Digital's DECstation Family Performance Summary

Version 2.0
November 1991
Order Number: EC-N0203-51

Digital Equipment Corporation
Maynard, Massachusetts

digital ™

First Printing, November 1991

This document was prepared using DECwrite, Version 1.1.

Contents

Figures

Tables

Part I

Executive Summary

1 Introduction

Results from a large selection of benchmarks are needed to understand system performance. A workstation application depends on all aspects of the system including the CPU, floating point processor, I/O, and graphics. Each application, however, uses these features to different degrees. Therefore, understanding the nature of your application environment and matching this information with benchmark results is crucial for accurate performance prediction. *Digital's DECstation Family Performance Summary* provides performance information on the DECstation family of systems and selected competitive computers, running standard industry benchmarks.

Digital's DECstation Family Performance Summary introduces Digital's newest UNIX-based RISC platforms:

- Personal DECstation 5000 Model 20
- Personal DECstation 5000 Model 25
- DECstation 5000 Model 133
- DECstation 5000 Model 240

The Personal DECstation is Digital's first RISC-based personal workstation, combining the power of a workstation with the productivity of a PC. The Personal DECstation Series consists of two products; the Personal DECstation 5000 Model 20 (R3000A/20MHz) and the Personal DECstation 5000 Model 25 (R3000A/25MHz). Both share the same modular design for investment protection, have built-in graphics, built-in audio, audio clips, and the ability to develop and run multimedia applications. TURBOchannel expansion slots allow use of 3D graphics, true-color graphics, high-resolution graphics, full motion video, specialized networking options (including FDDI networks), serial line expansion, and numbers I/O options. The Personal DECstation 5000 Series complements the DECstation workstation family with excellent low-end solutions. Both models are ACE compatible.

The DECstation 5000 Model 133 (33MHz) is Digital's newest member of the DECstation 500 Model 100 Series of systems. It has a 33MHz CPU on a 3"x 5" daughter card that allows DECstation 5000 Model 120 and DECstation 5000 Model 125 customers to upgrade processing power easily. The removable card will also allow an easy and economical upgrade to the R4000 generation of processors. The DECstation 5000 Model 133 workstation with the HX (2D) graphics option combines a low cost-of-entry with excellent performance for any application that requires fast 2D drawing speeds. The DECstation 5000 Model 133 is ACE compatible.

The DECstation 5000 Model 240 is Digital's newest high-performance UNIX-based RISC workstation. It provides customers with superb across-the-spectrum performance in all areas of workstation computation (graphics, I/O, integer and floating point, and network throughput), and all in a compact, low-cost desktop package. The DECstation 5000 Model 240 is a workstation for demanding applications. New graphics options improve 2D performance by 200-400%, and up to 33% for 3D wireframes and solids. The DECstation 5000 Model 240 is ACE compatible.

Digital's DECstation Family Performance Summary is a technical reference document for Digital sales support personnel, customers, and other individuals who need to understand performance characteristics of the DECstation family. The benchmarks results appear in the following order:

- SPEC Benchmark
- Dhrystone Benchmark
- Whetstone Benchmark
- Linpack Benchmark
- DR Labs CPU2 Benchmark
- Khornerstone Benchmark
- SoftPC Benchmarks
- 2D Graphics X11perf Benchmark
- 3D Graphics Benchmark
- 3D Polygons Benchmark
- Picture-Level Benchmarks

We ran the DECstation tests discussed in this document in October and November, 1991.

The benchmark results in this performance summary show

- At an entry price of $3,995 and performing at 16.3 SPECmark, the Personal DECstation 5000 Model 20 is the best price/performance workstation or PC under $4,000.
- The new HX 2D graphics accelerator offers leading X11 2D fill area for image applications and excellent 2D vector performance on the DECstation 5000 Model 240.
- The new PXG+ 3D graphics accelerator provides leading graphics performance for full configured systems priced $15,000-$20,000.

