines (Alpha DS20E/667, Alpha ES40/667, PW XP1000/667 plus API's UP2000/667) and the AMD K7/1200, although the ordering of the other leading processors in the SCF, MD and QMC benchmarks varies significantly.

Thus for the SCF kernel, the Compaq Alpha ES40/833 and SGI O3800/R14k-500 exhibit almost

identical run times, closely followed by the API UP2000 6/833, with the ES40 a factor of 1.1 times faster. The 833 MHz EV67-based machines outperform the corresponding 667 MHz CPUs (DS20E/667 and API UP2000/667) by the clock speed factor of 1.25. The DS20E and API UP2000 show identical performance to the Athlon AMD K7/1400 and SGIs' O3800/R12k-400 and Octane2/R12k-400. The O3800/R14k-500 outperforms the R12k/400 based Octane2/ and Origin 3800 by a factor of 1.24 and the O2000/R12k-400 by factors of 1.24 and 1.38. The leading eight machines are followed by two more EV67-based machines (the ES40 and XP1000) and the O2000/R12k-400. We note that the Compaq Alpha ES40/833 outperforms the HP PA-9000/J6000-552, the SUN Blade 1000/M1750 and the IBM SP/WH2-375 by factors of 1.62, 1.70 and 1.74 respectively.

The performance of SGIs Origin series is surprisingly good in the SCF benchmark, and is mirrored by the corresponding Octane2 and Octane. This effect was first noted with the 250 MHz R10k-based Origin, which is seen to be a factor of 2.3 faster than the 195MHz R10k Origin. This is almost certainly attributed to enhanced compiler optimisation under Irix 6.5; similar factors are also shown for the Octane/R10k-250 against all the 195 MHz-based machines that were benchmarked under Irix 6.2 and 6.3.

The SCF performance of the PC-based hardware is mixed. The AMD Athlon K7 series performs well, with the K7/1400, K7/1200 and K7/1000 factors of just 1.26, 1.46 and 1.76 times slower than the Compaq Alpha ES40/833. The Pentium III/1000 and Pentium III/866 are factors of 2.80 and 3.20 times slower. In contrast the performance of the Pentium 4 is disappointing, with the Pentium 4/1500 and 1400 performance little better than that of the Pentium III/1000, an effect due in part to the non-optimal maths libraries on the machine. Improvement factors of 1.51, 1.53 and 1.42 are found on the K7/1400, K7/1200 and K7/1000 when using pgf77 compared to g77.

Considering the MPP nodes, we find the IBM SP/WH2-375 CPU to be the superior CPU by far. The WH2 CPU outperforms the 222 MHz Nighthawk CPU and the Cray T3E/1200E by factors of 1.7 and 1.8 respectively. It is 2.48 times faster than the CRAY T3E/900, 3.5 times the speed of the HP PA-9000/V2200 and IBM SP2/160Thin, and a factor of 9.2 times faster than the Hitachi SR2201 node.

In the MD benchmark the 833MHz Compaq and API EV67-based machines, together with the AMD Athlon K7 and 667 MHz EV67-based machines are dominant, accounting for the leading 8 machines of Table 14. The Compaq Alpha ES40/833 outperforms the Athlon K7/1400 by a factor of 1.21, and is faster than the 667 MHz ES40/6-667, XP1000/667 and UP2000/667 by the clock speed factor of 1.25. These machines, together with the Athlon K7/1200, are followed by the SGI O3800/R14k-500 (1.45 times slower than the Alpha ES40/833), the HP PA-9000/J6000-552 (1.47 times slower), and the Pentium 4/1400 and AMD Athlon K7/1000, factors of 1.59 and 1.67 times slower. The Athlon K7/1000 exhibits comparable performance to the EV6-based machines (the DS20/6-500, ES40/6-500 and GS140), the IBM SP/WH2-375 (1.75 times slower than the ES40/6-833) and the 400 MHz R12k-based O2000 and Octane2 (1,78 times times slower). The poorest performer of the leading CPUs is the SUN Blade 1000/M1750, with the UltraSPARC-III based machine little better than the SUN Ultra80/450, a factor of 1.92 times slower than the ES40/6-833.

The HP PA-8500 machines (the J5000, N4000 and C3000 show performance comparable to the SUN Blade 1000, factors of 1.87, 1.91 and 2.14 slower than the ES40/6-833).

The MD performance on the PC-based hardware is similar to that found in the SCF benchmark, with the AMD Athlon performing well, in contrast to the Pentium III and 4. The pgi-compiled code on the Athlon K7/1400, K7/1200 and K7/1000 is a factor of 1.21, 1.37 and 1.66 times slower respectively than the Compaq Alpha ES40/833. Corresponding figures for the Pentium III/1000 and 866 are 2.45

and 2.66. Although the g77 code on the Pentium 4/1500 exhibits performs on a par with that of the AMD K7/1000, the pgi-based performance is slower. Thus the pgi-based Pentium 4/1500 outperforms the Pentium III/1000 by a factor of 1.34, but is a factor of 1.83 slower than the Alpha ES40/833.

Improvement factors of 1.14, 1.18 and 1.22 are found on the K7/1400, K7/1200 and K7/1000 when using pgf77 compared to g77. These figures are smaller than in the SCF benchmark. A similar factor is found on the Pentium III/866 (1.13), while both Pentium 4/1400 and 1500 are actually slower when using the pgf77.

Considering the MPP nodes, we find the IBM SP/WH2-375 CPU to be optimal, outperforming the 222 MHz Nighthawk CPU by a factor of 1.71, the SP2/160Thin and HP PA-9000/V2200 by a factor of 2.2, and the CRAY T3E/1200, CRAY T3E/900, and Hitachi SR2201 by factors of 2.45, 3.26 and 6.36 respectively.

The relative processor ordering found in the MD and SCF kernels is seen to be subject to significant change compared to that suggested by the JACOBI benchmark. The Mflop ratings of Table 14 suggest that two of the more recent additions to the machines featuring in these benchmarks now head this category. The Pentium 4 is the leading performer; with Mflop rates of 500.0 and 347.8 in the Pentium 4/1500 and Pentium 4/1400 respectively. These two lie some way ahead of the UltraSPARC-III SUN Blade 1000/M1750 (298.3 Mflops) and the HP PA-9000/J6000-552 (279.1 Mflop). The latter platform is followed closely by a number of systems, notably the EV67 Alpha-based machines, IBM RS/6000 systems and the PA8500-based machines.

The Compaq and API EV67 CPUs exhibit Mflop ratings of 269.0 and 264.7 in the Compaq ES40/6-667 and DS20E/6-667, 254.4 in the API UP2000 6/833, 231.3 in the Alpha ES40/833, 226.5 in the API UP2000 6/667, but a reduced figure of 160.8 in the XP1000/667.

For the RS/6000-based systems, the 375 MHz power3 in the IBM SP/WH2-375 and RS/6000 44P-270, the 160 MHz P2SC (RS/6000-397), 200 MHz power3 (RS/6000-43P) and 135 MHz P2SC RS/6000-595) exhibit Mflop rates of 260.0, 258.1, 237.6, 205.1, and 167.8 respectively. The PA8500-based HP machines exhibit figures of 255.3 Mflops (HP PA-9000/J5000), and 228.6 Mflops (HP PA-9000/N4000 and HP PA-9000/C3000). It is noticeable in the above that higher Mflop ratings are found in SMP-based hardware compared to single-CPU machines of the same clock speed, even though this is a single CPU benchmark.

Considering the EV6-based machines, we find Mflop ratings of 202.2 and 204.1 in the DS20/6-500 and ES40/6-500, 170.8 and 176.9 in the GS140 and XP1000/500, a lower figure of 139.6 in the DS10/466 and a much lower figure of 81.9 in the DEC Alpha 8400/6-575 i.e. only 40% of that in the DS20/6-500. Machines from both Silicon Graphics, together with the UltraSPARC-II systems from SUN, are some way behind. SUN-based hardware exhibit Mflop ratings of 131.6 Mflop (SUN Ultra80/450) and 106.6 Mflop (SUN HPC4500/400). SGI machines are arguably the poorest performers, although the Origin 3800 series reveals somewhat higher figures (192.3 in the O3800/R14k-500 and 179.8 in the O3800/R12k-400). Mflop ratings of 127.3, 110.5 and 95.8 are found in the R12k-based Octane2/R12k-400, O2000/R12k-400 and O2000/R12k-300, and 85.7 and 84.1 Mflop in the O2000/250 and O2000/195, respectively.

The Pentium III and AMD Athlon PC-based hardware performs adequately, with Mflop ratings of 160.0, 141.2, 102.1, 129.0 and 124.4 on the AMD Athlon K7/1400, K7/1200, K7/1000, K7/850 and K7/650, and rates of 136.4, 108.1, 103.1, and 124.4 on the Pentium III/1000, Pentium III/866,

Pentium III/800 and Pentium III/733. It is noticeable that the AMD Athlon K7/1000, with 256kb cache, achieves a lower rate (102.1) compared to the AMD machines with more cache (512 kb) but lower clock speed.

Considering other CPUs, we note that (i) the EV5-based machines from DEC/Compaq show much lower Mflop ratings; 66.4 and 63.6 Mflop on the DEC Alpha PW/600AU and DEC Alpha 8400/5-625 respectively, and (ii) the PA8200-based machines from HP exhibit ca. 50% the performance of the PA8500-based hardware, with figures of 121.2 and 110.0 Mflop on the HP PA-9000/C240 and C200.

It would appear that this benchmark is truly exercising the memory bandwidth associated with the CPU; indeed, increased clock speed can ultimately lead to little or no improvement in the Mflop rating; we return to this of memory bandwidth in the next section. Thus on the SGI machines, we find that the R12k/300 and R10k/250-based machines show comparable Mflop ratings to those found with the corresponding 195 MHz machines. The most dramatic illustration of this effect is found in the SGI O2 R12k/270 and R10k/175, with the known memory bandwidth problems of these machines being well illustrated. The Mflop performance of the O2 R12k (17.8) is seen to be a factor of 5.5 less than that found on the Octane/R12k-270 (97.7 Mflop), while that of the O2 R10k (12.6) is a factor of 5.9 times less than that found on the Octane/R10k-175 (74.3 Mflop), in both cases machines that house the same CPU. This effect is not adequately explained by the reduced cache on the O2 configurations. In fact the Mflop rating of the O2 R10k/175 is less than that of the O2 R5k/300 (18.8).

Of the MPP machines the IBM SP/WH2-375, SP2/160Thin and IBM RS/6000-SP/222 are not surprisingly superior by far, but the CRAY T3E/1200 and T3E/900 also perform well with Mflop ratings of 147.8 and 139.4 respectively.

In the QMC benchmark the AMD Athlon is the dominant CPU, with the K7/1400 and K7/1200 outperforming the 833 MHz Compaq ES40/833 and API UP2000/833 by factors of 1.4 and 1.2 respectively. Indeed the performance of the two 833 Mhz alpha-based machines is matched by the AMD Athlon K7/1000, with these three machines slightly ahead of the SGI Origin 3800/R14k-500. The leading six CPUs are followed by the 667 MHz EV67 CPUs of the Compaq DS20E/6-667 and API UP2000/667, the AMD Athlon K7/850, and Pentium 4/1500 (pgi). The Compaq PW XP1000/667 and ES40/6-667, together with the SGI Octane2/R12k-400, Pentium 4/1400 and Pentium III/1000 (pgi), and HP PA-9000/J6000-552 follow, between 1.8 and 2.0 times slower than AMD Athlon K7/1400.

The IBM SP/WH2-375 and 44P-270 follow, exhibiting similar performance to the EV6-based hardware and the Pentium III/866. The Compaq/DEC Alpha DS20/6-500, GS140 and ES40/6-500, XP1000/6-500 show comparable performance, some 10% faster than the DEC Alpha 8400/6-575 and DS10/466. The weakest family of processors on this benchmark would appear to be the SUN Ultra, with the SUN Blade 1000/M1750 a factor of 3.2 times slower than the AMD Athlon K7/1400; the SUN Ultra80/450 and SUN HPC4500/400 are outperformed by the SUN Blade by factors of 1.4 and 1.6 respectively.

As in the SCF benchmark and MD benchmarks, the EV6-based Compaq DS20/6-500 is only a factor of ca. 1.2 better than the EV5-based DEC Alpha PW/600AU and 8400/5-625, and the 250 MHz R10k-based SGI Onyx2 IR2/250 and SGI Octane/R10k-250, all of which exhibit almost identical run times.

To summarize the performance of the various workstations on the computational chemistry kernels as a whole, we show in Table 14 an overall single figure for each machine under the heading "Relative Performance". This is derived by normalising each of the individual benchmarks (SCF, MD, QMC and Jacobi) to the performance observed on the Compaq Alpha ES40/6-833, and taking the average of the four figures, expressed as a percentage.

Considering the leading CPU from each vendor, we find that Compaq Alpha ES40/6-833 (100%) and API UP2000/833 (100%) are the leading CPUs, marginally ahead of the Pentium 4/1500 (98%) and AMD Athlon K7/1400 (92%), and outperforming the Compaq Alpha DS20E/667 (88%) by a factor slightly less than the associated clock speed. The limitation of trying to provide a single performance figure across quite different benchmarks is well illustrated here. The apparent "advantage" of the Pentium 4/1500 over the AMD Athlon K7/1400 is determined solely by its performance in the Jabobi benchmark, for the K7/1400 outperforms the Pentium 4 in SCF, MD and QMC benchmarks. Following these 5 machines, we find that the SGI O3800/R14k-500 (86%), the Compaq ES40/667 (85%) and API UP2000/667 (82%) are somewhat faster than the AMD Athlon K7/1200 and HP PA-9000/J6000-552 (80%), the Pentium 4/1400 (pgf77, 78%), and Compaq PW XP1000/667 (74%) The leading hardware from IBM (the RS/6000-SP/375, 73%) and SUN (SUN Blade 1000/M1750 ,71%) follow, showing performance comparable to the SGI O3800/R12k-400 (73%). The SGI Octane2/R12k-400, HP PA-9000/J5000-440 and the leading EV6-based machine (the Compaq Alpha DS20/500) follow (66%), showing comparable performance to the AMD Athlon K7/1000 (65%).

Other notable points from Table 14 include (i) the SGI Octane2/R12k-400 (66%) is surprisingly somewhat faster than the SGI O2000/R12k-400 (61%), (ii) The UltraSPARC-III SUN Blade (71%) outperforms the SUN Ultra80/450 (41%) by a factor of 1.7, a figure in line with the relative clock speeds - a much higher figure was noted in the JACOBI benchmark, a much lower figure in SCF and MD benchmarks, (iii) the variety of EV6-based hardware exhibit between 47-66% of the Compaq Alpha ES40/6-833 performance, (iv) the relative performance of the HP hardware, the HP PA-9000/J6000-552 (80%), J5000-440 (66%), N4000-440 and C3000-400 (59%) is strongly tied to the version of the maths. libraries in use at the time of the benchmarks, (iii) the figure of 86% for the O3800/R14k-500 is to be compared with 73% for the O3800/R12k-400, 66% for the SGI Octane2/R12k-400, 61% for the SGI O2000/R12k-400 and 50% for the O2000/R12k-300.

The performance of the PC-based hardware is somewhat better than that expected from the corresponding SPEC ratings. As described above, the Pentium 4/1500 (98%) and AMD Athlon K7/1400 (92%) appear to outperform all CPUs other than the 833 MHz Alpha EV67, given use of the pgi compilers. Relative performance figures for the pgi-compiled benchmarks on the AMD K7/1400, K7/1200, K7/1000, K7/850 and K7/650 CPUs are 92%, 80%, 65%, 58% and 47% respectively. Corresponding figures for the g77-compiled benchmarks are 72%, 62%, 51%, 48% and 35%. Pgi-based figures for the Pentium 4/1500 and /1400 are 98% and 78%, with corresponding g77-values of 90% and 74%. The relative performance figures for the Pentium III CPUs are as follows; (a) pgi-compiled code: Pentium III/1000 (52%), Pentium III/866 (44%), Pentium III/800 (41%), Pentium III/733 (41%), Pentium III/750 (40%) and, (b) g77-compiled code: Pentium III/1000 (40%), Pentium III/866 (40%), Pentium III/800 (36%), Pentium III/733 (37%) and Pentium III/750 (36%).

Considering the MPP nodes, we see that the IBM SP/WH2-375 (100%) outperforms the IBM RS/6000-SP/222, IBM SP2/160Thin, the CRAY T3E/1200, CRAY T3E/900, HP PA-9000/V2200 and Hitachi SR2201 by factors of 1.5, 1.6, 2.0, 2.3, 2.6 and 4.0 respectively.

4.1 The STREAM Benchmark

To provide a more quantitative insight into the issue of memory bandwidth that characterized the behaviour Jacobi benchmark above, we have adopted the widely used STREAM benchmark due to John McCalpin, University of Virginia, Charlottesville, Virginia. STREAM is a simple synthetic benchmark program that measures sustainable memory bandwidth (in MB/s) and the corresponding computation rate for simple vector kernels. The benchmark is specifically designed to work with datasets much larger than the available cache on any given system, so that the results are (presumably) more indicative of the performance of very large, vector style applications.

For more details on STREAM, see: Sustainable Memory Bandwidth in Current High Performance Computers

A somewhat broader look on the issue is given in : Memory Bandwidth and Machine Balance in Current High Performance Computers, with a version of this paper published in the newsletter of the IEEE Technical Committee on Computer Architecture (TCCA) in December 1995.

A subset of the STREAM results, those for the TRIAD vector kernel (a(i) = b(i) + q*c(i)) for many of the CPUs discussed in this paper are given in Table 15. Note that for the older CPUs, we have taken values from the STREAM web site; for the more recent CPUs we have, where possible, repeated the runs to confirm the reported values.

The TRIAD values of Table 15 have been normalized to the measured value on the Compaq AlphaServer ES40/6-833. These results suggest that 13 of the leading CPUS are capable of sustaining in excess of 1 GByte/sec memory bandwidth. The well advertised enhancement in bandwidth of the Pentium 4 against both PentiumIII and AMD K7 is amply demonstrated, with the triad rate on the Pentium 4/1500 and 4/1400 (1600 MB/sec) well ahead of the other single processor figures. Of the following 8 machines, seven are EV67 and EV6 based, with relative performance figures ranging from 94% (Compaq Alpha DS20E/6-667) to 79% (API UP2000 6/833) of the ES40/833. The other CPU featuring in the top performers is the UltraSPARC-III, with the SUN Blade 1000/M1750 delivering 89% of the performance of the ES40/833, a major improvement over the figures found on all the UltraSPARC-II based hardware (typically 375 MB/sec).

The HP PA-9000/J6000-552 (979 MB/s) also performs well, delivering performance comparable to that on the Compaq PW XP1000 (960 MB/s) and outperforming the RS/6000- based hardware (e.g. IBM RS/6000 44P-270, 790 MB/s) and the PA8500-based machines (692 MB/s on the HP PA-9000/J5000-440). Note that that we have been unable to reproduce the higher value of 1103 MBytes/sec for the IBM RS/6000-43P listed on the STREAM web site, having consistently recorded a value of 764 MBytes/sec. This does not change the overall conclusion that the Compaq/API, Pentium 4, and IBM series of processors, together with the UltrsSPARC-III from SUN and PA8600 CPU from Hewlett Packard, consistently outperform all other CPUs. Thus we find TRIAD values of (i) 1600 MB/s on the Pentium 4/1500 and 4/1400, (ii) 1282 MB/s on the Compaq Alpha ES40/833, 1200 MB/s on the Compaq Alpha DS20E/667, 1171 MB/s on the Compaq Alpha DS20/6-500 and ES40/6-500, 1046 MB/s on the API UP2000/6-667 and 1010 MB/s on the API UP2000 6/833. These values are to be compared with (i) TRIAD ratings of 603 and 492 on the Compaq DS10/466 and Alpha GS140, (ii) 882, 790, 782 ,781 and 764 MB/s on IBM's RS/6000-397, RS/6000 44P-270, SP2/120Thin, SP/WH2-375 and RS/6000-43P, and (iii) 692 MB/s on HP's P9000/J5000.

Considerably lower values are found on SGI and the UltraSPARC-II based SUN hardware; 628 MB/s on the SGI O3800/R14k-500, 588 MB/s on the SGI O3800/R12k-400, 514 MB/s on the SGI Octane2/R12k-400, 380 and 388 MB/s on the SGI O2000/R12k-400 and O2000/R12k-300, and 358 MB/s on the SGI O2000/250, Figures on the UltraSPARC-II include 375 and 327 MB/s on the SUN Ultra80/450 and HPC4500/400. Older CPUs from DEC and HP also showed far lower values than

current hardware e.g. 246 MB/s on the DEC Alpha PW/600AU, 215 MB/s on the DEC Alpha 8400/5-625, and 235 MB/s on the HP PA-9000/V2200.

Considering the AMD Athlon and PentiumIII, we find the highest TRIAD figures on the AMD K7/1400 (800 MB/s) and PentiumIII/733 (686 MB/s). These figures are clearly more dependent on the memory sub-system of the host machine than processor clock speed, with the K7/850 showing the same TRIAD rate as the AMD/650, while the AMD Athlon K7/1000 exhibits inferior performance (480 MB/s). The PentiumIII/733 rate of 686 MB/s exceeds that found on both the Pentium III/866 and Pentium III/800 (480 MB/s) and is little better than the 400 MB/s of the PentiumIII/550.

Note that there is almost a 1:1 mapping between the STREAM ordering and the Mflop rates observed in the Jacobi benchmark of Table 14. Note also the reasonably high STREAM rating for both the Cray T3E/1200 and Cray T3E/900, and the expected dominance of the vector supercomputers in this benchmark, with the NEC SX5 STREAM rating a factor of 30 higher than the leading workstations.

Finally, we note that the figures of Table 15 say nothing about the multiprocessor capabilities of the CPUs. A significant performance degradation is observed when running multiple copies of the benchmark on those multiprocessor systems with "inferior" memory sub-systems. This effect must be considered when assessing the intuitive cost-effectiveness of multi-processor nodes. The delivered TRIAD rate per CPU for the dual-processor API UP2000/6-833 and -667 (i.e. when running two concurrent STREAM benchmarks) is half the figure of Table 15, while that on the DS20 remains at the listed figure (an effect caused by the reduced number of pipes to memory on the UP2000 6/667). Exactly the same effect is found on the dual process PentiumIII nodes, while the delivered rate on the IBM SP/WH2-375 slides from the 781 MB/sec for a single benchmark run on the quad-node to just 233 MB/s when all 4 CPUs are involved in benchmark runs.

5. THE CHEMISTRY APPLICATIONS BENCHMARK

5.1 The Quantum Chemistry Benchmark - GAMESS-UK-89

The GAMESS-UK-89 benchmark summarized below was designed to reflect the typical range of calculations performed by the *ab initio* quantum chemist. It includes 12 calculations carried out using the GAMESS-UK electronic structure code, and includes the following functionality;

- Conventional SCF Calculations, on morphine and 2,4,6 tri-nitro-toluene (Calculations 1. and 2. respectively);
- Valence-only ECP calculations, with a geometry optimization of Na_7Mg^+ in an ECP-DZ+D (Mg) basis of 70 GTOs (calculation 3).
- A Direct-SCF calculation on Cytosine (82 GTOs, 6-31G basis) Calculation 4);
- Multi-configuration SCF calculations, with a CASSCF geometry optimization on H_2CO (Calculation 5), and a larger CASSCF calculation, also on H_2CO (Calculation 6);
- Configuration interaction calculations, both Direct-CI on the H_2CO/H_2 +CO TS transition state (Calculation 7), and conventional table driven-CI on $TiCl_4$ (Calculation 8);
- Moller Plesset calculations, with a MP2 geometry optimization of H_3SiNCO (Calculation 9);
- Analytic second derivatives, at both the SCF (C_5H_5N molecule in a 6-31G basis, Calculation 10) and MP2 level (C_4 in a 6-31G* basis, Calculation 11);

- A Direct-MP2 calculation on C_5H_5N in a DZ + D(N) basis set (Calculation 12).

The data presented in Table 12 is collected under control of the UNIX command *time* where available, and includes CPU time (both user and system), total elapsed time and Efficiency, measured as CPU versus elapsed. While our original aim was to base comparisons strictly on elapsed times, such timings could not be consistently gathered over the range of machines considered. For example, the range of disk configurations varies enormously, from primitive SCSI disks to striped high-speed raid disks, and the loading on the machines varies, from effectively single-user loading on many of the workstations, to multi-user environments, such as on the DEC Alpha 8400/5/300. Thus while reporting the elapsed times, we use such figures to identify, where appropriate, the requirement for enhanced disk configurations, rather than as any implied criticism of the machine in question.

The total user CPU timings of Table 12 refer to the summed user CPU timings over all 12 calculations of the GAMESS-UK-89 benchmark. These suggest that the IBM pSeries 690Turbo and Regatta-HPC/1300 are dominant, outperforming the Compaq Alpha ES45/1250 and the various Itanium2/1000 systems. Three of the leading 12 entries feature the IBM pwr4 CPU, four the Itanium2 processor, three the HP/Compaq Alpha EV68 and EV7 processor, with a single IA32 CPU (from AMD) and PA-RISC system from HP.

The IBM pSeries 690Turbo (2.6 mins) is seen to outperform the Compaq Alpha ES45/1250 (3.0 mins) and Marvel EV7/1000 (3.2 mins) by a factor of ca. 1.2, the HP RX2600 Itanium2/1000 by a factor of 1.25, and the HP RX5670 Itanium2/1000, the IBM pSeries 630/1000 and HP PA-9000/RP7410-875, all of which show identical user CPU timings of 3.8 mins, by a factor of ca. 1.35. The leading 8 systems are followed by the Compaq Alpha ES45/1000 (3.7 mins), the Intel Tiger Itanium2/1000 and AMD MP2400+/2000 (pgi) (3.8 mins), and the HP ZX6000 Itanium2/900 (4.0 mins). Six systems exhibit user CPU timings of between 4-5 minutes, including the AMD MP2000+/1667 (pgi) (4.3 mins), the Pentium 4/2000 (ifc), HP PA-9000/J6700-750 and Compaq Alpha ES40/833 (4.4 mins), the AMD MP1800+/1533 (pgf77, 4.8 mins) and Pentium 4/2000 (pgf77, 5.0 mins). Systems with user CPU timings between 5-6 minutes include the AMD MP2000+/1667 (g77, 5.3 mins) the SUN Blade 2000/1056-Cu and AMD K7/1400 (pgf77, 5.4 mins), the 667 MHz Compaq Alpha machines (DS20E, 5.5 mins. and ES40, 5.6 mins) and API UP2000 6/833 (5.6 mins).

Eleven machines exhibit user CPU timings of between 6-7 minutes; these include the AMD MP1800+/1533 (g77, 6.0), the HP PA-9000/J6000-552 (6.1), the Pentium 4/1500 (pgf77, 6.2 mins.), the Pentium 4/2000 (g77), AMD K7/1200 (pgf77) and Compaq PW XP1000/667 (6.3 mins), the SUN Fire V880/900-Cu (6.5 mins), the AMD K7/1400 (g77, 6.7 mins), the SGI Onyx 300/R14k-600, and SUN Fire 6800/900-Cu (6.8 mins) and the API UP2000 6/667 (6.9 mins.).

Notable absences from the leading list of 30 systems include the Itanium1 systems (the HP Itanium/733-2M L3, 7.1 mins and Intel Itanium/800-4M L3, 7.6 mins), the SGI R14k-500 systems (O3800, 8.0 mins. and O300, 8.1 mins.) and the Pentium III/1000 (pgf77, 8.2 mins). The Pentium III/1000 is a factor of 3.1 times slower than the IBM pSeries 690Turbo.

Ten of the leading 20 systems feature proprietary CPUs from HP/Compaq (6), IBM (3), and Sun (1); four feature the Itanium2 CPU from Intel (the 3 systems from HP plus the Intel Tiger), and six the IA32 CPUs from Intel (2) and AMD (4). The fastest machine from SUN (the SUN Blade 2000/1056-Cu, 5.4 mins) is a factor of 2.1 times slower than the IBM pSeries 690Turbo. The 1056 MHz UltraSPARC III is outperformed by the AMD AMD MP1800+/1533 (4.8 mins.) and Intel's Pentium 4/2000 (5.0 mins.) We would again note that the performance of the Pentium 4 improved significantly with optimal maths libraries and disk configuration. The availability of Intel's MKL

libraries on the Pentium 4/1500 (and not on the 1400 MHz) accounts for the significant decrease in user time, from 8.4 to 6.2 mins. Eighteen systems are seen to lie within a factor of two of the fastest.

A somewhat modified picture emerges when considering the system CPU and elapsed times. With the exception of the Alpha, and to a lesser extent the SGI R10k, most machines exhibit a system CPU time of the order of 10-15% of the user time; this percentage increases significantly, particularly on the Alpha systems, to between 20-40% for the systems shown in the Table. The API UP/2000-833 shows an alarming increase, to a figure of 66%. Based on the summed CPU times, the position of the IBM pSeries 690Turbo and Regatta-HPC/1300 as the optimum CPU is marginally strengthened (3.2 mins), with the Compaq Alpha ES45/1250 (4.0 mins) now exhibiting comparable performance to the IBM pSeries 630/1000, and slower than the HP RX2600 and RX5670 Itanium2/1000 systems (3.8 and 3.9 mins). These six systems are followed by the HP PA-9000/RP7410-875 and Intel Tiger Itanium2/1000 (4.1 mins), the HP ZX6000 Itanium2/900 (4.3 mins) and Compaq Marvel EV7/1000 (4.4 mins), the Alpha system exhibiting a system CPU time of 25% of the user time.

Considering the elapsed times and associated efficiences for the most recent machines, efficiencies in excess of 98% are only seen on the HP/Compaq (both Alpha and Itanium2-based systems), the SGI R14k-based Onyx 300, the SUN Blade 2000/1056-Cu and SUN Fire V880/900-Cu, plus AMDs MP+ systems and and Intels Pentium 4/2000 and /1500. What is noticeable is the significant improvements in these efficiency ratios on the more recent SUN and Compaq/Digital hardware compared to the figures recorded in the past.

Overall factors of 91.3 (in total CPU) and 95.7 (in elapsed times) are found when comparing the ``slowest'' (SUN SPARCstation 10/30) and ``fastest'' (the IBM Regatta-HPC/1300) machines in Table 12. The corresponding CPU factors in both the Matrix-89 and Chemistry Kernels are somewhat higher, 62.5 and 55.8 respectively.

Considering machines based on a given family of processors, we find the following:

- The 1.3 GHz power4-based IBM pSeries 690Turbo outperforms the 1.0 HGz pwr4-based pSeries 630/1000 by a factor of 1.34, and the 375 MHz power3-based IBM SP/WH2-375 by a factor of 2.66 (CPU). CPU times for the IBM SP/WH2-375 are 1.8 times faster than the IBM RS/6000-SP/222 and RS/6000-43P, 2.5 times faster than the RS/6000-397, and 5.4 times faster than the IBM RS/6000-3CT; elapsed time ratios are 1.8, 2.7 and 6.3 respectively.
- The EV68 1.25 GHz Compaq AlphaServer ES45/1250 outperforms the 1 GHz EV7 Marvel-based system and the 1 GHz ES45/1000 by factors of 1.09 and 1.13, compared to the clock speed ratio of 1.25. Clearly the EV7 based system is only performing on a par with the 1 GHz EV68 ES45/1000; the latter system outperforms the 833 MHz EV67-based ES40/6-833 by a factor of 1.37 (CPU), compared to the clock speed ratio of 1.2. The ES40/6-833 itself outperforms the 667MHz ES40/6-667 by CPU factors of 1.08 and the EV6-based AlphaServer DS20/6-500 by a factor of 1.7. The DS20/6-500 in turn outperforms the EV5-based Alpha PW/600AU and 8400/5-625 by CPU factors of 1.7 and 2.0.
- The PA8700+ based RP7410-875 outperforms the PA8700-based HP PA-9000/J6700-750 by a factor of 1.22 and the PA8600-based HP PA-9000/J6000-552 by a factor of 1.64, broadly in line with the corresponding clock speed ratios of 1.17 and 1.59. The J6000 in turn outperforms the HP PA-9000/J5000-440, PA-9000/C3000-400, HP PA-9000/C240, HP PA-9000/V2200 and HP PA-9000/C200 by CPU factors of 1.34, 1.40, 2.37, 2.90, and 3.54 respectively.
- The SUN Blade 2000/1056-Cu outperforms the 900-Cu based systems, the SUN Fire V880/900-Cu and 6800/900-Cu, by factors of 1.19 and 1.31 (cf. clock speed ratio of 1.17). The 6800/900-Cu itself outperforms the SUN Blade 1000/M1750 by a factor of 1.31, while the SUN Blade outperforms the Ultra80/450, HPC3500/400, HPC4500/336, Ultra-2/300 and

Ultra-2/200 by CPU factors of 1,56, 1.78, 2.04, 2.39 and 3.38 respectively.

- The 600 MHz SGI Onyx 300/R14k outperforms the O300/R14k-500 and O3800/R14k-500 by factors of 1.18 and 1.25, in line with the figure of 1.20 based on clock speed. Surprisingly perhaps, the O300/R14k-500 is found to be marginally faster than the O3800 (9.5 vs 10 mins). The O3800/R14k-500 outperforms the 400 MHz R12k-based O3800 and O2000 by a factor of 1.2; the latter outperforms the O2000/R12k-300 by a factor of 1.24, the R10k/250 O2000 by a factor of 1.57, the R10k/195 machine by a factor of 1.90, and the R8k-based machines by a factor of ca. 4.4. The SGI O2 R12k/270 outperforms the R10k/175 and R5k/300 by factors of 1.36 and 1.69. The limited memory bandwidth and cache on the SGI O2 R12k/270 and R10k/175 are again apparent from the GAMESS-UK benchmarks, with the SGI Octane/R12k-270 a factor of 1.7 times faster than the O2 R12k, and the SGI Octane/R10k-175 a factor of 1.5 times faster than the O2 R10k.

We now comment on the performance of the Pentium and AMD IA32--based hardware; using the GNU g77 compiler resulted in summed CPU times of 6.7, 8.1 and 12.6 mins. for the Pentium 4/2000, P4/1500, and P4/1400, respectively. Corresponding timings on the Pentium III systems are; 11.3 mins. (Pentium III/1000), 12.1 mins (Pentium III/866), 11.2 mins. (PentiumIII/800), 12.9 mins (PIII/733), 15.2 mins. (PIII/750), 16.8 mins. (PentiumII/650) and 19.4 mins. (PII/550). The AMD Athlon is arguably more impressive, with CPU times of 6.1, 6.7, 7.7, 8.5, 10.4, 10.9, 13.2, 15.3 and 18.2 mins. on the MP2000+/1667, MP1800+/1533, Athlon K7/1400, Athlon K7/1200, K7/1000, K7/850, K7/650, K7/600 and K7/500 respectively. Use of the Portland Group pgf77 compiler produces a consistent level of performance improvement compared to g77, typically by a factor of between 1.14-1.22 for the Pentium III and AMD Athlon CPUs, while somewhat higher for the Pentium 4/2000 and P4/1500 (a factor of 1.25). Optimum performance on the Pentium 4 systems arises from use of Intel's ifc fortran compiler; an ifc/g77 performance ratio of 1.40 is found on the Pentium 4/2000, compared to the pgf77 figure of 1.23.

While the AMD Athlon MP2400+/2000 is 1.46 times slower than the IBM pSeries 690Turbo, we note that SPECfp-based predictions based on the ratings of Tables 1 and 2 would have led to much higher factors, 1.93 (SPECfp2000) and 1.99 (SPECfp_base2000).

Finally, we comment on the IA64-based systems. The performance of systems based on the Itanium1 CPU are again disappointing. The Intel Itanium/800-4M L3 and HP Itanium/733-2M L3 exhibit comparable summed CPU times of 9.0 and 9.5 mins. respectively. i.e. only around 50% of the performance of the AMD MP2400+/2000 and Pentium 4/2000, and little better than the IA32 1GHz Pentium III. This poor performance has been more than rectified with the Itanium2; as noted above, the leading systems feature this CPU, with the HP RX2600 Itanium2/1000 outperforming its predecessor in the above two systems by factors of between 2.4-2.8. Interestingly there is little to chose in performance terms between the (HPUX/f90) and (Linux/efc) environments - the (HPUX/f90)-based RX2600 and (Linux/efc)-based RX5670 exhibit almost identical CPU times, with the latter a factor of 1.08 faster than the Intel Tiger Itanium2/1000.

5.1.1 GAMESS-UK-97

The GAMESS-UK-97 benchmark summarized below is designed to reflect a more demanding range of calculations performed by the *ab initio* quantum chemist. It includes 10 calculations carried out using the GAMESS-UK electronic structure code (Version 6), and includes the following functionality;

- A Direct-SCF calculation on Morphine (227 GTOs, 6-31G basis); the calculation converges in

9 SCF cycles (Calculation 1);
- Conventional SCF Calculation on 2,4,6 tri-nitro-toluene (6-31G** basis, 265 GTOs); requires 11 iterative SCF cycles and uses 2e-integral format (Calculation 2);
- DFT B3LYP calculation on Cytosine (167 GTOs, 6-311G* basis) conventional SCF converging in 10 SCF cycles, high quadrature (Calculation 3);
- CASSCF Multi-configuration SCF calculation on H_2CO (Calculation 4) conducted in a CC-PVTZ basis of 100 GTOs. The 16 electrons in 13 MOS (109857 csfs) converged in 3 macro-iterations;
- Direct Configuration interaction calculation on the H_2CO/H_2 +CO TS transition state (Calculation 5). Conducted in a CC-PVTZ basis of 100 GTOS (88 spherical harmonics), the in-store calculation included 1,629,857 CSFs generated from 16 reference functions;
- A coupled cluster CCSD(T) calculation on the C_4 molecule conducted in a tzv+2D+1F basis of 144 GTOs; a total of 172,811 configurations (CCSD) (Calculation 6);
- Moller Plesset calculations, with a MP2 geometry optimization of H_3SiNCO (Calculation 7); TZVP basis (105 GTOs), 5 energy and 5 gradient calculations for convergence;
- Analytic second derivatives, at both the SCF (C_5 H_5N molecule in a 6-311G** basis, (144 GTOs, Calculation 8) and MP2 level (C_4 in a TZVP basis (2D on carbon, 104 GTOs, Calculation 9);
- A Direct-MP2 energy calculation on Cytosine in a 6-31G* basis set (130 GTOS, Calculation 10) requiring 2 integral passes.

The data presented in Table 17 is collected under control of the UNIX command *time* where available, and includes CPU time (both user and system), total elapsed time and Efficiency, measured as CPU versus elapsed. The total User CPU timings of Table 17 refer to the summed user CPU timings over all 10 calculations of the GAMESS-UK-97 benchmark. An examination of the results leads to similar conclusions to those based on the GAMESS-UK-89 benchmarks that have been described in detail above. The relative CPU ratios compared to the Compaq Alpha ES45/68-1000 are found in most cases to to be similar to those of the GAMESS-UK-89 benchmark. Machines that show a relative enhancement in CPU performance compared to GAMESS-UK-89 include the HP PA-9000/J6700-750 (95% compared to 90% in GAMESS-UK-89), the Compaq Alpha ES40/833 (76% and 73%) and the API UP2000/6-833 (56% and 50%).

Machines that perform less effectively relative to the Alpha ES45/68-1000 on the larger benchmark include the AMD Athlon K7, and the Pentium 4 and Pentium III. Thus the pgi-compiled GAMESS-UK-97 and GAMESS-UK-89 relative CPU ratios are 68% and 84% on the AMD MP1800+/1533, 57% and 71% on the K7/1400, and 51% and 64% on the K2/1200, while the g77-based ratios on the K7/1000 are 40% and 44% respectively. A similar degradation in relative performance is found with the Pentium 4 and Pentium III. Thus the GAMESS-UK-89 pgi-based ratios of 85% on the Pentium 4/2000 and 70% on the Pentium 4/1500 decrease to 71% and 63% respectively in GAMESS-UK-97. The ifc-based ratio of 95% on the Pentium 4/2000 decreases to 77% in GAMESS-UK-97. The pgi-based GAMESS-UK-89 ratios of 49% and 42% on the Pentium III/1000 and Pentium III/733 decrease in GAMESS-UK-97 to 37% and 33% respectively. Far smaller degradations are found in a number of other systems, including the SGI Octane2/R12k-400 (37% in GAMESS-UK-97, 40% in GAMESS-UK-89), Compaq Alpha DS10/466 (36% and 37%), SUN Ultra80/450 (27% and 29%), and the SGI O2 R12k/270 (14% in GAMESS-UK-97, 16% in GAMESS-UK-89).

5.2 The Molecular Simulation Benchmark - DL_POLY

The benchmark summarized below is designed to reflect the typical range of simulations undertaken

by the molecular dynamicist. It includes 6 calculations carried out using the DL_POLY molecular dynamics code, and includes the following functionality;

- Benchmark 1: Simulation of a sodium-potassium disilicate glass (1080 atoms, 300 time steps);
- Benchmark 2: Simulation of metallic aluminium with Sutton-Chen potential at 300K (256 atoms, 8000 time steps);
- Benchmark 3: Simulation of valinomycin in 1223 water molecules (3837 atoms, 100 time steps);
- Benchmark 4: Dynamic Shell model water structure (768 atoms, 1024 sites, 1000 time steps);
- Benchmark 5: Dynamic Shell model $MgCl_2$ structure (768 atoms, 1280 sites, 1000 time steps);
- Benchmark 8: Simulation of a model membrane with 2 membrane chains, 202 solute molecules and 2746 solvent molecules (3148 atoms, 1000 time steps).

The data presented in Table 14 is collected under control of the UNIX command *time* where available, and includes CPU time (both user and system), total elapsed time and Efficiency, measured as CPU versus elapsed. The total user CPU timings of Table 14 refer to the summed user CPU timings over all 6 calculations of the benchmark. Note that in contrast to the QC benchmark, little I/O is performed by the DL_POLY calculations, so that efficiency should always be high assuming the benchmarks were conducted on a dedicated resource.

The total timings of Table 14 suggest that the Itanium2 and Alpha EV68 are dominant, with the leading seven machines featuring these CPUs. The optimum timings are recorded by the 1GHz Itanium2-based Intel Tiger and HP RX5670, with the (Linux/efc) environment outperforming the (HPUX/f90)-based HP RX2600 by a factor of 1.2. Indeed the latter machine is also outperformed by the (Linux/efc)-based 900 MHz HP ZX6000. The Intel Tiger Itanium2/1000 (4.7 mins) is seen to outperform the Alpha-based systems, the Compaq Alpha ES45/1250 (5.7 mins) and ES45/1000 (7.0 mins) by factors of 1.22 and 1.51, while the EV7 Marvel-based system exhibits performance mid-way between the two EV68 machines (6.4 mins). Following the Itanium2 and Alpha systems, we find the HP PA-9000/RP7410-875 (7.6 mins), the 1.3 GHz power4 systems, the pSeries 690Turbo (8.3 mins) and Regatta-HPC/1300 (8.4 mins), and the Compaq Alpha ES40/833 (8.5 mins). This leading group of machines is followed by the 750 MHz PA8700 (HP PA-9000/J6700, 9.0 mins.), the 600 MHz MIPS R14k (SGI Onyx 300, 9.2 mins), and the AMD MP2400+/2000 and MP2000+/1667 (9.6 and 10.4 mins).

A number of EV67-based machines follow. The Tiger Itanium2/1000 outperforms the Compaq Alpha DS20E/667 by a factor of 2.26, the DS20E/667 exhibiting similar run times to the API UP2000 6/833, Compaq ES40/667 and XP1000/667 (10.5 - 11.2 mins.). Similar performance is apparent from a number of non-alpha CPUs, including the 1 GHz pwr4 IBM pSeries 630/1000 and 500 MHz R14k SGI Origin 3800 and O300 (10.9-11.1 mins), the Pentium 4/2000 (ifc, 11.3 mins.), the SUN Blade 2000/1056-Cu (11.4 mins) and the AMD MP1800+/1533 (pgf90, 11.6 mins.).

Ten of the leading twenty machines of Table 14 are neither Itanium2 nor Alpha-based; these include (with appropriate performance ratios against the HP RX2600 Itanium2/1000): HP PA-9000/RP7410-875 (72%), IBM pSeries 690Turbo and Regatta-HPC/1300 (66 and 65%), HP PA-9000/J6700-750 (61%), SGI Onyx 300/R14k-600 (59%), AMD MP2400+/2000 and MP2000+/1667 (57% and 53%), API UP2000 6/833 (52%), and SGI O3800/R14k-500 and IBM pSeries 630/1000 (50%).

When considering the performance of CPUs within a given family of processors, particularly those from SUN, IBM and Hewlett Packard, we would note the following:

- Within a given processor family, the performance of DLPOLY generally follows closely the

associated clock speed ratio, reflecting the small demand on memory bandwidth. Deviations from this behaviour typically reflect enhanced compiler developments.

- The treatment of dynamic memory within Version 2.11 of DL_POLY relies on usage of the f90 compiler. This in part explained the exceedingly poor performance historically of DL_POLY on the SUN Ultra80/450 and SUN HPC4500/400, for SUN's earlier releases of the f90 compiler generated rather inefficient code, in some cases running only half the speed of that generated using f77. The timings of Table 14 suggest the Ultra80/450 is a factor of 8.5 times slower than the HP RX2600 Itanium2/1000 compared to the SPECfp2000 ratio of 4.9. This situation has certainly improved, for the recent benchmark timings on the SUN Blade 2000/1056-Cu (11.4 mins) and SUN Fire V880/900-Cu (13.4 mins) suggest improved performance of 3.3-3.9 against the Ultra80/450, a factor well in excess of the clock speed ratios (again, note that DL_POLY places little demand on memory bandwidth).
- While Hewlett Packards f90 compiler also exhibited performance problems historically, there is some evidence of improvement here on more recent hardware. Thus the run time of 19.6 mins. on the J5000 (using HP F90 1.0.100) is reduced to 16.0 mins. on the N4000 when using HP F90 v2.3, both machines housing the 440 MHz PA8500. The run-time ratio on the N4000 compared to the HP PA-9000/RP7410-875 (2.11 times slower) is similar to what might be expected based on the clock speed ratio of 1.99.
- All CPUs from IBM perform poorly on this benchmark. Although the IBM pSeries 690Turbo is a factor of 2.6 times faster than the 375 MHz power3 IBM RS/6000-SP/375 and RS/6000 44P-270, it remains a factor of 1.8 times slower than the Intel Tiger Itanium2/1000. The IBM RS/6000-SP/375 and RS/6000 44P-270 are seen to be a factor of 3.1 times slower than the Compaq Alpha ES40/833; this factor is significantly higher than that suggested by the SPECfp2000 rating (2.5).
- Considering the fastest of the commodity IA32 CPUs, we find that the AMD MP+ Athlon-based CPUs have a clear performance edge in this benchmark. CPU times on the MP2400+/2000 and MP2000+/1667 (9.55 and 10.40 mins). are to be compared with that of 11.3 mins on the Pentium 4/2000. Indeed the latter ifc-compiled timing is comparable with that on the AMD MP1800+/1533 (pgi, 11.6 mins), with the MP1800+ somewhat faster based on the pgf90 timings (11.6 and 14.1 mins respectively). As with the GAMESS-UK benchmark, use of Intel's ifc compiler on the Pentium 4/2000 enhances performance by a factor of 1.25. Using the PGI compiler, the AMD Athlon K7/1400 outperforms the Pentium 4/2000 and Pentium 4/1500 by factors of 1.08 and 1.36, although the Athlon K7/1000 and Pentium III/1000-CM exhibit comparable performance. While the Pentium 4 CPU appears to underperform somewhat, the performance of the Athlon CPUs is somewhat better that the SPECfp2000-based predictions. Thus the AMD MP2400+/2000 and Pentium 4/2000 (ifc) are found to be 1.67 and 1.98 times slower than the Compaq Alpha ES45/1250, compared to the corresponding SPECfp2000 ratios of 2.07 and 1.91 respectively.
- As found with GAMESS-UK, the performance of the IA64 Itanium1 CPU is disappointing; run times of 15.2 mins for both HP Itanium/733-2M L3 and Intel Itanium/800-4M L3 are only a factor of 1.22 better than that found on the Pentium III/1000 (18.6 mins). This poor performance has been more than rectified with the Itanium2; as noted above, the leading systems feature this CPU, with the Tiger Itanium2/1000 outperforming its predecessor in the above two systems by a factor of 3.3.