2 Methodology

Wherever possible, we executed the same benchmark code on all systems. However, due to equipment availability of competitive systems and time constraints, some information is based on the most current, previously published data for those particular systems and has not been independently verified. See Appendix A, titled *Test Configurations,* for configuration, operating system and compiler versions, and source of each benchmark result.

3 Summary of Relative Performance

Tables 3-1 through Table 3-4 contain the benchmarking performance results of the DECstation family of systems and selected competitive systems.

Table 3-1: DECstations and Competitive Workstations CPU and FPU Benchmark Results

Workstation	SPEC-mark	SPEC Integer	SPEC Floating Point	Dhrystone MIPS	Dhrystone (Dhrystone per second)	Whetstone Single (KWIPS)	Whetstone Double (KWIPS)	Linpack Single Precision (MFLOPS)	Linpack Double Precision (MFLOPS)	DR Labs CPU2 (MVUPS)	Total Khorner-stones
DECstation 5000/20[1]	16.3	13.5	18.4	21.60	37951	20985	16865	5.32	2.44	22.78	26689
DECstation 5000/25[1]	19.1	15.7	21.7	26.70	46927	25860	20882	6.60	2.80	27.71	31257
DECstation 5000/120[1]	16.4	13.8	18.4	21.69	38116	20465	16560	5.31	2.56	22.00	29494
DECstation 5000/125[1]	19.3	16.1	21.7	26.80	47090	25627	20597	6.67	3.01	26.81	33731
DECstation 5000/133[1]	25.5	20.9	29.1	34.42	60475	33292	26724	8.79	5.93	37.10	39606
DECstation 5000/200[1]	23.5	19.5	26.7	27.27	47920	25679	20899	6.81	3.73	28.61	27604
DECstation 5000/240[1]	32.4	27.9	35.8	43.0	75557	42812	34457	10.80	6.04	47.16	50949
SPARCstation IPC[2]	13.5	12.8	14.0	15.70	27585	10204	6369	3.20	1.70	10.64	19030
SPARCstation ELC[2]	20.3	18.0	22.0	23.07	40540	23148	14663	3.61	2.20	17.29	23909
SPARCstation IPX[2]	24.4	21.7	26.5	26.68	46875	27778	19120	4.34	2.65	20.80	29111
SPARCstation 2[2]	25.0	21.7	27.4	28.50	50075	19920	14641	6.10	4.20	21.60	27142
HP 9000/425t	11.0	12.3	10.3	25.87	45454	4417	4112	1.69	1.62	8.47	14512
HP 9000/425e	10.3	12.2	9.3	33.09	58139	10858	10753	1.69	1.60	7.92	42753
HP 9000/720[2]	59.5	39.5	78.5	57.00	100149	56180	48310	22.90	17.20	47.70	44573
IBM RS/6000 320[2]	32.8	15.9	53.1	29.64	52083	19920	22173	8.22	6.91	27.86	54661
IBM RS/6000 320H[2]	41.2	20.0	66.8	37.10	65185	n/a	n/a	11.70	n/a	n/a	n/a
SGI Personal Iris 4D/25G	12.2	14.0	11.1	16.45	28901	12903	9615	2.94	1.42	16.15	20727
SGI 4D/35[2]	31.1	28.0	33.4	33.00	57981	n/a	n/a	n/a	6.00	n/a	n/a
SGI Indigo[2]	26.3	23.6	28.4	31.27	54945	22676	17921	4.30	3.15	26.13	92032
NeXTStation	10.2	11.9	9.2	14.11	24793	4167	5459	1.64	1.58	6.58	17200
Compaq 386/33	n/a	n/a	n/a	8.40	14749	6086	4710	1.27	.76	6.30	10838
Compaq 486/33	n/a	n/a	n/a	18.97	33333	7541	7353	1.42	1.29	8.47	14614

[1] SPEC benchmark results recorded using new advanced compiler technology which will be available in the Spring 1992
[2] SPEC benchmark results recorded using Kuck and Associates' pre-compilers