6. SUMMARY

As a summary of this work, we present in Table 19 the relative performance of 120 CPUs against the Compaq Alpha ES40/6-833 in terms of the CPU2000 benchmarks, and those from the present Matrix-97, Chemistry Kernels, GAMESS-UK and DL_POLY benchmarks. Note that while previous

versions of this report have driven this comparison across the CPU95 ratings, we have now attempted to transition to CPU2000. In doing this, we clearly have a problem in terms of relating older machines, for which only SPECfp95 results are available, with the newer systems. Thus many of the SPECfp entries of Table 19 are estimated CPU2000 figures based on extrapolations from the older CPU95 values. This extrapolation process has involved identifying systems for which both SPECfp2000 and SPECfp95 figures are available, deriving appropriate scaling factors based on these values, and applying this scaling to the older CPUs. While not an ideal metric, we would suggest this approach is preferable to the alternative of trying to derive extrapolated SPEC95 figures from measured SPECfp2000 figures for the more recent systems.

Based on the published SPECfp2000 ratings, and normalising with respect to the Compaq AlphaServer ES40/6-833 value of 777.0, we would expect (see section 1) the ES40/6-833 to lie comfortably ahead of the API/UP2000 6/833 (83%), the Pentium 4/1500 (79%) and Pentium 4/1400 (76%), with the latter CPU performing on a par with the 667 EV67-based DS20E (75%) and ES40/6-667 (72%).

These 6 systems in turn outperform the next eight, headed by the SGI O3800/R14k-500 (60%) and AMD Athlon K7/1400 (59%), that exhibit between 50-60% of the performance of the Alpha ES40/6-833. Also included here are the Compaq PW XP1000/667 (57%), the HP PA-9000/J6000-552 (56%), the Compaq Alpha DS20/500, AMD Athlon K7/1200, and SUN Blade 1000/M1750 (all at 54%), and the SGI O3800/R12k-400 (52%).

All other CPUs are no better than 50% of the performance of the Alpha ES40/6-833. These are headed by the leading system from IBM, the IBM RS/6000-SP/375 (49%), while the Pentium III/1000 performs at 40% of the Alpha ES40. Based on these relative SPECfp values given in the table, we expect a factor of 70.6 between the fastest and slowest processor, the SUN SPARC/10-41.

The 833 MHz EV67-based machines from Compaq and API, together with the Pentium 4 (1500 and 1400 MHz) and AMD Athlon K7 (1400 and 1200 Mhz) are also seen to dominate the SPECint95 ratings, with ratings between 565 (Alpha ES40/6-833) and 496 (AMD Athlon K7/1200), and relative performance between 88-100% of the ES40/6-833. Leading CPUS from other vendors include the HP PA-9000/J6000-552 (78%), the SGI O3800/R14k-500 (76%), SUN Blade 1000/M1750 (70%), and IBM RS/6000 44P-270 (48%). Note that the Pentium III/1000 (76%) now outperforms the SUN Blade 1000/M1750 and IBM RS/6000 44P-270.

When analysing the results, we wish to consider based on the present evaluation exercise, (i) do the SPECfp values provide a reliable metric for evaluating the capabilities of hardware in computational chemistry? If so, we would expect to find a close mapping of the ratios for the various chemistry benchmarks onto the SPECfp ratios, (ii) does any particular CPU consistently ``underperform'' based on the SPECfp criteria? - this would manifest itself as the ratios from the chemistry benchmarks falling below the SPECfp ratios, and (iii) do the ``simple'' Matrix and Chemistry Kernel benchmarks lead to the same conclusions as the GAMESS-UK and DL_POLY benchmarks?

In the interests of providing a single Performance Index (PI) covering all machines of Table 19, we have provided an average value of the Matrix-97, Chemistry Kernels and GAMESS-UK benchmarks. Note that that at this stage we have not included the DL_POLY benchmark results in computing the PI, since that these results are only available on a sub-set of the machines. The value of such an index is somewhat debatable, for not only does it omit the DL_POLY benchmark, it weights the chemistry kernels on an equal footing with the end-application codes, which is not ideal. Note that we have only provided PI estimates for those machines where data on all three benchmarks is available.

Summarising the major conclusions from the figures of Table 19, we would note the following;

- While the EV67-based Compaq AlphaServer ES40/6-833 provides the optimum CPU based on the benchmarks conducted in this report, its superiority is not as pronounced as might be expected from just a consideration of the SPECfp2000 rankings.
- Following the Compaq AlphaServer ES40/6-833 (100%), the optimum five CPUs based on the benchmarks and PI values of Table 19 exhibit between 80-90% of the performance of the ES40/6-833. These include the Pentium 4/1500 (pgi) and HP PA-9000/J6000-552 (87%), the Compaq Alpha DS20E/667 and ES40/667 (84 and 83%) and the API UP2000 6/833 (80%).
- Following these 6 systems, we find a total of seven machines that show between 70-80% of the performance of the ES40/6-833. These include the IBM RS/6000 SP/WH2-375 (79%), AMD Athlon K7/1400 (pgi,77%), IBM RS/6000 44P-270 and Pentium 4/1500 (g77) (76%), the Compaq PW/XP1000-667 (74%), the SGI O3800/R14k-500 (72%) and the AMD Athlon K7/1200(pgi) (70%).
- Nine systems exhibit PI indices between 60-70%. These include the HP PA-9000/J5000-440 (69%), the API UP2000/6-667 and Pentium 4/1400 (pgi, 67%), the AMD Athlon K7/1400 (g77) and Sun Blade 1000/M1750 (65%), the HP PA-9000/N4000-440 (63%), the Compaq Alpha DS20/500 and SGI O3800/R12k-400 (61%), and the HP PA-9000/C3000-400 (60%).
- Nine machines exhibit between 50-60% of the performance of the Compaq Alpha ES40/6-833. Four share the same PI index of 59% - the Compaq Alpha ES40/6-500, Pentium 4/1400 (g77), SGI Octane2/R12k-400 and the AMD Athlon K7/1200(g77). Other machines in this range include the Compaq PW XP1000/500 (56%), AMD Athlon K7/1000 (pgi, 55%), and two other EV6-based machines, the Compaq Alpha GS140 (54%) and DEC Alpha 8400/6-575 (63%). All other machines considered would appear to be less than half the speed of the Compaq AlphaServer ES40/6-833.
- The leading Pentium-III CPUs based on PGI-compiled code exhibit PI indices of 49% (Pentium III/1000), 43% (Pentium III/866), 42% (Pentium III/733) and 41% (Pentium III/800). Corresponding values using g77 are 41%, 39%, 37% and 34%, respectively.
- The apparent strength of the IBM SP/WH2-375 and RS/6000 44P-270 must be considered in light of the DL_POLY molecular dynamics benchmarks); inclusion of these figures would have lowered the PIs significantly (from 79 to 69% for the IBM SP/WH2, from 76% to 67% for the RS/6000 44P-270).
- With few exceptions, all non-Compaq machines exhibit PI's significantly greater than the corresponding SPECfp2000 ratios. Particularly striking are the systems from IBM and HP. Thus the IBM SP/WH2-375 and IBM RS/6000 44P-270 exhibit the same SPECfp2000 ratios of 49%, and PI values of 79% and 76% respectively. From HP, the PA8600-based HP PA-9000/J6000-552, HP PA-9000/J5000 and N4000 show SPECfp2000 ratios of 56%, 47% and 38%; corresponding PI values are 87%, 69% and 63%.
- The SUN Blade 1000/M1750, with a PI value of 65%, also exceeds our estimated SPECfp rating (54% of the ES40), although this PI figure would have slipped somewhat had the DLPOLY benchmark been included (to 62%). Having said that, recent improvements in the f90 compiler appear to have remedied the poor performance of the SUN Ultra80/450, SUN HPC4500/400 and SUN HPC4500/336 on the DL_POLY benchmark, caused by the status of SUN's f90 compiler at the time of benchmarking (see also [16] for similar Linpack statistics). The UltraSPARC-II systems from SUN, whose PI values exceed the SPECfp2000 ratings, would perform more in line with the SPECfp2000 ratings if this benchmark had been included in the final assessment.
- All machines from Silicon Graphics appear to exceed the SPCfp2000-based performance predictions in all benchmarks. Typical effects here are seen in the following machines: SGI O3800/R14k-500 (SPECfp, 60% vs. PI. 72%), O3800/R12k-400 (SPECfp, 52% vs. PI, 61%) Octane2/R12k-400 (44% vs. 59%), O2000/R12k-400 (44% vs 57%), O2000/R12k-300 (35%

vs 45%), Octane/R12k-270 (25% vs 40%) and the Octane/R10k-250 (21% vs 31%).

- The cost-effective performance of the Pentium 4/1500 and AMD Athlon K7/1400. While both CPUs underperform in the MATRIX-97 benchmarks relative to the SPECfp figures, the final PI values exceed the expected performance based on the SPEC ratios. Thus the Pentium 4/1500 exhibits a PI value of 87% compared to the SPECfp figure of 79%, while the PI value of 77% for the K7/1400 is significantly in excess of the SPECfp figure of 59%. The PI value for the Pentium III/1000 (49%) also exceeds the SPECfp2000 ratio (40%).
- In the chemistry kernel benchmark all machines, show higher performance ratios relative to the Compaq Alpha ES40/833 than expected based on their SPECfp2000 rating. This effect is often quite marked; the AMD Athlon K7/1400, K7/1200 and K7/1000 exhibit performance ratios ranging from 92 to 65%, to be compared with the SPECfp ratios of between 59 to 41%. Similarly, the IBM RS/6000-SP/375 SUN Blade 1000/M1750, HP PA-9000/J6000-552 and SGI O3800/R14k-500 exhibit performance ratios ranging from 71% to 80%, to be compared with the corresponding the SPECfp200 ratios that range from 49% to 60%. Clearly the Compaq Alpha ES40/833 is underperforming in these four benchmarks. The impact of the improved memory bandwidth in the JACOBI benchmark is particularly noticeable in (i) the Compaq DS20/6-500 and ES40/6-500 compared to the DEC Alpha 8400/6-575, (ii) the SUN Blade 1000/M1750 compared to the UltraSPARC-II based hardware, and (iii) the Pentium 4 compared to Pentium III.

In terms of performance ordering of CPUs, we find that the PI values and all the chemistry benchmarks are broadly in line with the SPECfp predictions; notable exceptions in addition to those already mentioned are summarized below:

- The good performance of the EV5-based PWAU series from Digital, with both the DEC Alpha PW/433AU and 600AU often outperforming other CPUs with higher SPECfp95 ratings.
- The memory bandwidth problems associated with the SGI O2 R12k/270 and R10k/175 [6], accounting for the poor relative SPECfp95 values (18% and 12% respectively), are not shown by either the Matrix-89 or chemistry kernels (with the exception of Jacobi). They are more evident in the GAMESS-UK benchmarks, where these CPUs performs in far inferior fashion to the corresponding SGI Octanes.
- The SPECfp95 rating of the IBM RS/6000-397 (26.6) is significantly higher than that expected from just clock speed considerations. Those CPUs featuring the same P2SC processor, the IBM RS/6000-595 (135 MHz) and IBM SP2/120Thin (120 MHz) exhibit SPECfp95 ratings some 68% and 64% of the 160 MHz RS/6000-397; based solely on clock speed, one might expect higher ratios of 84% and 75%. This effect has been attributed to the enhanced memory bandwidth of the IBM RS/6000-397. There is ample evidence that the benefits of this bandwidth are not apparent in most of the present chemistry benchmarks. Thus the relative figures for the matrix, kernels and GAMESS-UK benchmarks on the IBM RS/6000-595 are 83%, 79% and 81%, those on the IBM SP2/120Thin node, 74%, 75% and 76% respectively. These values are far more in line with the clock-speed predictions above than the enhanced SPECfp95 for the IBM RS/6000-397.

REFERENCES

1

M.F. Guest and S. Wilson, Daresbury Laboratory Preprint, DL/SCI/P290T; Supercomputers in Chemistry, ed. P. Lykos and I. Shavitt, A.C.S. Symposium series 173 (1981) 1; V.R. Saunders and M.F. Guest, Comp.Phys.Comm., 26 (1982) 389: M.F. Guest, in ``Supercomputer Simulations in Chemistry'', Ed. M. Dupuis, Lecture Notes in Chemistry, 44, Springer Verlag (1986) 98.

2

M.F. Guest, R.J. Harrison, J.H. van Lenthe and L.C.H. van Corler, ``Computational Chemistry on the FPS-X64 Scientific Computers: Experience on single- and multi-processor systems'', Theoret. Chim. Acta 71 (1987) 117.

3

M.F. Guest, ``Performance of Various Computers in Computational Chemistry,'' Proceedings of the Daresbury Machine Evaluation Workshop, November 1996.

4

GAMESS-UK is a package of ab initio programs written by M.F. Guest, J.H. van Lenthe, J. Kendrick, K. Schoeffel and P. Sherwood, with contributions from R.D. Amos, R.J. Buenker, M. Dupuis, N.C. Handy, I.H. Hillier, P.J. Knowles, V. Bonacic-Koutecky, W. von Niessen, R.J. Harrison, A.P. Rendell, V.R. Saunders, and A.J. Stone. The package is derived from the original GAMESS code due to M. Dupuis, D. Spangler and J. Wendoloski, NRCC Software Catalog, Vol. 1, Program No. QG01 (GAMESS), 1980.

5

DL_POLY is a parallel molecular dynamics simulation package developed at Daresbury Laboratory by W. Smith and T.R. Forester under the auspices of the Engineering and Physical Sciences Research Council (EPSRC) for the EPSRC's Collaborative Computational Project for the Computer Simulation of Condensed Phases (CCP5) and the Molecular Simulation Group (MSG) at Daresbury Laboratory. The package is the property of the Central Laboratory of the Research Councils.

6

In theory the O2-R10k should have outperformed the corresponding Indigo2; with better memory bandwidth, superior I/O and more tightly coupled integration it should have done well. However SGI made a design decision which has seriously impaired the performance of the O2 in some application areas. It took about 3 months for this "flaw" to be fully identified. Until December 1996, SGI were claiming that the O2 R10k would perform in the region of 10, 12 or even 15 SPECfp95. Indeed on some benchmarks it does indeed achieve performance that matches these figures. However, the O2 has a Unified Memory Architecture which uses main system memory as memory for the graphics display and operations. Despite the impressive bandwidth figures for the O2, it does seem that the O2 memory architecture severely impedes the performance of the R10k processor, particularly when compared with the Octane, Indigo2 and Origin systems. This is shown by the SPEC comparisons of Table 1; we suspect that the two main factors limiting performance in the memory subsystem are the main memory speed and the CRIME chip.

The CRIME chip, which acts as the memory interface between the memory and the three drains on it - the CPU (800 MByte/second), I/O engine (500 MByte/sec) and the monitor display (700 MByte/second) - is probably the main bottleneck. This chip was designed to work as a built in memory controller, but the design was biased toward the R5k; it can't work directly with the R10k because the R5k expects 32 byte cache refills while the R10k wants to have 64 or 128 byte refills. Therefore SGI supply a custom ASIC with the R10k daughter board. This interfaces the R10k's level 2 cache with the CRIME chip. Performance problems are caused by the ASIC having to break each 128 byte cache refill operation into 4, 32 byte refills. The net impact of this effect is that the O2 R10k will only work well with problems that fit into the L2 cache (1 MByte). Not surprisingly, the memory intensive SPECfp95 figures are badly affected, although the impact on less memory intensive applications is not so severe.

7

R. Shepard, R.A. Bair, R.A. Eades, A.F. Wagner, M.J. Davis, C.B. Harding and T.H. Dunning Jr., Int. J. Quant. Chem. , (1983) 17; R.A. Bair and T.H. Dunning Jr., J. Comp. Chem., 5 (1984) 44; R. Bair, ``FPS-164 Matrix Multiplication Subroutine Guide'', Argonne National Laboratory, (1984); T.H. Dunning Jr. and R.A. Bair, ``Advanced Theories and Computational Approaches to the Electronic Structure of Molecules'', NATO ASI Series, D. Reidel, 1984, p1.

8

IMSL Program Library, 1978.

9

NAG Fortran Library, Numerical Algorithms Group Ltd, 1984.

10

Y. Beppu, Computers and Chemistry, 6 (1982).

11

J.P. Stewart, ``MOPAC - A General Molecular Orbital Package'', QCPE 455, 1984.

12

V.R. Saunders and M.F. Guest, ``ATMOL3 Part 9'', RL-76-106, 1976; M.F. Guest and V.R. Saunders, Mol. Phys., 28 (1974) 819; D. Moncrieff and V.R. Saunders, ``ATMOL-Introduction Notes'', UMRCC, May, 1986; Cyber-205 Note Number 32, UMRCC, September, 1985.

13

J. Almlof et al, J. Comp. Chem., 3 (1982) 385. Performance of Various Computers in Computational Chemistry

14

see the following web page to obtain Pentium Pro Optimized BLAS and FFTs for Intel Linux: http://www.cs.utk.edu/ ghenry/distrib

15

the ATLAS blas http://www.netlib.org/atlas/index.html gives a 60% speed improvement over the latest intel blas library, given the changes suggested at http://www.cs.utk.edu/~rwhaley/ATLAS/errata.html

16

More evidence of the poor performance of Sun Fortran f90 Compiler is shown in the following figures Linpack 100X100 all Fortran benchmark kindly provided by Hans-Hermann Frese of ZIB, Berlin. The results using different Sun Fortran compiler releases on a Sun Ultra 60 Model 2360 used one UltraSPARC CPU at 360 MHz. The performance of the latest NAGWare f95 is also compared:

Linpack 100X100 Performance as a function of FORTRAN compiler.

Compiler	Options	Linpack 100X100
Sun f77 4.2	-fast -O5	164 Mflop/s
Sun f77 5.0	-fast -O5	166 Mflop/s
Sun f90 1.2	-fast	61 Mflop/s
Sun f90 2.0	-fast -ftrap=no%division	68 Mflop/s
NAGWare f95 4.0	-Wc,-fast	166 Mflop/s

These figures underline that the performance of the Sun Fortran 90 compiler is still poor compared with Sun's Fortran 77 compiler. Surprisingly, the performance of the NAGWare Fortran 95 compiler which produces intermediate C code is as good as Sun's native Fortran 77 compiler.

Table 1. SPEC CPU2000 - SPECfp and SPECint. Absolute and Relative Values.

SPEC CPU2000 - SPECfp and SPECint. Absolute Values and Values Relative to the IBM pSeries 690Turbo/1.3 GHz.

Rank	Machine	SPECfp	SPECint	Test	Relative Values (%)	
				Date	SPECfp	SPECint
1	HP Integrity RX2600/Itanium2,1500MHz	2119.0	1322.0	Jun-03	167%	158%
2	HP Integrity RX5670/Itanium2,1500MHz	2108.0	1312.0	Jun-03	167%	156%
3	HP ZX6000/Itanium2, 1.5GHz,6MB-L3, H	2106.0	1315.0	Jun-03	166%	157%
4	SGI Altix 3000 (1.5GHz, Itanium 2)	2100.0	1243.0	Jul-03	166%	148%
5	NovaScale 4040 Itanium2/1500	2015.0	1107.0	Jul-03	159%	132%
6	Dell PowerEdge 3250/1.5 GHz Itanium2	1875.0	1099.0	Jul-03	148%	131%
7	ION Computers I2X2 (1.4GHz Itanium2)	1817.0	926.0	Jul-03	144%	110%
8	SGI Altix 3000 (1.3GHz, Itanium 2)	1783.0	875.0	Jun-03	141%	104%
9	IBM eServer pSeries 690Turbo 1.7 GHz	1699.0	1113.0	May-03	134%	133%
10	IBM eServer pSeries 655 1700 MHz	1678.0	1103.0	May-03	133%	131%
11	IBM eServer pSeries 670 1.5 GHz	1520.0	981.0	May-03	120%	117%
12	IBM eServer pSeries 655 1500 MHz	1488.0	970.0	May-03	118%	116%
13	HP AlphaServer GS1280 7/1150	1482.0	877.0	Jan-03	117%	105%
14	Dell PowerEdge 3250/1.4 GHz Itanium2	1444.0	824.0	Sep-03	114%	98%
15	HP RX5670/Itanium2, 1GHz,3MB-L3, L	1431.0	-	Nov-02	113%	-
16	HP RX2600/Itanium2, 1GHz,3MB-L3, L	1427.0	-	Nov-02	113%	-
17	AMD ASUS SK8N Athlon FX-51/2.2GHz(W)	1423.0	1447.0	Sep-03	112%	172%
18	HP ZX6000/Itanium2, 1GHz,3MB-L3, L	1422.0	-	Nov-02	112%	-
19	SGI Altix 3000 (1GHz, Itanium 2)	1410.0	683.0	May-03	111%	81%
20	NovaScale 4040 Itanium2/1000	1404.0	719.0	Mar-03	111%	86%
21	AMD ASUS SK8N Athlon FX-51/2.2GHz(L)	1378.0	1395.0	Sep-03	109%	166%
22	HP AlphaServer ES45 68/1250	1365.0	928.0	Nov-02	108%	111%
23	PrimePower650 (SPARC64 GP/1350MHz)	1340.0	905.0	Jun-03	106%	108%
24	PrimePower900 (SPARC64 GP/1350MHz)	1322.0	892.0	May-03	104%	106%
25	HP RX5670/Itanium2, 1GHz,3MB-L3, H	1305.0	807.0	Jul-02	103%	96%
26	HP RX2600/Itanium2, 1GHz,3MB-L3, H	1301.0	810.0	Jul-02	103%	97%
27	IBM eServer pSeries 650/6M2 1450MHz	1295.0	935.0	Nov-02	102%	111%
28	AMD Rioworks HDAMA Opteron 246 / 2.0 G	1293.0	1317.0	Jul-03	102%	157%
29	HP AlphaServer ES80 7/1000	1288.0	761.0	Jan-03	102%	91%
30	HP AlphaServer ES47 7/1000	1288.0	761.0	Jan-03	102%	91%
31	Fujitsu Celsius M420 / 3.2GHz P4(800MHz bus)	1287.0	1261.0	Jul-03	102%	150%
32	Dell Prec. Workst. 360/3.2 GHz P4 DDR400	1285.0	1249.0	Jun-03	102%	149%
33	IBM eServer pSeries 655/651 1300 MHz	1281.0	848.0	Nov-02	101%	101%
34	Intel D875PBZ (3.2 GHz, Pentium4)	1267.0	1261.0	Jul-03	100%	150%
35	IBM eServer pSeries 690Turbo 1.3 GHz	1266.0	839.0	Apr-02	100%	100%
36	AMD MSI K8 Neo Athlon64 3200+/2 GHz	1250.0	1335.0	Sep-03	99%	159%
37	Dell Prec. Workst. 360/3.0 GHz P4 DDR400	1248.0	1193.0	Jun-03	99%	142%
38	Intel D875PBZ (3.0 GHz, Pentium4)	1229.0	1200.0	May-03	97%	143%
39	AMD Einox A4800/Opteron144 1.8GHz-I,WS	1219.0	1170.0	Apr-03	96%	139%
40	Dell Prec. Workst. 360/2.8 GHz P4 DDR400	1204.0	1129.0	Jun-03	95%	135%
41	ProLiant BL20p G2(3.06GHzXeon,1MBL3)	1193.0	1256.0	Aug-03	94%	150%
42	ProLiant DL380 G3(3.06GHz Xeon,L3)	1184.0	1258.0	Jun-03	94%	150%
43	ProLiant DL360 G3(3.06GHz Xeon,L3)	1183.0	1258.0	Jun-03	93%	150%

44	IBM IntelliStation POWER 275 (1450MHz)	1180.0	978.0	Jun-03	93%	117%
45	IBM eServer 325 2.0GHz Opteron 64-bitPGI	1180.0	1226.0	Jul-03	93%	146%
46	AMD Einox A4800/Opteron144 1.8GHz-I,SE	1168.0	1100.0	Apr-03	92%	131%
47	Dell Prec. Workst. 360/3.2 GHz P4 DDR333	1168.0	1201.0	Jun-03	92%	143%
48	Dell Prec. Workst. 360/2.6 GHz P4 DDR400	1160.0	1067.0	Jun-03	92%	127%
49	IBM eServer pSeries 630/6E4 1450MHz	1158.0	910.0	Feb-03	91%	108%
50	IBM eServer pSeries 630/6C4 1450MHz	1158.0	910.0	Feb-03	91%	108%
51	AMD Einox A4800/Opteron144 1.8GHz-I,SE	1154.0	1100.0	Apr-03	91%	131%
52	Dell PowerEdge 1750/3.06 GHz Xeon L3	1152.0	1243.0	Jul-03	91%	148%
53	HP RX2600/Itanium2,900MHz,1.5MB-L3,L	1151.0	-	Nov-02	91%	-
54	HP RX5670/Itanium2,900MHz,1.5MB-L3,L	1151.0	-	Nov-02	91%	-
55	HP ZX6000/Itanium2,900MHz,1.5MB-L3,L	1139.0	-	Nov-02	90%	-
56	Dell Prec. Workst. 360/3.0 GHz P4 DDR333	1137.0	1149.0	Jun-03	90%	137%
57	PrimePower650 (SPARC64 GP/1080MHz)	1129.0	737.0	May-03	89%	88%
58	Dell PowerEdge 6650/2.8 GHz Xeon MP	1120.0	1234.0	Jun-03	88%	147%
59	AMD Einox A4800/Opteron142 1.6GHz-I,WS	1120.0	1053.0	Apr-03	88%	126%
60	Sun Blade Model 2000 / 1200 MHz	1118.0	722.0	Mar-03	88%	86%
61	ProLiant BL40p (2.8GHz Xeon MP)	1112.0	1249.0	Sep-03	88%	149%
62	Dell Prec. Workst. 360/2.4 GHz P4 DDR400	1111.0	1003.0	Jun-03	88%	120%
63	Sun Netra 20 / 1200 MHz	1106.0	712.0	Mar-03	87%	85%
64	ProLiant DL560 (2.8GHz Xeon MP)	1105.0	1247.0	Sep-03	87%	149%
65	Dell Prec. Workst. 360/2.8 GHz P4 DDR333	1104.0	1093.0	Jun-03	87%	130%
66	Dell Prec. WorkSt. 350/3.06 GHz P4 Xeon	1103.0	1130.0	Nov-02	87%	135%
67	IBM eServer pSeries 655/651 1100 MHz	1103.0	722.0	Nov-02	87%	86%
68	ProLiant DL580 G2(2.8GHz Xeon MP)	1094.0	1233.0	Sep-03	86%	147%
69	Intel D850EMVR(3.06 GHz,Pentium4)	1092.0	1098.0	Apr-03	86%	131%
70	IBM eServer pSeries 650/6M2-1 1450MH	1091.0	886.0	Apr-03	86%	106%
71	Intel D850EMVR(3.06GHz,Pentium4,MT)	1091.0	1107.0	Dec-02	86%	132%
72	SGI Altix 3000 (900MHz, Itanium 2)	1090.0	-	Feb-03	86%	-
73	HP ZX2000/Itanium2,900MHz,1.5MB-L3,L	1086.0	-	Nov-02	86%	-
74	IBM eServer pSeries 670 POWER4/1.1 GHz	1075.0	708.0	Apr-02	85%	84%
75	ProLiant BL20p G2(3.06GHz Xeon)	1074.0	1075.0	Aug-03	85%	128%
76	Dell Prec. Workst. 360/2.6 GHz P4 DDR333	1067.0	1034.0	Jun-03	84%	123%
77	ProLiant DL380 G3(3.06GHz Xeon)	1065.0	1068.0	Jun-03	84%	127%
78	Dell Prec. WorkSt. 650/3.06 GHz P4 Xeon	1063.0	1138.0	Apr-03	84%	136%
79	Dell Prec. WorkSt. 350/2.8 GHz P4 Xeon	1060.0	1061.0	Nov-02	84%	126%
80	Intel D850EMVR (2.8 GHz, Pentium4)	1060.0	1041.0	Apr-03	84%	124%
81	ProLiant DL360 G3(3.06GHz Xeon)	1048.0	1070.0	Jun-03	83%	128%
82	Dell PowerEdge 1750/3.06 GHz Xeon	1044.0	1067.0	Jul-03	82%	127%
83	PrimePower450 (SPARC64 GP/1100MHz)	1037.0	682.0	May-03	82%	81%
84	Dell Prec. WorkSt. 350/2.66 GHz P4 Xeon	1036.0	1026.0	Nov-02	82%	122%
85	PrimePower250 (SPARC64 GP/1100MHz)	1030.0	680.0	May-03	81%	81%
86	Dell Prec. Workst. 360/2.4 GHz P4 DDR333	1027.0	972.0	Jun-03	81%	116%
87	Intel D850EMVR (2.67 GHz, Pentium4)	1024.0	1005.0	Oct-02	81%	120%
88	Dell Prec. WorkSt. 650/2.8 GHz P4 Xeon	1020.0	1068.0	Apr-03	81%	127%
89	IBM eServer pSeries 615/6C3 1200 MHz	1018.0	822.0	May-03	80%	98%
90	IBM eServer pSeries 615/6E3 1200 MHz	1018.0	822.0	May-03	80%	98%
91	IBM eServer pSeries 630/6E4 1200MHz	1014.0	767.0	Apr-03	80%	91%
92	HP AlphaServer GS160 68/1224	1014.0	833.0	Nov-02	80%	99%
93	HP AlphaServer GS320 68/1224	1014.0	833.0	Nov-02	80%	99%
94	IBM eServer pSeries 630/6C4 1200MHz	1014.0	767.0	Apr-03	80%	91%

95	HP AlphaServer GS80 68/1224	1014.0	833.0	Nov-02	80%	99%
96	AMD Einox A4800/Opteron140 1.4GHz-I,WS	1012.0	933.0	Apr-03	80%	111%
97	Sun Fire V65x / (3.06 GHz Xeon)	1011.0	1066.0	May-03	80%	127%
98	Dell Prec. WorkSt. 350/2.53 GHz P4 Xeon	1005.0	986.0	Nov-02	79%	118%
99	Dell PowerEdge 2650/3.06 GHz P4 Xeon	1003.0	1056.0	Apr-03	79%	126%
100	Dell Prec. WorkSt. 650/2.66 GHz P4 Xeon	1002.0	1033.0	Apr-03	79%	123%
101	Intel D850EMVR (2.53 GHz, Pentium4)	999.0	956.0	Apr-03	79%	114%
102	HP AlphaServer DS25 68/1000	985.0	678.0	Aug-02	78%	81%
103	IBM eServer pSeries 630/6E4-1 1450MH	984.0	856.0	Apr-03	78%	102%
104	IBM eServer pSeries 630/6C4-1 1450MH	984.0	856.0	Apr-03	78%	102%
105	AMD ASUS A7N8X XP 3200+ / 2200 MHz	982.0	1080.0	May-03	78%	129%
106	Dell Prec. WorkSt. 340/3.06 GHz P4 Xeon	982.0	1074.0	Nov-02	78%	128%
107	Sun Fire V880 / 1050 MHz Cu	982.0	626.0	Jun-03	78%	75%
108	Dell Prec. WorkSt. 350/2.4 GHz P4 Xeon	979.0	951.0	Nov-02	77%	113%
109	Dell Prec. Workst. 360/2.26 GHz P4 Xeon	965.0	904.0	Jun-03	76%	108%
110	Intel D850EMVR (2.4 GHz, Pentium4)	964.0	927.0	Oct-02	76%	110%
111	Sun Fire V480 / 1050MHz Cu	962.0	619.0	Jul-03	76%	74%
112	Compaq AlphaServer ES45 Model 68/1000	960.0	679.0	Oct-01	76%	81%
113	Dell Prec. WorkSt. 350/2.26 GHz P4 Xeon	949.0	909.0	Nov-02	75%	108%
114	Dell Prec. WorkSt. 340/2.8 GHz P4 Xeon	947.0	1010.0	Sep-02	75%	120%
115	Dell Prec. WorkSt. 650/2.4 GHz P4 Xeon	944.0	955.0	Apr-03	75%	114%
116	Intel D850EMVR (2.26 GHz, Pentium4)	934.0	888.0	Oct-02	74%	106%
117	Fujitsu CELSIUS R610 / 2.8GHz Pentium4 Xeon	930.0	1016.0	Feb-03	73%	121%
118	Intel D850EMV2 (2.8 GHz, Pentium4)	929.0	984.0	Aug-02	73%	117%
119	Dell Prec. WorkSt. 340/2.66 GHz P4 Xeon	927.0	978.0	Sep-02	73%	117%
120	Intel D850EMV2 (2.67 GHz, Pentium4)	911.0	952.0	Aug-02	72%	113%
121	Dell Prec. WorkSt. 340/2.53 GHz P4 Xeon	905.0	941.0	Sep-02	71%	112%
122	IBM IntelliStation POWER 275 (1000MHz)	901.0	683.0	Jun-03	71%	81%
123	Intel D850EMV2 (2.53GHz, Pentium4)	889.0	914.0	Aug-02	70%	109%
124	Dell Prec. WorkSt. 530/2.8 GHz P4 Xeon	887.0	957.0	Sep-02	70%	114%
125	IBM eServer pSeries 630/6E4 1000MHz	886.0	639.0	Jul-02	70%	76%
126	IBM eServer pSeries 630/6C4 1000MHz	886.0	639.0	Jul-02	70%	76%
127	Sun Blade 1500 / 1.062GHz	884.0	589.0	Jun-03	70%	70%
128	Dell Prec. WorkSt. 340/2.4 GHz P4 Xeon	882.0	905.0	Sep-02	70%	108%
129	IBM eServer pSeries 615/6E3 1200 MHz	877.0	822.0	May-03	69%	98%
130	IBM eServer pSeries 615/6C3 1200 MHz	877.0	822.0	May-03	69%	98%
131	Intel D850EMV2 (2.4 GHz, Pentium4)	870.0	882.0	Aug-02	69%	105%
132	Dell Prec. WorkSt. 650/2.0 GHz P4 Xeon	870.0	837.0	Apr-03	69%	100%
133	AMD ASUS A7N8X XP 3000+ / 2167 MHz	869.0	995.0	Feb-03	69%	119%
134	Dell Prec. WorkSt. 530/2.6 GHz P4 Xeon	860.0	911.0	Sep-02	68%	109%
135	IBM eServer pSeries 630/6E4-1 1200MH	852.0	720.0	Apr-03	67%	86%
136	IBM eServer pSeries 630/6C4-1 1200MH	852.0	720.0	Apr-03	67%	86%
137	Intel D850EMV2 (2.26GHz, Pentium4)	846.0	847.0	Aug-02	67%	101%
138	Sun Fire V1280 / 900MHz Cu	844.0	535.0	Feb-03	67%	64%
139	AMD ASUS A7N8X XP 2800+ / 2250 MHz	843.0	933.0	Sep-02	67%	111%
140	Sun Fire V210 / 1002MHz Cu	841.0	555.0	Mar-03	66%	66%
141	Sun Fire V240 / 1002MHz Cu	836.0	553.0	Mar-03	66%	66%
142	AMD ASUS A7N8X XP 2700+ / 2166 MHz	831.0	913.0	Sep-02	66%	109%
143	Dell Prec. WorkSt. 530/2.4 GHz P4 Xeon	827.0	859.0	Sep-02	65%	102%
144	Sun Blade Model 2050 / 1050 MHz	827.0	610.0	Nov-01	65%	73%
145	Dell Prec. WorkSt. 340/2.2 GHz P4	818.0	833.0	Sep-02	65%	99%

146	Sun Blade Model 2000 / 1050 MHz	817.0	-	Apr-02	65%	-
147	Intel D850MD (2.4 GHz, Pentium4)	812.0	833.0	Apr-02	64%	99%
148	Dell PowerEdge 2650/2.8 GHz P4 Xeon	810.0	907.0	Oct-02	64%	108%
149	Intel D850EMV2 (2.2 GHz, Pentium4)	808.0	811.0	Aug-02	64%	97%
150	Dell Prec. WorkSt. 530/2.2 GHz P4	795.0	810.0	Sep-02	63%	97%
151	Sun Fire 280R / 1015 MHz Cu	785.0	574.0	Nov-02	62%	68%
152	Compaq AlphaServer DS20E Model 68/833	784.0	571.0	Jun-01	62%	68%
153	Intel D850EMVR (2.0A GHz, Pentium4)	782.0	755.0	Apr-03	62%	90%
154	Dell Prec. WorkSt. 340/2.0 GHz P4	779.0	779.0	Sep-02	62%	93%
155	Intel D850MD (2.2 GHz, Pentium4)	777.0	784.0	Jan-02	61%	93%
156	Compaq AlphaServer ES40 Model 6/833	777.0	565.0	Jun-01	61%	67%
157	Sun Blade Model 2000 / 1015 MHz	775.0	576.0	Oct-02	61%	69%
158	Intel D850EMV2 (2.0A GHz, Pentium4)	773.0	759.0	Aug-02	61%	90%
159	Dell Prec. WorkSt. 530/2.0 GHz P4	758.0	757.0	Sep-02	60%	90%
160	Compaq AlphaServer GS320 Model 32 68/1001	756.0	621.0	Jun-01	60%	74%
161	Compaq AlphaServer GS80 Model 8 68/1001	756.0	621.0	Jun-01	60%	74%
162	Compaq AlphaServer GS160 Model 16 68/1001	756.0	621.0	Jun-01	60%	74%
163	Dell PowerEdge 2650/2.4 GHz P4 Xeon	750.0	815.0	Apr-02	59%	97%
164	Intel D850EMV2 (2.0 GHz, Pentium4)	745.0	684.0	Aug-02	59%	82%
165	Intel D850MD (2.0AGHz, Pentium4)	743.0	735.0	Jan-02	59%	88%
166	Sun Blade 1000 Model 900 / 900MHz Cu	731.0	533.0	Nov-01	58%	64%
167	Sun Fire V480 / 900 MHz Cu	727.0	531.0	Jun-02	57%	63%
168	Intel D850EMV2 (1.9 GHz, Pentium4)	726.0	660.0	Aug-02	57%	79%
169	Compaq AlphaServer DS20L Model 68/833	724.0	537.0	Apr-02	57%	64%
170	Dell Prec. WorkSt. 530/1.8 GHz P4	717.0	703.0	Sep-02	57%	84%
171	Intel D850GB (2.0 GHz Pentium4)	714.0	656.0	Aug-01	56%	78%
172	Intel D850MD (2.0 GHz, Pentium4)	713.0	653.0	Jan-02	56%	78%
173	Sun Netra 20 / 900 MHz Cu	713.0	533.0	May-02	56%	64%
174	Dell Prec. WorkSt. 340/1.8 GHz P4	711.0	650.0	Sep-02	56%	77%
175	AMD Epox 8KHA+ XP2600+ / 2133 MHz	710.0	839.0	Aug-02	56%	100%
176	Intel D850EMV2 (1.8 GHz, Pentium4)	708.0	638.0	Aug-02	56%	76%
177	Dell PowerEdge 7150 Itanium/800 4MB L3	703.0	-	Jun-01	56%	-
178	HP SERVER RX4610 Itanium/800 4MB L3	701.0	379.0	May-01	55%	45%
179	Sun Fire 280R / 900 MHz Cu	700.0	529.0	Nov-01	55%	63%
180	Dell PowerEdge 6650/2.0 GHz Xeon MP	699.0	842.0	Oct-02	55%	100%
181	Intel D850MD (1.9 GHz, Pentium4)	698.0	633.0	Jan-02	55%	75%
182	Sun Fire V880 / 900 MHz Cu	697.0	507.0	May-02	55%	60%
183	Intel D850GB (1.9 GHz Pentium4)	696.0	634.0	Aug-01	55%	76%
184	AMD Epox 8KHA+ XP2400+ / 2000 MHz	693.0	808.0	Aug-02	55%	96%
185	Dell PowerEdge 4600/2.0 GHz P4 Xeon	693.0	701.0	Jan-02	55%	84%
186	Intel D850EMV2 (1.7 GHz, Pentium4)	687.0	613.0	Aug-02	54%	73%
187	Intel D850MD (1.8 GHz, Pentium4)	679.0	612.0	Jan-02	54%	73%
188	Intel D850GB (1.8 GHz Pentium4)	678.0	613.0	Aug-01	54%	73%
189	Dell Prec. WorkSt. 340/1.7 GHz P4	675.0	596.0	Oct-01	53%	71%
190	HP 9000 Model C3750 / PA8700+/875	674.0	678.0	Oct-02	53%	81%
191	Dell Prec. WorkSt. 530/1.7 GHz P4	672.0	592.0	Oct-01	53%	71%
192	AMD Epox 8KHA+ XP2200+ / 1800 MHz	671.0	765.0	Jul-02	53%	91%
193	Dell Prec. WorkSt. 330/2.0 GHz P4	669.0	659.0	Aug-01	53%	79%
194	Intel D850EMV2 (1.6 GHz, Pentium4)	666.0	588.0	Aug-02	53%	70%
195	AMD Epox 8KHA+ XP2100+ / 1733 MHz	660.0	749.0	Apr-02	52%	89%
196	Intel D850GB (1.7 GHz Pentium4)	659.0	587.0	Aug-01	52%	70%

197	Intel D850MD (1.7 GHz, Pentium4)	659.0	588.0	Jan-02	52%	70%
198	AMD Asus A7M266-D MP2400+ / 2000 MHz	656.0	766.0	Nov-02	52%	91%
199	HP i2000 Itanium/800 2MB L3	655.0	-	May-01	52%	-
200	HP 9000 Model J6750 / PA8700+/875	651.0	676.0	Oct-02	51%	81%
201	AMD MSI K7D M-L MP2600+ / 2133 MHz	650.0	781.0	Feb-03	51%	93%
202	Dell Prec. WorkSt. 730/Itanium/800 2MB L3	645.0	314.0	Jul-01	51%	37%
203	Fujitsu PrimePower650 (SPARC64 GP/810MHz)	644.0	624.0	Jul-02	51%	74%
204	PrimePower650 (SPARC64 GP/810MHz)	644.0	624.0	Jul-02	51%	74%
205	API UP2000 833 MHz	644.0	533.0	Jun-00	51%	64%
206	AMD MSI K7D M-L MP2200+ / 1800 MHz	644.0	726.0	Aug-02	51%	87%
207	Intel D850EMV2 (1.5 GHz, Pentium4)	643.0	562.0	Aug-02	51%	67%
208	AMD Epox 8KHA+ XP2000+ / 1667 MHz	642.0	724.0	Jan-02	51%	86%
209	AMD MSI K7D M-L MP2100+ / 1733 MHz	637.0	713.0	Jun-02	50%	85%
210	Intel D850GB (1.6 GHz Pentium4)	637.0	565.0	Aug-01	50%	67%
211	Intel D850MD (1.6 GHz, Pentium4)	637.0	565.0	Jan-02	50%	67%
212	AMD Epox 8KHA+ XP1800 / 1600 MHz	634.0	701.0	Oct-01	50%	84%
213	Dell Prec. WorkSt. 330/1.8 GHz P4	631.0	619.0	Jul-01	50%	74%
214	Dell Prec. WorkSt. 530/1.5 GHz P4	629.0	545.0	Oct-01	50%	65%
215	Dell Prec. WorkSt. 340/1.5 GHz P4	629.0	547.0	Oct-01	50%	65%
216	HP SERVER RX4610 Itanium/733 2MB L3	623.0	-	May-01	49%	-
217	HP i2000 Itanium/733 2MB L3	623.0	-	May-01	49%	-
218	Intel D850MD (1.5 GHz, Pentium4)	616.0	539.0	Jan-02	49%	64%
219	Intel D850GB (1.5 GHz Pentium4)	615.0	539.0	Aug-01	49%	64%
220	AMD Epox 8KHA+ XP1800 / 1533 MHz	615.0	671.0	Oct-01	49%	80%
221	Fujitsu PrimePower850 (SPARC64 GP/810MHz)	613.0	617.0	Jul-02	48%	74%
222	PrimePower850 (SPARC64 GP/810MHz)	613.0	617.0	Jul-02	48%	74%
223	HP i2000 Itanium/800 4MB L3	610.0	365.0	Sep-01	48%	44%
224	Dell Prec. WorkSt. 330/1.7 GHz P4	607.0	591.0	May-01	48%	70%
225	AMD Epox 8KHA+ XP1700 / 1466 MHz	604.0	656.0	Oct-01	48%	78%
226	AMD Asus A7M266-D MP2000+ / 1667 MHz	596.0	662.0	Mar-02	47%	79%
227	Intel D850GB (1.4 GHz Pentium4)	590.0	512.0	Aug-01	47%	61%
228	AMD GA-7DX Motherboard, XP1800+/1533 M	588.0	644.0	Oct-01	46%	77%
229	Compaq AlphaServer DS20E Model 6/667	582.0	455.0	Aug-01	46%	54%
230	HP 9000 Model J6700 / PA8700-750	581.0	603.0	Apr-01	46%	72%
231	AMD GA-7DX Motherboard, XP1700+/1466 M	580.0	629.0	Oct-01	46%	75%
232	HP i2000 Itanium/733 4MB L3	577.0	-	Sep-01	46%	-
233	HP 9000 Model C3700 / PA8700-750	576.0	604.0	Apr-01	45%	72%
234	Intel D850GB (1.3 GHz Pentium4)	565.0	486.0	Aug-01	45%	58%
235	Dell Prec. WorkSt. 330/1.5 GHz P4	564.0	543.0	May-01	45%	65%
236	Compaq AlphaServer ES40 Model 6/667	562.0	433.0	Nov-99	44%	52%
237	Fujitsu CELSIUS 460/1.5 GHz P4 (400MHz Bus)	561.0	535.0	Dec-00	44%	64%
238	ProLiant BL10e G2(1GHz,ULV PentiumM)	552.0	687.0	Jul-03	44%	82%
239	PrimePower800/1000/2000 (788MHz)	551.0	591.0	Jul-02	44%	70%
240	Fujitsu PrimePower800/1000/2000 (788MHz)	551.0	591.0	Jul-02	44%	70%
241	AMD GA-7DX Motherboard, XP1600+/1400 M	547.0	595.0	Oct-01	43%	71%
242	AMD Tyan Thunder K7 MP1800+/1533 MHz	547.0	609.0	Oct-01	43%	73%
243	HP C3650/PA8700-625	542.0	508.0	Dec-01	43%	61%
244	Dell Prec. WorkSt. 330/1.4 GHz P4	541.0	517.0	May-01	43%	62%
245	Dell Prec. WorkSt. 530/1.4 GHz P4	540.0	516.0	May-01	43%	62%
246	Compaq Evo Workst. W6000/1.4 GHz P4 Xeon	538.0	509.0	Sep-01	42%	61%
247	AMD GA-7DX Motherboard, XP1500+/1333 M	536.0	577.0	Oct-01	42%	69%

248	API UP2000 750 MHz	533.0	456.0	Jun-00	42%	54%
249	Compaq AlphaStation XP1000 Model 6/667	532.0	403.0	Sep-01	42%	48%
250	SGI Origin 3200 1X 600MHz R14k	529.0	500.0	Feb-02	42%	60%
251	AMD Tyan Thunder K7 MP1600+/1400 MHz	526.0	571.0	Oct-01	42%	68%
252	HP SERVER RP7400/PA8700-750	524.0	551.0	Sep-01	41%	66%
253	HP SERVER RP5470/PA8700-750	522.0	549.0	Oct-01	41%	65%
254	Dell Prec. WorkSt. 330/1.3 GHz P4	516.0	490.0	May-01	41%	58%
255	AMD Tyan Thunder K7 MP1500+/1333 MHz	516.0	554.0	Oct-01	41%	66%
256	PrimePower650 (SPARC64 GP/675MHz)	509.0	478.0	Oct-01	40%	57%
257	Fujitsu PrimePower650 (SPARC64 GP/675MHz)	509.0	478.0	Oct-01	40%	57%
258	Fujitsu PrimePower400 (SPARC64 GP/700MHz)	506.0	521.0	Jul-02	40%	62%
259	PrimePower400 (SPARC64 GP/700MHz)	506.0	521.0	Jul-02	40%	62%
260	PrimePower200 (SPARC64 GP/700MHz-8MB	505.0	521.0	Jul-02	40%	62%
261	SGI Origin 300 1X 600MHz R14kA	495.0	483.0	Jul-02	39%	58%
262	Fujitsu PrimePower850 (SPARC64 GP/675MHz)	493.0	476.0	Oct-01	39%	57%
263	PrimePower850 (SPARC64 GP/675MHz)	493.0	476.0	Oct-01	39%	57%
264	HP SERVER RP7400/PA8700-650	489.0	493.0	Oct-01	39%	59%
265	HP SERVER RP5470/PA8700-650	488.0	491.0	Oct-01	39%	59%
266	AMD Tyan Thunder K7 1.2GHz Athlon MP	481.0	522.0	May-01	38%	62%
267	Fujitsu PrimePower200 (SPARC64 GP/700MHz)	476.0	-	Jul-02	38%	-
268	PrimePower200 (SPARC64 GP/700MHz-4MB	476.0	491.0	Jul-02	38%	59%
269	SGI Origin 3200 1X 500MHz R14k	463.0	427.0	Apr-01	37%	51%
270	AMD Gigabyte GA-7DX 1.4 GHz Athlon	458.0	554.0	May-01	36%	66%
271	PrimePower800/1000/2000 (675MHz)	456.0	475.0	Sep-01	36%	57%
272	Dell PowerEdge 1500SC/1.4 GHz PIII	456.0	664.0	Jan-02	36%	79%
273	Fujitsu PrimePower800/1000/2000 (675MHz)	456.0	475.0	Sep-01	36%	57%
274	AMD Gigabyte GA-7DX 1.33GHz Athlon	445.0	539.0	Mar-01	35%	64%
275	Compaq AlphaServer GS80 Model 6/731	444.0	397.0	Dec-00	35%	47%
276	Compaq AlphaServer GS160 Model 6/731	444.0	397.0	May-00	35%	47%
277	Compaq AlphaServer GS320 Model 6/731	444.0	397.0	Jun-00	35%	47%
278	Dell PowerEdge 1500SC/1.26GHz PIII	440.0	623.0	Jan-02	35%	74%
279	HP 9000 Model B2600 / PA8600-500	440.0	403.0	Apr-01	35%	48%
280	RLX 1200i (1.20 GHz Pentium III)	437.0	575.0	Sep-02	35%	69%
281	IBM RS/6000 44P-170 (450 MHz)	434.0	346.0	Jun-02	34%	41%
282	IBM RS/6000 44P-270 (450MHz, 8MBL2)	433.0	334.0	Oct-01	34%	40%
283	IBM RS/6000 SP-450MHz T/W (1 CPU)	433.0	334.0	Jan-02	34%	40%
284	HP 9000 model J6000 / PA8600-552 MHz	433.0	441.0	Oct-00	34%	53%
285	HP 9000 model C3600 / PA8600-552 MHz	433.0	432.0	Oct-00	34%	51%
286	IBM eServer pSeries 640/B80 450MHz	433.0	334.0	Oct-01	34%	40%
287	IBM eServer pSeries 610/6C1 450MHz	433.0	334.0	Oct-01	34%	40%
288	IBM eServer pSeries 610/6E1 450MHz	433.0	334.0	Oct-01	34%	40%
289	Fujitsu PrimePower400 (SPARC64 GP/600MHz)	428.0	424.0	Aug-01	34%	51%
290	PrimePower400 (SPARC64 GP/600MHz)	428.0	424.0	Aug-01	34%	51%
291	Compaq AlphaServer DS20 Model 6/500	422.0	313.0	Nov-99	33%	37%
292	Compaq AlphaServer ES40 Model 6/500	419.0	311.0	Nov-00	33%	37%
293	AMD Gigabyte GA-7DX 1.2GHz Athlon	417.0	496.0	Feb-01	33%	59%
294	Fujitsu PrimePower600 (SPARC64 GP/600MHz)	416.0	420.0	Aug-01	33%	50%
295	PrimePower600 (SPARC64 GP/600MHz)	416.0	420.0	Aug-01	33%	50%
296	Sun Netra 20 / 750 MHz	415.0	417.0	Nov-01	33%	50%
297	HP 9000 Model A500 / PA8600-550 MHz	414.0	422.0	Nov-00	33%	50%
298	Compaq AlphaServer DS10 6/600	411.0	364.0	Jun-00	32%	43%

299	IBM eServer pSeries 620/6F0 750 MHz	410.0	458.0	Apr-02	32%	55%
300	Sun Blade 1000 Model 1900 / 900MHz	410.0	466.0	Jul-01	32%	56%
301	IBM eServer pSeries 660/6H0 750 MHz	410.0	458.0	Apr-02	32%	55%
302	IBM eServer pSeries 660/6H1 750 MHz	410.0	458.0	Apr-02	32%	55%
303	IBM eServer pSeries 620/6F1 750 MHz	410.0	458.0	Apr-02	32%	55%
304	SGI Origin 3200 400MHz R12k	407.0	353.0	Sep-00	32%	42%
305	PrimePower200 (SPARC64 GP/600MHz)	403.0	406.0	Aug-01	32%	48%
306	Fujitsu PrimePower200 (SPARC64 GP/600MHz)	403.0	406.0	Aug-01	32%	48%
307	Dell PowerEdge 2550/1.13GHz PIII	402.0	568.0	Jan-02	32%	68%
308	IBM IntelliStation 265 (450MHz, 4MBL2)	401.0	318.0	Jan-02	32%	38%
309	Sun Blade 1000 Model 1750 / 750MHz	395.0	396.0	Jun-01	31%	47%
310	Sun Fire 280R / 750 MHz	392.0	394.0	Jun-01	31%	47%
311	SGI 2200 1X 500MHz R14k	386.0	412.0	Jul-01	30%	49%
312	IBM RS/6000 SP-375MHz T/W (1 CPU)	382.0	260.0	Jan-00	30%	31%
313	Sun Fire V880 / 750 MHz	378.0	390.0	Nov-01	30%	46%
314	IBM RS/6000 44P-270 (1 CPU, 8MB L2)	378.0	273.0	Sep-00	30%	33%
315	SGI Origin 300 1X 500MHz R14k	378.0	379.0	Oct-01	30%	45%
316	IBM eServer pSeries 640 (8 MB L2)	378.0	273.0	Sep-00	30%	33%
317	HP 9000 Model L3000 / PA8600-550	376.0	388.0	Dec-00	30%	46%
318	IBM IBM RS/6000 Model M80 (750 MHz)	376.0	439.0	Aug-01	30%	52%
319	IBM eServer pSeries 660/6M1 750 MHz	376.0	439.0	Aug-01	30%	52%
320	AMD ASUS A7V 1.3 GHz Athlon	374.0	491.0	Mar-01	30%	59%
321	IBM eServer pSeries 610/6C1 375MHz	372.0	277.0	Oct-01	29%	33%
322	IBM eServer pSeries 610/6E1 375MHz	372.0	277.0	Oct-01	29%	33%
323	HP 9000 Model N4000 / PA8600-552 MHz	369.0	379.0	Mar-00	29%	45%
324	IBM RS/6000 44P-270 (1 CPU, 4MB L2)	366.0	262.0	Sep-00	29%	31%
325	IBM eServer pSeries 640 (4 MB L2)	366.0	262.0	Sep-00	29%	31%
326	RLX 800i (800 MHz Pentium III)	363.0	435.0	Sep-02	29%	52%
327	IBM RS/6000 44P-270 (1 CPU)	360.0	251.0	Jan-00	28%	30%
328	IBM RS/6000 44P-170 (400 MHz)	359.0	280.0	Jun-02	28%	33%
329	HP 9000 model B2000 / PA8500-400 MHz	357.0	332.0	Oct-00	28%	40%
330	AMD ASUS A7V 1.2 GHz Athlon	352.0	458.0	Feb-01	28%	55%
331	SGI 2200 2X 400MHz R12k	343.0	347.0	May-00	27%	41%
332	AMD Gigabyte GA-7ZM motherboard 1.2 GH	342.0	-	Oct-00	27%	-
333	Dell Prec. WorkSt. 420/1.0 GHz P3	340.0	462.0	Nov-00	27%	55%
334	IBM RS/6000 SP-375MHz High Node(1 CPU)	337.0	252.0	Jun-00	27%	30%
335	Intel OR840 (1.0 GHz Pentium III)	335.0	442.0	Jul-00	26%	53%
336	IBM eServer pSeries 610/6E1 333MHz	333.0	241.0	Feb-02	26%	29%
337	IBM eServer pSeries 610/6C1 333MHz	333.0	241.0	Feb-02	26%	29%
338	AMD Gigabyte GA-7ZM motherboard 1.1 GH	331.0	-	Aug-00	26%	-
339	Intel VC820 (1.13GHz Pentium III)	331.0	464.0	Aug-00	26%	55%
340	Dell Prec. WorkSt. 420/933MHz P3	328.0	440.0	Nov-00	26%	52%
341	AMD ASUS A7V 1.0 GHz Athlon	321.0	-	Feb-01	25%	-
342	Intel VC820 (1.0BGHz, Pentium III)	318.0	448.0	Nov-00	25%	53%
343	Dell PowerEdge 4400/1.0 GHz PIII Xeon	317.0	451.0	Jan-02	25%	54%
344	Dell Prec. WorkSt. 420/866MHz P3	317.0	417.0	Nov-00	25%	50%
345	Intel VC820 (1.0 GHz Pentium III)	314.0	428.0	Jul-00	25%	51%
346	Sun Blade 1000 Model 1750 / 750MHz	312.0	396.0	Oct-01	25%	47%
347	Intel D815EEA2 (1.0BGHz Pentium III)	310.0	457.0	Aug-01	24%	54%
348	Intel VC820 (933 MHz, Pentium III)	309.0	429.0	Nov-00	24%	51%
349	Dell Prec. WorkSt. 420/800MHz P3	306.0	399.0	Nov-00	24%	48%

350	Intel VC820 (933 MHz Pentium III)	305.0	410.0	Jul-00	24%	49%
351	Intel D815EEA2 (933 MHz Pentium III)	300.0	428.0	Aug-01	24%	51%
352	Intel VC820 (866 MHz, Pentium III)	297.0	407.0	Nov-00	23%	49%
353	HP 9000 Model N4000 / PA8600-440 MHz	297.0	-	Nov-99	23%	-
354	Intel VC820 (866 MHz Pentium III)	294.0	390.0	Jul-00	23%	46%
355	Dell PowerEdge 6400/PIII Xeon 700	294.0	438.0	Apr-01	23%	52%
356	SGI 2100 1X 350MHz R12k	293.0	289.0	Mar-01	23%	34%
357	Intel D815EEA2 (866 MHz Pentium III)	292.0	417.0	Aug-01	23%	50%
358	Sun Enterprise 450 / 480MHz	291.0	234.0	Aug-00	23%	28%
359	SGI Origin200 360MHz R12k	290.0	298.0	Jun-00	23%	36%
360	Dell Prec. WorkSt. 420/733MHz P3	290.0	374.0	Nov-00	23%	45%
361	Sun Blade 1000 Model 1600 / 600MHz	288.0	311.0	Jul-01	23%	37%
362	Intel VC820 (800EB MHz, Pentium III)	286.0	386.0	Nov-00	23%	46%
363	Intel VC820 (800 MHz Pentium III)	282.0	371.0	Jul-00	22%	44%
364	Intel D815EEA2 (800 MHz Pentium III)	280.0	386.0	Aug-01	22%	46%
365	Sun Fire 6800 / 750 MHz	278.0	360.0	Oct-01	22%	43%
366	IBM RS/6000 44P-170 (333 MHz)	277.0	202.0	Jun-02	22%	24%
367	Sun Blade 150 (UltraSPARC IIi/650)	276.0	246.0	Aug-02	22%	29%
368	Intel VC820 (850 MHz Pentium III)	268.0	367.0	Jul-00	21%	44%
369	Intel D815EEA2 (1.1 GHz Pentium III)	268.0	427.0	Aug-01	21%	51%
370	Sun Enterp. 420R (UltraSPARC-II/450)	265.0	214.0	Mar-01	21%	26%
371	Intel D815EEA2 (1.0 GHz Pentium III)	264.0	408.0	Aug-01	21%	49%
372	Sun Enterprise 3500/4500 - 400 MHz	261.0	212.0	Oct-00	21%	25%
373	Dell PowerEdge 8450/PIII Xeon 700	260.0	422.0	Apr-01	21%	50%
374	Intel VC820 (800EB MHz Pentium III)	256.0	355.0	Mar-00	20%	42%
375	Sun Blade 150 (UltraSPARC IIi/550)	254.0	217.0	Aug-02	20%	26%
376	IBM eServer pSeries 660/6H0 600 MHz	252.0	310.0	May-01	20%	37%
377	IBM eServer pSeries 620/6F0 600 MHz	252.0	310.0	May-01	20%	37%
378	IBM eServer pSeries 660/6H1 600 MHz	252.0	310.0	Apr-01	20%	37%
379	IBM eServer pSeries 620/6F1 600 MHz	252.0	310.0	Apr-01	20%	37%
380	IBM RS/6000 Model 7026-M80 (1 CPU)	250.0	275.0	May-00	20%	33%
381	Intel VC820 (733 MHz Pentium III)	244.0	335.0	Mar-00	19%	40%
382	Intel OR840 (733MHz Pentium III)	243.0	336.0	Nov-99	19%	40%
383	Fujitsu CELSIUS 650 / 733 MHz Pentium III	242.0	337.0	Jan-00	19%	40%
384	Intel SE440BX-2 (800 MHz Pentium III	237.0	344.0	Mar-00	19%	41%
385	Intel VC820 (667 MHz Pentium III)	233.0	314.0	Mar-00	18%	37%
386	Intel SE440BX-2 (750 MHz Pentium III	230.0	330.0	Mar-00	18%	39%
387	Intel SE440BX-2 (700 MHz Pentium III	223.0	315.0	Mar-00	18%	38%
388	Intel SE440BX-2 (650 MHz Pentium III	215.0	299.0	Mar-00	17%	36%
389	IBM RS/6000 Model 7026-F80 (1 CPU)	210.0	234.0	May-00	17%	28%
390	IBM RS/6000 Model 7026-H80 (1 CPU)	210.0	234.0	May-00	17%	28%
391	Dell Prec. WorkSt. 410/700MHz PIII	205.0	307.0	Nov-99	16%	37%
392	Intel SE440BX-2 (500 MHz Pentium III	193.0	233.0	Feb-02	15%	28%
393	Sun Blade 100 (UltraSPARC-IIe/500)	182.0	174.0	Mar-01	14%	21%
394	IBM RS/6000 7043-260 (1 CPU)	180.0	-	Nov-99	14%	-
395	Intel SE440BX-2 (450 MHz Pentium III	178.0	213.0	Mar-02	14%	25%
396	Compaq AlphaServer 4100 5/533	176.0	176.0	Nov-99	14%	21%
397	Compaq DIGITAL PW 500au	158.0	161.0	Nov-99	12%	19%
398	Compaq AlphaStation 500/500	153.0	163.0	Nov-99	12%	19%
399	Ultra 10 333MHz	126.0	133.0	Nov-99	10%	16%
400	Sun Fire 280R / 1200 MHz Cu	110.0	712.0	Mar-03	9%	85%

401	IBM RS/6000 43P-150 (250MHz,xlf90)	90.8	105.0	Jun-00	7%	13%
402	IBM RS/6000 43P-150 (250MHz,xlf)	84.4	93.7	May-00	7%	11%

(*) Values derived under earlier releases of OS/compilers/libraries
(+) SPECfp_base2000 value

Table 2. SPEC CPU2000 - SPECfp_base and SPECint. Absolute and Relative Values.

SPEC CPU2000 - SPECfp_base and SPECint. Absolute Values and Values Relative to the IBM pSeries 690Turbo/1.3 GHz.

Rank	Machine	SPECfp	SPEC	Test	Relative Values (%)	
		_base	int	Date	SPECfp	SPEC
					_base	int
1	HP Integrity RX2600/Itanium2,1500MHz	2119.0	1322.0	Jun-03	176%	158%
2	HP Integrity RX5670/Itanium2,1500MHz	2108.0	1312.0	Jun-03	175%	156%
3	HP ZX6000/Itanium2, 1.5GHz,6MB-L3, H	2106.0	1315.0	Jun-03	175%	157%
4	SGI Altix 3000 (1.5GHz, Itanium 2)	2080.0	1243.0	Jul-03	173%	148%
5	NovaScale 4040 Itanium2/1500	1994.0	1107.0	Jul-03	166%	132%
6	Dell PowerEdge 3250/1.5 GHz Itanium2	1875.0	1099.0	Jul-03	156%	131%
7	ION Computers I2X2 (1.4GHz Itanium2)	1817.0	926.0	Jul-03	151%	110%
8	SGI Altix 3000 (1.3GHz, Itanium 2)	1770.0	875.0	Jun-03	147%	104%
9	IBM eServer pSeries 690Turbo 1.7 GHz	1598.0	1113.0	May-03	133%	133%
10	IBM eServer pSeries 655 1700 MHz	1576.0	1103.0	May-03	131%	131%
11	Dell PowerEdge 3250/1.4 GHz Itanium2	1444.0	824.0	Sep-03	120%	98%
12	IBM eServer pSeries 670 1.5 GHz	1432.0	981.0	May-03	119%	117%
13	HP RX5670/Itanium2, 1GHz,3MB-L3, L	1431.0	-	Nov-02	119%	-
14	HP RX2600/Itanium2, 1GHz,3MB-L3, L	1427.0	-	Nov-02	119%	-
15	HP ZX6000/Itanium2, 1GHz,3MB-L3, L	1422.0	-	Nov-02	118%	-
16	IBM eServer pSeries 655 1500 MHz	1398.0	970.0	May-03	116%	116%
17	SGI Altix 3000 (1GHz, Itanium 2)	1396.0	683.0	May-03	116%	81%
18	NovaScale 4040 Itanium2/1000	1391.0	719.0	Mar-03	116%	86%
19	AMD ASUS SK8N Athlon FX-51/2.2GHz(L)	1371.0	1395.0	Sep-03	114%	166%
20	AMD ASUS SK8N Athlon FX-51/2.2GHz(W)	1329.0	1447.0	Sep-03	111%	172%
21	Fujitsu Celsius M420 / 3.2GHz P4(800MHz bus)	1271.0	1261.0	Jul-03	106%	150%
22	Dell Prec. Workst. 360/3.2 GHz P4 DDR400	1267.0	1249.0	Jun-03	105%	149%
23	Intel D875PBZ (3.2 GHz, Pentium4)	1252.0	1261.0	Jul-03	104%	150%
24	Dell Prec. Workst. 360/3.0 GHz P4 DDR400	1229.0	1193.0	Jun-03	102%	142%
25	IBM eServer pSeries 650/6M2 1450MHz	1221.0	935.0	Nov-02	102%	111%
26	Intel D875PBZ (3.0 GHz, Pentium4)	1213.0	1200.0	May-03	101%	143%
27	AMD Rioworks HDAMA Opteron 246 / 2.0 G	1209.0	1317.0	Jul-03	101%	157%
28	IBM eServer pSeries 690Turbo 1.3 GHz	1202.0	839.0	Apr-02	100%	100%
29	IBM eServer pSeries 655/651 1300 MHz	1200.0	848.0	Nov-02	100%	101%
30	Dell Prec. Workst. 360/2.8 GHz P4 DDR400	1186.0	1129.0	Jun-03	99%	135%
31	AMD MSI K8 Neo Athlon64 3200+/2 GHz	1180.0	1335.0	Sep-03	98%	159%
32	HP RX5670/Itanium2, 1GHz,3MB-L3, H	1178.0	807.0	Jul-02	98%	96%
33	HP RX2600/Itanium2, 1GHz,3MB-L3, H	1174.0	810.0	Jul-02	98%	97%
34	IBM eServer 325 2.0GHz Opteron 64-bitPGI	1172.0	1226.0	Jul-03	98%	146%
35	ProLiant BL20p G2(3.06GHzXeon,1MBL3)	1160.0	1256.0	Aug-03	97%	150%

36	ProLiant DL360 G3(3.06GHz Xeon,L3)	1154.0	1258.0	Jun-03	96%	150%
37	Dell Prec. Workst. 360/3.2 GHz P4 DDR333	1153.0	1201.0	Jun-03	96%	143%
38	HP RX2600/Itanium2,900MHz,1.5MB-L3,L	1151.0	-	Nov-02	96%	-
39	HP RX5670/Itanium2,900MHz,1.5MB-L3,L	1151.0	-	Nov-02	96%	-
40	ProLiant DL380 G3(3.06GHz Xeon,L3)	1150.0	1258.0	Jun-03	96%	150%
41	Dell Prec. Workst. 360/2.6 GHz P4 DDR400	1141.0	1067.0	Jun-03	95%	127%
42	Dell PowerEdge 1750/3.06 GHz Xeon L3	1140.0	1243.0	Jul-03	95%	148%
43	HP ZX6000/Itanium2,900MHz,1.5MB-L3,L	1139.0	-	Nov-02	95%	-
44	IBM IntelliStation POWER 275 (1450MHz)	1129.0	978.0	Jun-03	94%	117%
45	HP AlphaServer GS1280 7/1150	1124.0	877.0	Jan-03	94%	105%
46	Dell Prec. Workst. 360/3.0 GHz P4 DDR333	1122.0	1149.0	Jun-03	93%	137%
47	AMD Einox A4800/Opteron144 1.8GHz-I,WS	1122.0	1170.0	Apr-03	93%	139%
48	Dell PowerEdge 6650/2.8 GHz Xeon MP	1103.0	1234.0	Jun-03	92%	147%
49	IBM eServer pSeries 630/6E4 1450MHz	1097.0	910.0	Feb-03	91%	108%
50	IBM eServer pSeries 630/6C4 1450MHz	1097.0	910.0	Feb-03	91%	108%
51	PrimePower650 (SPARC64 GP/1350MHz)	1096.0	905.0	Jun-03	91%	108%
52	AMD Einox A4800/Opteron144 1.8GHz-I,SE	1093.0	1100.0	Apr-03	91%	131%
53	Dell Prec. WorkSt. 350/3.06 GHz P4 Xeon	1092.0	1130.0	Nov-02	91%	135%
54	Dell Prec. Workst. 360/2.4 GHz P4 DDR400	1092.0	1003.0	Jun-03	91%	120%
55	IBM eServer pSeries 650/6M2-1 1450MH	1091.0	886.0	Apr-03	91%	106%
56	Dell Prec. Workst. 360/2.8 GHz P4 DDR333	1089.0	1093.0	Jun-03	91%	130%
57	HP ZX2000/Itanium2,900MHz,1.5MB-L3,L	1086.0	-	Nov-02	90%	-
58	SGI Altix 3000 (900MHz, Itanium 2)	1082.0	-	Feb-03	90%	-
59	ProLiant BL40p (2.8GHz Xeon MP)	1081.0	1249.0	Sep-03	90%	149%
60	Intel D850EMVR(3.06GHz,Pentium4,MT)	1077.0	1107.0	Dec-02	90%	132%
61	ProLiant DL560 (2.8GHz Xeon MP)	1075.0	1247.0	Sep-03	89%	149%
62	AMD Einox A4800/Opteron144 1.8GHz-I,SE	1070.0	1100.0	Apr-03	89%	131%
63	ProLiant DL580 G2(2.8GHz Xeon MP)	1063.0	1233.0	Sep-03	88%	147%
64	Intel D850EMVR(3.06 GHz,Pentium4)	1059.0	1098.0	Apr-03	88%	131%
65	Dell Prec. WorkSt. 650/3.06 GHz P4 Xeon	1053.0	1138.0	Apr-03	88%	136%
66	Dell Prec. Workst. 360/2.6 GHz P4 DDR333	1052.0	1034.0	Jun-03	88%	123%
67	Dell Prec. WorkSt. 350/2.8 GHz P4 Xeon	1048.0	1061.0	Nov-02	87%	126%
68	PrimePower900 (SPARC64 GP/1350MHz)	1047.0	892.0	May-03	87%	106%
69	ProLiant BL20p G2(3.06GHz Xeon)	1044.0	1075.0	Aug-03	87%	128%
70	ProLiant DL360 G3(3.06GHz Xeon)	1038.0	1070.0	Jun-03	86%	128%
71	IBM eServer pSeries 655/651 1100 MHz	1037.0	722.0	Nov-02	86%	86%
72	ProLiant DL380 G3(3.06GHz Xeon)	1033.0	1068.0	Jun-03	86%	127%
73	Intel D850EMVR (2.8 GHz, Pentium4)	1031.0	1041.0	Apr-03	86%	124%
74	Dell PowerEdge 1750/3.06 GHz Xeon	1030.0	1067.0	Jul-03	86%	127%
75	AMD Einox A4800/Opteron142 1.6GHz-I,WS	1029.0	1053.0	Apr-03	86%	126%
76	Dell Prec. WorkSt. 350/2.66 GHz P4 Xeon	1024.0	1026.0	Nov-02	85%	122%
77	HP AlphaServer ES45 68/1250	1019.0	928.0	Nov-02	85%	111%
78	IBM eServer pSeries 670 POWER4/1.1 GHz	1017.0	708.0	Apr-02	85%	84%
79	Intel D850EMVR (2.67 GHz, Pentium4)	1012.0	1005.0	Oct-02	84%	120%
80	Dell Prec. Workst. 360/2.4 GHz P4 DDR333	1011.0	972.0	Jun-03	84%	116%
81	Dell Prec. WorkSt. 650/2.8 GHz P4 Xeon	1010.0	1068.0	Apr-03	84%	127%
82	Sun Fire V65x / (3.06 GHz Xeon)	1010.0	1066.0	May-03	84%	127%
83	Dell PowerEdge 2650/3.06 GHz P4 Xeon	996.0	1056.0	Apr-03	83%	126%
84	Dell Prec. WorkSt. 350/2.53 GHz P4 Xeon	992.0	986.0	Nov-02	83%	118%
85	Dell Prec. WorkSt. 650/2.66 GHz P4 Xeon	991.0	1033.0	Apr-03	82%	123%
86	IBM eServer pSeries 630/6E4-1 1450MH	984.0	856.0	Apr-03	82%	102%

87	IBM eServer pSeries 630/6C4-1 1450MH	984.0	856.0	Apr-03	82%	102%
88	HP AlphaServer ES47 7/1000	975.0	761.0	Jan-03	81%	91%
89	HP AlphaServer ES80 7/1000	975.0	761.0	Jan-03	81%	91%
90	Intel D850EMVR (2.53 GHz, Pentium4)	973.0	956.0	Apr-03	81%	114%
91	Dell Prec. WorkSt. 340/3.06 GHz P4 Xeon	972.0	1074.0	Nov-02	81%	128%
92	IBM eServer pSeries 615/6E3 1200 MHz	966.0	822.0	May-03	80%	98%
93	IBM eServer pSeries 615/6C3 1200 MHz	966.0	822.0	May-03	80%	98%
94	Dell Prec. WorkSt. 350/2.4 GHz P4 Xeon	965.0	951.0	Nov-02	80%	113%
95	IBM eServer pSeries 630/6E4 1200MHz	961.0	767.0	Apr-03	80%	91%
96	IBM eServer pSeries 630/6C4 1200MHz	961.0	767.0	Apr-03	80%	91%
97	Sun Blade Model 2000 / 1200 MHz	953.0	722.0	Mar-03	79%	86%
98	Intel D850EMVR (2.4 GHz, Pentium4)	951.0	927.0	Oct-02	79%	110%
99	Dell Prec. Workst. 360/2.26 GHz P4 Xeon	951.0	904.0	Jun-03	79%	108%
100	Sun Fire 280R / 1200 MHz Cu	945.0	712.0	Mar-03	79%	85%
101	Sun Netra 20 / 1200 MHz	945.0	712.0	Mar-03	79%	85%
102	Dell Prec. WorkSt. 340/2.8 GHz P4 Xeon	938.0	1010.0	Sep-02	78%	120%
103	Dell Prec. WorkSt. 350/2.26 GHz P4 Xeon	936.0	909.0	Nov-02	78%	108%
104	AMD Einox A4800/Opteron140 1.4GHz-I,WS	934.0	933.0	Apr-03	78%	111%
105	Dell Prec. WorkSt. 650/2.4 GHz P4 Xeon	934.0	955.0	Apr-03	78%	114%
106	Intel D850EMVR (2.26 GHz, Pentium4)	922.0	888.0	Oct-02	77%	106%
107	Dell Prec. WorkSt. 340/2.66 GHz P4 Xeon	919.0	978.0	Sep-02	76%	117%
108	Intel D850EMV2 (2.8 GHz, Pentium4)	915.0	984.0	Aug-02	76%	117%
109	Fujitsu CELSIUS R610 / 2.8GHz Pentium4 Xeon	914.0	1016.0	Feb-03	76%	121%
110	PrimePower650 (SPARC64 GP/1080MHz)	912.0	737.0	May-03	76%	88%
111	Dell Prec. WorkSt. 340/2.53 GHz P4 Xeon	898.0	941.0	Sep-02	75%	112%
112	Intel D850EMV2 (2.67 GHz, Pentium4)	898.0	952.0	Aug-02	75%	113%
113	PrimePower450 (SPARC64 GP/1100MHz)	884.0	682.0	May-03	74%	81%
114	Dell Prec. WorkSt. 530/2.8 GHz P4 Xeon	878.0	957.0	Sep-02	73%	114%
115	IBM eServer pSeries 615/6C3 1200 MHz	877.0	822.0	May-03	73%	98%
116	IBM eServer pSeries 615/6E3 1200 MHz	877.0	822.0	May-03	73%	98%
117	Intel D850EMV2 (2.53GHz, Pentium4)	875.0	914.0	Aug-02	73%	109%
118	AMD ASUS A7N8X XP 3200+ / 2200 MHz	873.0	1080.0	May-03	73%	129%
119	Dell Prec. WorkSt. 340/2.4 GHz P4 Xeon	872.0	905.0	Sep-02	73%	108%
120	PrimePower250 (SPARC64 GP/1100MHz)	866.0	680.0	May-03	72%	81%
121	IBM IntelliStation POWER 275 (1000MHz)	862.0	683.0	Jun-03	72%	81%
122	Intel D850EMV2 (2.4 GHz, Pentium4)	858.0	882.0	Aug-02	71%	105%
123	Dell Prec. WorkSt. 650/2.0 GHz P4 Xeon	858.0	837.0	Apr-03	71%	100%
124	IBM eServer pSeries 630/6C4-1 1200MH	852.0	720.0	Apr-03	71%	86%
125	Dell Prec. WorkSt. 530/2.6 GHz P4 Xeon	852.0	911.0	Sep-02	71%	109%
126	IBM eServer pSeries 630/6E4-1 1200MH	852.0	720.0	Apr-03	71%	86%
127	Sun Fire V880 / 1050 MHz Cu	845.0	626.0	Jun-03	70%	75%
128	IBM eServer pSeries 630/6C4 1000MHz	843.0	639.0	Jul-02	70%	76%
129	IBM eServer pSeries 630/6E4 1000MHz	843.0	639.0	Jul-02	70%	76%
130	Intel D850EMV2 (2.26GHz, Pentium4)	833.0	847.0	Aug-02	69%	101%
131	Sun Fire V480 / 1050MHz Cu	826.0	619.0	Jul-03	69%	74%
132	Dell Prec. WorkSt. 530/2.4 GHz P4 Xeon	821.0	859.0	Sep-02	68%	102%
133	Dell Prec. WorkSt. 340/2.2 GHz P4	813.0	833.0	Sep-02	68%	99%
134	HP AlphaServer DS25 68/1000	812.0	678.0	Aug-02	68%	81%
135	Intel D850MD (2.4 GHz, Pentium4)	806.0	833.0	Apr-02	67%	99%
136	Intel D850EMV2 (2.2 GHz, Pentium4)	798.0	811.0	Aug-02	66%	97%
137	Dell Prec. WorkSt. 530/2.2 GHz P4	790.0	810.0	Sep-02	66%	97%

138	AMD ASUS A7N8X XP 2800+ / 2250 MHz	782.0	933.0	Sep-02	65%	111%
139	AMD ASUS A7N8X XP 3000+ / 2167 MHz	776.0	995.0	Feb-03	65%	119%
140	Compaq AlphaServer ES45 Model 68/1000	776.0	679.0	Oct-01	65%	81%
141	Dell PowerEdge 2650/2.8 GHz P4 Xeon	774.0	907.0	Oct-02	64%	108%
142	Dell Prec. WorkSt. 340/2.0 GHz P4	773.0	779.0	Sep-02	64%	93%
143	AMD ASUS A7N8X XP 2700+ / 2166 MHz	772.0	913.0	Sep-02	64%	109%
144	Intel D850MD (2.2 GHz, Pentium4)	766.0	784.0	Jan-02	64%	93%
145	Intel D850EMVR (2.0A GHz, Pentium4)	766.0	755.0	Apr-03	64%	90%
146	Intel D850EMV2 (2.0A GHz, Pentium4)	764.0	759.0	Aug-02	64%	90%
147	Sun Blade 1500 / 1.062GHz	757.0	589.0	Jun-03	63%	70%
148	Dell Prec. WorkSt. 530/2.0 GHz P4	753.0	757.0	Sep-02	63%	90%
149	HP AlphaServer GS80 68/1224	747.0	833.0	Nov-02	62%	99%
150	HP AlphaServer GS160 68/1224	747.0	833.0	Nov-02	62%	99%
151	HP AlphaServer GS320 68/1224	747.0	833.0	Nov-02	62%	99%
152	Intel D850EMV2 (2.0 GHz, Pentium4)	735.0	684.0	Aug-02	61%	82%
153	Sun Fire V1280 / 900MHz Cu	733.0	535.0	Feb-03	61%	64%
154	Intel D850MD (2.0AGHz, Pentium4)	732.0	735.0	Jan-02	61%	88%
155	Dell PowerEdge 2650/2.4 GHz P4 Xeon	726.0	815.0	Apr-02	60%	97%
156	Sun Fire V210 / 1002MHz Cu	722.0	555.0	Mar-03	60%	66%
157	Sun Fire V240 / 1002MHz Cu	718.0	553.0	Mar-03	60%	66%
158	Intel D850EMV2 (1.9 GHz, Pentium4)	716.0	660.0	Aug-02	60%	79%
159	Dell Prec. WorkSt. 530/1.8 GHz P4	715.0	703.0	Sep-02	59%	84%
160	Sun Blade Model 2000 / 1050 MHz	711.0	-	Apr-02	59%	-
161	Dell Prec. WorkSt. 340/1.8 GHz P4	709.0	650.0	Sep-02	59%	77%
162	Intel D850GB (2.0 GHz Pentium4)	704.0	656.0	Aug-01	59%	78%
163	Dell PowerEdge 7150 Itanium/800 4MB L3	703.0	-	Jun-01	58%	-
164	Intel D850MD (2.0 GHz, Pentium4)	702.0	653.0	Jan-02	58%	78%
165	Sun Blade Model 2050 / 1050 MHz	701.0	610.0	Nov-01	58%	73%
166	HP SERVER RX4610 Itanium/800 4MB L3	701.0	379.0	May-01	58%	45%
167	Intel D850EMV2 (1.8 GHz, Pentium4)	699.0	638.0	Aug-02	58%	76%
168	Sun Fire 280R / 1015 MHz Cu	688.0	574.0	Nov-02	57%	68%
169	Intel D850MD (1.9 GHz, Pentium4)	688.0	633.0	Jan-02	57%	75%
170	Intel D850GB (1.9 GHz Pentium4)	687.0	634.0	Aug-01	57%	76%
171	Sun Blade Model 2000 / 1015 MHz	682.0	576.0	Oct-02	57%	69%
172	Dell PowerEdge 6650/2.0 GHz Xeon MP	677.0	842.0	Oct-02	56%	100%
173	Intel D850EMV2 (1.7 GHz, Pentium4)	677.0	613.0	Aug-02	56%	73%
174	Dell PowerEdge 4600/2.0 GHz P4 Xeon	672.0	701.0	Jan-02	56%	84%
175	Intel D850GB (1.8 GHz Pentium4)	669.0	613.0	Aug-01	56%	73%
176	Intel D850MD (1.8 GHz, Pentium4)	667.0	612.0	Jan-02	55%	73%
177	Dell Prec. WorkSt. 340/1.7 GHz P4	659.0	596.0	Oct-01	55%	71%
178	Intel D850EMV2 (1.6 GHz, Pentium4)	656.0	588.0	Aug-02	55%	70%
179	Dell Prec. WorkSt. 530/1.7 GHz P4	656.0	592.0	Oct-01	55%	71%
180	AMD Epox 8KHA+ XP2600+ / 2133 MHz	655.0	839.0	Aug-02	54%	100%
181	HP i2000 Itanium/800 2MB L3	655.0	-	May-01	54%	-
182	Intel D850GB (1.7 GHz Pentium4)	650.0	587.0	Aug-01	54%	70%
183	Dell Prec. WorkSt. 330/2.0 GHz P4	649.0	659.0	Aug-01	54%	79%
184	Intel D850MD (1.7 GHz, Pentium4)	648.0	588.0	Jan-02	54%	70%
185	Dell Prec. WorkSt. 730/Itanium/800 2MB L3	645.0	314.0	Jul-01	54%	37%
186	Compaq AlphaServer DS20E Model 68/833	643.0	571.0	Jun-01	53%	68%
187	AMD Epox 8KHA+ XP2400+ / 2000 MHz	641.0	808.0	Aug-02	53%	96%
188	Sun Fire V480 / 900 MHz Cu	637.0	531.0	Jun-02	53%	63%

189	Intel D850EMV2 (1.5 GHz, Pentium4)	634.0	562.0	Aug-02	53%	67%
190	Sun Netra 20 / 900 MHz Cu	634.0	533.0	May-02	53%	64%
191	Sun Blade 1000 Model 900 / 900MHz Cu	629.0	533.0	Nov-01	52%	64%
192	Intel D850GB (1.6 GHz Pentium4)	628.0	565.0	Aug-01	52%	67%
193	Intel D850MD (1.6 GHz, Pentium4)	626.0	565.0	Jan-02	52%	67%
194	AMD Epox 8KHA+ XP2200+ / 1800 MHz	624.0	765.0	Jul-02	52%	91%
195	HP i2000 Itanium/733 2MB L3	623.0	-	May-01	52%	-
196	HP SERVER RX4610 Itanium/733 2MB L3	623.0	-	May-01	52%	-
197	Compaq AlphaServer ES40 Model 6/833	621.0	565.0	Jun-01	52%	67%
198	Dell Prec. WorkSt. 330/1.8 GHz P4	615.0	619.0	Jul-01	51%	74%
199	Dell Prec. WorkSt. 530/1.5 GHz P4	615.0	545.0	Oct-01	51%	65%
200	Dell Prec. WorkSt. 340/1.5 GHz P4	615.0	547.0	Oct-01	51%	65%
201	Sun Fire V880 / 900 MHz Cu	614.0	507.0	May-02	51%	60%
202	AMD Epox 8KHA+ XP2100+ / 1733 MHz	613.0	749.0	Apr-02	51%	89%
203	Intel D850GB (1.5 GHz Pentium4)	606.0	539.0	Aug-01	50%	64%
204	AMD Asus A7M266-D MP2400+ / 2000 MHz	605.0	766.0	Nov-02	50%	91%
205	Intel D850MD (1.5 GHz, Pentium4)	605.0	539.0	Jan-02	50%	64%
206	AMD MSI K7D M-L MP2600+ / 2133 MHz	602.0	781.0	Feb-03	50%	93%
207	HP 9000 Model C3750 / PA8700+/875	600.0	678.0	Oct-02	50%	81%
208	AMD Epox 8KHA+ XP2000+ / 1667 MHz	596.0	724.0	Jan-02	50%	86%
209	Sun Fire 280R / 900 MHz Cu	592.0	529.0	Nov-01	49%	63%
210	AMD MSI K7D M-L MP2200+ / 1800 MHz	592.0	726.0	Aug-02	49%	87%
211	Dell Prec. WorkSt. 330/1.7 GHz P4	591.0	591.0	May-01	49%	70%
212	AMD Epox 8KHA+ XP1800 / 1600 MHz	588.0	701.0	Oct-01	49%	84%
213	Compaq AlphaServer GS160 Model 16 68/1001	585.0	621.0	Jun-01	49%	74%
214	Compaq AlphaServer GS320 Model 32 68/1001	585.0	621.0	Jun-01	49%	74%
215	Compaq AlphaServer GS80 Model 8 68/1001	585.0	621.0	Jun-01	49%	74%
216	AMD MSI K7D M-L MP2100+ / 1733 MHz	584.0	713.0	Jun-02	49%	85%
217	Compaq AlphaServer DS20L Model 68/833	583.0	537.0	Apr-02	49%	64%
218	Intel D850GB (1.4 GHz Pentium4)	581.0	512.0	Aug-01	48%	61%
219	HP 9000 Model J6750 / PA8700+/875	580.0	676.0	Oct-02	48%	81%
220	AMD Epox 8KHA+ XP1800 / 1533 MHz	572.0	671.0	Oct-01	48%	80%
221	API UP2000 833 MHz	571.0	533.0	Jun-00	48%	64%
222	AMD Epox 8KHA+ XP1700 / 1466 MHz	561.0	656.0	Oct-01	47%	78%
223	Intel D850GB (1.3 GHz Pentium4)	557.0	486.0	Aug-01	46%	58%
224	Fujitsu CELSIUS 460/1.5 GHz P4 (400MHz Bus)	550.0	535.0	Dec-00	46%	64%
225	Dell Prec. WorkSt. 330/1.5 GHz P4	549.0	543.0	May-01	46%	65%
226	AMD Asus A7M266-D MP2000+ / 1667 MHz	548.0	662.0	Mar-02	46%	79%
227	ProLiant BL10e G2(1GHz,ULV PentiumM)	547.0	687.0	Jul-03	46%	82%
228	AMD GA-7DX Motherboard, XP1800+/1533 M	542.0	644.0	Oct-01	45%	77%
229	Compaq AlphaServer DS20E Model 6/667	535.0	455.0	Aug-01	45%	54%
230	AMD GA-7DX Motherboard, XP1700+/1466 M	535.0	629.0	Oct-01	45%	75%
231	Compaq Evo Workst. W6000/1.4 GHz P4 Xeon	530.0	509.0	Sep-01	44%	61%
232	Dell Prec. WorkSt. 330/1.4 GHz P4	527.0	517.0	May-01	44%	62%
233	HP i2000 Itanium/800 4MB L3	526.0	365.0	Sep-01	44%	44%
234	HP 9000 Model J6700 / PA8700-750	526.0	603.0	Apr-01	44%	72%
235	HP 9000 Model C3700 / PA8700-750	526.0	604.0	Apr-01	44%	72%
236	Dell Prec. WorkSt. 530/1.4 GHz P4	526.0	516.0	May-01	44%	62%
237	AMD GA-7DX Motherboard, XP1600+/1400 M	504.0	595.0	Oct-01	42%	71%
238	AMD Tyan Thunder K7 MP1800+/1533 MHz	504.0	609.0	Oct-01	42%	73%
239	Dell Prec. WorkSt. 330/1.3 GHz P4	502.0	490.0	May-01	42%	58%