Table current as of November 1991

n/a = not available

Refer to Appendix A for test configurations

Table 3-2: DECstations and Competitive Workstations Graphics Benchmark Results I

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)[2]	2D Vectors X11perf. 10-pixel line (Kvectors/sec.)[3]	3D Graphics 3D Vectors (Kvectors/sec.)	3D Graphics 3D Polygons (Kpolygons/sec.)*	GPC Picture-Level Benchmarks				
					pc_board	sys_chassis	cyl_head	head	shuttle
Personal DECstation 5000/20 board	5.7	153.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Personal DECstation 5000/25 board	6.4	183	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Personal DECstation 5000/25 HX	14.7	285.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Personal DECstation 5000/25 PXG+	18.3	339.0	312	68	11.2	11.9	16.2	20.9	20.0
DECstation 5000/120 MX	7.9	108.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/120 HX	14.6	272.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/120 PXG+	18.3	338.0	307	68	11.2	10.7	16.2	20.9	20.0
DECstation 5000/120 PXGT+[1]	12.3	434.0	310	102	12.1	11.4	17.0	21.3	21.1
DECstation 5000/125 MX	8.0	114.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/125 HX	14.6	284.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/125 PXG+	18.3	338.0	310	68	11.2	11.9	16.2	20.9	20.0
DECstation 5000/125 PXGT+[1]	12.3	434.0	313	102	12.2	12.5	17.0	21.3	21.1
DECstation 5000/133 MX	8.1	124.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/133 HX	14.8	298.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/133 PXG+	18.3	339.0	376	68	11.3	13.0	16.2	20.9	20.1
DECstation 5000/133 PXGT+[1]	12.3	434.0	405	102	12.2	13.7	17.1	21.3	21.1
DECstation 5000/200 MX	14.0	162.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/200 HX	30.3	510.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/200 PXG+	18.5	345.0	400	70	11.6	13.6	16.8	21.3	20.8
DECstation 5000/200 PXGT+[1]	12.3	445.0	434	106	12.6	14.9	17.7	21.7	21.9

Table current as of November 1991
Refer to Appendix A for test configuration

n/a=not available or not applicable

[1] not actually tested; expected results
[2] Mpixels=1,048,576 pixels

[3] Kvectors=1,000 vectors
* Kpolygons=1,000 polygons

Table 3-3: DECstations and Competitive Workstations Graphics Benchmark Results II

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)[2]	2D Vectors X11perf. 10-pixel line (Kvectors/sec.)[3]	3D Graphics 3D Vectors (Kvectors/sec.)	3D Graphics 3D Polygons (Kpolygons/sec.)~	GPC Picture-Level Benchmarks				
					pc_board	sys_chassis	cyl_head	head	shuttle
DECstation 5000/240 MX	20.3	248.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/240 HX	30.5	621.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
DECstation 5000/240 PXG+	18.5	345.0	401	70	11.6	13.8	16.8	21.3	20.9
DECstation 5000/240 PXGT+*	12.3	445.0	436	106	12.6	15.3	17.8	21.7	22.1
Sun SPARCstation IPC[1]	5.1	58.2	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sun SPARCstation ELC[1]	17.9	29.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sun SPARCstation IPX[1]	9.7	217.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Sun SPARCstation [1]	8.3	205.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HP 9000/425t Personal VRX[1]	.9	23.3	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HP 9000/425t[1]	1.5	69.1	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HP 9000/425e[1]	8.8	49.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
HP 9000 Model 720 CRX[1]	22.8	868.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a
SGI 4D/RPC Indigo[1]	8.6	141.0	n/a	n/a	n/a	n/a	n/a	n/a	n/a

Table current as of November 1991
Refer to Appendix A for test configuration

not available or not applicable
[1] X11perf results from Workstation Laboratories, Inc.