240	Compaq AlphaServer ES40 Model 6/667	500.0	433.0	Nov-99	42%	52%
241	SGI Origin 3200 1X 600MHz R14k	499.0	500.0	Feb-02	42%	60%
242	HP i2000 Itanium/733 4MB L3	494.0	-	Sep-01	41%	-
243	AMD GA-7DX Motherboard, XP1500+/1333 M	494.0	577.0	Oct-01	41%	69%
244	Fujitsu PrimePower650 (SPARC64 GP/810MHz)	483.0	624.0	Jul-02	40%	74%
245	AMD Tyan Thunder K7 MP1600+/1400 MHz	483.0	571.0	Oct-01	40%	68%
246	PrimePower650 (SPARC64 GP/810MHz)	483.0	624.0	Jul-02	40%	74%
247	HP C3650/PA8700-625	482.0	508.0	Dec-01	40%	61%
248	API UP2000 750 MHz	478.0	456.0	Jun-00	40%	54%
249	AMD Tyan Thunder K7 MP1500+/1333 MHz	473.0	554.0	Oct-01	39%	66%
250	SGI Origin 300 1X 600MHz R14kA	472.0	483.0	Jul-02	39%	58%
251	HP SERVER RP7400/PA8700-750	464.0	551.0	Sep-01	39%	66%
252	HP SERVER RP5470/PA8700-750	462.0	549.0	Oct-01	38%	65%
253	Fujitsu PrimePower850 (SPARC64 GP/810MHz)	458.0	617.0	Jul-02	38%	74%
254	PrimePower850 (SPARC64 GP/810MHz)	458.0	617.0	Jul-02	38%	74%
255	Compaq AlphaStation XP1000 Model 6/667	452.0	403.0	Sep-01	38%	48%
256	Dell PowerEdge 1500SC/1.4 GHz PIII	437.0	664.0	Jan-02	36%	79%
257	SGI Origin 3200 1X 500MHz R14k	436.0	427.0	Apr-01	36%	51%
258	AMD Tyan Thunder K7 1.2GHz Athlon MP	433.0	522.0	May-01	36%	62%
259	HP SERVER RP5470/PA8700-650	432.0	491.0	Oct-01	36%	59%
260	HP SERVER RP7400/PA8700-650	430.0	493.0	Oct-01	36%	59%
261	IBM RS/6000 44P-270 (450MHz, 8MBL2)	426.0	334.0	Oct-01	35%	40%
262	IBM RS/6000 SP-450MHz T/W (1 CPU)	426.0	334.0	Jan-02	35%	40%
263	IBM eServer pSeries 640/B80 450MHz	426.0	334.0	Oct-01	35%	40%
264	IBM eServer pSeries 610/6E1 450MHz	426.0	334.0	Oct-01	35%	40%
265	AMD Gigabyte GA-7DX 1.4 GHz Athlon	426.0	554.0	May-01	35%	66%
266	IBM eServer pSeries 610/6C1 450MHz	426.0	334.0	Oct-01	35%	40%
267	IBM RS/6000 44P-170 (450 MHz)	426.0	346.0	Jun-02	35%	41%
268	Dell PowerEdge 1500SC/1.26GHz PIII	422.0	623.0	Jan-02	35%	74%
269	Fujitsu PrimePower800/1000/2000 (788MHz)	420.0	591.0	Jul-02	35%	70%
270	RLX 1200i (1.20 GHz Pentium III)	420.0	575.0	Sep-02	35%	69%
271	PrimePower800/1000/2000 (788MHz)	420.0	591.0	Jul-02	35%	70%
272	AMD Gigabyte GA-7DX 1.33GHz Athlon	414.0	539.0	Mar-01	34%	64%
273	Compaq AlphaServer GS160 Model 6/731	405.0	397.0	May-00	34%	47%
274	Compaq AlphaServer GS320 Model 6/731	405.0	397.0	Jun-00	34%	47%
275	Compaq AlphaServer GS80 Model 6/731	405.0	397.0	Dec-00	34%	47%
276	HP 9000 model J6000 / PA8600-552 MHz	400.0	441.0	Oct-00	33%	53%
277	HP 9000 Model B2600 / PA8600-500	397.0	403.0	Apr-01	33%	48%
278	IBM IntelliStation 265 (450MHz, 4MBL2)	396.0	318.0	Jan-02	33%	38%
279	IBM eServer pSeries 620/6F0 750 MHz	396.0	458.0	Apr-02	33%	55%
280	IBM eServer pSeries 660/6H0 750 MHz	396.0	458.0	Apr-02	33%	55%
281	IBM eServer pSeries 660/6H1 750 MHz	396.0	458.0	Apr-02	33%	55%
282	IBM eServer pSeries 620/6F1 750 MHz	396.0	458.0	Apr-02	33%	55%
283	PrimePower400 (SPARC64 GP/700MHz)	394.0	521.0	Jul-02	33%	62%
284	Fujitsu PrimePower400 (SPARC64 GP/700MHz)	394.0	521.0	Jul-02	33%	62%
285	PrimePower200 (SPARC64 GP/700MHz-8MB	393.0	521.0	Jul-02	33%	62%
286	HP 9000 model C3600 / PA8600-552 MHz	392.0	432.0	Oct-00	33%	51%
287	HP 9000 Model A500 / PA8600-550 MHz	389.0	422.0	Nov-00	32%	50%
288	AMD Gigabyte GA-7DX 1.2GHz Athlon	387.0	496.0	Feb-01	32%	59%
289	Compaq AlphaServer DS20 Model 6/500	383.0	313.0	Nov-99	32%	37%
290	Compaq AlphaServer ES40 Model 6/500	382.0	311.0	Nov-00	32%	37%

291	SGI Origin 3200 400MHz R12k	382.0	353.0	Sep-00	32%	42%
292	Dell PowerEdge 2550/1.13GHz PIII	377.0	568.0	Jan-02	31%	68%
293	Compaq AlphaServer DS10 6/600	377.0	364.0	Jun-00	31%	43%
294	Sun Netra 20 / 750 MHz	376.0	417.0	Nov-01	31%	50%
295	Fujitsu PrimePower200 (SPARC64 GP/700MHz)	374.0	-	Jul-02	31%	-
296	PrimePower200 (SPARC64 GP/700MHz-4MB	374.0	491.0	Jul-02	31%	59%
297	Fujitsu PrimePower650 (SPARC64 GP/675MHz)	371.0	478.0	Oct-01	31%	57%
298	PrimePower650 (SPARC64 GP/675MHz)	371.0	478.0	Oct-01	31%	57%
299	Sun Blade 1000 Model 1900 / 900MHz	369.0	466.0	Jul-01	31%	56%
300	IBM eServer pSeries 610/6E1 375MHz	368.0	277.0	Oct-01	31%	33%
301	IBM eServer pSeries 610/6C1 375MHz	368.0	277.0	Oct-01	31%	33%
302	SGI 2200 1X 500MHz R14k	362.0	412.0	Jul-01	30%	49%
303	IBM IBM RS/6000 Model M80 (750 MHz)	359.0	439.0	Aug-01	30%	52%
304	PrimePower850 (SPARC64 GP/675MHz)	359.0	476.0	Oct-01	30%	57%
305	Fujitsu PrimePower850 (SPARC64 GP/675MHz)	359.0	476.0	Oct-01	30%	57%
306	IBM eServer pSeries 660/6M1 750 MHz	359.0	439.0	Aug-01	30%	52%
307	SGI Origin 300 1X 500MHz R14k	356.0	379.0	Oct-01	30%	45%
308	IBM RS/6000 44P-170 (400 MHz)	355.0	280.0	Jun-02	30%	33%
309	Sun Fire V880 / 750 MHz	354.0	390.0	Nov-01	29%	46%
310	RLX 800i (800 MHz Pentium III)	350.0	435.0	Sep-02	29%	52%
311	AMD ASUS A7V 1.3 GHz Athlon	348.0	491.0	Mar-01	29%	59%
312	HP 9000 Model L3000 / PA8600-550	345.0	388.0	Dec-00	29%	46%
313	HP 9000 Model N4000 / PA8600-552 MHz	338.0	379.0	Mar-00	28%	45%
314	PrimePower800/1000/2000 (675MHz)	332.0	475.0	Sep-01	28%	57%
315	Fujitsu PrimePower800/1000/2000 (675MHz)	332.0	475.0	Sep-01	28%	57%
316	IBM RS/6000 SP-375MHz T/W (1 CPU)	330.0	260.0	Jan-00	27%	31%
317	IBM eServer pSeries 610/6C1 333MHz	329.0	241.0	Feb-02	27%	29%
318	IBM eServer pSeries 610/6E1 333MHz	329.0	241.0	Feb-02	27%	29%
319	Dell Prec. WorkSt. 420/1.0 GHz P3	329.0	462.0	Nov-00	27%	55%
320	AMD ASUS A7V 1.2 GHz Athlon	328.0	458.0	Feb-01	27%	55%
321	IBM eServer pSeries 640 (8 MB L2)	327.0	273.0	Sep-00	27%	33%
322	Intel OR840 (1.0 GHz Pentium III)	327.0	442.0	Jul-00	27%	53%
323	IBM RS/6000 44P-270 (1 CPU, 8MB L2)	327.0	273.0	Sep-00	27%	33%
324	Sun Blade 1000 Model 1750 / 750MHz	326.0	396.0	Jun-01	27%	47%
325	Sun Fire 280R / 750 MHz	324.0	394.0	Jun-01	27%	47%
326	IBM RS/6000 SP-375MHz High Node(1 CPU)	322.0	252.0	Jun-00	27%	30%
327	HP 9000 model B2000 / PA8500-400 MHz	321.0	332.0	Oct-00	27%	40%
328	Intel VC820 (1.13GHz Pentium III)	320.0	464.0	Aug-00	27%	55%
329	SGI 2200 2X 400MHz R12k	319.0	347.0	May-00	27%	41%
330	Dell Prec. WorkSt. 420/933MHz P3	318.0	440.0	Nov-00	26%	52%
331	PrimePower400 (SPARC64 GP/600MHz)	314.0	424.0	Aug-01	26%	51%
332	Fujitsu PrimePower400 (SPARC64 GP/600MHz)	314.0	424.0	Aug-01	26%	51%
333	IBM RS/6000 44P-270 (1 CPU, 4MB L2)	313.0	262.0	Sep-00	26%	31%
334	IBM eServer pSeries 640 (4 MB L2)	313.0	262.0	Sep-00	26%	31%
335	Sun Blade 1000 Model 1750 / 750MHz	312.0	396.0	Oct-01	26%	47%
336	AMD Gigabyte GA-7ZM motherboard 1.1 GH	311.0	-	Aug-00	26%	-
337	IBM RS/6000 44P-270 (1 CPU)	309.0	251.0	Jan-00	26%	30%
338	Dell Prec. WorkSt. 420/866MHz P3	306.0	417.0	Nov-00	25%	50%
339	Intel VC820 (1.0 GHz Pentium III)	304.0	428.0	Jul-00	25%	51%
340	AMD Gigabyte GA-7ZM motherboard 1.2 GH	304.0	-	Oct-00	25%	-
341	Fujitsu PrimePower600 (SPARC64 GP/600MHz)	304.0	420.0	Aug-01	25%	50%

342	PrimePower600 (SPARC64 GP/600MHz)	304.0	420.0	Aug-01	25%	50%
343	Intel VC820 (1.0BGHz, Pentium III)	304.0	448.0	Nov-00	25%	53%
344	Dell PowerEdge 4400/1.0 GHz PIII Xeon	302.0	451.0	Jan-02	25%	54%
345	AMD ASUS A7V 1.0 GHz Athlon	298.0	-	Feb-01	25%	-
346	Fujitsu PrimePower200 (SPARC64 GP/600MHz)	298.0	406.0	Aug-01	25%	48%
347	PrimePower200 (SPARC64 GP/600MHz)	298.0	406.0	Aug-01	25%	48%
348	Intel D815EEA2 (1.0BGHz Pentium III)	297.0	457.0	Aug-01	25%	54%
349	Intel VC820 (933 MHz, Pentium III)	295.0	429.0	Nov-00	25%	51%
350	Dell Prec. WorkSt. 420/800MHz P3	295.0	399.0	Nov-00	25%	48%
351	Intel VC820 (933 MHz Pentium III)	295.0	410.0	Jul-00	25%	49%
352	Intel D815EEA2 (933 MHz Pentium III)	288.0	428.0	Aug-01	24%	51%
353	Intel VC820 (866 MHz, Pentium III)	285.0	407.0	Nov-00	24%	49%
354	Intel VC820 (866 MHz Pentium III)	284.0	390.0	Jul-00	24%	46%
355	Dell Prec. WorkSt. 420/733MHz P3	281.0	374.0	Nov-00	23%	45%
356	Intel D815EEA2 (866 MHz Pentium III)	280.0	417.0	Aug-01	23%	50%
357	SGI 2100 1X 350MHz R12k	278.0	289.0	Mar-01	23%	34%
358	Sun Fire 6800 / 750 MHz	278.0	360.0	Oct-01	23%	43%
359	Intel VC820 (800EB MHz, Pentium III)	274.0	386.0	Nov-00	23%	46%
360	Sun Enterprise 450 / 480MHz	274.0	234.0	Aug-00	23%	28%
361	SGI Origin200 360MHz R12k	274.0	298.0	Jun-00	23%	36%
362	IBM RS/6000 44P-170 (333 MHz)	274.0	202.0	Jun-02	23%	24%
363	Intel VC820 (800 MHz Pentium III)	273.0	371.0	Jul-00	23%	44%
364	Dell PowerEdge 6400/PIII Xeon 700	271.0	438.0	Apr-01	23%	52%
365	Intel D815EEA2 (800 MHz Pentium III)	269.0	386.0	Aug-01	22%	46%
366	HP 9000 Model N4000 / PA8600-440 MHz	266.0	-	Nov-99	22%	-
367	Sun Blade 150 (UltraSPARC IIi/650)	261.0	246.0	Aug-02	22%	29%
368	Sun Blade 1000 Model 1600 / 600MHz	260.0	311.0	Jul-01	22%	37%
369	Intel VC820 (850 MHz Pentium III)	259.0	367.0	Jul-00	22%	44%
370	Intel D815EEA2 (1.1 GHz Pentium III)	258.0	427.0	Aug-01	21%	51%
371	Intel D815EEA2 (1.0 GHz Pentium III)	254.0	408.0	Aug-01	21%	49%
372	Sun Enterp. 420R (UltraSPARC-II/450)	251.0	214.0	Mar-01	21%	26%
373	Sun Enterprise 3500/4500 - 400 MHz	246.0	212.0	Oct-00	20%	25%
374	IBM eServer pSeries 660/6H1 600 MHz	245.0	310.0	Apr-01	20%	37%
375	IBM eServer pSeries 620/6F1 600 MHz	245.0	310.0	Apr-01	20%	37%
376	IBM eServer pSeries 660/6H0 600 MHz	245.0	310.0	May-01	20%	37%
377	Intel VC820 (800EB MHz Pentium III)	245.0	355.0	Mar-00	20%	42%
378	IBM eServer pSeries 620/6F0 600 MHz	245.0	310.0	May-01	20%	37%
379	Intel OR840 (733MHz Pentium III)	243.0	336.0	Nov-99	20%	40%
380	IBM RS/6000 Model 7026-M80 (1 CPU)	243.0	275.0	May-00	20%	33%
381	Fujitsu CELSIUS 650 / 733 MHz Pentium III	242.0	337.0	Jan-00	20%	40%
382	Sun Blade 150 (UltraSPARC IIi/550)	240.0	217.0	Aug-02	20%	26%
383	Intel VC820 (733 MHz Pentium III)	234.0	335.0	Mar-00	19%	40%
384	Dell PowerEdge 8450/PIII Xeon 700	234.0	422.0	Apr-01	19%	50%
385	Intel SE440BX-2 (800 MHz Pentium III	226.0	344.0	Mar-00	19%	41%
386	Intel VC820 (667 MHz Pentium III)	222.0	314.0	Mar-00	18%	37%
387	Intel SE440BX-2 (750 MHz Pentium III	219.0	330.0	Mar-00	18%	39%
388	Intel SE440BX-2 (700 MHz Pentium III	213.0	315.0	Mar-00	18%	38%
389	IBM RS/6000 Model 7026-F80 (1 CPU)	205.0	234.0	May-00	17%	28%
390	IBM RS/6000 Model 7026-H80 (1 CPU)	205.0	234.0	May-00	17%	28%
391	Dell Prec. WorkSt. 410/700MHz PIII	205.0	307.0	Nov-99	17%	37%
392	Intel SE440BX-2 (650 MHz Pentium III	204.0	299.0	Mar-00	17%	36%

393	Intel SE440BX-2 (500 MHz Pentium III	191.0	233.0	Feb-02	16%	28%
394	IBM RS/6000 7043-260 (1 CPU)	180.0	-	Nov-99	15%	-
395	Intel SE440BX-2 (450 MHz Pentium III	177.0	213.0	Mar-02	15%	25%
396	Compaq AlphaServer 4100 5/533	176.0	176.0	Nov-99	15%	21%
397	Sun Blade 100 (UltraSPARC-IIe/500)	163.0	174.0	Mar-01	14%	21%
398	Compaq DIGITAL PW 500au	158.0	161.0	Nov-99	13%	19%
399	Compaq AlphaStation 500/500	153.0	163.0	Nov-99	13%	19%
400	Ultra 10 333MHz	126.0	133.0	Nov-99	10%	16%
401	IBM RS/6000 43P-150 (250MHz,xlf90)	90.8	105.0	Jun-00	8%	13%
402	IBM RS/6000 43P-150 (250MHz,xlf)	84.4	93.7	May-00	7%	11%

(*) Values derived under earlier releases of OS/compilers/libraries

Table 3. SPEC CPU2000 - SPECfp_rate and SPECint_rate. Absolute and Relative Values.

SPEC CPU2000 - SPECfp_rate and SPECint_rate. Absolute Values and Values Relative to the HP RX2600/1GHz Itanium2.

		SPEC	SPEC	Test	Relative Values (%)	
Machine	NCPU	fp	int	Date	SPECfp	SPECint
SGI Origin 3800 256X 600MHz R14kA	256	1215.0	1402.0	Aug-02	8046%	14931%
SGI Origin 3800 256X 500MHz R14k	256	1090.0	1189.0	Nov-01	7219%	12662%
128 CPUs						
SGI Origin 3800 128X 600MHz R14k	128	638.0	714.0	Apr-02	4225%	7604%
SGI Origin 3800 128X 500MHz R14k	128	570.0	605.0	Dec-01	3775%	6443%
SGI Origin 3800 128X 400MHz R12k	128	525.0	511.0	Aug-00	3477%	5442%
PrimePower2000 (SPARC64 GP/675MHz)	128	517.0	571.0	Oct-01	3424%	6081%
Fujitsu PrimePower2000 (SPARC64 GP/675MHz)	128	517.0	571.0	Oct-01	3424%	6081%
SGI 2800 128X 400MHz R12k	128	407.0	477.0	May-00	2695%	5080%
64 CPUs						
SGI Altix 3000 (1.5GHz, Itanium 2)	64	1257.0	854.0	Aug-03	8325%	9095%
HP AlphaServer GS1280 Model 64	64	1068.0	632.0	Aug-03	7073%	6731%
SGI Altix 3000 (1.3GHz, Itanium 2)	64	1059.0	601.0	Jun-03	7013%	6400%
HP Integrity Superdome(Itanium2/1.5G	64	928.0	904.0	Sep-03	6146%	9627%
SGI Altix 3000 (1GHz, Itanium 2)	64	862.0	-	Jan-03	5709%	-
SGI Altix 3000 (900MHz, Itanium 2)	64	693.0	389.0	Mar-03	4589%	4143%
Sun Fire 15K / 1200 MHz Cu	64	645.0	436.0	Mar-03	4272%	4643%
Compaq AlphaServer SC40 Cluster EV67/833	64	439.0	-	May-02	2907%	-
PrimePower800/1000/2000 (788MHz)	64	329.0	368.0	Aug-02	2179%	3919%
Fujitsu PrimePower800/1000/2000 (788MHz)	64	329.0	368.0	Aug-02	2179%	3919%
SGI Origin 3800 64X 600MHz R14k	64	327.0	362.0	Feb-02	2166%	3855%
SGI Origin 3800 64X 500MHz R14k	64	293.0	307.0	May-01	1940%	3269%
HP9000 Superdome 64-way PA8700+/875	64	288.0	413.0	Jul-02	1907%	4398%
PrimePower2000 (SPARC64 GP/675MHz)	64	281.0	319.0	Oct-01	1861%	3397%
Fujitsu PrimePower2000 (SPARC64 GP/675MHz)	64	281.0	319.0	Oct-01	1861%	3397%
HP9000 Superdome 64-way /PA8700-750	64	267.0	377.0	Sep-01	1768%	4015%
SGI Origin 3800 64X 400MHz R12k	64	265.0	259.0	Jul-00	1755%	2758%
SGI 2400 64X 500MHz R14k	64	228.0	289.0	Aug-01	1510%	3078%

HP9000 Superdome 64-way / PA8600-552	64	218.0	272.0	Apr-01	1444%	2897%
32 CPUs						
SGI Altix 3000 (1.5GHz, Itanium 2)	32	647.0	385.0	Jun-03	4285%	4100%
SGI Altix 3000 (1.3GHz, Itanium 2)	32	544.0	311.0	Jun-03	3603%	3312%
HP AlphaServer GS1280 7/1150	32	536.0	313.0	Apr-03	3550%	3333%
SGI Altix 3000 (1GHz, Itanium 2)	32	443.0	245.0	Jan-03	2934%	2609%
IBM eServer pSeries 690Turbo 1.7 GHz	32	372.0	339.0	May-03	2464%	3610%
SGI Altix 3000 (900MHz, Itanium 2)	32	352.0	199.0	Feb-03	2331%	2119%
PrimePower1500 (SPARC64 GP/1350MHz)	32	346.0	288.0	Jun-03	2291%	3067%
Sun Fire 12K / 1200 MHz Cu	32	338.0	232.0	Mar-03	2238%	2471%
HP AlphaServer GS320 68/1224	32	320.0	296.0	Nov-02	2119%	3152%
TX7/i9010 (1000MHz,Itanium 2)	32	303.0	-	Dec-02	2007%	-
IBM eServer pSeries 690Turbo 1.3 GHz	32	260.0	249.0	Apr-02	1722%	2652%
Compaq AlphaServer GS320 Model 32 68/1001	32	242.0	218.0	Jun-01	1603%	2322%
Fujitsu PrimePower800/1000/2000 (788MHz)	32	182.0	205.0	Aug-02	1205%	2183%
PrimePower800/1000/2000 (788MHz)	32	182.0	205.0	Aug-02	1205%	2183%
SGI Origin 3400 32X 600MHz R14k	32	166.0	183.0	Feb-02	1099%	1949%
Fujitsu PrimePower2000 (SPARC64 GP/675MHz)	32	154.0	170.0	Sep-01	1020%	1810%
PrimePower2000 (SPARC64 GP/675MHz)	32	154.0	170.0	Sep-01	1020%	1810%
SGI Origin 300 32X 600MHz R14kA	32	153.0	168.0	Jun-02	1013%	1789%
SGI Origin 3400 32X 500MHz R14k	32	149.0	155.0	May-01	987%	1651%
Compaq AlphaServer GS320 Model 6/731	32	148.0	142.0	May-00	980%	1512%
HP9000 Superdome 32-way /PA8700-750	32	138.0	193.0	Sep-01	914%	2055%
SGI Origin 3400 32X 400MHz R12k	32	134.0	130.0	Aug-00	887%	1384%
SGI 2400 32X 500MHz R14k	32	116.0	147.0	Aug-01	768%	1565%
SGI Origin 300 32X 500MHz R14k	32	115.0	136.0	Dec-01	762%	1448%
HP9000 Superdome 32-way / PA8600-552	32	112.0	140.0	Apr-01	742%	1491%
SGI 2400 32X 400MHz R12k	32	106.0	125.0	May-00	702%	1331%
24 CPUs						
Sun Fire 6800 / 1200 MHz Cu	24	205.0	180.0	May-03	1358%	1917%
Sun Fire 6800 / 1050 MHz Cu	24	140.0	151.0	May-02	927%	1608%
Sun Fire 6800 / 750 MHz	24	67.4	101.0	Oct-01	446%	1076%
16 CPUs						
SGI Altix 3000 (1.5GHz, Itanium 2)	16	329.0	195.0	Jun-03	2179%	2077%
SGI Altix 3000 (1.3GHz, Itanium 2)	16	279.0	158.0	Jun-03	1848%	1683%
HP AlphaServer GS1280 7/1150	16	274.0	162.0	Jan-03	1815%	1725%
SGI Altix 3000 (1GHz, Itanium 2)	16	227.0	124.0	Jan-03	1503%	1321%
NovaScale 5160 Itanium2/1500MHz	16	215.0	169.0	Jul-03	1424%	1800%
NovaScale 5160 Itanium2/1400MHz	16	203.0	158.0	Jul-03	1344%	1683%
PrimePower900 (SPARC64 GP/1350MHz)	16	194.0	154.0	May-03	1285%	1640%
PrimePower850 (SPARC64 GP/1350MHz)	16	194.0	154.0	Jun-03	1285%	1640%
PrimePower1500 (SPARC64 GP/1350MHz)	16	193.0	149.0	Jun-03	1278%	1587%
IBM eServer pSeries 670 1.5 GHz	16	187.0	156.0	May-03	1238%	1661%
IBM eServer pSeries 690 HPC 1.3 GHz	16	187.0	149.0	Jul-02	1238%	1587%
Unisys ES7000 Aries 130 Server	16	181.0	-	Mar-03	1199%	-
SGI Altix 3000 (900MHz, Itanium 2)	16	178.0	99.7	Feb-03	1179%	1062%
NovaScale 5160 HPC Itanium2/1000	16	177.0	117.0	Mar-03	1172%	1246%
Sun Fire 12K / 1200 MHz Cu	16	174.0	119.0	Mar-03	1152%	1267%
PrimePower850 (SPARC64 GP/1080MHz)	16	171.0	128.0	Jun-03	1132%	1363%
PrimePower900 (SPARC64 GP/1350MHz)*	16	169.0	147.0	Mar-03	1119%	1565%
HP AlphaServer GS160 68/1224	16	161.0	148.0	Nov-02	1066%	1576%

Unisys ES7000 Aries130/Itanium2,1000MHz	16	159.0	-	Dec-02	1053%	-
TX7/i9010 (1000MHz,Itanium 2)	16	159.0	-	Dec-02	1053%	-
Sun Fire 6800 / 1200 MHz Cu	16	153.0	122.0	May-03	1013%	1299%
IBM eServer pSeries 690Turbo 1.3 GHz	16	145.0	131.0	Jul-02	960%	1395%
Compaq AlphaServer GS160 Model 16 68/1001	16	122.0	111.0	Jun-01	808%	1182%
Fujitsu PrimePower800/1000/2000 (788MHz)	16	93.9	105.0	Aug-02	622%	1118%
PrimePower800/1000/2000 (788MHz)	16	93.9	105.0	Aug-02	622%	1118%
PrimePower850 (SPARC64 GP/675MHz)	16	87.0	88.0	Oct-01	576%	937%
Fujitsu PrimePower850 (SPARC64 GP/675MHz)	16	87.0	88.0	Oct-01	576%	937%
SGI Origin 3400 16X 600MHz R14k	16	83.2	91.6	Feb-02	551%	976%
Fujitsu PrimePower800/1000/2000 (675MHz)	16	78.6	85.9	Sep-01	521%	915%
PrimePower800/1000/2000 (675MHz)	16	78.6	85.9	Sep-01	521%	915%
SGI Origin 300 16X 600MHz R14kA	16	76.8	84.1	Jun-02	509%	896%
SGI Origin 3400 16X 500MHz R14k	16	74.8	77.5	Apr-01	495%	825%
Compaq AlphaServer GS160 Model 6/731	16	73.3	69.9	May-00	485%	744%
HP9000 Superdome 16-way /PA8700-750	16	72.9	99.4	Sep-01	483%	1059%
HP SERVER RP8400/PA8700-750	16	71.0	98.2	Sep-01	470%	1046%
SGI Origin 3400 16X 400MHz R12k	16	66.9	65.3	Aug-00	443%	695%
HP9000 Superdome 16-way / PA8600-552	16	59.0	72.1	Apr-01	391%	768%
SGI 2400 16X 500MHz R14k	16	58.2	74.3	Jul-01	385%	791%
SGI Origin 300 16X 500MHz R14k	16	57.9	68.3	Dec-01	383%	727%
IBM RS/6000 SP-375MHz High Node(16 CPU)	16	51.7	46.0	Jun-00	342%	490%
14 CPUs						
Sun Enterprise 4500	14	33.5	34.5	Oct-00	222%	367%
12 CPUs						
Sun Fire 4800 / 1200 MHz Cu	12	122.0	91.8	May-03	808%	978%
Sun Fire V1280 / 900MHz Cu	12	104.0	72.9	Feb-03	689%	776%
IBM RS/6000 SP-375MHz High Node(12 CPU)	12	41.1	34.6	Jun-00	272%	368%
8 CPUs						
SGI Altix 3000 (1.5GHz, Itanium 2)	8	165.0	98.3	Jun-03	1093%	1047%
NovaScale 5160 HPC Itanium2/1500MHz	8	152.0	93.3	Jul-03	1007%	994%
SGI Altix 3000 (1.3GHz, Itanium 2)	8	142.0	79.4	Jun-03	940%	846%
HP AlphaServer GS1280 7/1150	8	133.0	80.7	Jan-03	881%	859%
NovaScale 5080 Itanium2/1500MHz	8	125.0	92.0	Jul-03	828%	980%
HP AlphaServer ES80 7/1000	8	117.0	68.9	Jan-03	775%	734%
SGI Altix 3000 (1GHz, Itanium 2)	8	116.0	62.1	May-03	768%	661%
NovaScale 5160 HPC Itanium2/1000	8	113.0	61.4	Mar-03	748%	654%
PrimePower850 (SPARC64 GP/1350MHz)	8	111.0	79.2	Jun-03	735%	843%
PrimePower900 (SPARC64 GP/1350MHz)	8	110.0	79.2	May-03	728%	843%
PrimePower900 (SPARC64 GP/1350MHz)*	8	99.9	74.9	Mar-03	662%	798%
PrimePower650 (SPARC64 GP/1350MHz)	8	99.6	-	Jun-03	660%	-
PrimePower850 (SPARC64 GP/1080MHz)	8	96.1	65.8	Jun-03	636%	701%
IBM eServer pSeries 655 1500 MHz	8	92.8	77.5	May-03	615%	825%
Unisys ES7000 Aries130/Itanium2,1000MHz	8	91.0	-	Dec-02	603%	-
SGI Altix 3000 (900MHz, Itanium 2)	8	89.8	50.3	Feb-03	595%	536%
PrimePower650 (SPARC64 GP/1080MHz)	8	87.8	65.4	May-03	581%	696%
Sun Fire 4800 / 1200 MHz Cu	8	86.3	61.4	May-03	572%	654%
IBM eServer pSeries 650/6M2 1450MHz	8	82.4	75.5	Nov-02	546%	804%
HP AlphaServer GS80 68/1224	8	81.0	76.4	Nov-02	536%	814%
Sun Fire V880 / 1050 MHz Cu	8	73.7	55.9	Jun-03	488%	595%
IBM eServer pSeries 655/651 1100 MHz	8	68.1	56.9	Nov-02	451%	606%

Compaq AlphaServer GS80 Model 8 68/1001	8	60.0	56.0	Jun-01	397%	596%
Fujitsu PrimePower650 (SPARC64 GP/810MHz)	8	54.4	56.5	Aug-02	360%	602%
PrimePower650 (SPARC64 GP/810MHz)	8	54.4	56.5	Aug-02	360%	602%
Sun Fire V880 / 900 MHz Cu	8	53.3	47.6	May-02	353%	507%
PrimePower650/850 (SPARC64 GP/675MHz	8	44.0	43.9	Oct-01	291%	468%
Fujitsu PrimePower650/850 (SPARC64 GP/675MHz	8	44.0	43.9	Oct-01	291%	468%
SGI Origin 3200 8X 600MHz R14k	8	41.7	45.9	Feb-02	276%	489%
SGI Origin 300 8X 600MHz R14kA	8	38.7	43.3	May-02	256%	461%
Compaq AlphaServer GS80 Model 6/731	8	38.5	36.0	Dec-00	255%	383%
SGI Origin 3200 8X 500MHz R14k	8	37.7	38.5	Apr-01	250%	410%
HP SERVER RP7410/PA8700-750	8	36.8	49.9	Feb-02	244%	531%
HP SERVER RP8400/PA8700-750	8	35.9	49.9	Sep-01	238%	531%
SGI Origin 3200 8X 400MHz R12k	8	33.8	32.6	Sep-00	224%	347%
HP SERVER RP7400/PA8700-750	8	32.1	46.7	Sep-01	213%	497%
PrimePower600 (SPARC64 GP/600MHz)	8	31.5	37.2	Sep-01	209%	396%
Fujitsu PrimePower600 (SPARC64 GP/600MHz)	8	31.5	37.2	Sep-01	209%	396%
Sun Fire V880 / 750 MHz	8	31.2	36.2	Nov-01	207%	386%
HP SERVER RP7400/PA8700-650	8	30.5	42.6	Oct-01	202%	454%
IBM eServer pSeries 660/6M1 750MHz	8	30.0	38.5	Aug-01	199%	410%
IBM IBM RS/6000 Model M80 (750 MHz)	8	30.0	38.5	Aug-01	199%	410%
SGI 2200 8X 500MHz R14k	8	29.3	37.3	Jul-01	194%	397%
SGI Origin 300 8X 500MHz R14k	8	28.9	34.0	Nov-01	191%	362%
IBM RS/6000 SP-375MHz High Node(8 CPU)	8	28.0	23.1	Jun-00	185%	246%
SGI 2200 8X 400MHz R12k	8	26.2	30.5	May-00	174%	325%
HP 9000 Model N4000 / PA8600-552 MHz	8	23.0	32.7	Mar-00	152%	348%
SGI 2100 8X 350MHz R12k	8	22.8	25.1	May-00	151%	267%
IBM RS/6000 Model 7026-M80 (8 CPU)	8	21.1	25.1	May-00	140%	267%
Sun Enterprise 3500/4500 - 400 MHz	8	20.9	19.5	Oct-00	138%	208%
Dell PowerEdge 8450/PIII Xeon 700	8	9.2	25.7	Apr-01	61%	274%
6 CPUs						
IBM eServer pSeries 660/6H1 668MHz	6	17.3	26.5	Apr-01	115%	282%
IBM eServer pSeries 620/6F1 668MHz	6	17.3	26.5	Apr-01	115%	282%
IBM RS/6000 Model 7026-F80 (6 CPU)	6	13.2	18.0	May-00	87%	192%
IBM RS/6000 Model 7026-H80 (6 CPU)	6	13.2	18.0	May-00	87%	192%
4 CPUs						
SGI Altix 3000 (1.5GHz, Itanium 2)	4	82.7	-	Jun-03	548%	-
IBM eServer pSeries 655 1700 MHz	4	68.5	-	May-03	454%	-
HP AlphaServer GS1280 7/1150	4	68.2	40.6	Jan-03	452%	432%
HP Integrity RX5670/Itanium2,1500MHz	4	66.4	60.0	Jun-03	440%	639%
NovaScale 4040 Itanium2/1500	4	64.6	50.6	Jul-03	428%	539%
HP AlphaServer ES80 7/1000	4	58.9	34.6	Jan-03	390%	368%
HP AlphaServer ES47 7/1000	4	58.9	34.6	Jan-03	390%	368%
SGI Altix 3000 (1GHz, Itanium 2)	4	58.4	31.0	May-03	387%	330%
IBM eServer pSeries 655/651 1300 MHz	4	51.7	38.3	Nov-02	342%	408%
HP AlphaServer ES45 68/1250	4	50.0	42.0	Nov-02	331%	447%
HP RX5670/Itanium2, 1GHz,3MB-L3, L	4	49.3	-	Nov-02	326%	-
AMD Einox A4800/Opteron844 1.8GHz-I,WS	4	49.2	48.5	Apr-03	326%	517%
NovaScale 4040 Itanium2/1000	4	48.8	32.9	Feb-03	323%	350%
Unisys ES7000 Aries130/Itanium2,1000MHz	4	48.0	-	Dec-02	318%	-
SGI Altix 3000 (900MHz, Itanium 2)	4	45.0	25.3	Feb-03	298%	269%
AMD Einox A4800/Opteron842 1.6GHz-I,WS	4	45.0	45.1	Apr-03	298%	480%

HP RX5670/Itanium2, 1GHz,3MB-L3, H	4	43.7	36.8	Jul-02	289%	392%
Sun Fire V880 / 1050 MHz Cu	4	41.4	28.2	Jun-03	274%	300%
PrimePower450 (SPARC64 GP/1100MHz)	4	41.4	30.5	May-03	274%	325%
AMD Einox A4800/Opteron840 1.4GHz-I,WS	4	40.7	40.0	Apr-03	270%	426%
Sun Fire V480 / 1050MHz Cu	4	40.1	28.2	Jul-03	266%	300%
IBM eServer pSeries 630/6C4 1450MHz	4	38.8	37.0	Feb-03	257%	394%
IBM eServer pSeries 630/6E4 1450MHz	4	38.8	37.0	Feb-03	257%	394%
HP RX5670/Itanium2,900MHz,1.5MB-L3,L	4	38.7	-	Nov-02	256%	-
Compaq AlphaServer ES45 Model 68/1000	4	36.8	30.8	Oct-01	244%	328%
IBM eServer pSeries 630/6C4 1200MHz	4	35.1	31.4	Apr-03	232%	334%
IBM eServer pSeries 630/6E4 1200MHz	4	35.1	31.4	Apr-03	232%	334%
Sun Fire V880 / 900 MHz Cu	4	30.6	23.9	May-02	203%	255%
Sun Fire V480 / 900 MHz Cu	4	29.9	24.1	Jun-02	198%	257%
Compaq AlphaServer ES40 Model 6/833	4	29.2	25.8	Jun-01	193%	275%
Compaq AlphaServer ES40 Model 6/833*	4	26.1	24.7	Feb-01	173%	263%
Dell PowerEdge 6650/2.8 GHz Xeon MP	4	25.4	47.4	Jun-03	168%	505%
ProLiant DL580 G2(2.8GHz Xeon MP)	4	24.6	47.6	Sep-03	163%	507%
Dell PowerEdge 7150 Itanium/800 4MB L3	4	23.0	-	Jun-01	152%	-
ProLiant BL40p (2.8GHz Xeon MP)	4	22.8	46.5	Sep-03	151%	495%
ProLiant DL560 (2.8GHz Xeon MP)	4	22.7	46.5	Sep-03	150%	495%
HP SERVER RX4610 Itanium/800 4MB L3	4	22.4	-	May-01	148%	-
Compaq AlphaServer ES40 Model 6/667	4	21.9	19.8	Nov-00	145%	211%
SGI Origin 3200 4X 600MHz R14k	4	21.0	23.0	Feb-02	139%	245%
HP SERVER RP7400/PA8700-750	4	20.5	24.6	Sep-01	136%	262%
HP SERVER RX4610 Itanium/800 4MB L3*	4	20.3	-	Aug-01	134%	-
Dell PowerEdge 6650/2.0 GHz Xeon MP	4	20.2	34.7	Oct-02	134%	370%
HP SERVER RX4610 Itanium/733 4MB L3	4	20.1	-	May-01	133%	-
HP SERVER RP5470/PA8700-750	4	19.9	24.5	Oct-01	132%	261%
SGI Origin 300 4X 600MHz R14kA	4	19.5	21.6	May-02	129%	230%
HP SERVER RP7400/PA8700-650	4	19.3	22.1	Oct-01	128%	235%
SGI Origin 3200 4X 500MHz R14k	4	19.0	19.6	May-01	126%	209%
HP SERVER RP7410/PA8700-750	4	18.9	25.3	Feb-02	125%	269%
HP SERVER RP8400/PA8700-750	4	18.8	25.7	Sep-01	125%	274%
HP SERVER RP5470/PA8700-650	4	18.7	22.0	Oct-01	124%	234%
PrimePower400 (SPARC64 GP/600MHz)	4	18.0	19.3	Sep-01	119%	206%
Fujitsu PrimePower400 (SPARC64 GP/600MHz)	4	18.0	19.3	Sep-01	119%	206%
PrimePower600 (SPARC64 GP/600MHz)	4	17.4	19.0	Sep-01	115%	202%
Fujitsu PrimePower600 (SPARC64 GP/600MHz)	4	17.4	19.0	Sep-01	115%	202%
SGI Origin 3200 4X 400MHz R12k	4	16.9	16.3	Sep-00	112%	174%
IBM IBM RS/6000 Model M80 (750 MHz)	4	16.5	20.3	Aug-01	109%	216%
IBM eServer pSeries 660/6M1 750MHz	4	16.5	20.3	Aug-01	109%	216%
IBM eServer pSeries 620/6F1 750MHz	4	15.6	20.5	Apr-02	103%	218%
IBM eServer pSeries 660/6H0 750MHz	4	15.6	20.5	Apr-02	103%	218%
IBM eServer pSeries 620/6F0 750MHz	4	15.6	20.5	Apr-02	103%	218%
IBM eServer pSeries 660/6H1 750MHz	4	15.6	20.5	Apr-02	103%	218%
Compaq AlphaServer ES40 Model 6/500	4	15.6	13.7	Nov-00	103%	146%
SGI 2200 4X 500MHz R14k	4	14.8	18.6	Jul-01	98%	198%
IBM RS/6000 SP-375MHz High Node(4 CPU)	4	14.5	11.6	Jun-00	96%	124%
HP 9000 Model L3000 / PA8600-550	4	14.5	17.4	Dec-00	96%	185%
SGI Origin 300 4X 500MHz R14k	4	14.5	17.1	Oct-01	96%	182%
HP 9000 Model N4000 / PA8600-552 MHz	4	14.4	17.0	Mar-00	95%	181%

IBM RS/6000 SP-450MHz T/W (4 CPU)	4	14.1	15.2	Jan-02	93%	162%
IBM RS/6000 44P-270 (450MHz, 8MBL2)	4	14.1	15.2	Oct-01	93%	162%
IBM eServer pSeries 640/B80 450MHz	4	14.1	15.2	Oct-01	93%	162%
SGI 2200 4X 400MHz R12k	4	13.2	15.4	May-00	87%	164%
IBM eServer pSeries 640 (8 MB L2)	4	12.8	12.4	Sep-00	85%	132%
IBM RS/6000 44P-270 (4 CPU, 8MBL2)	4	12.8	12.4	Sep-00	85%	132%
IBM RS/6000 44P-270 (4 CPU, 4MBL2)	4	11.9	11.7	Sep-00	79%	125%
IBM eServer pSeries 640 (4 MB L2)	4	11.9	11.7	Sep-00	79%	125%
IBM RS/6000 44P-270 (4 CPU)	4	11.8	11.2	Jan-00	78%	119%
SGI 2100 4X 350MHz R12k	4	11.5	12.8	Jun-00	76%	136%
IBM eServer pSeries 660/6H0 600MHz	4	11.1	15.0	May-01	74%	160%
Sun Enterprise 450 / 480MHz	4	11.1	10.9	Aug-00	74%	116%
IBM eServer pSeries 620/6F1 600MHz	4	11.1	15.0	Apr-01	74%	160%
IBM eServer pSeries 660/6H1 600MHz	4	11.1	15.0	Apr-01	74%	160%
IBM eServer pSeries 620/6F0 600MHz	4	11.1	15.0	May-01	74%	160%
Sun Enterprise 3500/4500 - 400 MHz	4	11.1	9.7	Oct-00	74%	103%
IBM RS/6000 Model 7026-H80 (4 CPU)	4	9.4	11.3	May-00	63%	120%
IBM RS/6000 Model 7026-F80 (4 CPU)	4	9.4	11.3	May-00	63%	120%
Dell PowerEdge 6400/PIII Xeon 700	4	8.9	17.9	Apr-01	59%	191%
2 CPUs						
HP Integrity RX5670/Itanium2,1500MHz	2	42.6	30.3	Jun-03	282%	323%
HP Integrity RX2600/Itanium2,1500MHz	2	42.4	30.5	Jun-03	281%	325%
HP ZX6000/Itanium2, 1.5GHz,6MB-L3, H	2	42.4	-	Jun-03	281%	-
Dell PowerEdge 3250/1.5 GHz Itanium2	2	37.3	25.4	Jul-03	247%	271%
ION Computers I2X2 (1.4GHz Itanium2)	2	36.8	21.3	Jul-03	244%	227%
HP AlphaServer GS1280 7/1150	2	33.9	20.3	Jan-03	225%	216%
HP RX5670/Itanium2, 1GHz,3MB-L3, L	2	30.7	-	Nov-02	203%	-
HP ZX6000/Itanium2, 1GHz,3MB-L3, L	2	30.0	-	Nov-02	199%	-
HP RX2600/Itanium2, 1GHz,3MB-L3, L	2	29.9	-	Nov-02	198%	-
AMD Rioworks HDAMA Opteron 246 / 2.0 G	2	29.9	30.5	Jul-03	198%	325%
HP AlphaServer ES80 7/1000	2	29.6	17.4	Jan-03	196%	185%
HP AlphaServer ES47 7/1000	2	29.6	17.4	Jan-03	196%	185%
HP AlphaServer ES45 68/1250	2	29.0	21.3	Nov-02	192%	227%
HP RX5670/Itanium2, 1GHz,3MB-L3, H	2	27.0	18.6	Jul-02	179%	198%
IBM eServer 325 2.0GHz Opteron 64-bitPGI	2	27.0	26.6	Jul-03	179%	283%
AMD Einox A4800/Opteron244 1.8GHz-I,WS	2	26.7	26.8	Apr-03	177%	285%
HP RX2600/Itanium2, 1GHz,3MB-L3, H	2	26.5	18.7	Jul-02	175%	199%
AMD Einox A4800/Opteron242 1.6GHz-I,WS	2	25.1	24.0	Apr-03	166%	256%
AMD Einox A4800/Opteron144 1.8GHz-I,SE	2	24.9	-	Apr-03	165%	-
HP RX5670/Itanium2,900MHz,1.5MB-L3,L	2	24.5	-	Nov-02	162%	-
RSN-1164/op (1.8 GHz Opteron)	2	24.2	25.1	Apr-03	160%	267%
HP RX2600/Itanium2,900MHz,1.5MB-L3,L	2	23.9	-	Nov-02	158%	-
Sun Blade Model 2000 / 1200 MHz	2	23.9	16.4	Apr-03	158%	175%
HP ZX6000/Itanium2,900MHz,1.5MB-L3,L	2	23.9	-	Nov-02	158%	-
Sun Netra 20 / 1200 MHz Cu	2	23.6	16.3	Mar-03	156%	174%
Sun Fire 280R / 1200 MHz Cu	2	23.6	16.3	Mar-03	156%	174%
AMD Einox A4800/Opteron240 1.4GHz-I,WS	2	22.7	21.2	Apr-03	150%	226%
AMD Einox A4800/Opteron244 1.8GHz-I,SE	2	21.6	-	Apr-03	143%	-
Sun Fire V880 / 1050 MHz Cu	2	21.6	14.1	Jun-03	143%	150%
HP AlphaServer DS25 68/1000	2	21.5	15.5	Aug-02	142%	165%
PrimePower250 (SPARC64 GP/1100MHz	2	21.3	15.3	May-03	141%	163%