* not actually tested; expected results
[2] Mpixels=1,048,576 pixels

[3] Kvectors=1,000 vectors
~ Kpolygons=1,000 polygons

Table 3-4: DECstations and Competitive Workstations SoftPC Benchmark Results

Workstations	SoftPC Norton SI	SoftPC Dhrystone	SoftPC *PC Magazine's* Bench V4.0
DECstation 5000/25 board @66Hz **DECstation 5000/25 HX @66Hz** **DECstation 5000/25 HX @72Hz**	13.1 12.5 13.0	2806 2750 3193	3.2 3.1 3.2
DECstation 5000/120 MX	9.8	2528	2.5
DECstation 5000/125 PXG	13.0	2517	3.1
DECstation 5000/200 CX	13.1	3479	3.3
IBM PC/AT (*MHz)	6.9	1761	1.0
NeXTStation	n/a	1949	n/a

n/a = not available

Refer to Appendix A for test configuration

Table current as of November 1991

Part II

Benchmark Results

A variety of systems have been tested and compared in this document. Our tests are primarily CPU and/or graphics-intensive and the reader is encouraged to carefully consider the appropriateness of mapping these results into their own environments.

Presented in this section for each benchmark is a brief description of the benchmark ran and the results and conclusions. The table appearing on this page explains the systems' abbreviations used in the graphs.

Specific configuration details and source of benchmark results are presented in Appendix A. References are listed in Appendix B.

Table 3-5: Key to Graphs

Key to Graphs	
Abbreviation	**Full Product Description**
DS 5000/20	Digital Personal DECstation 5000 Model 20
DS 5000/25	Digital Personal DECstation 5000 Model 25
DS 5000/120	Digital DECstation 5000 Model 120
DS 5000/125	Digital DECstation 5000 Model 125
DS 5000/133	Digital DECstation 5000 Model 133
DS 5000/200	Digital DECstation 5000 Model 200
DS 5000/240	Digital DECstation 5000 Model 240
SPARCstation IPC	Sun SPARCstation IPC
SPARCstation ELC	Sun SPARCstation ELC
SPARCstation IPX	Sun SPARCstation IPX
SPARCstation 2	Sun SPARCstation 2
HP 9000/425t	Hewlett-Packard 9000 Model 425t
HP 9000/425t PVRX	Hewlett-Packard 9000 Model 425t Personal VRX
HP 9000/425e	Hewlett-Packard 9000 Model 425e
HP 9000/720	Hewlett-Packard 9000 Model 720
IBM AT 80286	IBM AT 80286
IBM RS/6000 320	IBM RISC System/6000 Model 320
IBM RS/6000 320H	IBM RISC System/6000 Model 320H
SGI 4D/25G	Silicon Graphics Personal Iris 4D/25G
SGI 4D/35	Silicon Graphics 4D/35
SGI Indigo	Silicon Graphics 4D/RPC Indigo
NeXTStation	NeXT Computer NeXTStation
Compaq 386/33	Compaq Deskpro 386/33
Compaq 486/33	Compaq Systempro 486/33

4 SPEC Benchmark Suite

4.1 Background

Systems Performance Evaluation Cooperative (SPEC) is a nonprofit organization formed to develop a standard suite of benchmark programs that characterize system performance. Digital is a member of SPEC and endorses its goals.

The release 1.2 suite consists of ten compute intensive codes/programs. The performance metric used by SPEC is elapsed time. Four of the ten programs are written in C and are classified as compute intensive. The geometric mean of these make up the SPEC metric called SPECint. The other six programs are written in FORTRAN and are floating point intensive. The geometric mean of these make up the SPECfp metric. SPECmark is the geometric mean of all ten elapsed times normalized to the VAX 11/780.