Compaq AlphaServer ES45 Model 68/1000	2	21.1	15.6	Oct-01	140%	166%
Sun Fire V480 / 1050MHz Cu	2	20.8	14.2	Jul-03	138%	151%
IBM IntelliStation POWER 275 (1450MHz)	2	19.9	20.0	Jun-03	132%	213%
ProLiant DL380 G3(3.06GHz Xeon,L3)	2	19.9	26.7	Jun-03	132%	284%
ProLiant BL20p G2(3.06GHzXeon,1MBL3)	2	19.9	26.8	Aug-03	132%	285%
ProLiant DL360 G3(3.06GHz Xeon,L3)	2	19.9	27.1	Jun-03	132%	289%
Dell PowerEdge 1750/3.06 GHz Xeon L3	2	19.8	27.0	Jul-03	131%	288%
Dell PowerEdge 6650/2.8 GHz Xeon MP	2	19.3	27.0	Jun-03	128%	288%
ProLiant DL580 G2(2.8GHz Xeon MP)	2	19.0	26.9	Sep-03	126%	286%
Dell Prec. WorkSt. 650/3.06GHz P4 Xeon L3	2	18.2	26.8	Jun-03	121%	285%
ProLiant DL560 (2.8GHz Xeon MP)	2	18.2	26.8	Sep-03	121%	285%
ProLiant BL40p (2.8GHz Xeon MP)	2	18.2	26.9	Sep-03	121%	286%
IBM eServer pSeries 615/6C3 1200 MHz	2	18.0	16.9	May-03	119%	180%
IBM eServer pSeries 615/6E3 1200 MHz	2	18.0	16.9	May-03	119%	180%
ProLiant BL20p G2(3.06GHz Xeon)	2	17.7	22.2	Aug-03	117%	236%
ProLiant DL380 G3(3.06GHz Xeon)	2	17.6	22.4	Jun-03	117%	239%
Dell PowerEdge 1750/3.06 GHz Xeon	2	17.4	22.5	Jul-03	115%	240%
ProLiant DL360 G3(3.06GHz Xeon)	2	17.3	22.1	Jun-03	115%	235%
Dell PowerEdge 2650/3.06 GHz P4 Xeon	2	17.0	22.2	Apr-03	113%	236%
Sun Blade Model 2000 / 1050 MHz	2	16.8	-	Apr-02	111%	-
Sun Fire 280R / 1015 MHz Cu	2	16.4	13.2	Oct-02	109%	141%
Compaq AlphaServer ES40 Model 6/833	2	16.4	13.0	Jun-01	109%	138%
Sun Blade Model 2000 / 1015 MHz	2	16.1	13.2	Oct-02	107%	141%
Compaq AlphaServer DS20E Model 68/833	2	15.9	13.1	Jun-01	105%	140%
Sun Fire V880 / 900 MHz Cu	2	15.9	12.0	May-02	105%	128%
Dell Prec. WorkSt. 650/3.06 GHz P4 Xeon	2	15.8	22.5	Apr-03	105%	240%
Sun Fire V480 / 900 MHz Cu	2	15.5	12.2	Jun-02	103%	130%
Dell Prec. WorkSt. 650/2.8 GHz P4 Xeon	2	15.5	21.3	Apr-03	103%	227%
Dell Prec. WorkSt. 650/2.66 GHz P4 Xeon	2	15.3	20.7	Apr-03	101%	220%
Sun Fire V210 / 1002MHz Cu	2	14.9	11.7	Mar-03	99%	125%
Sun Netra 20 / 900 MHz Cu	2	14.9	12.2	May-02	99%	130%
Sun Fire V240 / 1002MHz Cu	2	14.9	11.8	Mar-03	99%	126%
Sun Blade 1000 Model 2900 / 900 MHz	2	14.9	12.0	Nov-01	99%	128%
Dell Prec. WorkSt. 650/2.4 GHz P4 Xeon	2	14.9	19.4	Apr-03	99%	207%
Dell Prec. WorkSt. 530/2.8 GHz P4 Xeon	2	14.7	19.6	Sep-02	97%	209%
Compaq AlphaServer ES40 Model 6/833*	2	14.4	12.6	Mar-01	95%	134%
Dell Prec. WorkSt. 530/2.6 GHz P4 Xeon	2	14.4	18.8	Sep-02	95%	200%
Sun Fire 280R / 900 MHz Cu	2	14.3	11.9	Nov-01	95%	127%
Compaq AlphaServer DS20L Model 68/833	2	14.3	12.2	May-02	95%	130%
HP SERVER RX4610 Itanium/800 4MB L3	2	14.2	-	May-01	94%	-
Dell PowerEdge 7150 Itanium/800 4MB L3	2	14.2	-	Jun-01	94%	-
Dell Prec. WorkSt. 530/2.4 GHz P4 Xeon*	2	14.2	17.7	Apr-02	94%	188%
Dell Prec. WorkSt. 530/2.4 GHz P4 Xeon	2	13.8	17.7	Sep-02	91%	188%
Dell Prec. WorkSt. 650/2.0 GHz P4 Xeon	2	13.8	17.2	Apr-03	91%	183%
Dell PowerEdge 6650/2.0 GHz Xeon MP	2	13.8	18.7	Oct-02	91%	199%
Dell Prec. WorkSt. 530/2.2 GHz P4*	2	13.6	16.8	Jan-02	90%	179%
Dell Prec. WorkSt. 530/2.2 GHz P4	2	13.5	16.9	Sep-02	89%	180%
HP i2000 Itanium/800 2MB L3	2	13.2	-	May-01	87%	-
Dell Prec. WorkSt. 530/2.0 GHz P4*	2	13.2	15.9	Jan-02	87%	169%
Dell PowerEdge 2650/2.8 GHz P4 Xeon	2	13.2	18.8	Oct-02	87%	200%
Dell Prec. WorkSt. 730/Itanium/800 2MB L3	2	13.1	7.2	Jul-01	87%	76%

Dell Prec. WorkSt. 530/2.0 GHz P4	2	13.0	15.9	Sep-02	86%	169%
HP SERVER RX4610 Itanium/800 4MB L3*	2	13.0	-	Aug-01	86%	-
Dell PowerEdge 2650/2.4 GHz P4 Xeon	2	12.9	17.2	Apr-02	85%	183%
HP SERVER RX4610 Itanium/733 2MB L3	2	12.7	-	May-01	84%	-
Dell Prec. WorkSt. 530/1.8 GHz P4	2	12.6	14.9	Sep-02	83%	159%
Dell Prec. WorkSt. 530/2.0 GHz P4**	2	12.4	15.7	Oct-01	82%	167%
Compaq AlphaServer DS20E Model 6/667	2	12.4	10.1	Aug-01	82%	108%
Compaq AlphaServer ES40 Model 6/667	2	12.2	10.3	Nov-00	81%	110%
Dell Prec. WorkSt. 530/1.7 GHz P4	2	11.9	12.2	Oct-01	79%	130%
HP SERVER RP5470/PA8700-750	2	11.5	12.5	Oct-01	76%	133%
HP 9000 Model J6750 / PA8700+/875	2	11.5	14.9	Oct-02	76%	159%
Dell Prec. WorkSt. 530/1.5 GHz P4	2	11.2	11.3	Oct-01	74%	120%
AMD Asus A7M266-D MP2400+ / 2000 MHz	2	11.2	15.4	Nov-02	74%	164%
AMD MSI K7D M-L MP2200+ / 1800 MHz	2	11.1	14.7	Aug-02	74%	157%
PrimePower200 (SPARC64 GP/700MHz,8MB	2	11.1	11.5	Jul-02	74%	122%
AMD MSI K7D M-L MP2600+ / 2133 MHz	2	11.0	15.7	Feb-03	73%	167%
AMD MSI K7D M-L MP2100+ / 1733 MHz	2	11.0	14.4	Jun-02	73%	153%
HP SERVER RP7400/PA8700-750	2	11.0	12.5	Sep-01	73%	133%
HP SERVER RP5470/PA8700-650	2	10.8	11.2	Oct-01	72%	119%
Dell Prec. WorkSt. 530/1.7 GHz P4*	2	10.8	12.1	May-01	72%	129%
AMD Asus A7M266-D MP2000+ / 1667 MHz	2	10.6	13.9	Mar-02	70%	148%
HP 9000 Model J6700 / PA8700-750	2	10.5	13.4	Apr-01	70%	143%
Fujitsu PrimePower200 (SPARC64 GP/700MHz,8MB	2	10.5	11.5	Jul-02	70%	122%
PrimePower200 (SPARC64 GP/700MHz,4MB	2	10.5	10.9	Jul-02	70%	116%
HP SERVER RP7400/PA8700-650	2	10.4	11.3	Oct-01	69%	120%
Sun Blade 1000 Model 2900 / 900MHz*	2	10.2	10.7	Sep-00	68%	114%
Dell Prec. WorkSt. 530/1.5 GHz P4*	2	10.2	11.2	May-01	68%	119%
AMD Tyan Thunder K7 MP1800+/1533 MHz	2	10.1	13.0	Oct-01	67%	138%
Compaq Evo Workst. W6000/1.4 GHz P4 Xeon	2	10.0	10.6	Sep-01	66%	113%
AMD Tyan Thunder K7 MP1600+/1400 MHz	2	10.0	12.4	Oct-01	66%	132%
Dell Prec. WorkSt. 530/1.4 GHz P4	2	10.0	10.7	May-01	66%	114%
AMD Tyan Thunder K7 MP1500+/1333 MHz	2	9.8	12.1	Oct-01	65%	129%
PrimePower400 (SPARC64 GP/600MHz)	2	9.7	9.8	Sep-01	64%	104%
Fujitsu PrimePower400 (SPARC64 GP/600MHz)	2	9.7	9.8	Sep-01	64%	104%
Fujitsu PrimePower600 (SPARC64 GP/600MHz)	2	9.2	9.7	Sep-01	61%	103%
PrimePower600 (SPARC64 GP/600MHz)	2	9.2	9.7	Sep-01	61%	103%
AMD Tyan Thunder K7 Motherboard, 1.2 G	2	9.1	11.1	May-01	61%	118%
Compaq AlphaServer ES40 Model 6/500	2	9.0	7.1	Nov-00	60%	75%
Sun Blade 1000 Model 2750 / 750MHz*	2	9.0	9.0	Sep-00	60%	96%
IBM RS/6000 44P-270 (450MHz, 8MBL2)	2	9.0	7.7	Oct-01	60%	82%
IBM eServer pSeries 610/6E1 450MHz	2	9.0	7.7	Oct-01	60%	82%
IBM eServer pSeries 610/6C1 450MHz	2	9.0	7.7	Oct-01	60%	82%
IBM RS/6000 SP-450MHz T/W (2 CPU)	2	9.0	7.7	Jan-02	60%	82%
IBM eServer pSeries 640/B80 450MHz	2	9.0	7.7	Oct-01	60%	82%
PrimePower200 (SPARC64 GP/600MHz)	2	8.9	9.3	Sep-01	59%	99%
Fujitsu PrimePower200 (SPARC64 GP/600MHz)	2	8.9	9.3	Sep-01	59%	99%
Sun Netra 20 / 750 MHz	2	8.9	9.4	Nov-01	59%	101%
Sun Blade 1000 Model 2900 / 900MHz	2	8.9	10.7	Jul-01	59%	114%
Compaq AlphaServer DS20 Model 6/500	2	8.8	7.3	Mar-01	58%	77%
Sun Blade 1000 Model 2750 / 750MHz	2	8.6	9.1	Jun-01	57%	97%
Sun Fire 280R / 750 MHz*	2	8.5	9.1	Jun-01	57%	97%

HP 9000 Model L3000 / PA8600-550	2	8.3	8.9	Dec-00	55%	95%
IBM IntelliStation 265 (450MHz, 4MBL2)	2	8.2	7.3	Jan-02	54%	78%
HP 9000 model J6000 / PA8600-552	2	8.0	9.7	Oct-00	53%	104%
IBM RS/6000 44P-270 (2 CPU, 8MBL2)	2	8.0	6.2	Sep-00	53%	66%
IBM eServer pSeries 640 (8 MB L2)	2	8.0	6.2	Sep-00	53%	66%
Sun Fire 280R / 750 MHz	2	7.8	9.0	Jul-01	52%	95%
HP 9000 Model N4000 / PA8600-552 MHz	2	7.8	8.7	Mar-00	52%	93%
Sun Blade 1000 Model 2750 / 750MHz**	2	7.8	9.0	Jul-01	52%	96%
IBM eServer pSeries 610/6C1 375MHz	2	7.8	6.3	Oct-01	52%	68%
IBM eServer pSeries 610/6E1 375MHz	2	7.8	6.3	Oct-01	52%	68%
IBM eServer pSeries 640 (4 MB L2)	2	7.6	6.0	Sep-00	50%	64%
IBM RS/6000 44P-270 (2 CPU, 4MBL2)	2	7.6	6.0	Sep-00	50%	64%
HP 9000 Model A500 / PA8600-550 MHz	2	7.6	9.3	Nov-00	50%	99%
IBM RS/6000 44P-270 (2 CPU)	2	7.6	5.8	Jan-00	50%	61%
Sun Blade 1000 Model 2600 / 600MHz*	2	7.2	7.1	Sep-00	48%	76%
IBM eServer pSeries 610/6E1 333MHz	2	7.1	5.6	Feb-02	47%	59%
IBM eServer pSeries 610/6C1 333MHz	2	7.1	5.6	Feb-02	47%	59%
Dell PowerEdge 1500SC/1.4 GHz PIII	2	6.9	13.1	Jan-02	46%	140%
Dell PowerEdge 1500SC/1.26GHz PIII	2	6.8	12.4	Jan-02	45%	132%
SGI 2200 2X 400MHz R12k	2	6.7	7.8	May-00	44%	83%
Dell PowerEdge 2550/1.13GHz PIII	2	6.3	11.4	Jan-02	42%	121%
Sun Blade 1000 Model 2600 / 600MHz	2	6.3	7.1	Jul-01	42%	76%
Dell Prec. WorkSt. 420/1.0 GHz P3	2	6.2	9.6	Dec-00	41%	102%
Sun Enterprise 3500/4500 - 400 MHz	2	5.8	4.9	Oct-00	38%	52%
1 CPUs						
HP Integrity RX2600/Itanium2,1500MHz	1	24.6	15.3	Jun-03	163%	163%
HP Integrity RX5670/Itanium2,1500MHz	1	24.5	15.2	Jun-03	162%	162%
HP ZX6000/Itanium2, 1.5GHz,6MB-L3, H	1	24.4	-	Jun-03	162%	-
Dell PowerEdge 3250/1.5 GHz Itanium2	1	21.7	12.7	Jul-03	144%	135%
ION Computers I2X2 (1.4GHz Itanium2)	1	21.1	10.8	Jul-03	140%	115%
HP AlphaServer GS1280 7/1150	1	17.2	10.2	Jan-03	114%	109%
HP RX5670/Itanium2, 1GHz,3MB-L3, L	1	16.6	-	Nov-02	110%	-
HP RX2600/Itanium2, 1GHz,3MB-L3, L	1	16.6	-	Nov-02	110%	-
HP ZX6000/Itanium2, 1GHz,3MB-L3, L	1	16.5	-	Nov-02	109%	-
HP AlphaServer ES45 68/1250	1	15.8	10.8	Nov-02	105%	115%
HP RX5670/Itanium2, 1GHz,3MB-L3, H	1	15.1	9.4	Jul-02	100%	100%
HP RX2600/Itanium2, 1GHz,3MB-L3, H	1	15.1	9.4	Jul-02	100%	100%
HP AlphaServer ES80 7/1000	1	14.9	8.8	Jan-03	99%	94%
HP AlphaServer ES47 7/1000	1	14.9	8.8	Jan-03	99%	94%
AMD Einox A4800/Opteron144 1.8GHz-I,WS	1	14.1	13.6	Apr-03	93%	145%
ProLiant BL20p G2(3.06GHzXeon,1MBL3)	1	13.8	14.6	Aug-03	91%	155%
Dell Prec. WorkSt. 650/3.06GHz P4 Xeon L3	1	13.8	15.0	Jun-03	91%	160%
IBM eServer 325 2.0GHz Opteron 64-bitPGI	1	13.7	14.2	Aug-03	91%	151%
ProLiant DL360 G3(3.06GHz Xeon,L3)	1	13.7	14.5	Jun-03	91%	154%
ProLiant DL380 G3(3.06GHz Xeon,L3)	1	13.7	14.5	Jun-03	91%	154%
Intel D850EMVR(3.06GHz,Pentium4,MT)	1	13.7	14.1	Dec-02	91%	150%
AMD Einox A4800/Opteron144 1.8GHz-I,SE	1	13.5	12.9	Apr-03	89%	137%
Dell PowerEdge 1750/3.06 GHz Xeon L3	1	13.4	14.4	Jul-03	89%	153%
AMD Einox A4800/Opteron144 1.8GHz-I,SE	1	13.4	12.8	Apr-03	89%	136%
HP RX2600/Itanium2,900MHz,1.5MB-L3,L	1	13.4	-	Nov-02	89%	-
HP RX5670/Itanium2,900MHz,1.5MB-L3,L	1	13.3	-	Nov-02	88%	-

HP ZX6000/Itanium2,900MHz,1.5MB-L3,L	1	13.2	-	Nov-02	87%	-
AMD Einox A4800/Opteron142 1.6GHz-I,WS	1	13.0	12.2	Apr-03	86%	130%
Sun Blade Model 2000 / 1200 MHz	1	13.0	8.4	Apr-03	86%	89%
Dell PowerEdge 6650/2.8 GHz Xeon MP	1	13.0	14.3	Jun-03	86%	152%
Dell Prec. WorkSt. 350/3.06 GHz P4 Xeon	1	12.8	13.1	Nov-02	85%	140%
ProLiant BL40p (2.8GHz Xeon MP)	1	12.8	14.5	Sep-03	85%	154%
ProLiant DL560 (2.8GHz Xeon MP)	1	12.8	14.4	Sep-03	85%	153%
ProLiant DL580 G2(2.8GHz Xeon MP)	1	12.7	14.3	Sep-03	84%	152%
Intel D850EMVR(3.06GHz,Pentium4,MT)*	1	12.7	12.8	Dec-02	84%	136%
HP ZX2000/Itanium2,900MHz,1.5MB-L3,L	1	12.6	-	Nov-02	83%	-
ProLiant BL20p G2(3.06GHz Xeon)	1	12.5	12.5	Aug-03	83%	133%
Dell Prec. WorkSt. 650/3.06 GHz P4 Xeon	1	12.3	13.2	Apr-03	81%	141%
Dell Prec. WorkSt. 350/2.8 GHz P4 Xeon	1	12.3	12.3	Nov-02	81%	131%
ProLiant DL360 G3(3.06GHz Xeon)	1	12.2	12.4	Jun-03	81%	132%
Dell PowerEdge 1750/3.06 GHz Xeon	1	12.1	12.4	Jul-03	80%	132%
ProLiant DL380 G3(3.06GHz Xeon)	1	12.1	12.4	Jun-03	80%	132%
Dell Prec. WorkSt. 350/2.66 GHz P4 Xeon	1	12.0	11.9	Nov-02	79%	127%
Dell Prec. WorkSt. 650/2.8 GHz P4 Xeon	1	11.8	12.4	Apr-03	78%	132%
HP AlphaServer GS80 68/1224	1	11.7	9.7	Nov-02	77%	103%
Dell Prec. WorkSt. 350/2.53 GHz P4 Xeon	1	11.7	11.4	Nov-02	77%	121%
HP AlphaServer GS160 68/1224	1	11.7	9.7	Nov-02	77%	103%
HP AlphaServer GS320 68/1224	1	11.7	9.7	Nov-02	77%	103%
AMD Einox A4800/Opteron140 1.4GHz-I,WS	1	11.7	10.8	Apr-03	77%	115%
Dell Prec. WorkSt. 650/2.66 GHz P4 Xeon	1	11.6	12.0	Apr-03	77%	128%
Dell PowerEdge 2650/3.06 GHz P4 Xeon	1	11.6	12.2	Apr-03	77%	130%
Dell Prec. WorkSt. 350/2.4 GHz P4 Xeon	1	11.4	11.0	Nov-02	75%	117%
Dell Prec. WorkSt. 340/3.06 GHz P4 Xeon	1	11.4	12.5	Nov-02	75%	133%
HP AlphaServer DS25 68/1000	1	11.4	7.9	Aug-02	75%	84%
Compaq AlphaServer ES45 Model 68/1000	1	11.1	7.9	Oct-01	74%	84%
Dell Prec. WorkSt. 350/2.26 GHz P4 Xeon	1	11.0	10.5	Nov-02	73%	112%
Dell Prec. WorkSt. 340/2.8 GHz P4 Xeon	1	11.0	11.7	Sep-02	73%	125%
Dell Prec. WorkSt. 650/2.4 GHz P4 Xeon	1	11.0	11.1	Apr-03	73%	118%
Dell Prec. WorkSt. 340/2.66 GHz P4 Xeon	1	10.8	11.3	Sep-02	72%	120%
Dell Prec. WorkSt. 340/2.53 GHz P4 Xeon	1	10.5	10.9	Sep-02	70%	116%
Dell Prec. WorkSt. 340/2.53 GHz P4 Xeon*	1	10.4	10.7	May-02	69%	114%
Dell Prec. WorkSt. 530/2.8 GHz P4 Xeon	1	10.3	11.1	Sep-02	68%	118%
Sun Blade 1500 / 1.062GHz	1	10.3	6.8	Jun-03	68%	73%
Dell Prec. WorkSt. 340/2.4 GHz P4 Xeon*	1	10.2	10.3	Apr-02	68%	110%
Dell Prec. WorkSt. 340/2.4 GHz P4 Xeon	1	10.2	10.5	Sep-02	68%	112%
Dell Prec. WorkSt. 650/2.0 GHz P4 Xeon	1	10.1	9.7	Apr-03	67%	103%
Dell Prec. WorkSt. 530/2.6 GHz P4 Xeon	1	10.0	10.6	Sep-02	66%	113%
Sun Fire V1280 / 900MHz Cu	1	9.8	6.2	Feb-03	65%	66%
AMD ASUS A7N8X XP 2800+ / 2250 MHz	1	9.8	10.8	Sep-02	65%	115%
AMD ASUS A7N8X XP 2700+ / 2166 MHz	1	9.6	10.6	Sep-02	64%	113%
Dell Prec. WorkSt. 530/2.4 GHz P4 Xeon	1	9.6	10.0	Sep-02	64%	106%
Dell Prec. WorkSt. 340/2.2 GHz P4	1	9.5	9.6	Sep-02	63%	103%
Dell PowerEdge 2650/2.8 GHz P4 Xeon	1	9.4	10.5	Oct-02	62%	112%
Dell Prec. WorkSt. 340/2.2 GHz P4*	1	9.3	9.4	Jan-02	62%	100%
Dell Prec. WorkSt. 530/2.2 GHz P4	1	9.2	9.4	Sep-02	61%	100%
Compaq AlphaServer DS20E Model 68/833	1	9.1	6.6	Jun-01	60%	71%
Dell Prec. WorkSt. 340/2.0 GHz P4	1	9.1	9.1	Sep-02	60%	96%

Compaq AlphaServer ES40 Model 6/833	1	9.0	6.5	Jun-01	60%	70%
Dell Prec. WorkSt. 340/2.0A GHz P4	1	8.9	-	Jan-02	59%	-
Dell Prec. WorkSt. 530/2.0 GHz P4	1	8.8	8.8	Sep-02	58%	94%
Compaq AlphaServer GS160 Model 16 68/1001	1	8.8	7.2	Jun-01	58%	77%
Compaq AlphaServer GS80 Model 8 68/1001	1	8.8	7.2	Jun-01	58%	77%
Compaq AlphaServer GS320 Model 32 68/1001	1	8.8	-	Jun-01	58%	-
Dell PowerEdge 2650/2.4 GHz P4 Xeon	1	8.7	9.5	Apr-02	58%	101%
Compaq AlphaServer DS20L Model 68/833	1	8.4	6.2	Apr-02	56%	66%
Dell Prec. WorkSt. 530/1.8 GHz P4	1	8.3	8.2	Sep-02	55%	87%
Dell Prec. WorkSt. 340/1.8 GHz P4	1	8.2	7.5	Sep-02	55%	80%
Dell PowerEdge 7150 Itanium/800 4MB L3	1	8.2	-	Jun-01	54%	-
HP SERVER RX4610 Itanium/800 4MB L3	1	8.1	-	May-01	54%	-
Dell PowerEdge 6650/2.0 GHz Xeon MP	1	8.1	9.8	Oct-02	54%	104%
Dell PowerEdge 4600/2.0 GHz P4 Xeon	1	8.0	8.1	Jan-02	53%	87%
Compaq AlphaServer ES40 Model 6/833*	1	7.6	6.3	Oct-00	51%	67%
AMD Asus A7M266-D MP2400+ / 2000 MHz	1	7.6	8.9	Nov-02	50%	95%
HP i2000 Itanium/800 2MB L3	1	7.6	-	May-01	50%	-
HP SERVER RX4610 Itanium/800 4MB L3*	1	7.6	-	Aug-01	50%	-
AMD MSI K7D M-L MP2600+ / 2133 MHz	1	7.5	9.1	Feb-03	50%	97%
AMD MSI K7D M-L MP2200+ / 1800 MHz	1	7.5	8.4	Aug-02	49%	90%
AMD MSI K7D M-L MP2100+ / 1733 MHz	1	7.4	8.3	Jun-02	49%	88%
Dell Prec. WorkSt. 330/1.8 GHz P4	1	7.3	-	Jul-01	48%	-
HP i2000 Itanium/733 2MB L3	1	7.2	-	May-01	48%	-
HP SERVER RX4610 Itanium/733 2MB L3	1	7.2	-	May-01	48%	-
Dell Prec. WorkSt. 330/1.7 GHz P4	1	7.0	-	May-01	46%	-
AMD Asus A7M266-D MP2000+ / 1667 MHz	1	6.9	7.7	Mar-02	46%	82%
Compaq AlphaServer DS20E Model 6/667	1	6.8	5.3	Aug-01	45%	56%
HP 9000 Model C3700 / PA8700-750	1	6.7	7.0	Apr-01	44%	75%
Dell Prec. WorkSt. 330/1.5 GHz P4	1	6.5	6.1	May-01	43%	65%
Compaq AlphaServer ES40 Model 6/667	1	6.5	5.0	Nov-00	43%	54%
ProLiant BL10e G2(1GHz,ULV PentiumM)	1	6.4	8.0	Jul-03	42%	85%
Dell Prec. WorkSt. 330/1.5 GHz P4*	1	6.4	-	Dec-00	42%	-
AMD Tyan Thunder K7 MP1800+/1533 MHz	1	6.3	7.1	Oct-01	42%	75%
HP C3650/PA8700-625	1	6.3	5.9	Dec-01	42%	63%
Dell Prec. WorkSt. 330/1.4 GHz P4	1	6.3	5.8	May-01	41%	62%
Compaq Evo Workst. W6000/1.4 GHz P4 Xeon	1	6.2	5.9	Sep-01	41%	63%
Compaq AlphaStation XP1000 Model 6/667	1	6.2	4.7	Sep-01	41%	50%
Dell Prec. WorkSt. 330/1.4 GHz P4*	1	6.2	-	Dec-00	41%	-
AMD Tyan Thunder K7 MP1600+/1400 MHz	1	6.1	6.6	Oct-01	40%	71%
HP SERVER RP7400/PA8700-750	1	6.1	6.4	Sep-01	40%	68%
HP SERVER RP5470/PA8700-750	1	6.0	6.4	Oct-01	40%	68%
AMD Tyan Thunder K7 MP1500+/1333 MHz	1	6.0	6.4	Oct-01	40%	68%
HP SERVER RP5470/PA8700-650	1	5.7	5.7	Oct-01	38%	61%
HP SERVER RP7400/PA8700-650	1	5.7	5.7	Oct-01	38%	61%
AMD Tyan Thunder K7 Motherboard, 1.2 G	1	5.6	6.0	May-01	37%	64%
Dell PowerEdge 1500SC/1.4 GHz PIII	1	5.3	7.7	Jan-02	35%	82%
Compaq AlphaServer GS80 Model 6/731	1	5.2	4.6	Mar-01	34%	49%
Compaq AlphaServer GS320 Model 6/731	1	5.2	4.6	Jun-00	34%	49%
Compaq AlphaServer GS160 Model 6/731	1	5.2	4.6	Jun-00	34%	49%
Dell PowerEdge 1500SC/1.26GHz PIII	1	5.1	7.2	Jan-02	34%	77%
HP 9000 Model B2600 / PA8600-500	1	5.1	4.7	Apr-01	34%	50%

HP 9000 model C3600 / PA8600-552	1	5.0	5.0	Oct-00	33%	53%
Compaq AlphaServer ES40 Model 6/500	1	4.9	3.6	Nov-00	32%	38%
Compaq AlphaServer DS20 Model 6/500	1	4.8	3.7	Mar-01	32%	39%
Compaq AlphaServer DS10 6/600	1	4.8	4.2	Jun-00	32%	45%
HP 9000 Model L3000 / PA8600-550	1	4.4	4.5	Dec-00	29%	48%
HP 9000 model B2000 / PA8500-400	1	4.2	3.9	Oct-00	27%	41%
Dell PowerEdge 4400/1.0 GHz PIII Xeon	1	3.7	5.2	Jan-02	24%	56%
Sun Enterprise 3500/4500 - 400 MHz	1	3.0	2.5	Oct-00	20%	26%

Table 4. Vector Whetstone-97 Benchmark.

Vector Whetstone-97 Benchmark. Total CPU times (seconds), Mflop Ratings (see text) and MWIPS Ratings

Rank	Machine	Mflop ratings (VI=1024)			Total CPU	MWIPS
		N2	N3	N8	(seconds)	
1	Pentium 4/2666 (ifc)	1966	444	1201	10.4	3532
2	HP RX5670 Madison/1500 (+)	492	3441	3069	10.6	3532
3	IBM pSeries 690Turbo/1.7	1996	475	1841	10.8	3472
4	Compaq Alpha ES45/1250	1679	815	1925	10.9	3441
5	IBM Regatta-HPC/1300	492	444	1454	11.5	3281
6	IBM pSeries 690Turbo/1.3	1996	353	1905	11.7	3260
7	Intel Tiger Madison/1500	1549	2472	1481	12.5	3014
8	Compaq Marvel EV7/1000	1340	842	1637	13.0	2894
9	Compaq Alpha ES45/1000	1343	653	1538	13.6	2778
10	IBM pSeries 630/1000	983	270	1416	15.4	2461
11	HP RX2600 Itanium2/1000	492	2294	1973	15.9	2369
12	AMD Opteron244/1800 (pgi)	1966	1251	1285	15.9	2358
13	SGI Onyx 300/R14k-600	359	399	-	16.4	2280
14	AMD MP2400+/2000 (pgi)	1966	860	1042	16.9	2209
15	Intel Tiger Madison/1200 (+)	1258	1985	1183	18.7	2006
16	SGI O300/R14k-500	631	208	-	19.6	1914
17	SGI O3800/R14k-500	624	158	-	20.2	1851
18	AMD MP2000+/1667 (pgi)	983	459	863	20.3	1814
19	Compaq Alpha ES40/833	959	547	767	21.1	1777
20	Pentium 4/2000 (ifc)	655	336	801	21.2	1772
21	AMD MP1800+/1533 (pgi)	983	765	789	21.9	1710
22	HP RX5670 Itanium2/1000	1060	1658	1164	22.2	1675
23	Intel Tiger Itanium2/1000	1060	1639	985	22.4	1670
24	Pentium 4/2666 (pgi)	1966	810	1347	22.8	1638
25	API UP2000 6/833	1006	524	369	23.4	1593
26	AMD MP2400+/2000	983	529	921	23.6	1584
27	HP ZX6000 Itanium2/900	959	1484	1488	24.1	1568
28	AMD Athlon K7/1400(pgi)	983	626	717	24.3	1541
29	SGI Octane2/R12k-400	240	310	-	24.4	1526
30	SGI O3800/R12k-400	500	122	-	24.4	1472
31	Compaq PW XP1000/667	775	324	603	26.1	1433
32	Compaq Alpha DS20E/667	806	437	613	26.3	1429
33	API UP2000 6/667	805	430	607	26.4	1411
34	SGI Troon IA64/666	575	434	559	28.0	1484
35	HP PA-9000/RP7410-875	393	551	986	28.6	1303

36	Compaq Alpha ES40/667	775	376	582	28.6	1307
37	AMD Athlon K7/1200(pgi)	983	529	526	28.9	1290
38	HP PA-9000/J6700-750	983	918	877	29.3	1275
39	AMD MP2000+/1667	983	306	757	30.0	1239
40	HP Itanium/733-2M L3	1966	1147	1534	30.7	1230
41	Pentium 4/2533 (pgi)	983	430	354	31.6	1180
42	SUN Fire 6800/900-Cu	257	1141	-	32.3	1150
43	AMD MP1800+/1533	983	626	690	32.5	1139
44	SUN Blade 2000/1056-Cu	496	492	457	32.7	1131
45	SGI O2000/R12k-400	240	311	-	32.8	1135
46	IBM Itanium/800-4M L3	959	792	432	33.0	1140
47	Compaq PW XP1000/500	576	243	461	34.8	1074
48	AMD Athlon K7/1000(pgi)	492	265	476	35.1	1055
49	Compaq Alpha DS20/500	576	326	459	35.6	1055
50	AMD Athlon K7/1400	983	430	600	35.9	1029
51	AlphaPC 264DP-500	559	239	447	36.2	1034
52	Compaq Alpha GS140	593	298	470	36.9	1008
53	Compaq Alpha ES40/500	517	289	440	37.6	985
54	Compaq XP1000 6/450	480	269	408	38.0	982
55	Compaq Alpha DS10/466	517	217	419	38.2	980
56	IBM RS/6000 44P-270	179	205	449	38.6	967
57	SUN Fire V880/900-Cu	379	398	391	39.5	938
58	HP PA-9000/J6000-552	983	655	642	39.8	939
59	Pentium 4/2000 (pgi)	655	336	279	39.8	934
60	AMD Athlon K7/850 (pgi)	492	382	386	39.9	936
61	SGI O2000/R12k-300	180	124	-	39.9	936
62	DEC Alpha 8400/6-575	610	342	514	40.3	927
63	Pentium 4/2666	983	459	373	40.7	913
64	Pentium III/1000-CM(pgi)	492	212	409	41.1	905
65	Pentium 4/2533	655	430	352	41.8	892
66	AMD Athlon K7/1200	655	444	511	42.1	887
67	SGI Octane/R12k-270	162	111	-	44.5	839
68	SGI O2 R12k/270	169	148	-	46.4	801
69	AMD Athlon K7/1000	492	382	422	47.3	790
70	Pentium III/866-CM(pgi)	393	184	329	47.4	779
71	HP PA-9000/J5000-440	492	551	493	48.0	778
72	Pentium 4/2000	655	328	279	50.5	738
73	Pentium III/800-CM(pgi)	328	170	307	51.5	719
74	SUN Blade 1000/M1750	214	224	-	52.2	716
75	AMD Athlon K7/650 (pgi)	328	174	299	53.0	694
76	HP PA-9000/C3000-400	492	492	453	53.0	705
77	Pentium 4/1500 (pgi)	492	250	207	53.5	696
78	Pentium III/1000-CM	393	212	288	53.7	694
79	DEC Alpha 8400/5-625	469	264	245	54.9	675
80	SGI O2000/R10k-250	154	115	-	55.1	679
81	SGI Onyx2 IR2/R10k-250	154	116	-	55.1	678
82	Pentium III/750-CM(pgi)	328	156	282	55.1	669
83	Pentium III/733-CM(pgi)	328	153	282	56.1	658
84	SGI Octane/R10k-250	153	96	-	56.1	665
85	Pentium III/800 (pgi)	393	168	257	56.3	650
86	Pentium 4/1400 (pgi)	492	233	192	57.5	648

87	HP PA-9000/785 C360	492	444	403	57.6	647
88	Pentium III/866-CM	393	170	295	57.9	640
89	DEC Alpha PW/600AU	458	257	266	58.1	637
90	AMD Athlon K7/850	218	320	339	58.4	632
91	HP PA-9000/N4000-440	246	115	682	59.3	628
92	DEC Alpha 1200/5-533	387	210	218	59.5	614
93	SGI Origin200/225	138	104	-	61.2	611
94	Pentium III/800	328	158	241	62.9	582
95	Pentium III/800-CM	328	158	271	63.4	584
96	Pentium III/650-CM(pgi)	281	136	244	63.6	580
97	SGI O2 R5k/300	95	76	-	66.7	558
98	Pentium III/750-CM	328	148	225	67.9	540
99	DEC Alpha 500/5-500	380	213	247	68.3	542
100	IBM RS/6000-43P	94	127	316	68.3	548
101	AMD Athlon K7/600 (pgi)	393	168	157	68.7	543
102	Pentium III/733-CM	328	142	220	69.8	524
103	AMD Athlon K7/500 (pgi)	281	94	226	76.6	483
104	Pentium 4/1500	492	246	208	76.9	486
105	Pentium III/650-CM	281	129	196	78.4	467
106	AMD Athlon K7/650	197	246	252	78.8	464
107	SGI Octane/R10k-195	120	89	147	79.5	452
108	SGI PChall-R10k/195	120	88	147	79.6	450
109	Pentium 4/1400	492	233	196	79.7	467
110	AMD Athlon K7/600	328	219	256	80.3	460
111	DEC Alpha PW/433AU	330	185	191	80.8	457
112	SUN Ultra80/450	406	256	578	81.1	459
113	SGI O2000/R10k-195	120	76	150	83.4	448
114	Pentium III/550 (pgi)	197	94	126	85.1	417
115	SGI Origin200/180	111	82	136	86.1	417
116	HP PA-9000/C240	328	287	261	87.4	428
117	SGI O2 R10k/175	111	77	191	87.5	424
118	SGI Octane/R10k-175	107	78	131	88.9	403
119	DEC Alpha 500/5-400	305	171	188	90.8	408
120	SUN HPC4500/400	361	228	514	91.5	407
121	Pentium III/550	197	90	109	96.6	362
122	AMD Athlon K7/500	281	110	217	97.2	379
123	HP PA-9000/V2250	123	63	371	107.1	375
124	DEC Alpha 8400/5-300	229	129	175	111.4	343
125	HP PA-9000/C200	109	113	708	112.0	337
126	SGI O2 R5k/180	50	60	-	112.6	331
127	IBM RS/6000-397	98	138	115	113.9	326
128	SUN HPC4500/336	40	40	360	115.8	321
129	ProLiant PII/450	164	73	95	116.3	303
130	DEC Alpha 600/5-333	198	53	149	117.4	313
131	Pentium II/400 (pgi)	123	65	74	125.1	276
132	HP PA-9000/C160	219	186	178	127.0	291
133	SUN Ultra30/300	35	35	80	130.9	286
134	SUN Ultra-2/300	35	35	317	131.7	282
135	Pentium II/400 (abs)	86	51	70	132.7	271
136	Pentium III/500	86	49	33	158.9	226
137	Pentium II/300 (abs)	61	39	49	174.8	201

138	Pentium II/450	82	49	27	175.6	201
139	Pentium II/266 (pgi)	86	42	51	179.4	189
140	Pentium II/266 (abs)	56	34	46	199.7	180
141	Pentium II/400	63	38	24	201.8	175
142	Pentium II/300	53	34	19	282.4	127
143	Pentium II/266	47	30	22	290.9	126
144	Dell Optiplex/266	44	27	19	328.7	111
145	HP PA-9000/755	36	44	31	356.3	105
146	SGI Indigo2 R4400/250	55	33	23	380.2	95
147	Pentium 233 MMX	33	24	12	397.8	84
148	Pentium Pro/200	25	18	16	416.8	90
	MPP nodes					
1	IBM RS/6000-SP/375	197	202	449	38.5	970
2	IBM RS/6000-SP/222	109	123	266	63.8	585
3	Cray T3E/1200	193	173	475	77.1	485
4	IBM SP2/160Thin	131	156	341	101.1	370
5	Cray T3E/900	145	130	357	102.6	364
6	HP PA-9000/V2200	109	52	154	136.2	273
7	IBM SP2/120Thin	140	148	120	152.1	328
8	IBM SP2/77Wide	55	61	49	277.6	135
	Vector Supercomputers					
1	NEC SX-5	3932	4587	6905	5.7	12997
2	FUJITSU VPP-300	1175	1023	1158	18.9	3311

(+) Prototype, pre-release System

Table 5. The Matrix-97 Benchmark - Sparse MMO.

The Matrix-97 Benchmark - Sparse MMO.
Total CPU times(seconds) for a Series of
Sparse MMOs (R = A X B, see text)
Implemented in Fortran.

Rank	Machine	Sparsity in B-Matrix	
		0% (secs.)	50% (secs.)
1	IBM pSeries 690Turbo/1.7	1.0	0.5
2	HP RX5670 Madison/1500 (+)	1.3	0.6
3	IBM Regatta-HPC/1300	1.3	0.6
4	IBM pSeries 690Turbo/1.3	1.4	0.6
5	Intel Tiger Madison/1500	1.5	0.8
6	IBM pSeries 630/1000	1.8	0.9
7	HP RX2600 Itanium2/1000	1.9	0.9
8	Intel Tiger Madison/1200 (+)	1.9	1.0
9	HP RX5670 Itanium2/1000	2.3	1.2
10	Intel Tiger Itanium2/1000	2.3	1.2
11	Compaq Alpha ES45/1250	2.9	1.5
12	AMD Opteron244/1800 (pgi)	3.2	1.5
13	HP ZX6000 Itanium2/900	3.4	1.4
14	IBM RS/6000 44P-270	3.5	1.8
15	HP PA-9000/J6700-750	3.5	1.2

16	Pentium 4/2666 (ifc)	3.6	1.5
17	Compaq Alpha ES45/1000	3.6	1.8
18	SGI Onyx 300/R14k-600	3.7	1.9
19	Compaq Marvel EV7/1000	3.8	1.6
20	HP PA-9000/RP7410-875	3.9	1.1
21	Pentium 4/2666 (pgi)	3.9	1.6
22	Compaq Alpha ES40/833	4.0	2.1
23	SGI O300/R14k-500	4.1	2.5
24	Pentium 4/2666	4.5	1.8
25	IBM Itanium/800-4M L3	4.6	2.0
26	Compaq Alpha ES40/667	4.9	2.6
27	Compaq Alpha DS20E/667	4.9	2.6
28	SGI O3800/R14k-500	5.0	2.7
29	Pentium 4/2533 (pgi)	5.0	2.2
30	SGI O2000/R12k-400	5.1	2.7
31	SUN Blade 2000/1056-Cu	5.2	2.6
32	Pentium 4/2000 (ifc)	5.2	2.2
33	Pentium 4/2533	5.4	2.3
34	HP Itanium/733-2M L3	5.4	2.2
35	Compaq PW XP1000/667	5.5	3.0
36	SGI Octane2/R12k-400	5.8	2.9
37	Pentium 4/1500 (pgi)	5.8	2.3
38	SGI O3800/R12k-400	5.9	3.1
39	SUN Fire V880/900-Cu	5.9	3.0
40	Pentium 4/1400 (pgi)	6.0	2.3
41	IBM RS/6000-43P	6.1	3.2
42	Pentium 4/2000 (pgi)	6.1	2.4
43	SUN Blade 1000/M1750	6.2	3.2
44	HP PA-9000/J6000-552	6.6	2.0
45	Pentium 4/2000	6.7	2.5
46	Pentium 4/1500	6.9	2.8
47	Compaq Alpha DS20/500	7.0	3.8
48	Compaq Alpha GS140	7.1	3.9
49	DEC Alpha 8400/6-575	7.1	3.8
50	Compaq PW XP1000/500	7.2	3.9
51	SGI O2000/R12k-300	7.3	3.9
52	API UP2000 6/833	7.5	3.2
53	AMD MP2400+/2000	7.7	3.8
54	AMD MP1800+/1533 (pgi)	7.7	3.9
55	Pentium 4/1400	7.7	3.0
56	Compaq Alpha ES40/500	7.7	4.1
57	AMD MP1800+/1533	7.9	3.9
58	HP PA-9000/J5000-440	7.9	3.3
59	AMD MP2400+/2000 (pgi)	8.3	3.9
60	Compaq XP1000 6/450	8.4	4.4
61	HP PA-9000/C3000-400	8.4	2.9
62	SGI Octane/R12k-270	8.6	4.6
63	AMD MP2000+/1667 (pgi)	8.6	4.1
64	AMD MP2000+/1667	8.7	4.1
65	HP PA-9000/C240	9.1	5.0
66	HP PA-9000/N4000-440	9.3	3.4

67	SGI Onyx2 IR2/R10k-250	9.4	5.0
68	API UP2000 6/667	9.5	4.2
69	SUN Fire 6800/900-Cu	9.7	4.9
70	SGI O2000/R10k-250	10.1	5.2
71	SGI Origin200/225	10.8	5.7
72	HP PA-9000/V2250	11.8	6.8
73	IBM RS/6000-397	11.9	6.3
74	AlphaPC 264DP-500	12.5	5.6
75	Compaq Alpha DS10/466	12.8	5.8
76	SGI Troon IA64/666	13.5	4.9
77	SGI O2000/R10k-195	13.7	7.4
78	AMD Athlon K7/1200(pgi)	14.4	7.2
79	DEC Alpha 8400/5-625	15.1	8.0
80	AMD Athlon K7/1400(pgi)	15.1	6.8
81	DEC Alpha 1200/5-533	15.2	7.9
82	DEC Alpha PW/600AU	15.7	8.2
83	AMD Athlon K7/1200	16.4	7.2
84	AMD Athlon K7/1400	16.5	6.4
85	HP PA-9000/785 C360	16.9	5.7
86	HP PA-9000/C200	17.4	8.5
87	AMD Athlon K7/850 (pgi)	17.5	7.7
88	SUN Ultra80/450	17.6	9.0
89	DEC Alpha 500/5-500	18.5	9.9
90	SGI Octane/R10k-250	18.5	6.8
91	AMD Athlon K7/850	18.9	8.3
92	Pentium III/733-CM(pgi)	19.5	8.1
93	SGI Octane/R10k-195	19.5	7.6
94	SUN HPC4500/400	19.6	10.0
95	Pentium III/1000-CM(pgi)	19.7	9.0
96	SUN HPC4500/336	20.4	10.4
97	SGI Origin200/180	21.2	8.2
98	AMD Athlon K7/650 (pgi)	21.2	8.8
99	Pentium III/733-CM	21.6	9.5
100	SGI Octane/R10k-175	21.8	8.6
101	HP PA-9000/C160	21.9	10.2
102	Pentium III/800-CM(pgi)	22.2	10.3
103	Pentium III/1000-CM	22.3	10.1
104	AMD Athlon K7/600	22.6	9.8
105	AMD Athlon K7/600 (pgi)	22.6	10.0
106	AMD Athlon K7/1000(pgi)	22.6	9.7
107	Pentium III/866-CM(pgi)	22.9	9.8
108	Pentium III/750-CM(pgi)	23.4	10.7
109	AMD Athlon K7/1000	24.2	9.8
110	AMD Athlon K7/500 (pgi)	24.2	10.6
111	AMD Athlon K7/650	24.4	10.0
112	AMD Athlon K7/500	24.8	10.6
113	Pentium III/650-CM(pgi)	25.1	11.5
114	Pentium III/800 (pgi)	25.4	10.9
115	Pentium III/800	25.4	11.3
116	Pentium III/800-CM	25.4	12.4
117	Pentium III/550 (pgi)	25.6	11.1

118	DEC Alpha 8400/5-300	26.9	14.1
119	DEC Alpha PW/433AU	27.0	12.3
120	DEC Alpha 600/5-333	27.1	14.1
121	Pentium III/750-CM	27.4	12.7
122	Pentium III/550	27.5	11.9
123	Pentium III/866-CM	27.5	12.2
124	SUN Ultra-2/300	28.7	12.9
125	Pentium III/500	28.8	12.9
126	SUN Ultra30/300	29.2	13.4
127	Pentium III/650-CM	29.2	13.4
128	ProLiant PII/450	30.3	11.9
129	DEC Alpha 500/5-400	30.4	13.8
130	Pentium II/400 (pgi)	31.2	14.2
131	Pentium II/450	31.7	13.8
132	Pentium II/400	32.5	14.9
133	SGI PChall-R10k/195	35.2	12.7
134	Pentium II/400 (abs)	40.3	18.1
135	Pentium II/300	49.1	21.0
136	Pentium II/300 (abs)	51.8	21.7
137	SGI O2 R12k/270	52.6	13.4
138	Pentium II/266	60.7	25.5
139	Dell Optiplex/266	62.1	26.3
140	SGI Indigo2 R4400/250	65.0	32.4
141	Pentium II/266 (abs)	68.5	29.8
142	SGI O2 R5k/300	72.4	28.1
143	Pentium II/266 (pgi)	74.2	32.6
144	SGI O2 R10k/175	74.6	19.2
145	Pentium Pro/200	86.0	41.6
146	Pentium 233 MMX	93.4	44.5
147	SGI O2 R5k/180	104.7	46.6
148	HP PA-9000/755	122.2	55.6
	MPP nodes		
1	IBM RS/6000-SP/375	3.3	1.7
2	IBM RS/6000-SP/222	6.9	3.5
3	HP PA-9000/V2200	9.7	5.3
4	IBM SP2/160Thin	11.6	6.3
5	Cray T3E/1200	14.6	7.5
6	IBM SP2/120Thin	15.1	7.9
7	Cray T3E/900	16.3	8.3
8	IBM SP2/77Wide	30.0	15.8
	Vector Supercomputers		
1	NEC SX-5	0.6	0.5
2	FUJITSU VPP-300	3.7	2.5

(+) Prototype, pre-release System

Table 6. The Matrix-97 Benchmark - Similarity Transformation.