4.2 Results and Conclusions

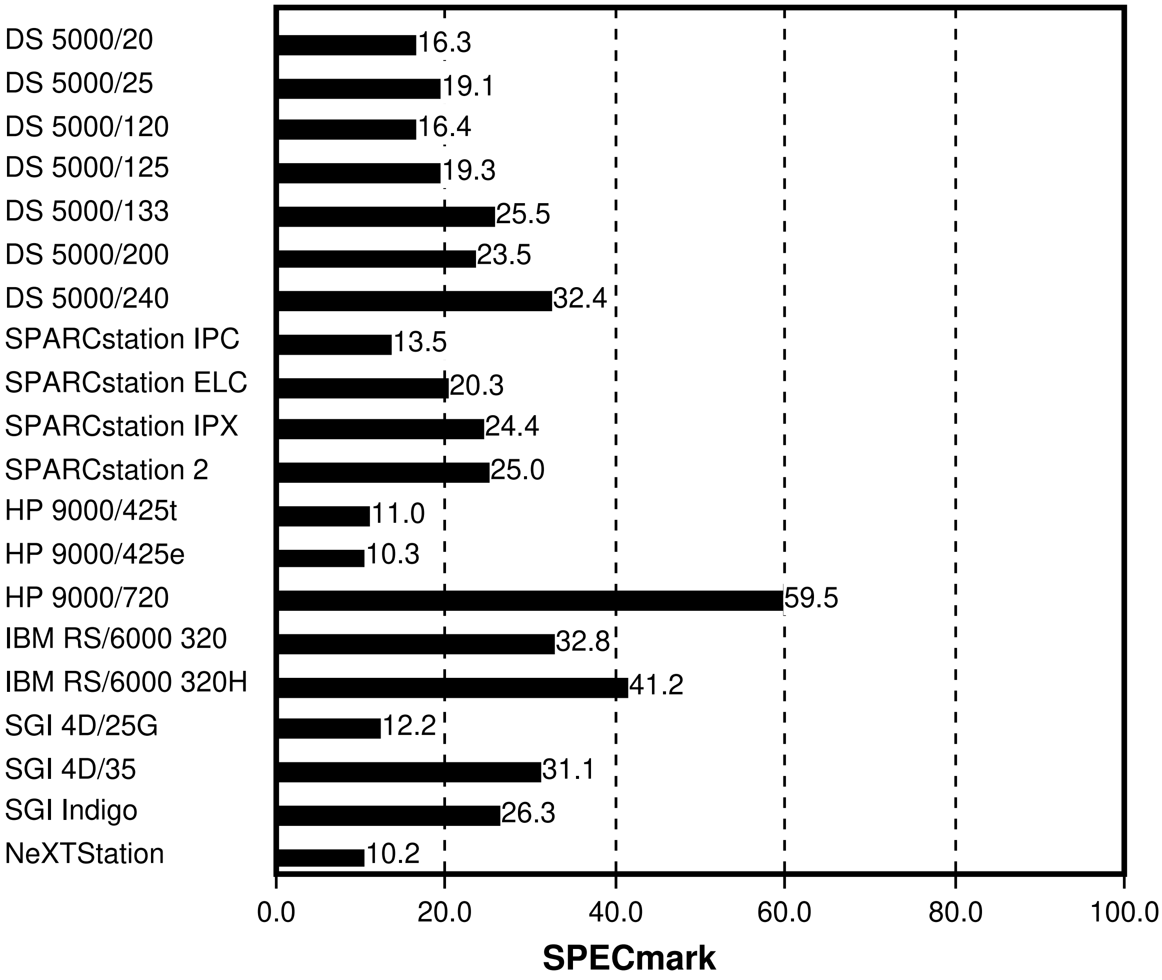
Shown on the following pages are the SPEC Benchmark Suite results graphed and various conclusions from the SPEC benchmark testing.

Note: Compaq 386/33 and Compaq 486/33 SPEC results were not available.

For the SPEC benchmarks

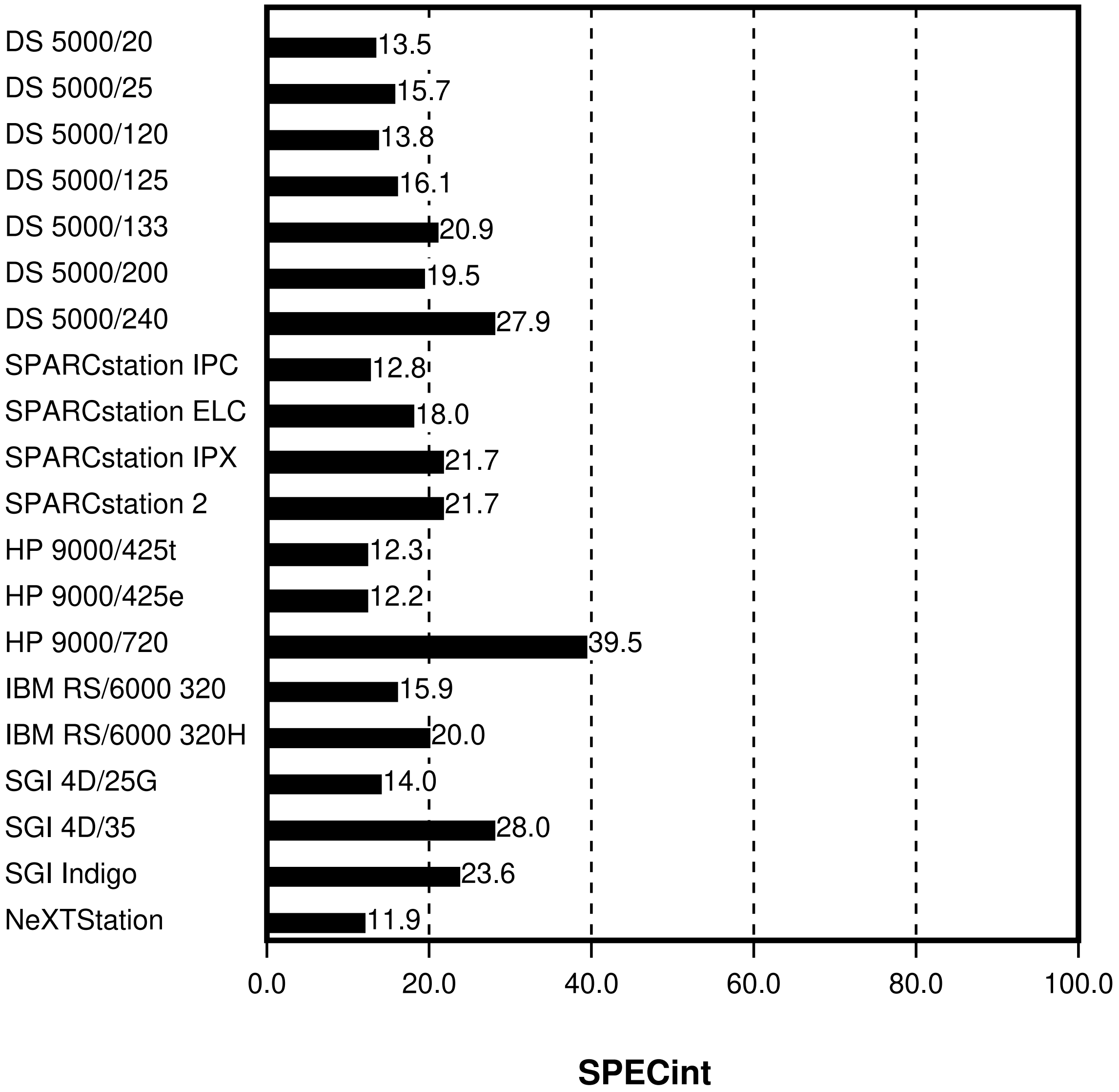
- At an entry price of $3,995 and performing at 16.3 SPECmark, the Personal DECstation 5000 Model 20 is the best price/performance workstation or PC under $4,000.
- The Personal DECstation Models 20 and 25 offer better overall SPECmark performance than the SPARCstation IPC, the HP 9000 Models 425t and 425e, SGI's Personal Iris 4D/25, and the NeXTStation. The Model 25 offers similar performance to the SPARCstation ELC.
- The DECstation 5000 Model 133 offers similar performance to the SPARCstation 2 and SPARCstation IPX at a lower entry price.
- The DECstation 5000 Model 240 offers better overall performance than the SPARCstation 2 and SGI's Iris Indigo.