The Matrix-97 Benchmark - Sparse MMO.

Total CPU times(seconds) for a Series of Similarity Transformations (H=Q*HQ, see text) Using Both Scalar and Vector Algorithms.

Rank	Machine	Algorithm	
		Scalar (secs.)	Vector (secs.)
1	Intel Tiger Madison/1500	19.4	5.4
2	HP RX5670 Madison/1500 (+)	9.6	5.5
3	Intel Tiger Madison/1200 (+)	22.2	7.0
4	IBM pSeries 690Turbo/1.7	16.9	7.7
5	HP RX2600 Itanium2/1000	14.4	8.0
6	Intel Tiger Itanium2/1000	26.7	8.3
7	HP RX5670 Itanium2/1000	26.5	9.4
8	IBM Regatta-HPC/1300	18.1	10.0
9	IBM pSeries 690Turbo/1.3	22.3	10.2
10	HP PA-9000/RP7410-875	23.9	11.2
11	HP PA-9000/J6700-750	27.9	12.2
12	HP ZX6000 Itanium2/900	29.6	13.1
13	Pentium 4/2666 (ifc)	27.0	13.3
14	IBM pSeries 630/1000	29.4	13.5
15	HP Itanium/733-2M L3	34.6	13.7
16	Compaq Alpha ES45/1250	20.9	14.2
17	AMD Opteron244/1800 (pgi)	20.5	15.9
18	Pentium 4/2666	31.3	16.0
19	IBM Itanium/800-4M L3	46.2	16.0
20	Pentium 4/2666 (pgi)	24.3	16.9
21	HP PA-9000/J6000-552	37.6	17.2
22	Compaq Alpha ES45/1000	26.0	17.9
23	Pentium 4/2533 (pgi)	42.3	18.0
24	Pentium 4/2533	30.6	18.3
25	SUN Blade 2000/1056-Cu	29.3	18.9
26	Compaq Marvel EV7/1000	27.1	19.1
27	SUN Fire V880/900-Cu	33.4	20.7
28	Compaq Alpha ES40/833	36.4	20.7
29	SUN Fire 6800/900-Cu	33.8	20.9
30	HP PA-9000/J5000-440	74.7	22.5
31	HP PA-9000/N4000-440	86.0	22.8
32	API UP2000 6/833	45.3	23.4
33	SUN Blade 1000/M1750	62.3	25.4
34	Compaq Alpha DS20E/667	45.4	25.7
35	SGI Onyx 300/R14k-600	45.8	26.3
36	Pentium 4/2000 (ifc)	48.5	26.9
37	SGI Troon IA64/666	39.8	28.9
38	IBM RS/6000 44P-270	43.6	26.9
39	AMD MP2400+/2000	98.2	30.9
40	API UP2000 6/667	49.2	31.0
41	AMD MP2400+/2000 (pgi)	89.7	31.7
42	Pentium 4/2000	53.3	32.1
43	Pentium 4/1500	52.7	32.6
44	Pentium 4/1500 (pgi)	71.5	32.8
45	AMD MP1800+/1533	101.2	32.9

46	Pentium 4/2000 (pgi)	64.4	33.0
47	AMD MP1800+/1533 (pgi)	96.7	33.0
48	SGI O3800/R14k-500	59.3	33.0
49	SGI O300/R14k-500	58.1	34.0
50	AMD MP2000+/1667	104.7	34.1
51	Compaq PW XP1000/667	47.9	34.3
52	AMD MP2000+/1667 (pgi)	95.2	34.3
53	Compaq Alpha DS20/500	61.7	36.1
54	Pentium 4/1400 (pgi)	76.2	36.8
55	Pentium 4/1400	63.2	38.5
56	Compaq Alpha ES40/667	48.0	38.6
57	AMD Athlon K7/1400	139.4	38.7
58	SGI O3800/R12k-400	69.7	39.0
59	AMD Athlon K7/1400(pgi)	116.8	39.2
60	SGI Octane2/R12k-400	68.5	39.7
61	HP PA-9000/C3000-400	52.7	39.9
62	AMD Athlon K7/1200(pgi)	113.6	40.6
63	SUN Ultra80/450	76.7	40.8
64	AMD Athlon K7/1200	124.9	41.2
65	HP PA-9000/V2250	115.7	42.2
66	SGI O2000/R12k-400	66.2	43.7
67	DEC Alpha 8400/6-575	56.6	44.9
68	SUN HPC4500/400	83.3	46.7
69	IBM RS/6000-43P	82.9	48.2
70	SUN HPC4500/336	99.8	51.1
71	HP PA-9000/785 C360	68.4	51.4
72	Compaq XP1000 6/450	72.4	52.8
73	Compaq Alpha GS140	60.9	54.6
74	AlphaPC 264DP-500	67.9	54.7
75	Compaq Alpha ES40/500	62.3	54.8
76	Compaq PW XP1000/500	63.7	57.3
77	SGI O2000/R12k-300	88.0	58.6
78	AMD Athlon K7/1000	160.1	59.1
79	AMD Athlon K7/1000(pgi)	148.1	61.0
80	AMD Athlon K7/850 (pgi)	155.6	62.6
81	SUN Ultra-2/300	129.6	64.2
82	IBM RS/6000-397	89.0	64.7
83	Compaq Alpha DS10/466	74.6	65.6
84	SGI Octane/R12k-270	100.0	66.1
85	AMD Athlon K7/850	134.7	66.6
86	Pentium III/1000-CM(pgi)	167.5	66.7
87	Pentium III/1000-CM	170.0	67.1
88	HP PA-9000/C240	103.9	67.3
89	AMD Athlon K7/650 (pgi)	201.5	71.8
90	DEC Alpha 1200/5-533	184.4	73.7
91	DEC Alpha 8400/5-625	101.9	73.9
92	Pentium III/733-CM(pgi)	202.9	74.1
93	Pentium III/800-CM(pgi)	173.8	75.2
94	SGI Onyx2 IR2/R10k-250	108.7	75.5
95	DEC Alpha PW/600AU	104.8	75.9
96	AMD Athlon K7/650	161.0	78.3

97	Pentium III/866-CM	193.5	78.6
98	SGI O2000/R10k-250	123.6	78.8
99	AMD Athlon K7/600	163.5	79.7
100	Pentium III/750-CM(pgi)	218.4	81.2
101	Pentium III/866-CM(pgi)	176.5	81.7
102	Pentium III/800-CM	170.6	81.7
103	Pentium III/733-CM	204.1	82.9
104	HP PA-9000/C200	151.1	82.9
105	SGI Origin200/225	121.3	83.7
106	Pentium III/750-CM	243.4	84.9
107	SGI Octane/R10k-250	118.7	85.6
108	SGI O2000/R10k-195	149.8	87.2
109	Pentium III/650-CM	247.9	91.1
110	SUN Ultra30/300	153.7	91.5
111	SGI O2 R12k/270	140.5	91.9
112	AMD Athlon K7/500	185.2	91.9
113	Pentium III/550	186.3	92.0
114	DEC Alpha PW/433AU	143.9	92.0
115	SGI Octane/R10k-195	156.3	92.7
116	ProLiant PII/450	186.9	92.8
117	Pentium III/550 (pgi)	285.1	93.2
118	AMD Athlon K7/500 (pgi)	248.2	93.3
119	AMD Athlon K7/600 (pgi)	235.1	94.1
120	Pentium III/800	223.8	94.7
121	Pentium III/650-CM(pgi)	232.6	98.4
122	Pentium III/800 (pgi)	308.6	98.9
123	SGI Origin200/180	169.3	100.6
124	SGI PChall-R10k/195	165.1	103.2
125	SGI Octane/R10k-175	176.1	104.2
126	DEC Alpha 500/5-400	151.0	105.7
127	HP PA-9000/C160	186.0	107.4
128	DEC Alpha 500/5-500	125.2	107.4
129	Pentium III/500	292.5	108.1
130	DEC Alpha 600/5-333	226.2	113.1
131	DEC Alpha 8400/5-300	181.0	113.4
132	Pentium II/450	314.3	116.9
133	Pentium II/400	365.6	130.3
134	SGI O2 R10k/175	201.8	131.5
135	Pentium II/400 (pgi)	392.9	132.0
136	Pentium II/400 (abs)	279.4	132.0
137	Pentium II/300	485.5	184.1
138	Pentium II/300 (abs)	354.3	194.2
139	Pentium II/266	516.4	203.2
140	Pentium II/266 (abs)	414.1	208.0
141	Pentium II/266 (pgi)	561.2	211.6
142	SGI O2 R5k/300	441.9	338.2
143	Dell Optiplex/266	523.6	442.0
144	HP PA-9000/755	892.3	469.5
145	SGI O2 R5k/180	651.0	498.5
146	Pentium Pro/200	1002.7	590.2
147	Pentium 233 MMX	782.7	844.4

	MPP nodes		
1	IBM RS/6000-SP/375	43.5	26.1
2	HP PA-9000/V2200	158.3	44.1
3	IBM RS/6000-SP/222	75.8	49.4
4	IBM SP2/160Thin	103.2	64.9
5	IBM SP2/120Thin	114.2	84.3
6	Cray T3E/1200	178.9	86.4
7	Cray T3E/900	187.9	94.7
8	IBM SP2/77Wide	231.0	164.7
	Vector Supercomputers		
1	NEC SX-5	61.4	4.5
2	FUJITSU VPP-300	115.1	41.6

(+) Prototype, pre-release System

Table 7. The Matrix-97 Benchmark - Diagonalization.

The Matrix-97 Benchmark - Diagonalization. Total CPU times (seconds) for a Series of Matrix Diagonalizations (see text) Using Eight Different Routines.

Rank	Machine	CPU Time (seconds)	CPU Time (-JACO)	Compiler Options
1	HP RX5670 Madison/1500 (+)	6.6	2.5	+Ofaster +O3 +DSitanium2
2	IBM pSeries 690Turbo/1.7	6.6	3.5	-O4 -qipa=level=2:noobject
3	Intel Tiger Madison/1500	8.5	4.3	-O3 -ipo -tpp2 -fno-alias
4	IBM pSeries 690Turbo/1.3	8.7	4.6	-O4 -qipa=level=2:noobject
5	IBM Regatta-HPC/1300	8.9	4.7	-O4 -qarch=auto
6	AMD Opteron244/1800 (pgi)	9.6	5.3	-fastsse
7	Pentium 4/2666 (ifc)	9.7	5.1	-O3 -ipo -tpp7 -fno-alias
8	Compaq Alpha ES45/1250	9.8	4.5	-fast -arch ev68
9	HP PA-9000/RP7410-875	10.0	4.2	+O3 +Oaggressive +DA2.0
10	HP RX2600 Itanium2/1000	10.2	3.9	+Ofaster +O3 +DSitanium2
11	Compaq Marvel EV7/1000	10.3	5.1	-fast -arch ev68
12	Intel Tiger Madison/1200 (+)	10.7	5.4	-O3 -ipo -w -tpp2
13	Pentium 4/2666 (pgi)	10.9	5.8	-fast -Mdalign
14	IBM pSeries 630/1000	11.5	6.2	-O4 -qipa=level=2:noobject
15	HP PA-9000/J6700-750	11.8	4.9	+O3 +Oaggressive +DA2.0
16	Compaq Alpha ES45/1000	11.9	5.5	-fast -arch ev68
17	Pentium 4/2533 (pgi)	12.0	6.3	-fast -Mdalign
18	Pentium 4/2666	12.4	6.2	-O3 -malign-double
19	HP RX5670 Itanium2/1000	12.4	6.1	-O3 -ipo -tpp2
20	Intel Tiger Itanium2/1000	12.8	6.5	-O3 -ipo -tpp2
21	Pentium 4/2533	13.0	6.2	-O3 -malign-double
22	Compaq Alpha ES40/833	13.8	6.6	-fast -arch ev67
23	HP ZX6000 Itanium2/900	14.1	6.9	-O3 -ipo -tpp2
24	HP PA-9000/J6000-552	16.1	6.7	+O3 +Oaggressive +DA2.0
25	Compaq Alpha DS20E/667	17.3	8.3	-fast -arch ev67
26	Compaq Alpha ES40/667	17.4	8.5	-fast -arch EV6
27	API UP2000 6/833	17.8	8.6	-fast -arch ev67 -tune ev67

28	Pentium 4/2000 (ifc)	17.9	8.7	-O3 -ipo ifpp -tpp7
29	SGI Onyx 300/R14k-600	19.0	9.8	-Ofast=ip35 -LNO:fusion=2
30	AMD MP2400+/2000 (pgi)	19.4	10.3	-fast -Mdalign
31	Pentium 4/2000 (pgi)	20.1	9.8	-fast -Mdalign
32	HP PA-9000/N4000-440	20.3	8.6	+O3 +DA2.0
33	AMD MP2400+/2000	20.4	10.6	-O3 -malign-double
34	Pentium 4/2000	20.6	9.4	-O3 -malign-double
35	HP PA-9000/J5000-440	20.7	9.1	+O3 +Oaggressive +DA2.0
36	Pentium 4/1500 (pgi)	21.0	10.5	-fast -Mdalign
37	Compaq PW XP1000/667	21.1	10.2	-fast -arch ev6
38	AMD MP2000+/1667 (pgi)	21.6	11.7	-fast -Mdalign
39	SUN Blade 2000/1056-Cu	21.7	9.8	-fast -xarch=v8plusb -xchip=ultra3
40	HP Itanium/733-2M L3	21.9	8.9	+Ofast +DSitanium
41	AMD MP1800+/1533 (pgi)	22.1	11.8	-fast -Mdalign
42	API UP2000 6/667	22.2	10.5	-fast -arch ev67 -tune ev67
43	SGI O300/R14k-500	22.2	11.2	-Ofast=ip35 -LNO:fusion=2
44	AMD MP2000+/1667	22.2	11.6	-O3 -malign-double
45	Pentium 4/1400 (pgi)	22.4	11.1	-fast -Mdalign
46	HP PA-9000/C3000-400	22.5	9.8	+O3 +Oaggressive +DA2.0
47	SGI O3800/R14k-500	22.7	11.4	-Ofast=ip35 -LNO:fusion=2
48	Pentium 4/1500	23.1	10.7	-O3 -malign-double
49	AMD MP1800+/1533	23.4	12.0	-O3 -malign-double
50	IBM RS/6000 44P-270	23.7	10.7	-O3 -qhot
51	IBM Itanium/800-4M L3	24.5	12.6	-O2 -ipo
52	SUN Fire V880/900-Cu	24.6	11.5	-fast -xarch=v8plusb -xchip=ultra3
53	Pentium 4/1400	24.7	11.2	-O3 -malign-double
54	Compaq Alpha DS20/500	24.9	11.7	-fast -arch ev6
55	SUN Fire 6800/900-Cu	25.7	12.6	-fast -xarch=v8plusb -xchip=ultra3
56	Compaq Alpha GS140	26.1	12.6	-fast -arch ev6
57	SGI Octane2/R12k-400	26.9	13.8	-Ofast=ip30 -LNO:fusion=2
58	DEC Alpha 8400/6-575	27.1	12.4	-fast
59	SGI O2000/R12k-400	27.1	14.3	-Ofast=ip27 -LNO:fusion=2
60	Compaq Alpha ES40/500	27.2	11.8	-fast -arch ev6
61	AMD Athlon K7/1400(pgi)	27.5	15.2	-fast -Mdalign
62	HP PA-9000/785 C360	27.5	11.8	+O3 +Oaggressive +DA2.0
63	SGI O3800/R12k-400	27.6	14.1	-Ofast=ip35 -LNO:fusion=2
64	AlphaPC 264DP-500	27.9	12.3	-arch host -tune ev6 -O5
65	Compaq PW XP1000/500	28.0	13.3	-fast -arch EV6
66	AMD Athlon K7/1400	28.5	15.2	-O3 -malign-double
67	Compaq XP1000 6/450	28.9	13.4	-fast -arch ev6
68	AMD Athlon K7/1200(pgi)	29.4	16.0	-fast -Mdalign
69	SUN Blade 1000/M1750	30.3	14.5	-fast -xarch=v9 -xchip=ultra2 -xO5
70	AMD Athlon K7/1200	30.7	16.1	-O3 -malign-double
71	Compaq Alpha DS10/466	31.2	15.3	-fast -arch ev6
72	SGI O2000/R12k-300	35.1	17.8	-Ofast=ip27 -LNO:fusion=2
73	SUN Ultra80/450	37.9	19.2	-fast -O5 -xsafe=mem -fsimple=2
74	Pentium III/1000-CM(pgi)	38.0	21.3	-fast -Mdalign
75	AMD Athlon K7/1000(pgi)	38.4	20.8	-fast -Mdalign
76	AMD Athlon K7/850 (pgi)	38.6	20.1	-O -Mdalign
77	SGI Octane/R12k-270	39.0	19.8	-Ofast=ip27 -LNO:fusion=2
78	AMD Athlon K7/1000	39.2	21.2	-O3 -malign-double

79	HP PA-9000/C240	39.7	18.2	+O2 +Oaggressive
80	Pentium III/866-CM(pgi)	40.7	23.6	-fast -Mdalign
81	Pentium III/1000-CM	40.8	22.2	-O3 -malign-double
82	HP PA-9000/V2250	40.9	18.9	+O3 +DA2.0
83	IBM RS/6000-43P	40.9	18.3	-O3 -qnosave -qalias=noaryovrlp -qarch=p
84	SGI O2000/R10k-250	41.1	20.4	-Ofast=ip27 -LNO:fusion=2
85	AMD Athlon K7/850	41.2	20.7	-O3 -malign-double
86	SGI Onyx2 IR2/R10k-250	41.4	20.7	-Ofast=ip27 -LNO:fusion=2
87	SUN HPC4500/400	41.6	21.6	-fast -O5 -xsafe=mem -fsimple=2
88	Pentium III/866-CM	43.0	23.2	-O3 -malign-double
89	Pentium III/733-CM(pgi)	43.8	24.8	-fast -Mdalign
90	AMD Athlon K7/650 (pgi)	45.5	24.2	-O -Mdalign
91	SGI Origin200/225	45.7	22.6	-Ofast=ip27 -LNO:fusion=2
92	DEC Alpha 8400/5-625	45.8	21.8	-fast
93	AMD Athlon K7/600	46.0	22.2	-O3 -malign-double
94	DEC Alpha PW/600AU	46.6	22.3	-fast
95	Pentium III/733-CM	46.9	25.1	-O3 -malign-double
96	SUN HPC4500/336	47.5	24.7	-fast -X05 -fsimple=2
97	HP PA-9000/C200	47.8	22.0	+Oall +Oaggressive
98	Pentium III/750-CM(pgi)	47.8	27.3	-fast -Mdalign
99	Pentium III/800-CM(pgi)	48.3	27.0	-fast -Mdalign
100	SGI Octane/R10k-250	48.6	24.5	-Ofast=ip27 -LNO:fusion=2
101	DEC Alpha 1200/5-533	50.0	23.1	-fast
102	AMD Athlon K7/650	50.1	24.1	-O3 -malign-double
103	SGI O2 R12k/270	51.0	26.1	-Ofast=ip32_10k -LNO:fusion=2
104	Pentium III/800-CM	51.6	27.6	-O3 -malign-double
105	Pentium III/650-CM(pgi)	51.7	29.7	-fast -Mdalign
106	Pentium III/750-CM	53.0	28.8	-O3 -malign-double
107	AMD Athlon K7/500 (pgi)	54.2	28.5	-O -Mdalign
108	AMD Athlon K7/500	54.5	25.6	-O3 -malign-double
109	Pentium III/800 (pgi)	54.8	31.3	-O -Mdalign
110	Pentium III/800	55.7	30.0	-O3 -malign-double
111	AMD Athlon K7/600 (pgi)	55.7	28.3	-O -Mdalign
112	SUN Ultra-2/300	56.4	29.8	-fast -O4
113	Pentium III/650-CM	57.2	30.7	-O3 -malign-double
114	Pentium III/550 (pgi)	58.2	34.1	-O -Mdalign
115	SGI O2000/R10k-195	59.3	30.2	-O3 -mips4 etc
116	SGI Octane/R10k-195	60.1	30.8	-O3 -mips4 etc
117	Pentium III/550	60.2	32.7	-O3 -malign-double
118	DEC Alpha 500/5-500	60.8	31.1	-fast
119	SGI PChall-R10k/195	61.4	31.5	-O3 -mips4
120	DEC Alpha PW/433AU	61.5	28.5	-fast
121	SGI Troon IA64/666	61.9	41.5	-O3
122	ProLiant PII/450	62.1	33.3	-O3 -malign-double
123	SUN Ultra30/300	62.7	34.4	-fast -X05 -fsimple=2
124	SGI Origin200/180	65.0	33.3	-O3 -mips4 etc
125	HP PA-9000/C160	65.2	31.6	+Oall +Oaggressive
126	DEC Alpha 500/5-400	66.8	31.6	-fast
127	SGI Octane/R10k-175	67.6	34.9	-O3 -mips4
128	SGI O2 R10k/175	72.4	37.4	-O3 -mips4
129	Pentium III/500	75.6	43.6	-O -malign-double

130	DEC Alpha 600/5-333	80.9	36.1	-fast
131	DEC Alpha 8400/5-300	82.2	37.5	-fast
132	Pentium II/400 (pgi)	83.6	49.2	-O -Mdalign
133	Pentium II/450	85.4	49.4	-O -malign-double
134	Pentium II/400 (abs)	85.6	48.3	-O -s -f -B108 -B100
135	Pentium II/400	90.9	51.6	-O -malign-double
136	IBM RS/6000-397	91.2	35.1	-O3 -qhot
137	Pentium II/300 (abs)	116.4	63.8	-O
138	Pentium II/266 (pgi)	125.1	73.2	-O -Mdalign
139	Pentium II/266 (abs)	126.0	69.9	-O -s
140	SGI O2 R5k/300	135.6	79.3	-Ofast=ip32_5k -LNO:fusion=2
141	Pentium II/266	159.3	97.4	-O -malign-double
142	Dell Optiplex/266	169.5	104.4	-O -malign-double
143	Pentium II/300	175.5	100.9	-O -malign-double
144	SGI Indigo2 R4400/250	178.8	100.9	-O2 -mips2 -sopt
145	SGI O2 R5k/180	203.6	117.9	-O3 -mips4
146	Pentium Pro/200	218.5	129.5	-G6 -O2
147	HP PA-9000/755	260.2	137.5	+O3
148	Pentium 233 MMX	338.0	209.6	-O -malign-double
	MPP nodes			
1	IBM RS/6000-SP/375	23.8	10.8	-O4 -qhot
2	IBM RS/6000-SP/222	39.1	17.8	-O3 -qnosave -qalias=noaryovrlp -qarch=p
3	HP PA-9000/V2200	45.2	19.4	+O2 +Oaggressive
4	IBM SP2/160Thin	94.1	35.7	-O3 -qhot
5	Cray T3E/1200	107.0	50.4	-O,aggress,scalar3,unroll2,inline3
6	IBM SP2/120Thin	118.1	48.1	-O3 -qhot
7	Cray T3E/900	123.5	58.7	-O,aggress,scalar3,unroll2,inline3
8	IBM SP2/77Wide	171.9	65.9	
	Vector Supercomputers			
1	NEC SX-5	63.1	29.2	-Nw -float0 -C hopt -Wf"-Nesc"
2	FUJITSU VPP-300	310.0	80.6	

(+) Prototype, pre-release System

Table 8. The Matrix-97 Benchmark: Performance Relative to the IBM pSeries 690Turbo/1.3 GHz.

The Matrix-97 Benchmark: Performance Relative to the IBM pSeries 690Turbo/1.3 GHz

Rank	Machine	MMO (FORTRAN)	QHQ transform	Diagonalisation	TOTAL (%)
1	HP RX5670 Madison/1500 (+)	106%	186%	132%	141%
2	IBM pSeries 690Turbo/1.7	137%	133%	131%	134%
3	Intel Tiger Madison/1500	90%	190%	101%	127%
4	IBM Regatta-HPC/1300	104%	102%	97%	101%
5	IBM pSeries 690Turbo/1.3	100%	100%	100%	100%
6	Intel Tiger Madison/1200 (+)	72%	147%	81%	100%
7	HP RX2600 Itanium2/1000	72%	128%	85%	95%
8	Intel Tiger Itanium2/1000	59%	123%	68%	83%
9	HP RX5670 Itanium2/1000	60%	108%	70%	79%

10	IBM pSeries 630/1000	77%	76%	75%	76%
11	HP PA-9000/RP7410-875	35%	91%	86%	71%
12	Compaq Alpha ES45/1250	47%	72%	89%	69%
13	Pentium 4/2666 (ifc)	38%	77%	89%	68%
14	AMD Opteron244/1800 (pgi)	42%	64%	91%	66%
15	HP PA-9000/J6700-750	39%	84%	73%	65%
16	HP ZX6000 Itanium2/900	40%	78%	62%	60%
17	Pentium 4/2666 (pgi)	35%	60%	79%	58%
18	Compaq Marvel EV7/1000	36%	53%	84%	58%
19	Compaq Alpha ES45/1000	38%	57%	73%	56%
20	Pentium 4/2666	30%	64%	70%	55%
21	Pentium 4/2533 (pgi)	27%	57%	72%	52%
22	Pentium 4/2533	26%	56%	67%	49%
23	Compaq Alpha ES40/833	35%	49%	63%	49%
24	HP Itanium/733-2M L3	25%	74%	39%	46%
25	HP PA-9000/J6000-552	21%	59%	54%	45%
26	IBM Itanium/800-4M L3	30%	64%	35%	43%
27	SGI Onyx 300/R14k-600	37%	39%	46%	40%
28	SUN Blade 2000/1056-Cu	26%	54%	40%	40%
29	Compaq Alpha DS20E/667	28%	40%	50%	39%
30	Pentium 4/2000 (ifc)	26%	38%	48%	38%
31	API UP2000 6/833	18%	44%	49%	37%
32	IBM RS/6000 44P-270	39%	35%	37%	37%
33	SUN Fire V880/900-Cu	23%	49%	35%	36%
34	HP PA-9000/J5000-440	17%	45%	42%	35%
35	Compaq Alpha ES40/667	28%	26%	50%	35%
36	SGI O300/R14k-500	33%	30%	39%	34%
37	HP PA-9000/N4000-440	15%	45%	43%	34%
38	SUN Fire 6800/900-Cu	14%	49%	34%	32%
39	Pentium 4/2000 (pgi)	22%	31%	43%	32%
40	SGI O3800/R14k-500	27%	31%	38%	32%
41	Compaq PW XP1000/667	25%	30%	41%	32%
42	Pentium 4/1500 (pgi)	23%	31%	41%	32%
43	Pentium 4/2000	21%	32%	42%	31%
44	AMD MP2400+/2000 (pgi)	17%	32%	45%	31%
45	AMD MP2400+/2000	18%	33%	42%	31%
46	SUN Blade 1000/M1750	22%	40%	29%	30%
47	Pentium 4/1400 (pgi)	23%	28%	39%	30%
48	Pentium 4/1500	20%	31%	37%	30%
49	AMD MP1800+/1533 (pgi)	18%	31%	39%	29%
50	API UP2000 6/667	14%	33%	39%	29%
51	AMD MP2000+/1667 (pgi)	16%	30%	40%	29%
52	AMD MP1800+/1533	17%	31%	37%	28%
53	AMD MP2000+/1667	16%	30%	39%	28%
54	Compaq Alpha DS20/500	20%	28%	35%	28%
55	SGI O2000/R12k-400	27%	23%	32%	27%
56	SGI Octane2/R12k-400	23%	26%	32%	27%
57	SGI O3800/R12k-400	23%	26%	31%	27%
58	HP PA-9000/C3000-400	16%	26%	38%	27%
59	Pentium 4/1400	18%	27%	35%	26%
60	DEC Alpha 8400/6-575	19%	23%	32%	25%

61	Compaq Alpha GS140	19%	19%	33%	24%
62	Compaq Alpha ES40/500	18%	19%	32%	23%
63	Compaq PW XP1000/500	19%	18%	31%	23%
64	AMD Athlon K7/1400(pgi)	9%	26%	32%	22%
65	Compaq XP1000 6/450	16%	19%	30%	22%
66	AMD Athlon K7/1400	8%	26%	30%	22%
67	IBM RS/6000-43P	23%	21%	21%	22%
68	AMD Athlon K7/1200(pgi)	10%	25%	29%	21%
69	AMD Athlon K7/1200	8%	25%	28%	20%
70	SGI O2000/R12k-300	19%	17%	25%	20%
71	AlphaPC 264DP-500	11%	19%	31%	20%
72	SGI Troon IA64/666	10%	35%	14%	20%
73	HP PA-9000/785 C360	8%	20%	31%	20%
74	HP PA-9000/V2250	12%	24%	21%	19%
75	SUN Ultra80/450	8%	25%	23%	19%
76	Compaq Alpha DS10/466	11%	16%	28%	18%
77	SGI Octane/R12k-270	16%	15%	22%	18%
78	HP PA-9000/C240	15%	15%	22%	17%
79	SUN HPC4500/400	7%	22%	21%	17%
80	SGI Onyx2 IR2/R10k-250	15%	14%	21%	16%
81	SGI O2000/R10k-250	14%	13%	21%	16%
82	AMD Athlon K7/850 (pgi)	8%	16%	22%	16%
83	AMD Athlon K7/1000(pgi)	6%	17%	23%	15%
84	Pentium III/1000-CM(pgi)	7%	15%	23%	15%
85	AMD Athlon K7/1000	6%	17%	22%	15%
86	SUN HPC4500/336	7%	20%	18%	15%
87	SGI Origin200/225	13%	12%	19%	15%
88	AMD Athlon K7/850	7%	15%	21%	15%
89	Pentium III/1000-CM	6%	15%	21%	14%
90	DEC Alpha 8400/5-625	9%	14%	19%	14%
91	DEC Alpha PW/600AU	9%	13%	19%	14%
92	Pentium III/733-CM(pgi)	7%	14%	20%	14%
93	DEC Alpha 1200/5-533	9%	14%	17%	13%
94	Pentium III/866-CM(pgi)	6%	13%	21%	13%
95	AMD Athlon K7/650 (pgi)	6%	14%	19%	13%
96	HP PA-9000/C200	8%	12%	18%	13%
97	Pentium III/866-CM	5%	13%	20%	13%
98	AMD Athlon K7/600	6%	13%	19%	13%
99	Pentium III/800-CM(pgi)	6%	14%	18%	13%
100	SGI Octane/R10k-250	7%	12%	18%	12%
101	Pentium III/733-CM	6%	12%	18%	12%
102	IBM RS/6000-397	12%	16%	9%	12%
103	Pentium III/750-CM(pgi)	6%	13%	18%	12%
104	SGI O2000/R10k-195	10%	12%	15%	12%
105	SUN Ultra-2/300	5%	16%	15%	12%
106	AMD Athlon K7/650	6%	13%	17%	12%
107	Pentium III/800-CM	5%	12%	17%	12%
108	Pentium III/750-CM	5%	12%	16%	11%
109	AMD Athlon K7/500 (pgi)	6%	11%	16%	11%
110	Pentium III/650-CM(pgi)	5%	10%	17%	11%
111	AMD Athlon K7/500	6%	11%	16%	11%

112	AMD Athlon K7/600 (pgi)	6%	11%	16%	11%
113	SGI Octane/R10k-195	7%	11%	14%	11%
114	Pentium III/800	5%	11%	16%	11%
115	Pentium III/800 (pgi)	5%	10%	16%	11%
116	Pentium III/550 (pgi)	5%	11%	15%	10%
117	DEC Alpha 500/5-500	7%	10%	14%	10%
118	Pentium III/650-CM	5%	11%	15%	10%
119	SGI O2 R12k/270	3%	11%	17%	10%
120	Pentium III/550	5%	11%	14%	10%
121	DEC Alpha PW/433AU	5%	11%	14%	10%
122	SGI Origin200/180	6%	10%	13%	10%
123	SUN Ultra30/300	5%	11%	14%	10%
124	ProLiant PII/450	5%	11%	14%	10%
125	HP PA-9000/C160	6%	10%	13%	10%
126	SGI Octane/R10k-175	6%	10%	13%	10%
127	SGI PChall-R10k/195	4%	10%	14%	9%
128	DEC Alpha 500/5-400	5%	10%	13%	9%
129	Pentium III/500	5%	9%	11%	9%
130	DEC Alpha 600/5-333	5%	9%	11%	8%
131	DEC Alpha 8400/5-300	5%	9%	11%	8%
132	Pentium II/450	4%	9%	10%	8%
133	Pentium II/400 (pgi)	4%	8%	10%	7%
134	Pentium II/400	4%	8%	10%	7%
135	SGI O2 R10k/175	2%	8%	12%	7%
136	Pentium II/400 (abs)	3%	8%	10%	7%
137	Pentium II/300 (abs)	3%	5%	7%	5%
138	Pentium II/266 (abs)	2%	5%	7%	5%
139	Pentium II/266 (pgi)	2%	5%	7%	5%
140	Pentium II/300	3%	6%	5%	4%
141	Pentium II/266	2%	5%	5%	4%
142	SGI O2 R5k/300	2%	3%	6%	4%
143	Dell Optiplex/266	2%	2%	5%	3%
144	SGI O2 R5k/180	1%	2%	4%	3%
145	Pentium Pro/200	2%	2%	4%	2%
146	SGI Indigo2 R4400/250	2%	0%	5%	2%
147	HP PA-9000/755	1%	2%	3%	2%
148	Pentium 233 MMX	1%	1%	3%	2%
	MPP nodes				
1	IBM RS/6000-SP/375	42%	39%	36%	39%
2	IBM RS/6000-SP/222	20%	21%	22%	21%
3	HP PA-9000/V2200	14%	23%	19%	19%
4	IBM SP2/160Thin	12%	16%	9%	12%
5	Cray T3E/1200	9%	12%	8%	10%
6	IBM SP2/120Thin	9%	12%	7%	10%
7	Cray T3E/900	8%	11%	7%	9%
8	IBM SP2/77Wide	5%	6%	5%	5%
	Vector Supercomputers				
1	NEC SX-5	225%	227%	14%	155%
2	FUJITSU VPP-300	37%	25%	3%	21%

(+) Prototype, pre-release System

Table 9. The Matrix-89 Benchmark: Performance Relative to the IBM pSeries 690Turbo/1.3 GHz.

The Matrix-89 Benchmark: Performance Relative to the IBM pSeries 690Turbo/1.3 GHz.

Rank	Machine	MMO (FORTRAN)	QHQ transform	Diagonalisation	TOTAL (%)
1	HP RX5670 Madison/1500 (+)	90%	212%	123%	142%
2	IBM pSeries 690Turbo/1.7	113%	132%	131%	125%
3	Intel Tiger Madison/1500	73%	187%	98%	119%
4	Pentium 4/2666 (ifc)	90%	97%	121%	103%
5	IBM pSeries 690Turbo/1.3	100%	100%	100%	100%
6	IBM Regatta-HPC/1300	90%	103%	100%	98%
7	Intel Tiger Madison/1200 (+)	57%	148%	80%	95%
8	HP RX2600 Itanium2/1000	60%	123%	81%	88%
9	HP PA-9000/RP7410-875	56%	109%	83%	83%
10	Pentium 4/2666 (pgi)	60%	89%	99%	82%
11	Compaq Alpha ES45/1250	49%	78%	118%	82%
12	Intel Tiger Itanium2/1000	48%	124%	66%	79%
13	Pentium 4/2533 (pgi)	60%	79%	96%	78%
14	AMD Opteron244/1800 (pgi)	47%	67%	118%	77%
15	AMD MP2400+/2000 (pgi)	39%	71%	114%	75%
16	HP RX5670 Itanium2/1000	48%	107%	69%	75%
17	IBM pSeries 630/1000	69%	79%	76%	75%
18	AMD MP2400+/2000	41%	67%	105%	71%
19	Pentium 4/2666	47%	77%	88%	71%
20	HP PA-9000/J6700-750	45%	93%	72%	70%
21	Compaq Marvel EV7/1000	42%	62%	100%	68%
22	Compaq Alpha ES45/1000	40%	64%	96%	67%
23	Pentium 4/2533	43%	65%	92%	67%
24	HP ZX6000 Itanium2/900	43%	93%	63%	66%
25	Pentium 4/2000 (ifc)	56%	55%	88%	66%
26	AMD MP2000+/1667 (pgi)	31%	59%	95%	62%
27	AMD MP2000+/1667	36%	56%	86%	59%
28	AMD MP1800+/1533 (pgi)	30%	59%	87%	59%
29	Pentium 4/2000 (pgi)	47%	45%	76%	56%
30	Compaq Alpha ES40/833	35%	54%	80%	56%
31	AMD MP1800+/1533	33%	54%	79%	55%
32	API UP2000 6/833	35%	48%	78%	53%
33	Pentium 4/2000	41%	44%	73%	53%
34	HP PA-9000/J6000-552	35%	69%	52%	52%
35	AMD Athlon K7/1400(pgi)	27%	48%	80%	52%
36	HP Itanium/733-2M L3	36%	71%	42%	50%
37	AMD Athlon K7/1400	27%	48%	72%	49%
38	Pentium 4/1500 (pgi)	38%	46%	57%	47%
39	AMD Athlon K7/1200(pgi)	24%	43%	72%	46%
40	Compaq Alpha DS20E/667	28%	43%	64%	45%
41	SGI Onyx 300/R14k-600	31%	40%	60%	44%
42	Pentium 4/1400 (pgi)	32%	43%	55%	43%
43	AMD Athlon K7/1200	24%	42%	63%	43%

44	API UP2000 6/667	27%	37%	62%	42%
45	Compaq PW XP1000/667	27%	34%	63%	41%
46	IBM RS/6000 44P-270	38%	39%	46%	41%
47	SUN Blade 2000/1056-Cu	22%	48%	52%	40%
48	IBM Itanium/800-4M L3	33%	47%	41%	40%
49	HP PA-9000/N4000-440	28%	51%	42%	40%
50	Compaq Alpha ES40/667	27%	30%	64%	40%
51	HP PA-9000/J5000-440	28%	51%	41%	40%
52	Pentium 4/1500	26%	42%	52%	40%
53	Pentium 4/1400	24%	41%	52%	39%
54	AMD Athlon K7/1000(pgi)	19%	34%	59%	37%
55	SGI O300/R14k-500	26%	32%	51%	36%
56	AMD Athlon K7/1000	17%	33%	55%	35%
57	SUN Fire V880/900-Cu	18%	42%	44%	35%
58	SGI O3800/R14k-500	23%	32%	50%	35%
59	SUN Fire 6800/900-Cu	20%	40%	45%	35%
60	Pentium III/1000-CM(pgi)	21%	27%	53%	34%
61	Compaq Alpha DS20/500	21%	31%	48%	33%
62	DEC Alpha 8400/6-575	20%	26%	49%	32%
63	HP PA-9000/C3000-400	26%	28%	38%	31%
64	AlphaPC 264DP-500	20%	24%	47%	30%
65	Compaq Alpha GS140	20%	22%	49%	30%
66	Pentium III/1000-CM	15%	28%	46%	30%
67	SGI Octane2/R12k-400	22%	27%	41%	30%
68	SUN Blade 1000/M1750	17%	35%	37%	30%
69	Compaq PW XP1000/500	21%	21%	47%	29%
70	AMD Athlon K7/850 (pgi)	15%	27%	46%	29%
71	Pentium III/866-CM(pgi)	18%	25%	45%	29%
72	SGI O2000/R12k-400	22%	24%	40%	29%
73	SGI O3800/R12k-400	19%	27%	40%	29%
74	AMD Athlon K7/850	15%	27%	45%	29%
75	Compaq Alpha ES40/500	18%	21%	43%	27%
76	HP PA-9000/785 C360	22%	25%	34%	27%
77	Compaq Alpha DS10/466	18%	19%	44%	27%
78	Pentium III/800-CM(pgi)	16%	22%	41%	26%
79	Compaq XP1000 6/450	16%	22%	39%	26%
80	Pentium III/866-CM	14%	23%	40%	25%
81	Pentium III/800 (pgi)	16%	21%	38%	25%
82	Pentium III/750-CM(pgi)	16%	21%	38%	25%
83	Pentium III/733-CM(pgi)	15%	22%	37%	25%
84	Pentium III/800-CM	13%	21%	36%	23%
85	AMD Athlon K7/650 (pgi)	12%	22%	35%	23%
86	AMD Athlon K7/650	11%	23%	36%	23%
87	Pentium III/800	13%	18%	36%	22%
88	SGI Troon IA64/666	16%	34%	16%	22%
89	Pentium III/733-CM	12%	20%	33%	22%
90	Pentium III/750-CM	12%	19%	34%	22%
91	Pentium III/650-CM(pgi)	14%	18%	33%	22%
92	HP PA-9000/V2250	15%	26%	23%	21%
93	SGI O2000/R12k-300	16%	18%	31%	21%
94	AMD Athlon K7/600	12%	18%	32%	21%

95	IBM RS/6000-43P	13%	22%	26%	20%
96	AMD Athlon K7/600 (pgi)	10%	17%	31%	19%
97	Pentium III/650-CM	10%	18%	29%	19%
98	SGI Octane/R12k-270	14%	16%	27%	19%
99	SUN Ultra80/450	7%	24%	25%	19%
100	SGI O2 R12k/270	14%	15%	26%	18%
101	DEC Alpha 8400/5-625	9%	18%	27%	18%
102	HP PA-9000/C240	14%	16%	22%	18%
103	DEC Alpha PW/600AU	9%	18%	26%	17%
104	AMD Athlon K7/500	10%	15%	27%	17%
105	DEC Alpha 1200/5-533	10%	19%	23%	17%
106	AMD Athlon K7/500 (pgi)	9%	16%	27%	17%
107	SGI Onyx2 IR2/R10k-250	12%	14%	25%	17%
108	SUN HPC4500/400	6%	21%	23%	17%
109	SGI O2000/R10k-250	12%	14%	25%	17%
110	SGI Octane/R10k-250	11%	13%	23%	16%
111	Pentium III/550 (pgi)	10%	14%	24%	16%
112	IBM RS/6000-397	12%	19%	16%	16%
113	SUN HPC4500/336	6%	20%	21%	16%
114	HP PA-9000/C200	13%	14%	19%	15%
115	SGI Origin200/225	11%	13%	22%	15%
116	Pentium III/550	8%	14%	23%	15%
117	SUN Ultra-2/300	5%	17%	18%	13%
118	SUN Ultra30/300	5%	17%	18%	13%
119	DEC Alpha PW/433AU	7%	14%	19%	13%
120	IBM RS/6000-595	10%	16%	13%	13%
121	DEC Alpha 500/5-500	7%	12%	19%	13%
122	SGI O2000/R10k-195	8%	12%	18%	13%
123	SGI Octane/R10k-195	8%	12%	18%	13%
124	ProLiant PII/450	7%	12%	19%	13%
125	SGI PChall-R10k/195	8%	11%	17%	12%
126	DEC Alpha 500/5-400	6%	13%	17%	12%
127	SGI Origin200/180	7%	11%	17%	12%
128	Pentium III/500	6%	11%	18%	12%
129	SGI Octane/R10k-175	7%	11%	16%	11%
130	SGI O2 R10k/175	7%	11%	16%	11%
131	HP PA-9000/C160	9%	8%	16%	11%
132	SGI Indigo2-R10k/175	8%	10%	15%	11%
133	Pentium II/400 (pgi)	6%	9%	16%	11%
134	Pentium II/450	6%	10%	16%	10%
135	DEC Alpha 600/5-333	5%	11%	14%	10%
136	Pentium II/400	6%	9%	14%	10%
137	Pentium II/400 (abs)	4%	9%	16%	10%
138	DEC Alpha 8400/5-300	5%	10%	13%	9%
139	SUN Ultra-2/200	4%	10%	12%	9%
140	SGI O2 R5k/300	6%	5%	12%	8%
141	DEC Alpha 2100/5-250	3%	9%	10%	7%
142	SUN Ultra-1/170	3%	9%	10%	7%
143	Pentium II/300 (abs)	3%	7%	12%	7%
144	DEC Alpha 600/5-266	4%	7%	10%	7%
145	Pentium II/266 (abs)	3%	6%	11%	7%

146	SGI R8k Indigo2	5%	8%	7%	7%
147	SGI PChall-R8k/75	5%	8%	7%	7%
148	Pentium II/266 (pgi)	3%	6%	10%	7%
149	Pentium II/300	4%	7%	8%	6%
150	IBM RS/6000-3CT	5%	7%	7%	6%
151	SUN Ultra-1/140	3%	7%	9%	6%
152	Pentium Pro/200	4%	4%	10%	6%
153	Pentium II/266	3%	6%	8%	6%
154	IBM RS/6000-590	5%	6%	6%	6%
155	DEC Alpha 250/4-266	3%	5%	7%	5%
156	HP PA-9000/735-125	4%	4%	7%	5%
157	IBM RS/6000-3BT	4%	4%	6%	5%
158	HP PA-9000/J200	4%	4%	6%	5%
159	SGI O2 R5k/180	3%	3%	8%	5%
160	Dell Optiplex/266	3%	3%	7%	4%
161	DEC AXP/3000-700	2%	4%	6%	4%
162	SGI Indy-R5k	2%	3%	7%	4%
163	HP PA-9000/755	3%	3%	5%	4%
164	HP PA-9000/735	3%	3%	5%	4%
165	SGI Indigo2 R4400/250	2%	3%	6%	4%
166	DEC AXP/3000-600	2%	3%	4%	3%
167	HP PA-9000/715-100	3%	2%	4%	3%
168	SUN SPARC 20/HS21	3%	2%	4%	3%
169	IBM PowerPC-43P	2%	2%	5%	3%
170	IBM RS/6000-370	2%	3%	4%	3%
171	DEC AXP/3000-500	2%	3%	4%	3%
172	HP PA-9000/715-80	2%	2%	3%	3%
173	DEC AXP/3000-300	1%	2%	3%	2%
174	IBM RS/6000-360	1%	2%	3%	2%
175	Pentium 233 MMX	2%	1%	4%	2%
176	SGI Indigo2 R4400/150	1%	2%	4%	2%
177	IBM RS/6000-550	2%	3%	2%	2%
178	SGI Challenge L/150	1%	2%	3%	2%
179	HP PA-9000/750	2%	2%	3%	2%
180	IBM RS/6000-350	1%	2%	3%	2%
181	SGI Challenge L/100	1%	1%	3%	2%
182	IBM RS/6000-530H	1%	1%	2%	2%
183	IBM RS/6000-340	1%	2%	2%	2%
184	IBM PowerPC-25T	1%	1%	2%	1%
185	IBM PowerPC-250	1%	1%	2%	1%
186	SUN SPARCserver 1000	1%	1%	2%	1%
187	HP PA-9000/720	1%	1%	2%	1%
188	SGI R4000 Indigo	1%	1%	2%	1%
189	SUN SPARC/5-85	1%	1%	2%	1%
190	SUN SPARC 10/41	1%	1%	2%	1%
191	IBM RS/6000-320	1%	1%	1%	1%
192	SUN SPARC 10/30	1%	0%	1%	1%
193	Stardent VISTRA-800	0%	0%	1%	1%
194	SGI 4D/420	0%	0%	1%	1%
195	SGI 4D/320	0%	0%	1%	0%
196	SGI R3000 indigo	0%	0%	1%	0%

197	SUN SPARC 2/GS	0%	0%	1%	0%
198	DEC S5000/200	0%	0%	1%	0%
199	HP/Apollo DN10020	0%	0%	1%	0%
200	SGI 4D/220	0%	0%	1%	0%
201	Stardent 1520	0%	0%	0%	0%
202	DEC S5000/120	0%	0%	0%	0%
203	SOLBOURNE S4000	0%	0%	0%	0%
204	SUN 4/370	0%	0%	0%	0%
	MPP nodes				
1	IBM RS/6000-SP/375	33%	40%	46%	40%
2	IBM RS/6000-SP/222	19%	23%	26%	23%
3	HP PA-9000/V2200	12%	24%	19%	18%
4	Cray T3E/1200	15%	17%	19%	17%
5	IBM SP2/160Thin	12%	19%	15%	15%
6	Cray T3E/900	13%	14%	15%	14%
7	IBM SP2/120Thin	9%	15%	12%	12%
8	IBM SP2/66Thin	5%	8%	6%	6%
9	Hitachi SR2201	3%	5%	6%	5%
10	Cray T3D/AXP-150	1%	3%	2%	2%
11	KSR-2	1%	2%	2%	2%
	Vector Supercomputers				
1	NEC SX-5	49%	136%	20%	68%
2	NEC SX-4	24%	65%	9%	33%
3	Cray YMP-C98/4256	10%	26%	5%	14%
4	FUJITSU VPP-300	8%	15%	3%	9%
5	CRAY YMP/J90	3%	7%	2%	4%

(+) Prototype, pre-release System

Table 10. The Computational Chemistry Kernels.