Figure 4-1: SPECmark Benchmark Results



SPECint measures a CPU's integer performance which is important to CASE, electronic publishing, office, and many other commercial applications. The DECstation 5000 Model 240 has significantly better SPEC integer performance than Sun's SPARCstation 2 and both the IBM RS/6000 Models 320 and 320H. Additionally, while the DECstation 5000 Model 240 is 54% of the overall SPEC performance of the HP 9000/720, it is 71% of the HP 9000/720's SPECint performance.

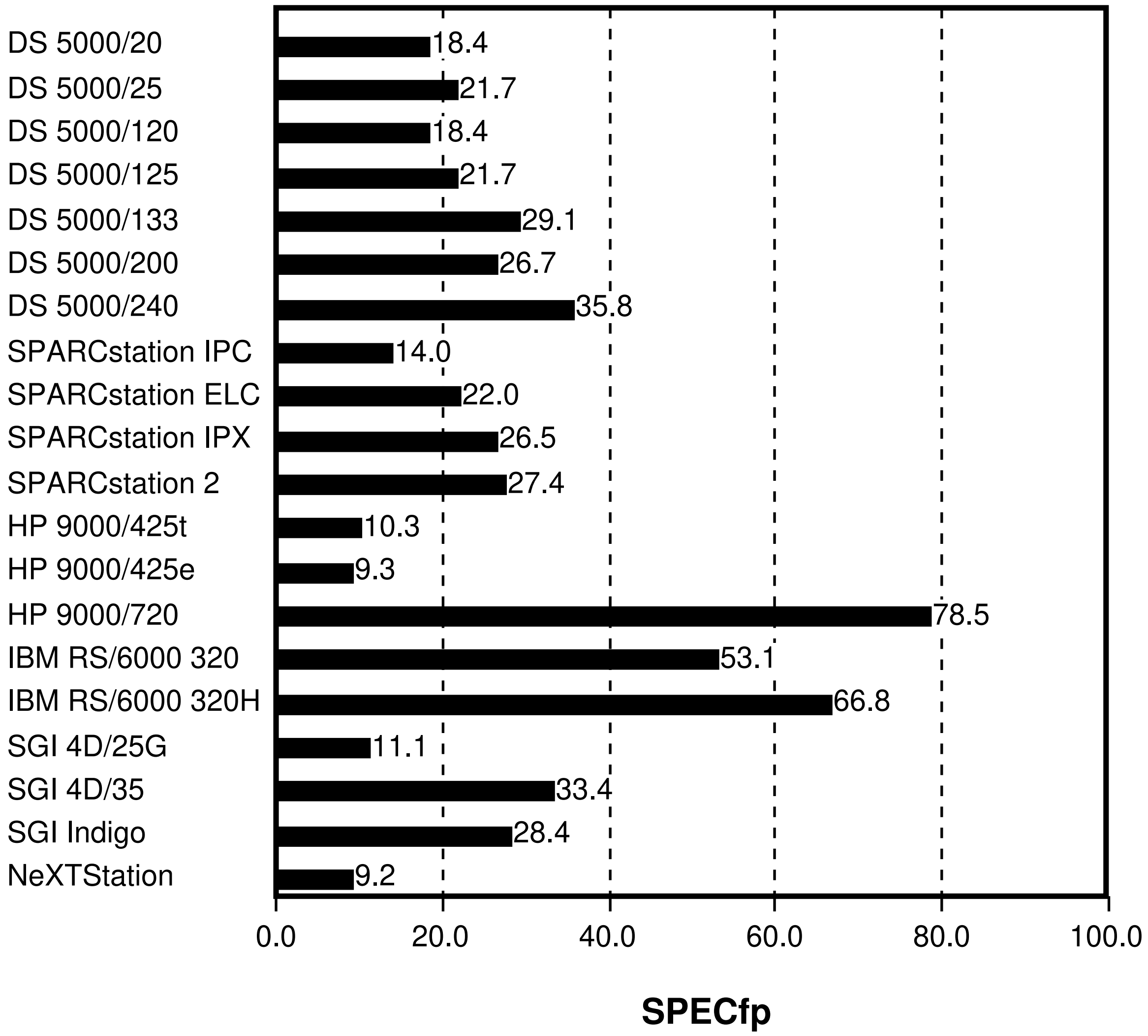
Figure 4-2: SPEC Integer Benchmark Results