The Computational Chemistry Kernels Benchmark.

Rank	Machine	Total CPU Times (seconds)			Mflop	Relative
		SCF	MD	MC	JACOBI	Performance (%)
1	HP RX5670 Madison/1500 (+)	3.6	12.6	2.7	1500.0	179
2	Intel Tiger Madison/1500	6.9	10.4	3.4	1388.5	149
3	IBM pSeries 690Turbo/1.7	5.9	16.3	3.4	1142.9	129
4	HP RX2600 Itanium2/1000	5.5	19.7	4.0	1333.3	126
5	Intel Tiger Madison/1200 (+)	9.9	13.1	4.4	1357.8	123
6	Pentium 4/2666 (ifc)	7.0	19.4	2.4	615.4	119
7	AMD Opteron244/1800 (pgi)	8.9	18.2	2.3	521.7	113
8	HP RX5670 Itanium2/1000	10.7	15.6	5.2	1286.7	108
9	Intel Tiger Itanium2/1000	12.0	15.7	5.2	1307.2	107
10	Compaq Alpha ES45/1250	5.8	18.8	3.4	416.1	106
11	IBM Regatta-HPC/1300	7.2	22.4	4.3	923.1	102
12	IBM pSeries 690Turbo/1.3	7.8	21.4	4.4	923.1	100
13	Pentium 4/2666 (pgi)	10.8	21.6	2.6	489.8	98
14	AMD MP2400+/2000 (pgi)	7.4	23.2	2.7	193.6	95
15	Compaq Marvel EV7/1000	7.2	25.1	4.2	677.5	93

16	HP ZX6000 Itanium2/900	12.3	17.4	5.8	948.9	91
17	Pentium 4/2000 (ifc)	11.0	26.0	2.9	444.4	88
18	Compaq Alpha ES45/1000	7.2	22.9	4.6	355.4	84
19	AMD MP2000+/1667 (pgi)	8.8	27.9	3.2	189.0	80
20	AMD MP2400+/2000	9.6	23.5	3.5	187.5	80
21	AMD MP1800+/1533 (pgi)	9.6	30.5	3.5	201.7	75
22	Pentium 4/2533 (pgi)	11.4	29.1	4.0	436.4	75
23	IBM pSeries 630/1000	10.2	28.1	5.8	571.4	72
24	HP PA-9000/RP7410-875	8.4	26.1	4.9	214.3	72
25	Pentium 4/2666	13.9	22.9	5.1	406.8	70
26	Compaq Alpha ES40/833	8.4	27.8	5.4	231.3	69
27	Pentium 4/2533	14.4	23.9	5.4	406.8	67
28	API UP2000 6/833	9.0	28.4	5.6	254.4	67
29	AMD Athlon K7/1400(pgi)	10.6	33.6	3.9	160.0	67
30	HP PA-9000/J6700-750	10.1	30.8	5.8	300.0	64
31	AMD MP2000+/1667	12.7	31.6	4.4	187.5	63
32	SUN Blade 2000/1056-Cu	10.8	39.8	5.2	360.8	62
33	Pentium 4/2000 (pgi)	14.6	38.5	5.2	490.0	62
34	SGI O3800/R14k-500	8.5	40.4	5.8	192.3	60
35	SGI O300/R14k-500	8.5	40.2	5.8	180.1	60
36	AMD Athlon K7/1200(pgi)	12.3	38.2	4.5	141.2	58
37	SGI Onyx 300/R14k-600	10.4	33.9	6.0	186.5	58
38	Compaq Alpha DS20E/667	10.5	34.7	6.9	264.7	57
39	Pentium 4/2000	18.4	31.3	6.8	480.0	57
40	AMD MP1800+/1533	14.4	34.4	5.2	192.0	56
41	API UP2000 6/667	10.6	37.9	6.9	226.5	54
42	Compaq Alpha ES40/667	11.7	35.2	7.5	269.0	54
43	SUN Fire V880/900-Cu	12.8	49.1	6.1	351.1	54
44	SUN Fire 6800/900-Cu	14.4	44.4	6.0	320.0	53
45	Compaq PW XP1000/667	11.7	36.0	7.1	160.8	51
46	Pentium 4/1500 (pgi)	19.5	50.9	7.0	500.0	50
47	AMD Athlon K7/1400	16.0	38.4	5.7	161.1	50
48	SGI O3800/R12k-400	10.6	47.5	7.2	179.8	50
49	HP Itanium/733-2M L3	17.9	36.4	9.1	421.1	49
50	HP PA-9000/J6000-552	13.7	40.9	7.9	279.1	49
51	SGI Octane2/R12k-400	10.5	49.7	7.3	127.3	48
52	AMD Athlon K7/1000(pgi)	14.8	46.2	5.5	102.1	47
53	IBM Itanium/800-4M L3	30.1	33.1	8.7	356.2	45
54	SGI Troon IA64/666	27.8	21.2	12.1	118.8	45
55	SGI O2000/R12k-400	11.7	49.6	8.0	110.5	44
56	IBM RS/6000 44P-270	14.7	48.6	8.5	258.1	44
57	Pentium 4/1500	28.2	46.7	9.7	500.0	43
58	Compaq Alpha DS20/500	14.1	48.6	8.8	202.2	43
59	Pentium 4/1400 (pgi)	20.9	55.3	7.8	347.8	43
60	AMD Athlon K7/1200	18.8	45.0	6.9	149.1	42
61	Compaq Alpha ES40/500	15.4	46.5	9.6	204.1	41
62	Compaq Alpha GS140	14.9	47.3	9.2	170.8	41
63	AlphaPC 264DP-500	15.2	48.1	9.5	189.6	41
64	SUN Blade 1000/M1750	14.3	53.5	12.4	298.3	41
65	AMD Athlon K7/850 (pgi)	17.8	58.1	6.8	129.0	40
66	Pentium 4/1400	26.6	44.2	9.8	342.9	40

67	Compaq PW XP1000/500	15.7	50.8	9.3	176.9	40
68	HP PA-9000/J5000-440	18.2	52.1	9.9	255.3	39
69	AMD Athlon K7/1000	21.0	56.5	7.5	101.3	36
70	Compaq XP1000 6/450	17.0	50.6	10.6	142.9	36
71	Compaq Alpha DS10/466	17.2	52.4	10.4	139.6	36
72	SGI O2000/R12k-300	14.1	63.8	9.9	95.8	36
73	HP PA-9000/C3000-400	20.0	59.6	10.9	228.6	35
74	HP PA-9000/N4000-440	23.8	52.9	11.2	228.6	34
75	Pentium III/1000-CM(pgi)	23.3	68.2	7.7	136.4	34
76	DEC Alpha 8400/6-575	19.7	47.6	10.8	81.9	34
77	SGI Octane/R12k-270	15.8	70.9	11.0	97.7	33
78	AMD Athlon K7/850	24.6	72.7	8.6	129.0	32
79	AMD Athlon K7/650 (pgi)	23.4	78.3	8.8	124.4	31
80	Pentium III/866-CM(pgi)	26.8	74.0	8.8	108.1	30
81	HP PA-9000/785 C360	23.1	65.4	11.9	118.2	29
82	SGI O2 R12k/270	17.4	75.1	11.4	17.8	28
83	SGI O2000/R10k-250	18.3	83.4	12.7	85.7	28
84	Pentium III/800-CM(pgi)	28.9	81.2	9.5	103.0	28
85	AMD Athlon K7/600 (pgi)	28.8	85.9	10.5	121.0	27
86	Pentium III/866-CM	30.3	84.1	10.4	107.1	26
87	Pentium III/750-CM(pgi)	31.1	85.5	10.2	110.6	26
88	Pentium III/733-CM(pgi)	31.7	87.1	10.4	123.1	26
89	SGI Onyx2 IR2/R10k-250	22.1	87.0	12.6	88.9	26
90	Pentium III/800 (pgi)	31.6	83.8	10.7	112.2	26
91	IBM RS/6000-43P	27.0	91.4	15.4	205.1	26
92	DEC Alpha PW/600AU	24.6	75.2	12.3	66.4	26
93	SGI Octane/R10k-250	22.4	91.0	12.7	87.3	26
94	DEC Alpha 8400/5-625	23.9	75.5	12.7	63.6	26
95	SUN Ultra80/450	33.0	54.9	17.9	131.6	25
96	SGI Origin200/225	20.3	92.5	14.0	78.5	25
97	Pentium III/1000-CM	31.8	94.5	10.8	120.0	25
98	DEC Alpha 1200/5-533	26.9	81.0	13.2	73.7	24
99	Pentium III/800	32.9	91.6	11.3	96.4	24
100	Pentium III/800-CM	33.3	91.6	11.4	98.4	24
101	AMD Athlon K7/600	35.6	89.2	12.2	121.8	24
102	Pentium III/733-CM	36.1	100.2	12.4	124.4	23
103	Pentium III/750-CM	35.2	98.4	12.1	108.6	23
104	AMD Athlon K7/500 (pgi)	34.1	98.3	12.5	112.2	23
105	Pentium III/650-CM(pgi)	36.0	100.7	11.8	103.9	23
106	AMD Athlon K7/650	35.6	101.6	12.4	108.6	23
107	SUN HPC4500/400	36.8	61.8	20.1	106.6	22
108	IBM RS/6000-397	59.5	107.6	16.8	237.6	21
109	HP PA-9000/C240	33.4	101.2	17.7	121.2	21
110	AMD Athlon K7/500	41.0	100.4	14.8	111.6	21
111	DEC Alpha 500/5-500	32.0	94.0	14.9	50.9	21
112	Pentium III/650-CM	40.6	113.3	14.0	106.7	20
113	DEC Alpha PW/433AU	33.7	102.6	17.0	58.8	19
114	Pentium III/550 (pgi)	46.5	120.3	15.7	100.9	18
115	SUN HPC4500/336	47.3	73.2	22.2	71.7	18
116	HP PA-9000/C200	40.5	110.6	20.0	110.1	18
117	HP PA-9000/V2250	43.3	95.1	20.5	81.1	18

118	DEC Alpha 500/5-400	38.7	112.8	18.1	50.4	17
119	SGI O2000/R10k-195	41.5	112.1	20.4	84.1	17
120	SGI Octane/R10k-195	42.6	112.0	20.1	82.7	17
121	IBM RS/6000-595	72.4	137.1	20.0	167.8	17
122	Pentium III/550	48.7	187.0	16.7	100.8	16
123	SGI Origin200/180	46.1	121.3	21.8	75.0	16
124	SGI PChall-R10k/195	42.7	106.0	22.4	39.1	16
125	SGI Octane/R10k-175	46.6	126.9	23.5	74.3	15
126	Pentium II/400 (abs)	56.4	150.5	19.6	82.5	15
127	SUN Ultra-2/300	55.1	85.2	29.5	41.8	15
128	DEC Alpha 600/5-333	45.8	136.6	20.9	44.9	15
129	ProLiant PII/450	59.0	166.4	20.2	78.4	14
130	SUN Ultra30/300	58.5	96.1	29.6	54.3	14
131	Pentium II/400 (pgi)	64.7	167.0	21.5	82.5	14
132	Pentium III/500	62.2	171.9	22.1	85.4	14
133	SGI O2 R10k/175	48.1	126.4	23.7	12.6	13
134	HP PA-9000/C160	49.1	142.8	25.4	39.6	13
135	SGI O2 R5k/300	68.4	136.7	18.8	16.2	13
136	DEC Alpha 8400/5-300	52.6	149.3	25.8	46.6	13
137	Pentium II/450	64.8	205.9	23.6	83.3	13
138	SGI Indigo2-R10k/175	62.1	134.7	24.3	30.3	12
139	Pentium II/400	74.9	230.0	27.5	82.5	11
140	SUN Ultra-2/200	81.8	120.9	43.0	56.5	11
141	DEC Alpha 2100/5-250	59.4	186.9	28.0	27.3	11
142	DEC Alpha 600/5-266	57.2	209.8	30.6	41.0	11
143	Pentium II/300 (abs)	74.5	216.8	27.2	47.6	10
144	Pentium II/266 (abs)	85.0	227.1	29.6	48.7	10
145	SUN Ultra-1/170	98.3	145.8	58.4	47.3	9
146	Pentium II/266 (pgi)	96.0	262.1	33.0	49.1	9
147	Pentium II/300	99.6	291.4	37.0	44.9	8
148	DEC Alpha 250/4-266	78.8	272.0	37.0	20.9	8
149	SGI O2 R5k/180	115.9	212.6	33.6	14.2	8
150	Pentium II/266	106.3	339.1	35.5	47.5	8
151	SUN Ultra-1/140	110.1	186.0	60.7	45.2	8
152	IBM RS/6000-590	146.0	453.0	43.0	86.0	7
153	IBM RS/6000-3CT	138.3	461.6	42.2	81.1	7
154	SGI PChall-R8k/75	138.5	217.8	47.6	32.9	7
155	SGI Indy-R5k	123.2	219.4	42.2	12.5	7
156	SGI R8k Indigo2	138.9	218.3	47.9	23.7	7
157	Pentium Pro/200	142.0	321.0	38.0	28.2	7
158	IBM RS/6000-3BT	140.1	389.4	43.1	44.8	7
159	SGI Indigo2 R4400/250	136.3	319.6	46.6	16.9	6
160	HP PA-9000/735-125	103.0	236.0	91.0	15.0	6
161	Pentium Pro/200-f77m	141.9	424.2	45.6	20.4	6
162	DEC AXP/3000-700	146.3	410.8	54.0	21.7	5
163	IBM PowerPC-43P	134.8	470.3	55.6	14.8	5
164	HP PA-9000/J200	121.1	292.3	92.4	12.4	5
165	HP PA-9000/735	131.0	284.0	102.0	18.6	5
166	SUN SPARC 20/HS21	132.3	319.0	84.0	16.3	5
167	Pentium 233 MMX	177.0	480.2	50.3	14.1	5
168	Convex C-3860	453.0	342.0	141.0	69.9	5

169	HP PA-9000/715-100	176.5	354.0	106.7	17.3	4
170	SGI Indigo2 R4400/150	234.0	522.9	77.5	13.7	4
171	SGI Challenge L/150	233.0	517.0	78.0	13.3	4
172	DEC AXP/3000-600	313.9	540.5	79.0	21.6	4
173	IBM RS/6000-370	370.0	844.0	93.0	44.2	4
174	HP PA-9000/715-80	220.0	426.6	133.2	17.1	3
175	IBM RS/6000-360	433.0	1071.0	117.0	35.1	3
176	HP PA-9000/750	237.0	554.0	163.0	11.5	3
177	DEC AXP/3000-300	426.6	715.5	98.1	12.0	3
178	IBM RS/6000-550	563.0	1266.0	149.0	39.9	3
179	SGI R4000 Indigo	375.0	809.0	112.0	9.5	2
180	DEC AXP/3000-500	194.0	853.0	248.0	12.1	2
181	IBM RS/6000-350	523.0	1288.0	141.0	27.4	2
182	SGI Challenge L/100	400.0	794.0	130.0	9.5	2
183	IBM PowerPC-250	409.0	1258.0	145.0	15.6	2
184	SUN SPARCserver 1000	441.0	783.0	148.0	6.7	2
185	Convex C-220	1015.0	1017.0	329.0	33.1	2
186	IBM RS/6000-340	692.0	1608.0	187.0	21.2	2
187	SUN SPARC 5/85	1036.8	1082.2	195.0	6.7	1
188	SUN SPARC 10/41	665.0	1788.0	266.0	6.6	1
189	SUN SPARC 10/30	758.0	2214.0	299.0	6.9	1
	MPP nodes					
1	IBM RS/6000-SP/375	14.6	48.6	8.5	260.0	44
2	IBM RS/6000-SP/222	24.3	83.0	14.0	195.1	28
3	Cray T3E/1200	26.3	119.2	18.4	147.8	22
4	IBM SP2/160Thin	59.3	108.0	16.6	244.9	22
5	Cray T3E/900	36.2	158.2	22.8	139.4	17
6	HP PA-9000/V2200	50.7	111.1	21.2	106.7	17
7	IBM SP2/120Thin	79.3	141.8	22.4	173.9	16
8	Hitachi SR2201	133.9	309.1	45.4	100.4	8
9	IBM SP2/66Thin	137.7	382.8	42.5	68.6	7
	Vector Supercomputers					
1	NEC SX-5	81.9	28.1	26.9	7892.9	239
3	FUJITSU VPP-300	347.1	64.1	120.0	1811.2	59
3	FUJITSU VPP-300	347.1	64.1	120.0	1811.2	43

(+) Prototype, pre-release System

Table 11. The STREAM Benchmark - TRIAD Rates.

The STREAM Benchmark: TRIAD Rates (MBytes/second) (see text)

Rank	Machine	TRIAD rate MBytes / second	Relative Values (%)
1	NEC SX-5	47104.2(*)	1222%
2	NEC SX-4	15898.0	413%
3	IBM pSeries 690Turbo/1.7	5870.9	152%
4	Compaq Marvel EV7/1000	5396.5	140%
5	IBM pSeries 690Turbo/1.3	3853.4	100%

6	HP RX5670 Madison/1500 (+)	3843.5	100%
7	Intel Tiger Madison/1500	3783.3	98%
8	HP RX2600 Itanium2/1000	3591.2	93%
9	HP RX5670 Itanium2/1000	3433.1	89%
10	Intel Tiger Itanium2/1000	3385.1	88%
11	Intel Tiger Madison/1200 (+)	3373.0	88%
12	Pentium 4/2666 (ifc)	2797.3	73%
13	HP ZX6000 Itanium2/900	2634.0	68%
14	IBM Regatta-HPC/1300	2528.4	66%
15	Pentium 4/2666 (pgi)	2400.0	62%
16	Compaq Alpha ES40/667	2240.0	58%
17	Compaq Alpha ES45/1250	2036.0	53%
18	AMD Opteron244/1800 (pgi)	2018.4	52%
19	Pentium 4/2666	2000.0	52%
20	Compaq Alpha ES45/1000	1943.9	50%
21	IBM pSeries 630/1000	1690.3	44%
22	Pentium 4/1400 (pgi)	1600.0	42%
23	Pentium 4/2000	1600.0	42%
24	Pentium 4/2000 (pgi)	1600.0	42%
25	Pentium 4/2000 (ifc)	1600.0	42%
26	Pentium 4/1500	1600.0	42%
27	Pentium 4/1500 (pgi)	1600.0	42%
28	Pentium 4/1400	1600.0	42%
29	Compaq Alpha ES40/833	1281.8	33%
30	HP Itanium/733-2M L3	1238.0	32%
31	Pentium 4/2533	1200.0	31%
32	Pentium 4/2533 (pgi)	1200.0	31%
33	Compaq Alpha DS20E/667	1199.5	31%
34	Compaq Alpha DS20/500	1171.0	30%
35	Compaq Alpha ES40/500	1171.0	30%
36	IBM Itanium/800-4M L3	1151.6	30%
37	SUN Blade 1000/M1750	1138.5	30%
38	AlphaPC 264DP-500	1063.8	28%
39	API UP2000 6/667	1045.8	27%
40	API UP2000 6/833	1010.0	26%
41	SUN Fire V880/900-Cu	987.6	26%
42	HP PA-9000/J6700-750	986.6	26%
43	HP PA-9000/J6000-552	979.3	25%
44	SUN Fire 6800/900-Cu	977.5	25%
45	SUN Blade 2000/1056-Cu	963.3	25%
46	Compaq PW XP1000/500	960.0	25%
47	Compaq PW XP1000/667	919.3	24%
48	IBM RS/6000-397	882.4	23%
49	AMD MP2000+/1667 (pgi)	800.0	21%
50	AMD MP2400+/2000 (pgi)	800.0	21%
51	AMD Athlon K7/1400(pgi)	800.0	21%
52	AMD MP1800+/1533 (pgi)	800.0	21%
53	IBM RS/6000 44P-270	789.7	20%
54	IBM SP2/120Thin	782.1	20%
55	IBM RS/6000-SP/375	780.7	20%
56	HP PA-9000/RP7410-875	771.0	20%

57	IBM RS/6000-43P	763.8	20%
58	AMD MP2400+/2000	720.0	19%
59	AMD MP2000+/1667	720.0	19%
60	HP PA-9000/J5000-440	692.0	18%
61	IBM RS/6000-595	689.5	18%
62	Pentium III/733-CM(pgi)	685.7	18%
63	AMD Athlon K7/1200(pgi)	685.7	18%
64	AMD Athlon K7/1400	685.7	18%
65	SGI O300/R14k-500	668.9	17%
66	AMD MP1800+/1533	654.5	17%
67	SGI Onyx 300/R14k-600	649.0	17%
68	HP PA-9000/C3000-400	637.0	17%
69	SGI O3800/R14k-500	628.3	16%
70	Cray T3E/1200	604.0	16%
71	Compaq Alpha DS10/466	603.4	16%
72	AMD Athlon K7/1200	600.0	16%
73	SGI O3800/R12k-400	588.2	15%
74	IBM RS/6000-SP/222	563.1	15%
75	AMD Athlon K7/650 (pgi)	533.3	14%
76	AMD Athlon K7/850	533.3	14%
77	AMD Athlon K7/850 (pgi)	533.3	14%
78	AMD Athlon K7/650	533.3	14%
79	Compaq XP1000 6/450	528.8	14%
80	SGI Troon IA64/666	522.9	14%
81	Cray T3E/900	515.0	13%
82	SGI Octane2/R12k-400	514.1	13%
83	Compaq Alpha GS140	491.8	13%
84	Pentium III/800-CM(pgi)	480.0	12%
85	AMD Athlon K7/500 (pgi)	480.0	12%
86	Pentium III/800 (pgi)	480.0	12%
87	AMD Athlon K7/1000(pgi)	480.0	12%
88	AMD Athlon K7/600	480.0	12%
89	Pentium III/866-CM(pgi)	480.0	12%
90	AMD Athlon K7/600 (pgi)	480.0	12%
91	HP PA-9000/N4000-440	468.7	12%
92	Pentium III/1000-CM(pgi)	436.5	11%
93	AMD Athlon K7/1000	436.4	11%
94	AMD Athlon K7/500	436.4	11%
95	Pentium III/650-CM(pgi)	436.4	11%
96	Pentium III/750-CM(pgi)	400.0	10%
97	Pentium III/550 (pgi)	400.0	10%
98	Pentium III/733-CM	400.0	10%
99	SGI Octane/R12k-270	393.4	10%
100	SGI Octane/R10k-250	389.3	10%
101	SGI O2000/R12k-300	388.0	10%
102	SGI O2000/R12k-400	380.0	10%
103	SUN Ultra80/450	375.2	10%
104	Pentium III/1000-CM	369.2	10%
105	Pentium III/800-CM	369.2	10%
106	SGI O2000/R10k-250	358.0	9%
107	SGI Octane/R10k-195	351.8	9%

108	Pentium II/400 (abs)	342.9	9%
109	Pentium III/866-CM	342.9	9%
110	Pentium II/400 (pgi)	342.9	9%
111	SUN HPC4500/400	326.5	8%
112	Pentium III/750-CM	320.0	8%
113	HP PA-9000/785 C360	320.0	8%
114	Pentium III/650-CM	320.0	8%
115	SGI O2000/R10k-195	317.0	8%
116	SGI Octane/R10k-175	316.6	8%
117	SGI Origin200/225	310.9	8%
118	Pentium III/800	300.0	8%
119	Pentium II/400	300.0	8%
120	SGI Origin200/180	286.0	7%
121	SUN HPC4500/336	285.0	7%
122	Pentium III/550	282.4	7%
123	Pentium III/500	270.4	7%
124	SUN Ultra30/300	268.0	7%
125	ProLiant PII/450	266.7	7%
126	Pentium II/450	266.0	7%
127	DEC Alpha 1200/5-533	259.0	7%
128	SUN Ultra-1/170	253.8	7%
129	DEC Alpha PW/600AU	246.0	6%
130	HP PA-9000/V2200	235.3	6%
131	DEC Alpha PW/433AU	223.5	6%
132	HP PA-9000/V2250	217.0	6%
133	DEC Alpha 8400/5-625	214.8	6%
134	HP PA-9000/C240	212.6	6%
135	Pentium II/300 (abs)	209.0	5%
136	Pentium II/300	209.0	5%
137	DEC Alpha 8400/5-300	196.7	5%
138	HP PA-9000/C160	194.6	5%
139	SGI PChall-R10k/195	193.9	5%
140	Pentium II/266 (pgi)	192.0	5%
141	Pentium II/266 (abs)	192.0	5%
142	SUN Ultra-2/200	189.9	5%
143	Cray T3D/AXP-150	176.8	5%
144	Pentium 233 MMX	160.0	4%
145	SUN Ultra-1/140	154.4	4%
146	SGI PChall-R8k/75	134.8	3%
147	SGI Indigo2-R10k/175	116.7	3%
148	Stardent VISTRA-800	115.2	3%
149	IBM RS/6000-530H	114.3	3%
150	DEC AXP/3000-500	99.7	3%
151	SGI R8k Indigo2	82.1	2%
152	SGI O2 R5k/300	80.2	2%
153	HP PA-9000/735	80.0	2%
154	SGI Indigo2 R4400/250	76.0	2%
155	HP PA-9000/735-125	73.6	2%
156	SGI O2 R12k/270	72.8	2%
157	IBM PowerPC-43P	70.6	2%
158	SGI Indigo2 R4400/150	70.6	2%

159	Stardent 1520	70.1	2%
160	SGI O2 R5k/180	69.3	2%
161	IBM RS/6000-320	60.0	2%
162	SUN SPARC 10/30	57.0	1%
163	SGI Challenge L/150	54.5	1%
164	SGI Challenge L/100	54.5	1%
165	SUN SPARC 10/41	54.0	1%
166	HP PA-9000/720	53.3	1%
167	DEC AXP/3000-300	38.9	1%
168	DEC S5000/200	23.0	1%
169	SGI 4D/220	19.0	0%

(*) value from STREAM web site = 47779.0
(+) Prototype, pre-release System

Table 12. The GAMESS-UK-89 Benchmark.

The GAMESS-UK-89 Benchmark: Total CPU Time (User and System), Elapsed Time (minutes) and Efficiency (%) for Calculations 1-12 (see text)

Rank	Machine	CPU Time			Elapsed	Efficiency	Relative
		User	System	Total	Time	(%)	Performance (%)
1	IBM pSeries 690Turbo/1.7	2.0	0.4	2.3	3.3	71%	137%
2	Intel Tiger Madison/1500	2.3	0.2	2.5	2.8	91%	127%
3	IBM Regatta-HPC/1300	2.7	0.4	3.1	3.2	95%	104%
4	Intel Tiger Madison/1200 (*)	2.9	0.3	3.2	3.3	97%	100%
5	IBM pSeries 690Turbo/1.3	2.6	0.6	3.2	4.1	78%	100%
6	AMD Opteron244/1800 (pgi)	2.9	0.3	3.3	3.4	95%	98%
7	Pentium 4/2666 (ifc)	2.9	0.4	3.3	3.6	93%	96%
8	Intel Tiger Itanium2/1000	3.4	0.4	3.8	4.1	93%	85%
9	HP RX2600 Itanium2/1000	3.2	0.6	3.8	3.9	99%	84%
10	Pentium 4/2666 (pgi)	3.5	0.4	3.8	4.2	92%	83%
11	HP RX5670 Itanium2/1000	3.5	0.4	3.9	4.1	95%	83%
12	Compaq Alpha ES45/1250	3.0	1.0	4.0	4.0	101%	79%
13	IBM pSeries 630/1000	3.5	0.6	4.1	4.4	94%	78%
14	HP PA-9000/RP7410-875	3.5	0.7	4.1	4.2	98%	77%
15	Pentium 4/2533 (pgi)	3.9	0.4	4.3	4.8	88%	75%
16	HP ZX6000 Itanium2/900	4.0	0.3	4.3	4.3	100%	75%
17	Compaq Marvel EV7/1000	3.2	1.2	4.4	4.6	95%	73%
18	AMD MP2400+/2000 (pgi)	3.8	0.6	4.4	4.4	100%	72%
19	Pentium 4/2666	4.0	0.4	4.4	4.6	96%	72%
20	Compaq Alpha ES45/1000	3.7	0.9	4.6	4.7	98%	70%
21	Pentium 4/2000 (ifc)	4.4	0.4	4.8	4.8	99%	67%
22	AMD MP2000+/1667 (pgi)	4.3	0.8	5.0	4.9	103%	64%
23	HP PA-9000/J6700-750	4.4	0.7	5.1	5.7	89%	63%
24	Pentium 4/2533	4.8	0.4	5.2	5.6	92%	62%
25	Pentium 4/2000 (pgi)	5.0	0.4	5.4	5.5	99%	59%
26	AMD MP1800+/1533 (pgi)	4.8	0.7	5.5	5.5	100%	59%
27	SUN Blade 2000/1056-Cu	5.4	0.5	5.9	6.0	99%	54%

28	AMD MP2000+/1667	5.3	0.8	6.1	6.1	101%	52%
29	Compaq Alpha ES40/833	4.4	1.9	6.3	6.4	99%	51%
30	AMD Athlon K7/1400(pgi)	5.4	1.1	6.5	6.6	99%	49%
31	Pentium 4/1500 (pgi)	6.2	0.3	6.5	6.5	100%	49%
32	Pentium 4/2000	6.3	0.4	6.7	6.7	100%	48%
33	AMD MP1800+/1533	6.0	0.7	6.7	6.7	100%	48%
34	Compaq Alpha ES40/667	5.6	1.2	6.8	7.1	95%	47%
35	HP PA-9000/J6000-552	6.1	0.7	6.8	7.3	93%	47%
36	SUN Fire V880/900-Cu	6.5	0.6	7.0	7.2	98%	45%
37	AMD Athlon K7/1200(pgi)	6.3	0.9	7.2	10.9	66%	45%
38	Compaq Alpha DS20E/667	5.5	1.9	7.4	7.7	96%	43%
39	Compaq Alpha ES40/667 (+)	5.5	1.9	7.4	7.7	96%	43%
40	Compaq PW XP1000/667	6.3	1.4	7.7	9.0	85%	42%
41	AMD Athlon K7/1400	6.7	1.1	7.7	7.8	99%	41%
42	SUN Fire 6800/900-Cu	6.8	0.9	7.8	8.0	97%	41%
43	SGI Onyx 300/R14k-600	6.8	1.2	8.0	8.0	100%	40%
44	Pentium 4/1500	7.8	0.3	8.1	8.1	100%	39%
45	IBM RS/6000-SP/375	7.2	1.0	8.2	9.2	89%	39%
46	IBM RS/6000 44P-270	7.4	1.0	8.4	9.6	87%	38%
47	AMD Athlon K7/1200	7.7	0.8	8.5	12.4	68%	38%
48	AMD Athlon K7/1000(pgi)	7.8	1.2	9.0	9.8	92%	36%
49	IBM Itanium/800-4M L3	7.6	1.5	9.0	17.0	53%	35%
50	HP PA-9000/J5000-440	7.9	1.2	9.1	10.1	90%	35%
51	API UP2000 6/833	5.6	3.7	9.2	9.4	98%	35%
52	Pentium III/1000-CM(pgi)	8.2	1.2	9.4	9.4	100%	34%
53	SGI O300/R14k-500	8.1	1.3	9.5	9.5	100%	34%
54	HP PA-9000/C3000-400	8.4	1.1	9.5	11.1	85%	34%
55	HP Itanium/733-2M L3	7.1	2.4	9.5	16.6	57%	34%
56	Compaq Alpha ES40/500	8.0	1.9	9.9	11.2	89%	32%
57	SGI O3800/R14k-500	8.0	1.9	10.0	12.4	80%	32%
58	API UP2000 6/667	6.9	3.1	10.0	10.4	96%	32%
59	SUN Blade 1000/M1750	9.5	0.8	10.2	10.4	99%	31%
60	Compaq Alpha DS20/500	8.0	2.3	10.3	13.3	77%	31%
61	Compaq Alpha DS20/500 (+)	8.0	2.3	10.3	13.3	77%	31%
62	Pentium 4/1400 (pgi)	8.4	2.0	10.3	12.1	85%	31%
63	AMD Athlon K7/1000	9.3	1.1	10.4	11.1	94%	31%
64	DEC Alpha 8400/6-575-S	8.5	2.0	10.5	16.2	65%	30%
65	DEC Alpha 8400/6-575	8.5	2.0	10.5	11.1	95%	30%
66	Pentium III/866-CM(pgi)	9.3	1.3	10.5	17.2	61%	30%
67	Compaq PW XP1000/500	8.3	2.4	10.7	11.2	95%	30%
68	Compaq XP1000 6/450	9.2	1.6	10.8	17.6	62%	30%
69	AMD Athlon K7/850	9.6	1.3	10.9	11.5	95%	29%
70	AlphaPC 264DP-500	8.9	2.0	11.0	11.1	99%	29%
71	Pentium III/733-CM(pgi)	10.2	0.8	11.0	11.3	97%	29%
72	Pentium III/800-CM(pgi)	10.2	1.0	11.2	13.0	86%	29%
73	Pentium III/1000-CM	10.0	1.3	11.3	11.2	100%	28%
74	SGI Octane2/R12k-400	9.9	1.6	11.5	14.2	81%	28%
75	HP PA-9000/785 C360	10.2	1.6	11.8	14.4	82%	27%
76	Pentium III/866-CM	10.8	1.3	12.1	19.2	63%	26%
77	SGI O3800/R12k-400	9.7	2.5	12.2	15.5	78%	26%
78	SGI O2000/R12k-400	9.9	2.3	12.2	12.3	99%	26%

79	Compaq Alpha DS10/466	9.2	3.1	12.3	52.1	24%	26%
80	Pentium 4/1400	10.7	1.9	12.6	14.3	88%	26%
81	Compaq Alpha GS140	8.2	4.4	12.6	13.1	96%	25%
82	Pentium III/733-CM	12.1	0.9	12.9	13.0	100%	25%
83	Pentium III/800-CM	12.1	1.0	13.1	14.9	88%	24%
84	AMD Athlon K7/650	11.8	1.4	13.2	14.4	92%	24%
85	Pentium III/750-CM(pgi)	11.0	2.4	13.4	13.6	98%	24%
86	Pentium III/800	12.6	1.5	14.0	15.6	90%	23%
87	IBM RS/6000-SP/222	12.7	1.8	14.5	15.6	93%	22%
88	Pentium III/650-CM(pgi)	12.1	2.4	14.6	14.6	100%	22%
89	IBM RS/6000-43P	13.2	1.5	14.8	16.3	90%	22%
90	SGI O2000/R12k-300	12.8	2.3	15.1	15.1	100%	21%
91	Pentium III/750-CM	12.9	2.3	15.2	15.6	98%	21%
92	AMD Athlon K7/600	13.7	1.6	15.2	17.2	89%	21%
93	SUN Ultra80/450	14.4	1.5	15.9	16.6	96%	20%
94	HP PA-9000/C240	14.4	1.7	16.1	20.2	80%	20%
95	Pentium III/650-CM	14.4	2.4	16.8	17.4	97%	19%
96	SGI Octane/R12k-270	14.6	2.3	16.9	29.2	58%	19%
97	DEC Alpha PW/600AU	14.0	3.1	17.1	24.3	70%	19%
98	AMD Athlon K7/500	16.1	2.1	18.1	26.9	67%	18%
99	SUN HPC3500/400	16.4	1.8	18.2	19.5	93%	18%
100	SUN HPC4500/400	16.9	1.8	18.6	21.1	88%	17%
101	SGI O2000/R10k-250	16.6	2.6	19.2	19.7	97%	17%
102	Pentium III/550	17.6	1.8	19.4	19.7	99%	16%
103	HP PA-9000/V2200	17.0	2.7	19.7	21.3	92%	16%
104	SGI Origin200/225	17.5	2.5	20.0	20.3	98%	16%
105	DEC Alpha 8400/5-625	14.4	6.0	20.4	20.4	100%	16%
106	IBM RS/6000-397 (+)	18.9	1.5	20.4	24.6	83%	16%
107	IBM RS/6000-397	18.9	1.5	20.4	24.6	83%	16%
108	SUN HPC4500/336	18.8	1.9	20.8	29.9	69%	15%
109	DEC Alpha PW/433AU	18.8	3.6	22.4	25.1	89%	14%
110	DEC Alpha 1200/5-533	14.3	8.3	22.6	28.5	79%	14%
111	Pentium II/450	21.4	1.8	23.2	28.9	80%	14%
112	SGI Octane/R10k-195	20.6	2.6	23.2	24.2	96%	14%
113	SGI O2000/R10k-195 (+)	20.2	3.1	23.2	27.2	85%	14%
114	SGI O2000/R10k-195	20.0	3.2	23.2	24.5	95%	14%
115	HP PA-9000/C200 (+)	22.1	1.9	24.1	34.8	69%	13%
116	SUN Ultra-2/300 (+)	22.1	2.4	24.4	26.3	93%	13%
117	SUN Ultra30/300	22.7	2.4	25.1	82.6	30%	13%
118	IBM RS/6000-595 (+)	23.2	1.9	25.1	32.9	76%	13%
119	SGI Origin200/180	22.4	3.2	25.6	27.9	92%	12%
120	DEC Alpha 500/5-500	17.7	8.0	25.7	29.5	87%	12%
121	SGI Octane/R10k-175	23.0	3.0	26.0	27.8	93%	12%
122	DEC Alpha 500/5-400	21.5	4.7	26.2	37.2	70%	12%
123	SGI PChall-R10k/195 (+)	23.1	3.6	26.7	36.6	73%	12%
124	Pentium II/400	24.4	2.5	26.9	36.9	73%	12%
125	IBM SP2/120Thin	25.0	2.0	26.9	32.2	84%	12%
126	Pentium III/500	25.5	2.8	28.2	29.9	94%	11%
127	SGI O2 R12k/270	21.4	7.0	28.5	34.1	83%	11%
128	SGI PChall-R10k/175 (+)	26.0	4.8	30.8	70.7	44%	10%
129	DEC Alpha 600/5-333 (+)	23.4	7.6	31.0	34.2	91%	10%

130	HP PA-9000/C160 (+)	27.7	3.7	31.4	45.9	68%	10%
131	SUN Ultra-2/200 (+)	31.5	3.0	34.5	38.1	91%	9%
132	DEC Alpha 8400/5-300 (+)	25.9	9.5	35.4	37.3	95%	9%
133	Pentium II/300	33.1	2.5	35.6	37.2	96%	9%
134	DEC Alpha 600/5-266 (+)	30.6	6.4	37.0	62.2	59%	9%
135	DEC Alpha 2100/5-250 (+)	30.2	8.2	38.3	43.6	88%	8%
136	SGI O2 R10k/175	29.9	8.7	38.6	48.5	80%	8%
137	Cray YMP-C98/4256 (+)	37.9	2.0	40.0	41.2	97%	8%
138	Pentium II/266	40.7	3.7	44.4	58.7	76%	7%
139	IBM RS/6000-3CT (+)	40.1	4.4	44.5	58.3	76%	7%
140	SUN Ultra-1/170 (+)	40.5	4.9	45.4	56.2	81%	7%
141	SGI O2 R5k/300	38.6	9.4	48.0	52.3	92%	7%
142	IBM RS/6000-590H	43.9	4.8	48.7	74.5	65%	7%
143	SUN Ultra-1/140 (+)	45.3	5.7	51.0	139.8	36%	6%
144	IBM RS/6000-590 (+)	46.6	4.7	51.2	74.8	68%	6%
145	SGI PChall-R8k/75 (+)	48.1	5.5	53.7	55.2	97%	6%
146	DEC Alpha 250/4-266 (+)	46.0	9.7	55.7	85.7	65%	6%
147	SGI R8k Indigo2 (+)	50.8	7.2	58.0	60.6	96%	6%
148	Pentium Pro/200	55.0	4.5	59.5	91.4	65%	5%
149	HP PA-9000/735-125 (+)	51.6	8.4	59.9	93.3	64%	5%
150	Cray Y-MP (+)	56.8	6.0	62.8	188.4	33%	5%
151	DEC AXP/3000-700 (+)	53.4	11.5	64.9	105.4	62%	5%
152	SGI Indigo2 R4400/250 (+)	59.1	8.8	67.9	88.2	77%	5%
153	SGI O2 R5k/180	57.4	12.6	70.0	92.0	76%	5%
154	HP PA-9000/735 (+)	64.9	7.3	72.2	93.1	78%	4%
155	HP PA-9000/755 (+)	64.9	8.8	73.7	98.2	75%	4%
156	HP PA-9000/735	62.9	11.1	74.0	112.4	66%	4%
157	PowerPC	67.4	12.4	79.8	98.3	81%	4%
158	Hitachi SR2201	82.7	0.0	82.7	245.3	34%	4%
159	SGI Indy-R5k (+)	72.9	11.3	84.2	101.0	83%	4%
160	DEC AXP/3000-600 (+)	72.1	14.1	86.2	195.8	44%	4%
161	IBM RS/6000-370 (+)	78.7	8.4	87.1	108.8	80%	4%
162	Pentium 233 MMX	73.6	18.7	92.3	127.4	72%	3%
163	HP PA-9000/715-100 (+)	81.3	14.3	95.6	124.7	77%	3%
164	SUN SPARC 20/HS21 (+)	82.5	16.2	98.7	202.7	49%	3%
165	SGI Challenge L/150 (+)	93.3	10.3	103.5	110.6	94%	3%
166	SGI Indigo2 R4400/150 (+)	94.3	10.0	104.3	120.6	86%	3%
167	HP PA-9000/715-80 (+)	93.7	15.9	109.6	140.1	78%	3%
168	Pentium Pro/200-f2c	108.8	5.3	114.1	143.0	80%	3%
169	Convex C3840 (+)	124.3	3.5	127.9	210.9	61%	3%
170	HP PA-9000/750 (+)	111.1	17.4	128.5	140.2	92%	2%
171	IBM RS/6000-550 (+)	117.6	11.2	128.8	146.4	88%	2%
172	SUN SPARC 20	115.8	15.4	131.2	152.0	86%	2%
173	DEC AXP/3000-500 (+)	93.0	40.0	133.1	148.6	90%	2%
174	SGI Challenge L/100 (+)	140.8	17.1	158.0	178.0	89%	2%
175	DEC AXP/3000-300 (+)	129.8	39.6	169.4	184.0	92%	2%
176	SGI R4000 Indigo (+)	153.2	17.7	170.9	206.0	83%	2%
177	SUN SPARC 10/41 (+)	201.4	21.0	222.5	260.4	85%	1%
178	SUN SPARCserver 1000 (+)	175.1	50.8	225.9	445.6	51%	1%
179	SUN SPARC/5-85 (+)	240.5	25.8	266.3	299.0	89%	1%
180	SUN SPARC 10/30 (+)	251.4	31.7	283.1	306.3	92%	1%

(+) Version 5.0 of the GAMESS-UK Code
(*) Prototype, pre-release System

Table 13. The GAMESS-UK-97 Benchmark.

The GAMESS-UK Benchmark-97: Total CPU Time (User and System), Elapsed Time (minutes) and Efficiency (%) for Calculations 1-10 (see text)

Rank	Machine	CPU Time			Elapsed	Efficiency	Relative
		User	System	Total	Time	(%)	Performance (%)
1	IBM pSeries 690Turbo/1.7	18.3	2.0	20.3	23.1	88%	133%
2	Intel Tiger Madison/1500	20.7	1.4	22.1	23.2	95%	122%
3	IBM pSeries 690Turbo/1.3	23.7	3.4	27.1	37.7	72%	100%
4	HP RX2600 Itanium2/1000	24.9	3.5	28.4	29.8	95%	95%
5	Intel Tiger Madison/1200 (+)	27.4	1.8	29.2	29.9	98%	93%
6	IBM Regatta-HPC/1300	27.4	2.2	29.6	29.8	99%	91%
7	Pentium 4/2666 (ifc)	28.2	2.8	31.0	33.2	93%	87%
8	Compaq Alpha ES45/1250	26.0	6.0	31.9	31.9	100%	85%
9	AMD Opteron244/1800 (pgi)	30.2	2.3	32.5	36.8	88%	83%
10	Intel Tiger Itanium2/1000	31.5	2.2	33.7	34.5	98%	80%
11	HP RX5670 Itanium2/1000	31.3	2.4	33.8	34.8	97%	80%
12	Pentium 4/2666 (pgi)	33.4	2.5	35.9	38.0	95%	75%
13	IBM pSeries 630/1000	32.4	3.6	36.0	37.5	96%	75%
14	HP PA-9000/RP7410-875	32.9	3.8	36.7	37.3	98%	74%
15	Compaq Marvel EV7/1000	30.2	7.1	37.3	37.5	100%	73%
16	Compaq Alpha ES45/1000	32.6	5.1	37.7	38.7	97%	72%
17	HP ZX6000 Itanium2/900	36.7	2.0	38.8	40.5	96%	70%
18	HP PA-9000/J6700-750	36.5	3.4	39.9	49.7	80%	68%
19	Pentium 4/2666	38.1	2.8	40.8	43.4	94%	66%
20	Pentium 4/2533 (pgi)	39.0	2.3	41.3	46.9	88%	66%
21	AMD MP2400+/2000 (pgi)	44.6	3.9	48.5	48.7	100%	56%
22	Pentium 4/2000 (ifc)	46.2	2.6	48.8	49.7	98%	56%
23	Pentium 4/2533	46.6	2.3	48.9	54.8	89%	55%
24	Compaq Alpha ES40/833	38.5	11.4	49.9	54.3	92%	54%
25	Pentium 4/2000 (pgi)	50.2	2.6	52.7	54.0	98%	51%
26	HP PA-9000/J6000-552	49.5	3.6	53.1	63.2	84%	51%
27	AMD MP2000+/1667 (pgi)	48.5	5.0	53.5	66.0	81%	51%
28	AMD MP1800+/1533 (pgi)	50.9	4.4	55.3	59.6	93%	49%
29	SUN Blade 2000/1056-Cu	54.5	3.7	58.3	58.4	100%	47%
30	Compaq Alpha DS20E/667	47.7	11.3	59.0	77.0	77%	46%
31	AMD MP2000+/1667	54.2	5.0	59.2	71.5	83%	46%
32	Pentium 4/1500 (pgi)	57.3	2.1	59.5	76.5	78%	46%
33	Compaq PW XP1000/667	57.3	8.4	65.7	103.8	63%	41%
34	AMD Athlon K7/1400(pgi)	59.9	6.7	66.6	82.6	81%	41%
35	API UP2000 6/833	50.0	16.9	66.9	78.6	85%	40%
36	IBM RS/6000 44P-270	62.0	5.2	67.2	72.3	93%	40%
37	SGI Onyx 300/R14k-600	60.3	7.0	67.3	68.5	98%	40%
38	Pentium 4/1500	65.9	2.1	68.0	84.8	80%	40%
39	SUN Fire V880/900-Cu	67.3	3.8	71.1	71.2	100%	38%

40	HP PA-9000/J5000-440	65.9	7.8	73.7	81.9	90%	37%
41	HP PA-9000/N4000-440	67.8	6.6	74.4	75.9	98%	36%
42	AMD Athlon K7/1200(pgi)	69.2	5.3	74.5	124.8	60%	36%
43	AMD Athlon K7/1400	67.9	6.7	74.6	93.1	80%	36%
44	HP PA-9000/C3000-400	68.9	6.8	75.7	83.6	91%	36%
45	SGI O3800/R14k-500	69.1	11.0	80.1	95.2	84%	34%
46	AMD Athlon K7/1200	77.2	5.1	82.3	119.3	69%	33%
47	API UP2000 6/667	71.6	12.2	83.8	107.1	78%	32%
48	Compaq Alpha DS20/500	66.7	18.3	85.0	99.8	85%	32%
49	Compaq PW XP1000/500	75.8	13.9	89.7	109.1	82%	30%
50	SGI O3800/R12k-400	80.4	13.7	94.0	121.8	77%	29%
51	AMD Athlon K7/1000	87.0	7.3	94.3	121.0	78%	29%
52	SGI Octane2/R12k-400	90.6	10.0	100.5	143.6	70%	27%
53	Pentium III/1000-CM(pgi)	94.1	7.9	102.1	102.5	100%	27%
54	AMD Athlon K7/850	94.6	10.3	104.9	136.7	77%	26%
55	Compaq Alpha DS10/466	87.8	17.8	105.6	224.9	47%	26%
56	Pentium III/1000-CM	104.4	7.9	112.3	112.6	100%	24%
57	Pentium III/733-CM(pgi)	108.6	6.2	114.8	148.3	77%	24%
58	AMD Athlon K7/650	112.3	8.9	121.1	188.3	64%	22%
59	SGI O2000/R12k-300	112.7	15.7	128.4	213.4	60%	21%
60	Pentium III/733-CM	128.1	5.7	133.8	162.4	82%	20%
61	Pentium III/750-CM(pgi)	116.7	17.8	134.5	161.8	83%	20%
62	AMD Athlon K7/600	126.3	11.6	137.9	187.0	74%	20%
63	SUN Ultra80/450	130.4	10.1	140.4	142.5	99%	19%
64	AMD Athlon K7/500	146.1	12.9	159.0	232.4	68%	17%
65	Pentium III/550	153.4	10.7	164.1	197.2	83%	17%
66	DEC Alpha 1200/5-533	128.7	45.0	173.8	231.0	75%	16%
67	DEC Alpha PW/433AU	161.2	20.0	181.2	243.8	74%	15%
68	SGI O2000/R10k-195	176.8	19.4	196.2	220.0	89%	14%
69	IBM SP2/120Thin	207.0	20.2	227.2	329.0	69%	12%
70	SGI O2 R12k/270	230.1	46.3	276.4	368.4	75%	10%

(+) Prototype, pre-release System

Table 14. The DL_POLY Benchmark.

The DLPOLY Benchmark: Total CPU Time (User and System) and Elapsed Time (minutes) for Calculations 1-6 (see text) and Performance Relative to the IBM pSeries 690Turbo/1.3 GHz.

Rank	Machine	CPU Time			Elapsed	Relative
		User	System	Total	Time	Performance (%)
1	Intel Tiger Madison/1500	3.1	0.0	3.1	3.1	264%
2	HP RX5670 Madison/1500 (+)	3.5	0.0	3.5	3.5	237%
3	Intel Tiger Madison/1200 (+)	4.0	0.0	4.0	4.0	208%
4	Intel Tiger Itanium2/1000	4.7	0.0	4.7	4.7	177%
5	HP RX5670 Itanium2/1000	4.7	0.0	4.7	4.7	176%
6	HP ZX6000 Itanium2/900	5.3	0.0	5.3	5.3	156%
7	HP RX2600 Itanium2/1000	5.5	0.0	5.5	5.6	151%

8	Compaq Alpha ES45/1250	5.7	0.0	5.7	6.3	146%
9	AMD Opteron244/1800 (pgi)	5.7	0.0	5.7	5.7	145%
10	IBM pSeries 690Turbo/1.7	6.3	0.0	6.3	6.3	131%
11	Compaq Marvel EV7/1000	6.4	0.0	6.4	6.9	128%
12	Compaq Alpha ES45/1000	7.0	0.0	7.0	7.0	117%
13	Pentium 4/2666 (ifc)	7.1	0.0	7.1	7.1	117%
14	HP PA-9000/RP7410-875	7.6	0.0	7.6	7.6	109%
15	IBM pSeries 690Turbo/1.3	8.3	0.0	8.3	8.3	100%
16	IBM Regatta-HPC/1300	8.4	0.0	8.4	8.4	98%
17	Compaq Alpha ES40/833	8.4	0.0	8.5	8.5	97%
18	HP PA-9000/J6700-750	9.0	0.0	9.0	9.0	92%
19	SGI Onyx 300/R14k-600	9.2	0.0	9.2	9.3	89%
20	AMD MP2400+/2000 (pgi)	9.5	0.0	9.6	9.5	86%
21	Pentium 4/2666 (pgi)	9.6	0.0	9.6	9.6	86%
22	Pentium 4/2533 (pgi)	10.4	0.0	10.4	10.4	80%
23	AMD MP2000+/1667 (pgi)	10.4	0.0	10.4	10.4	79%
24	Compaq Alpha DS20E/667	10.5	0.0	10.6	10.5	78%
25	API UP2000 6/833	10.6	0.0	10.6	10.7	78%
26	Compaq Alpha ES40/667	10.8	0.0	10.8	10.7	77%
27	SGI O3800/R14k-500	10.9	0.0	10.9	10.9	76%
28	IBM pSeries 630/1000	10.9	0.0	10.9	10.9	76%
29	SGI O300/R14k-500	11.1	0.0	11.1	11.1	74%
30	Compaq PW XP1000/667	11.2	0.0	11.2	11.2	74%
31	Pentium 4/2000 (ifc)	11.3	0.0	11.3	11.3	73%
32	SUN Blade 2000/1056-Cu	11.4	0.0	11.4	11.4	72%
33	AMD MP1800+/1533 (pgi)	11.6	0.0	11.6	11.6	71%
34	HP PA-9000/J6000-552	12.2	0.0	12.2	12.3	68%
35	API UP2000 6/667	12.5	0.0	12.5	12.7	66%
36	SGI O2000/R12k-400	13.0	0.0	13.0	13.3	64%
37	AMD Athlon K7/1400(pgi)	13.1	0.0	13.1	13.1	63%
38	SGI Octane2/R12k-400	13.1	0.1	13.2	13.6	62%
39	SGI O3800/R12k-400	13.3	0.0	13.3	13.3	62%
40	SUN Fire V880/900-Cu	13.3	0.0	13.3	13.4	62%
41	Compaq Alpha GS140	13.9	0.0	13.9	13.9	59%
42	SUN Fire 6800/900-Cu	14.1	0.0	14.1	14.1	59%
43	Pentium 4/2000 (pgi)	14.1	0.0	14.1	14.1	59%
44	Compaq Alpha DS20/500	14.4	0.0	14.4	14.4	57%
45	Compaq Alpha ES40/500	14.5	0.0	14.6	14.5	57%
46	AMD Athlon K7/1200(pgi)	14.7	0.0	14.7	14.7	56%
47	Compaq PW XP1000/500	14.8	0.0	14.8	14.8	56%
48	HP Itanium/733-2M L3	10.3	4.9	15.2	15.2	54%
49	IBM Itanium/800-4M L3	15.1	0.1	15.2	15.2	54%
50	Compaq XP1000 6/450	15.6	0.0	15.6	15.6	53%
51	HP PA-9000/N4000-440	15.9	0.1	16.0	16.1	52%
52	Compaq Alpha DS10/466	16.3	0.2	16.5	33.1	50%
53	SUN Blade 1000/M1750	16.7	0.0	16.7	16.7	49%
54	SGI Troon IA64/666	17.6	0.0	17.6	17.6	47%
55	Pentium 4/1500 (pgi)	17.7	0.0	17.8	17.8	47%
56	AMD Athlon K7/1000(pgi)	17.9	0.0	17.9	17.9	46%
57	AlphaPC 264DP-500	18.4	0.0	18.4	18.8	45%
58	Pentium III/1000-CM(pgi)	18.6	0.0	18.6	18.6	44%

59	SGI O2000/R12k-300	18.7	0.0	18.7	18.8	44%
60	HP PA-9000/J5000-440	19.6	0.0	19.6	19.7	42%
61	DEC Alpha 8400/5-625	19.7	0.1	19.8	19.9	42%
62	Pentium 4/1400 (pgi)	19.9	0.0	20.0	20.5	41%
63	HP PA-9000/C3000-400	20.1	0.0	20.1	20.2	41%
64	DEC Alpha PW/600AU	20.2	0.0	20.3	20.2	41%
65	SGI Octane/R12k-270	20.9	0.0	20.9	20.9	40%
66	Pentium III/866-CM(pgi)	21.2	0.0	21.2	21.2	39%
67	AMD Athlon K7/850 (pgi)	21.3	0.0	21.3	21.3	39%
68	SGI O2000/R10k-250	21.6	0.0	21.6	21.7	38%
69	IBM RS/6000 44P-270	21.7	0.0	21.7	21.6	38%
70	IBM RS/6000-SP/375	21.7	0.0	21.7	21.7	38%
71	Pentium III/800-CM(pgi)	23.0	0.0	23.0	23.3	36%
72	DEC Alpha 1200/5-533	23.2	0.1	23.3	24.6	36%
73	Pentium III/800 (pgi)	24.0	0.0	24.1	24.0	34%
74	SGI Origin200/225	24.0	0.0	24.1	24.1	34%
75	SGI Octane/R10k-250	24.5	0.0	24.5	24.5	34%
76	Pentium III/750-CM(pgi)	24.7	0.0	24.7	24.7	33%
77	Pentium III/800-CM(pgi)	24.9	0.0	24.9	24.9	33%
78	AMD Athlon K7/650 (pgi)	26.5	0.0	26.5	26.9	31%
79	DEC Alpha PW/433AU	28.1	0.0	28.2	28.8	29%
80	AMD Athlon K7/600 (pgi)	28.3	0.0	28.3	28.3	29%
81	Pentium III/650-CM(pgi)	28.4	0.0	28.4	28.4	29%
82	SGI O2 R12k/270	29.5	0.1	29.6	30.2	28%
83	SGI O2000/R10k-195	29.9	0.0	29.9	30.8	28%
84	HP PA-9000/V2250	30.7	0.1	30.7	30.8	27%
85	SGI PChall-R10k/195	33.0	0.1	33.1	33.2	25%
86	AMD Athlon K7/500 (pgi)	33.3	0.0	33.3	33.3	25%
87	HP PA-9000/V2200	33.5	0.1	33.5	33.6	25%
88	Pentium III/550 (pgi)	34.3	0.0	34.3	34.3	24%
89	IBM RS/6000-43P	35.8	0.0	35.8	35.7	23%
90	HP PA-9000/C240	36.2	0.0	36.3	36.5	23%
91	DEC Alpha 8400/5-300	37.2	0.1	37.2	37.2	22%
92	IBM RS/6000-SP/222	38.0	0.0	38.0	38.0	22%
93	SGI Octane/R10k-175	40.4	0.1	40.4	40.5	20%
94	ProLiant PII/450 (pgi)	41.1	0.0	41.1	41.2	20%
95	Cray T3E/1200	41.2	0.6	41.8	42.6	20%
96	SUN Ultra80/450	44.0	0.0	44.0	44.1	19%
97	SUN HPC4500/400	49.1	0.0	49.1	49.2	17%
98	Pentium II/400 (pgi)	50.4	0.0	50.5	50.5	16%
99	Cray T3E/900	51.0	0.7	51.7	52.3	16%
100	SGI O2 R5k/300	51.7	0.1	51.8	53.0	16%
101	SUN HPC4500/336	62.6	0.0	62.6	62.7	13%
102	Pentium II/300 (pgi)	65.6	0.0	65.6	65.7	13%
103	IBM SP2/120Thin	67.5	0.0	67.5	68.1	12%
104	Pentium II/300 (abs)	72.1	0.0	72.1	72.1	11%
105	Pentium II/266 (pgi)	76.4	0.0	76.5	76.5	11%
106	SGI O2 R5k/180	80.5	0.2	80.7	83.5	10%
107	Pentium II/266 (abs)	83.8	0.0	83.8	83.8	10%
108	IBM RS/6000-59H	107.7	0.0	107.7	108.3	8%
107	IBM RS/6000-59H	107.7	0.0	107.7	108.3	5%

(+) Prototype, pre-release System

Table 15. Summary of The Chemistry Benchmarks.

The Chemistry Benchmark: Performance (%, see text) Relative to the IBM pSeries 690Turbo/1.3 GHz.

Rank	Machine	SPEC fp2000	SPEC int2000	Matrix-97 (Mat-89)	Chem. Kernels	GAMESS CPU	DLPOLY CPU	Final Index(%)
1	HP RX5670 Madison/1500d (+)	155	144	141	179	-	237	186
2	Intel Tiger Madison/1500	162	145	127	149	127	264	167
3	Intel Tiger Madison/1200 (+)	129	116	100	123	100	208	133
4	IBM pSeries 690Turbo/1.7	134	133	134	129	137	131	133
5	HP RX2600 Itanium2/1000	103	97	95	126	84	151	114
6	Intel Tiger Itanium2/1000	107	97	83	107	85	177	113
7	HP RX5670 Itanium2/1000	113	96	79	108	83	176	112
8	AMD Opteron244/1800 (pgi)	91	131	66	113	98	145	106
9	IBM Regatta-HPC/1300	100	100	101	102	104	98	101
10	Compaq Alpha ES45/1250	108	111	69	106	79	146	100
11	Pentium 4/2666 (ifc)	81	120	68	119	96	117	100
12	IBM pSeries 690Turbo/1.3	100	100	100	100	100	100	100
13	HP ZX6000 Itanium2/900	90	80	60	91	75	156	96
14	HP PA-9000/RP7410-875	53	81	71	72	77	109	82
15	Compaq Alpha ES45/1000	76	81	56	84	70	117	82
16	Pentium 4/2666 (pgi)	81	120	58	98	83	86	81
17	IBM pSeries 630/1000	70	76	76	72	78	76	76
18	AMD MP2400+/2000 (pgi)	52	91	31	95	72	86	71
19	HP PA-9000/J6700-750	46	68	65	64	63	92	71
20	Pentium 4/2533 (pgi)	78	115	52	75	75	80	71
21	Compaq Alpha ES40/833	61	67	49	69	51	97	67
22	Pentium 4/2000 (ifc)	56	78	38	88	67	73	67
23	Pentium 4/2666	81	120	55	70	72	-	66
24	AMD MP2000+/1667 (pgi)	47	79	29	80	64	79	63
25	Pentium 4/2533	78	115	49	67	62	-	59
26	AMD MP1800+/1533 (pgi)	43	73	29	75	59	71	59
27	SUN Blade 2000/1056-Cu	65	69	40	62	54	72	57
28	SGI Onyx 300/R14k-600	39	58	40	58	40	89	57
29	AMD MP2400+/2000	52	91	31	80	-	-	56
30	Compaq Alpha DS20E/667	46	54	39	57	43	78	54
31	API UP2000 6/833	51	64	37	67	35	78	54
32	Compaq Alpha ES40/667	44	52	35	54	47	77	53
33	Pentium 4/2000 (pgi)	56	78	32	62	59	59	53
34	HP PA-9000/J6000-552	34	53	45	49	47	68	52
35	SGI O300/R14k-500	30	45	34	60	34	74	51
36	AMD Athlon K7/1400(pgi)	36	66	22	67	49	63	50
37	SGI O3800/R14k-500	37	51	32	60	32	76	50
38	Compaq PW XP1000/667	35	48	32	51	42	74	50
39	SUN Fire V880/900-Cu	55	60	36	54	45	62	49
40	AMD MP2000+/1667	47	79	28	63	52	-	48
41	SUN Fire 6800/900-Cu	55	61	32	53	41	59	46

42	HP Itanium/733-2M L3	49	66	46	49	34	54	46
43	Pentium 4/2000	56	78	31	57	48	-	45
44	API UP2000 6/667	29	41	29	54	32	66	45
45	AMD Athlon K7/1200(pgi)	33	59	21	58	45	56	45
46	Pentium 4/1500 (pgi)	49	64	32	50	49	47	45
47	IBM Itanium/800-4M L3	55	78	43	45	35	54	44
48	AMD MP1800+/1533	43	73	28	56	48	-	44
49	SGI O3800/R12k-400	32	42	27	50	26	62	41
50	SGI Octane2/R12k-400	27	41	27	48	28	62	41
51	SGI O2000/R12k-400	27	41	27	44	26	64	40
52	IBM RS/6000-SP/375	30	31	39	44	39	38	40
53	HP PA-9000/N4000-440	23	0	34	34	-	52	40
54	Compaq Alpha DS20/500	33	37	28	43	31	57	40
55	IBM RS/6000 44P-270	30	33	37	44	38	38	39
56	Compaq Alpha ES40/500	33	37	23	41	32	57	38
57	SUN Blade 1000/M1750	33	47	30	41	31	49	38
58	HP PA-9000/J5000-440	29	40	35	39	35	42	38
59	AMD Athlon K7/1400	36	66	22	50	41	-	38
60	Pentium 4/1500	49	64	30	43	39	-	37
61	Compaq Alpha GS140	26	37	24	41	25	59	37
62	Compaq PW XP1000/500	30	36	23	40	30	56	37
63	Pentium 4/1400 (pgi)	47	61	30	43	31	41	36
64	AMD Athlon K7/1000(pgi)	25	46	15	47	36	46	36
65	HP PA-9000/C3000-400	28	0	27	35	34	41	34
66	AMD Athlon K7/1200	33	59	20	42	38	-	33
67	Compaq Alpha DS10/466	27	33	18	36	26	50	33
68	Pentium III/1000-CM(pgi)	25	51	15	34	34	44	32
69	AMD Athlon K7/850 (pgi)	22	39	16	40	-	39	32
70	Pentium 4/1400	47	61	26	40	26	-	31
71	SGI O2000/R12k-300	21	31	20	36	21	44	30
72	DEC Alpha 8400/6-575	27	33	25	34	30	-	30
73	Pentium III/866-CM(pgi)	23	49	13	30	30	39	28
74	SGI Octane/R12k-270	15	27	18	33	19	40	28
75	AMD Athlon K7/1000	25	46	15	36	31	-	27
76	Pentium III/800-CM(pgi)	22	44	13	28	29	36	27
77	AMD Athlon K7/850	22	39	15	32	29	-	25
78	HP PA-9000/785 C360	15	32	20	29	27	-	25
79	DEC Alpha PW/600AU	14	21	14	26	19	41	25
80	AMD Athlon K7/650 (pgi)	18	31	13	31	-	31	25
81	SGI O2000/R10k-250	15	26	16	28	17	38	25
82	DEC Alpha 8400/5-625	13	24	14	26	16	42	25
83	SGI Octane/R10k-250	13	23	12	26	-	34	24
84	Pentium III/750-CM(pgi)	18	39	12	26	24	33	24
85	Pentium III/800 (pgi)	22	44	11	26	-	34	24
86	IBM RS/6000-43P	18	21	22	26	22	23	23
87	IBM RS/6000-SP/222	17	22	21	28	22	22	23
88	Pentium III/733-CM(pgi)	19	40	14	26	29	-	23
89	Pentium III/1000-CM	25	51	14	25	28	-	22
90	AMD Athlon K7/600 (pgi)	17	29	11	27	-	29	22
91	DEC Alpha 1200/5-533	14	22	13	24	14	36	22
92	Pentium III/866-CM	23	49	13	26	26	-	22

93	HP PA-9000/V2250	13	20	19	18	-	27	21
94	Pentium III/650-CM(pgi)	17	36	11	23	22	29	21
95	SGI Onyx2 IR2/R10k-250	15	26	16	26	-	-	21
96	SUN Ultra80/450	21	26	19	25	20	19	21
97	HP PA-9000/C240	14	21	17	21	20	23	20
98	Pentium III/800-CM	22	44	12	24	24	-	20
99	Pentium III/733-CM	19	40	12	23	25	-	20
100	AMD Athlon K7/500 (pgi)	15	24	11	23	-	25	20
101	AMD Athlon K7/650	18	31	12	23	24	-	20
102	Pentium III/800	22	44	11	24	23	-	19
103	AMD Athlon K7/600	17	29	13	24	21	-	19
104	HP PA-9000/V2200	12	17	19	17	16	25	19
105	SGI O2 R12k/270	7	21	10	28	11	28	19
106	Pentium III/750-CM	18	39	11	23	21	-	18
107	SUN HPC4500/400	21	25	17	22	17	17	18
108	DEC Alpha PW/433AU	11	18	10	19	14	29	18
109	SGI O2000/R10k-195	12	16	12	17	14	28	18
110	Cray T3E/1200	14	24	10	22	-	20	17
111	Pentium III/550 (pgi)	11	25	10	18	-	24	17
112	IBM SP2/160Thin	15	14	12	22	-	-	17
113	AMD Athlon K7/500	15	24	11	21	18	-	17
114	Pentium III/650-CM	17	24	10	20	19	-	16
115	IBM RS/6000-397	16	14	12	21	16	-	16
116	SGI PChall-R10k/195	9	15	9	16	12	25	16
117	SUN HPC4500/336	18	21	15	18	15	13	15
118	HP PA-9000/C200	12	18	13	18	13	-	15
119	IBM RS/6000-595	10	10	(13)	17	13	-	14
120	DEC Alpha 500/5-500	12	19	10	21	12	-	14
121	SGI Octane/R10k-175	10	14	10	15	12	20	14
122	Pentium III/550	11	25	10	16	16	-	14
123	SGI Octane/R10k-195	11	16	11	17	14	-	14
124	Cray T3E/900	10	18	9	17	-	16	14
125	SUN Ultra-2/300	10	17	12	15	13	-	13
126	DEC Alpha 8400/5-300	7	10	8	13	9	22	13
127	DEC Alpha 500/5-400	8	16	9	17	12	-	13
128	IBM SP2/120Thin	10	9	10	16	12	12	13
129	SUN Ultra30/300	12	17	10	14	13	-	12
130	Pentium II/400 (pgi)	10	19	7	14	-	16	12
131	ProLiant PII/450	10	19	10	14	-	-	12
132	Pentium II/450	10	20	8	13	14	-	12
133	Pentium III/500	11	23	9	14	11	-	11
134	Pentium II/400 (abs)	10	19	7	15	-	-	11
135	HP PA-9000/C160	9	13	10	13	10	-	11
136	DEC Alpha 600/5-333	8	12	8	15	10	-	11
137	Pentium II/400	10	19	7	11	12	-	10
138	SGI O2 R5k/300	6	14	4	13	7	16	10
139	SUN Ultra-2/200	7	11	(9)	11	9	-	10
140	SGI O2 R10k/175	5	15	7	13	8	-	9
141	DEC Alpha 600/5-266	7	10	(7)	11	9	-	9
142	Pentium II/300 (abs)	7	14	5	10	-	11	9
143	DEC Alpha 2100/5-250	5	8	(7)	11	8	-	9

144	Pentium II/266 (pgi)	6	12	5	9	-	11	8
145	Pentium II/266 (abs)	6	12	5	10	-	10	8
146	SUN Ultra-1/170	6	8	(7)	9	7	-	8
147	Pentium II/300	7	14	4	8	9	-	7
148	IBM RS/6000-3CT	6	5	(6)	7	7	-	7
149	SUN Ultra-1/140	5	7	(6)	8	6	-	7
150	SGI O2 R5k/180	3	8	3	8	5	10	7
151	IBM SP2/66Thin	6	5	(6)	7	-	-	7
152	IBM RS/6000-590	6	5	(6)	7	6	-	6
153	DEC Alpha 250/4-266	4	7	(5)	8	6	-	6
154	Pentium II/266	6	12	4	8	7	-	6
155	IBM RS/6000-3BT	4	5	(5)	7	-	-	6
156	HP PA-9000/735-125	2	5	(5)	6	5	-	5
157	SGI Indy-R5k	3	7	(4)	7	4	-	5
158	HP PA-9000/J200	3	4	(5)	5	-	-	5
159	Pentium Pro/200	5	9	2	7	5	-	5
160	DEC AXP/3000-700	3	5	(4)	5	5	-	5
161	HP PA-9000/735	2	4	(4)	5	4	-	4
162	IBM PowerPC-43P	2	6	(3)	5	-	-	4
163	DEC AXP/3000-600	3	4	(3)	4	4	-	4
164	HP PA-9000/715-100	2	4	(3)	4	3	-	3
165	Pentium 233 MMX	4	0	2	5	3	-	3
166	DEC AXP/3000-500	2	3	(3)	2	2	-	2
167	IBM PowerPC-250	1	3	(1)	2	-	-	2
168	Dell Optiplex/266	6	12	3	0	-	-	2
169	SUN SPARC 10/41	1	2	(1)	1	1	-	1

(+) Prototype, pre-release System
(*) Estimated SPECfp2000 and SPECint200 values (see text)

Table 16. APPENDIX: Machine Configurations under Evaluation.

APPENDIX: Machine Configurations under Evaluation.

Machine	Configuration	Location
SUN SPARCstation 10/30	SuperSPARC/36 MHz	DL (loan)
SUN SPARCstation 2/GS	SPARC/40 MHz	DL (loan)
SUN 4/370		DL
Solbourne S4000		DL (loan)
SUN SPARCstation 10/41	SuperSPARC/40 MHz	PNNL
SUN SPARCserver 1000	SuperSPARC/50 MHz	DL (loan)
SUN SPARCstation 5/85	MicroSPARC II/85 MHz	DL (loan)
SUN SPARCstation 20/HS21	HyperSPARC/125 MHz	DL (loan)
SUN Ultra-1 Model 170	UltraSPARC-1/167 MHz	DL
SUN Ultra-2 Model 2200	UltraSPARC-2/200 MHz	DL (loan)
SUN Ultra-1 Model 140	UltraSPARC-1/143 MHz	DL (loan)
SUN Ultra-2 Model 2300	UltraSPARC-2/300 MHz	DL (8MEW)
SUN Ultra30/300	UltraSPARC-2/296 MHz	Adelaide
SUN HPC4500/336	UltraSPARC-2/336 MHz	SUN (9MEW)

SUN HPC4500/400	UltraSPARC-2/400 MHz	SUN
SUN Ultra80/450	UltraSPARC-2/450 MHz	SUN
SUN Blade 1000/M1750	UltraSPARC-3/750 MHz	SUN
SUN Fire 6800/900-Cu	UltraSPARC-3/900 Cu	SUN
SUN Blade 2000/1056-Cu	UltraSPARC-3/1056 Cu	SUN
SUN Fire V880/900-Cu	UltraSPARC-3/900 Cu	SUN
HP PA-9000/755	PA7100/99 MHz	DL
HP PA-9000/750	PA7000/66 MHz	DL
HP PA-9000/720	PA7000/50 MHz	DL
HP/Apollo DN10020	PRISM	DL
HP PA-9000/735	PA7100/99 MHz	DL
HP PA-9000/735/125	PA7150/125 MHz	PNNL
HP PA-9000/715-80	PA7100LC/80 MHz	DL (loan)
HP PA-9000/715-100	PA7100LC/100 MHz	DL (loan)
HP PA-9000/J200	PA7200/100 MHz	DL (loan)
HP PA-9000/C160	PA8000/160 MHz	Berlin
HP PA-9000/C200	PA8200/200 MHz	DL (8MEW)
HP PA-9000/V2200	PA8200/200 MHz	Oxford
HP PA-9000/C240	PA8200/236 MHz	DL (9MEW)
HP PA-9000/785 C360	PA8500/367 MHz	Berlin
HP PA-9000/C3000-400	PA8500/400 MHz	DL (10MEW)
HP PA-9000/J5000-440	PA8500/440 MHz	DL (10MEW)
HP PA-9000/V2250	PA8200/240 MHz	HP
HP PA-9000/N4000-440	PA8500/440 MHz	HP
HP PA-9000/J6000-552	PA8600/552 MHz	DL (11MEW)
HP Itanium/733-2M L3	HP RX4610 Itanium 733/2M	HP
HP PA-9000/J6700-750	PA8700/750 MHz	DL (12MEW)
HP RX2600 Itanium2/1000	Itanium2 1000/3MB L3,f90	HP
HP PA-9000/RP7410-875	PA8700+/850 MHz	HP
HP RX5670 Itanium2/1000	Itanium2 1000/3MBL3,efc	HP
HP ZX6000 Itanium2/900	Itanium2 900/1.5MBL3,efc	HP
HP RX5670 Madsion/1500 (+)	Madison 1500/6MBL3 f90	HP
DEC S5000/200	R3000A/R3010A 25 MHz	DL (loan)
DEC S5000/120	R3000A/R3010A 20 MHz	DL (loan)
DEC AXP/3000-500	AXP A21064/150 MHz	DL (loan)
DEC AXP/3000-600	AXP A21064/175 MHz	PNNL
DEC AXP/3000-300	AXP A21064/150 MHz	PNNL
DEC AXP/3000-700	AXP A21064A/225 MHz	DL (loan)
DEC Alpha 250/4-266	AXP A21064A/266 MHz	DL (loan)
DEC Alpha 8400/5-300	AXP A21164/300 MHz	RAL
DEC Alpha 600/5-266	AXP A21164/266 MHz	DL (loan)
DEC Alpha 600/5-333	AXP A21164/333 MHz	DL (loan)
DEC Alpha 2100/5-250	AXP A21164/250 MHz	DL (loan)
DEC Alpha 500/5-400	AXP A21164/400 MHz	DL
DEC Alpha 500/5-500	AXP A21164/500 MHz	DL (8MEW)
DEC Alpha PW/433AU	AXP A21164/433 MHz	DL
DEC Alpha 8400/5-625	AXP A21164/625 MHz	RAL
DEC Alpha 8400/6-575	AXP A21264/575 MHz	CCC (Galway)
Compaq XP1000 6/450	AXP A21264/450 MHz	DL (loan)
DEC Alpha PW/600AU	AXP A21164/600 MHz	DL (9MEW)
Compaq Alpha DS20/500	AXP A21264/500 MHz	CCC (Galway)

Compaq Alpha ES40/500	AXP A21264/500 MHz	CCC (Galway)
Compaq Alpha GS140	AXP A21264/525 MHz	CCC (Galway)
AlphaPC 264DP-500	AXP A21264/500 MHz	DL (loan)
Compaq PW XP1000/500	AXP A21264/500 MHz	DL
Compaq Alpha DS10/466	AXP A21264/466 MHz	DL
DEC Alpha 1200/5-533	AXP A21164/533 MHz	Compaq TestD
Compaq Alpha ES40/667	AXP A21264A/667 MHz	CCC (Galway)
Compaq PW XP1000/667	AXP A21264A/667 MHz	DL (10MEW)
API UP2000 6/667	Alpha UP2000 6/667	DL
Compaq Alpha DS20E/667	AXP A21264A/667 MHz	DL
Compaq Alpha ES40/833	AXP A21264A/833 MHz	CCC (Galway)
API UP2000 6/833	Alpha UP2000 6/833-4L2	DL (11MEW)
Compaq Alpha ES45/1000	AXP A21264C/1000 MHz	DL (12MEW)
Compaq Alpha ES45/1250	AXP A21264C/1250 MHz	HP/Compaq
Compaq Marvel EV7/1000	Alpha EV7 Marvel / 1000	HP/Compaq
SGI R4000 Indigo	R4000/R4010 100 MHz	DL (loan)
SGI 4D/420		DL (loan)
SGI 4D/320	R3000A/R3010A 33 MHz	DL (loan)
SGI R3000 Indigo	R3000A/R3010A 33 MHz	DL (loan)
SGI 4D/220 GTX		DL
SGI Challenge L/100	R4400/R4010 100 MHz	Utrecht
SGI PChall-R8k/75	R8000/R8010 75 MHz	DL (loan)
SGI Indigo2 R4400/150	R4400/R4010 150 MHz	DL (loan)
SGI Challenge L/150	R4400/R4010 150 MHz	Southampton
SGI R8k Indigo2	R8000/R8010 75 MHz	DL (loan)
SGI PChall-R10k/195	R10000/R10010 195 MHz	DL (loan)
SGI Indy-R5k	R5000/R5000 180 MHz	DL (loan)
SGI Indigo2-R10k/175	R10000/R10010 175 MHz	Liverpool
SGI Indigo2 R4400/250	R4400/R4010 250 MHz	DL
SGI O2000/R10k-195	R10000/R10010 195 MHz	Manchester
SGI Octane/R10k-195	R10000/R10010 195 MHz	DL (8MEW)
SGI Origin200/180	R10000/R10010 180 MHz	DL
SGI O2 R5k/180	R5000/R5010 180 MHz	DL (loan)
SGI O2 R10k/175	R10000/R10010 175 MHz	UNCC
SGI Octane/R10k-175	R10000/R10010 175 MHz	Oxford
SGI O2000/R10k-250	R10000/R10010 250 MHz	Manchester
SGI Octane/R10k-250	R10000/R10010 250 MHz	DL (9MEW)
SGI Onyx2 IR2/R10k-250	R10000/R10010 250 MHz	DL (9MEW)
SGI O2000/R12k-300	R12000/R12010 300 MHz	Utrecht
SGI O2 R12k/270	R12000/R12010 270 MHz	DL
SGI Octane/R12k-270	R12000/R12010 270 MHz	DL (10MEW)
SGI Origin200/225	R10000/R10010 225 MHz	DL
SGI O2 R5k/300	R5000/R5000 300 MHz	Aberdeen
SGI Octane2/R12k-400	R12000/R12010 400 MHz	DL (11MEW)
SGI Troon IA64/666	Itanium IA64 (666MHz)	CSAR
SGI O2000/R12k-400	R12000/R12010 400 MHz	CSAR
SGI O3800/R12k-400	R12000/R12010 400 MHz	SARA
SGI O3800/R14k-500	R14000/R14010 500 MHz	SARA
SGI O300/R14k-500	R14000/R14010 500 MHz	DL (12MEW)
SGI Onyx 300/R14k-600	R14000/R14010 600 MHz	DL (13MEW)
Stardent VISTRA-800		DL (loan)

Stardent 1520		DL
IBM Power1 RS/6000-550	RS6000/41.6 MHz	Perugia
IBM Power1 RS/6000-340	RS6000/33 MHz	DL (loan)
IBM Power1 RS/6000-320		DL (loan)
IBM Power1 RS/6000-350	RS6000/41.6 MHz	DL (loan)
IBM Power1 RS/6000-360	RS6000/50 MHz	DL (loan)
IBM Power1 RS/6000-530H	RS6000/33 MHz	DL
IBM Power2 RS/6000-590	RS6000/66 MHz	IBM
IBM Power1 RS/6000-370	RS6000/62.5 MHz	DL
IBM PowerPC-250		DL
IBM Power2 RS/6000-3CT	RS6000/72 MHz	DL (loan)
IBM PowerPC-25T	MPC601 66 MHz	DL
IBM Power2 RS/6000-3BT	RS6000/67 MHz	DL (loan)
IBM PowerPC-43P	MPC604 100 MHz	DL
IBM Power2 RS/6000-595	RS6000/P2SC-135 MHz	IBM
IBM Power2 RS/6000-397	RS6000/P2SC-160 MHz	DL (8MEW)
IBM RS/6000-630*	RS6000/Power3-160 MHz	IBM (Austin)
IBM Power3 RS/6000-43P	RS6000/Power3-200 MHz	DL (9MEW)
IBM RS/6000-SP/375	RS6000/Power3 WH2/375MHz	DL
IBM RS/6000-SP/222	RS6000/Power3 N/222MHz	Perugia
IBM RS/6000 44P-270	RS6000/Power3 375/8L2	DL (11MEW)
IBM pSeries 690Turbo*	RS6000/Power4 1300/32L3	IBM (Austin)
IBM Itanium/800-4M L3	IBM Itanium 800/4M L3	NCSA
IBM Regatta-HPC/1300	RS6000/Power4 1300/32L3	IBM (France)
IBM pSeries 630/1000	RS6000/Power4 1000/32L3	DL (13MEW)
IBM pSeries 690Turbo/1.3	RS6000/Power4 1300/32L3	DL HPCx
IBM pSeries 690Turbo/1.7	RS6000/Power4 1700/32L3	DL (HPCx)
Commodity CPUs		
Netpower PC	Pentium Pro/200MHz	DL (loan)
Pentium II/266	Intel AL440LX (266MHz)	DL
Pentium II/266 (pgi)	Intel AL440LX (266MHz)	DL
Pentium 233 MMX	Intel LT430TX (233MHz)	Sussex
Dell Optiplex/266	Intel AL440LX (266MHz)	Edinburgh
Pentium II/300	Intel AL440LX (300MHz)	Perugia
Pentium II/300 (abs)	Intel AL440LX (300MHz)	Perugia
Pentium II/266 (abs)	Intel AL440LX (266MHz)	DL
Pentium II/400	Intel SE440BX (400MHz)	RAL
Pentium II/400 (abs)	Intel SE440BX (400MHz)	RAL
Pentium II/400 (pgi)	Intel SE440BX (400MHz)	RAL
Pentium II/450	Intel SE440BX (450MHz)	Porto
Pentium III/500	Intel SE440BX (500MHz)	Birkbeck
Pentium III/550	Intel SE440BX (550MHz)	Berlin
Pentium III/550 (pgi)	Intel SE440BX (550MHz)	Berlin
ProLiant PII/450	Intel SE440BX (450MHz)	Compaq TestD
Pentium III/800	Intel VC820 (800MHz)	DL
Pentium III/800 (pgi)	Intel VC820 (800MHz)	DL
Pentium III/800-CM	Intel VC820 (800MHz)	DL (11MEW)
Pentium III/800-CM(pgi)	Intel VC820 (800MHz)	DL (11MEW)
Pentium III/733-CM	Intel VC820 (733MHz)	Limerick
Pentium III/733-CM(pgi)	Intel VC820 (733MHz)	Limerick
Pentium III/750-CM	Intel VC820 (750MHz)	DL (11MEW)

Pentium III/750-CM(pgi)	Intel VC820 (750MHz)	DL (11MEW)
Pentium III/866-CM	Intel VC820 (866MHz)	DL (loan)
Pentium III/866-CM(pgi)	Intel VC820 (866MHz)	DL (11MEW)
Pentium III/650-CM	Intel VC820 (650MHz)	DL (11MEW)
Pentium III/650-CM(pgi)	Intel VC820 (650MHz)	DL (11MEW)
Pentium 4/1400	Intel D850GB (1.4GHz)	Lancaster
Pentium 4/1400 (pgi)	Intel D850GB (1.4GHz)	Lancaster
Pentium III/1000-CM	Intel VC820 (1.0GHz)	Berlin
Pentium III/1000-CM(pgi)	Intel VC820 (1.0GHz)	Berlin
Pentium 4/1500	Intel D850GB (1.5GHz)	DL
Pentium 4/1500 (pgi)	Intel D850GB (1.5GHz)	DL
Pentium 4/2000	Intel D850GB (2.0GHz)	DL (12MEW)
Pentium 4/2000 (pgi)	Intel D850GB (2.0GHz)	DL (12MEW)
Pentium 4/2000 (ifc)	Intel D850GB (2.0GHz)	DL (12MEW)
Pentium 4/2533	Intel D850GB (2.533GHz)	Milan
Pentium 4/2533 (pgi)	Intel D850GB (2.533GHz)	Milan
Pentium 4/2666	Intel D850EMVR (2.666GHz)	Hull Univ.
Pentium 4/2666 (pgi)	Intel D850EMVR (2.666GHz)	Hull Univ.
Pentium 4/2666 (ifc)	Intel D850EMVR (2.666GHz)	Hull Univ.
Intel Tiger Itanium2/1000	Tiger Itanium 2/1000	DL
Intel Tiger Madison/1200 (+)	Tiger Itanium2/120	OCF
Intel Tiger Madison/1500	Madison 1500/6MBL3 efc	DL (loan)
AMD Athlon K7/500	Microstar MS-6167	DL (loan)
AMD Athlon K7/500 (pgi)	Microstar MS-6167	DL (loan)
AMD Athlon K7/600	Microstar MS-6167	RAL
AMD Athlon K7/600 (pgi)	Microstar MS-6167	RAL
AMD Athlon K7/650	Microstar MS-6167	RAL
AMD Athlon K7/650 (pgi)	Microstar MS-6167	RAL
AMD Athlon K7/850	Asus K7V-RM(Via KX-133)	RAL
AMD Athlon K7/850 (pgi)	Asus K7V-RM(Via KX-133)	RAL
AMD Athlon K7/1000	AMD Microstar K7T Pro1G	Strathclyde
AMD Athlon K7/1000(pgi)	AMD Microstar K7T Pro1G	Strathclyde
AMD Athlon K7/1200	AMD Gigabyte GA-7DX	SARA
AMD Athlon K7/1200(pgi)	AMD Gigabyte GA-7DX	SARA
AMD Athlon K7/1400	AMD Gigabyte GA-7DX	DL
AMD Athlon K7/1400(pgi)	AMD Gigabyte GA-7DX	DL
AMD MP1800+/1533	Tyan Thunder MP1800+	Berlin
AMD MP1800+/1533 (pgi)	Tyan Thunder MP1800+	Berlin
AMD MP2000+/1667	Asus A7M266-D MP2000+	DL (13MEW)
AMD MP2000+/1667 (pgi)	Asus A7M266-D MP2000+	DL (13MEW)
AMD MP2400+/2000	Asus A7M266-D MP2400+	DL (13MEW)
AMD MP2400+/2000 (pgi)	Asus A7M266-D MP2400+	DL (13MEW)
AMD Opteron244/1800 (pgi)	Opteron 244 (1.8 GHz)	DL (loan)
Vector Supercomputers		
CRAY YMP C98/4256		SARA
CRAY YMP J90/10		EPCC
NEC SX-4		NLR
FUJITSU VPP-300/3		RAL
NEC SX-5		NLR
MPP nodes		
KSR-2	KSR-2 node (80 MHz)	PNNL

Cray T3D/AXP-150	AXP node (150 MHz)	Edinburgh
IBM SP2/66Thin	TN2 node (67 MHz)	DL
Cray T3E/900	AXP node (450 MHz)	Berlin
Hitachi SR2201	300 Mflop node	Cambridge
IBM SP2/120Thin	P2SC node (120 MHz)	DL
IBM SP2/160Thin	P2SC node (160 MHz)	IBM (POK)
Cray T3E/1200	AXP EV5 node (600MHz)	Minnesota

(8MEW) Machine on loan for the 8th Daresbury Machine Evaluation Workshop

(9MEW) Machine on loan for the 9th Daresbury Machine Evaluation Workshop

(10MEW) Machine on loan for the 10th Daresbury Machine Evaluation Workshop

(11MEW) Machine on loan for the 11th Daresbury Machine Evaluation Workshop

(12MEW) Machine on loan for the 12th Daresbury Machine Evaluation Workshop

(13MEW) Machine on loan for the 13th Daresbury Machine Evaluation Workshop

M.F.Guest
Sat Sep 27 03:59:30 BST 2003