Comparing SPECfp results show

- The Personal DECstation 5000 Models 20 and 25 offer approximately twice the SPEC floating point performance of the HP 9000 Models 425t and 425e, and the NeXTStation.
- The DECstation 5000 Model 240 offers approximately 25% better performance than the SPARCstations 2 and IPX.

Figure 4-3: SPEC Floating Point Benchmark Results



The SPEC Ratio for a benchmark is the quotient derived from dividing the SPEC reference time by a particular machine's corresponding run time. For Release 1.2, the SPEC reference time is the time (in seconds) that it takes a VAX 11/780 machine to run each particular benchmark in the suite.

Table 4-1: DECstations' SPEC Ratios (SPEC Reference Time/Elapsed Time)

Benchmark No. & Name	Type	DS 5000/20[1]	DS 5000/25[1]	DS 5000/120[1]	DS 5000/125[1]	DS 5000/133[1]	DS 5000/200[1]	DS 5000/240[1]
001.gcc	INT[2]	11.0	12.2	12.1	13.7	16.8	18.1	23.3
008.espresso	INT	14.2	17.4	14.2	17.4	22.7	18.3	28.7
013.spice 2g6	FP[3]	9.7	11.4	9.7	11.4	14.8	14.3	16.5
015.doduc	FP	15.6	18.7	15.4	18.8	25.2	20.8	30.8
020.nasa7	FP	17.5	19.9	17.5	20.0	25.4	27.7	32.0
022.li	INT	15.5	17.5	15.6	17.4	22.4	23.1	32.5
023.eqntott	INT	13.6	16.5	13.6	16.4	22.3	18.7	28.0
030.matrix300	FP	47.4	57.4	47.5	57.0	82.7	66.5	99.0
042.fpppp	FP	18.4	22.1	18.3	21.9	28.4	25.1	38.4
047.tomcatv	FP	17.0	19.5	17.1	19.5	27.1	26.4	33.8

[1] SPEC results recorded using new advanced compiler technology which will be available Spring 1992.
[2] Integer benchmark written in C
[3] Floating-point benchmark written in FORTRAN

Table 4-2: Competitors' SPEC ratios (SPEC Reference Time/Elapsed Time)

Benchmark No. & Name	Type	SPARC-station IPC[1]	SPARC-station ELC[1]	SPARC-station IPX[1]	SPARC-station 2[1]	HP 9000/ 425e	HP 9000/ 720[1]	IBM 6000/ 320[1]	IBM 6000/ 320H[1]	SGI Indigo[1]
001.gcc	INT[2]	11.3	16.6	19.9	20.0	11.8	36.0	13.5	16.9	23.5
008.espresso	INT	13.1	18.0	21.7	21.7	12.5	43.4	15.9	19.9	22.8
013.spice 2g6	FP[3]	10.3	13.4	16.1	16.5	9.4	44.5	20..6	26.0	19.4
015.doduc	FP	8.1	14.0	16.6	18.2	7.5	47.6	22.9	28.8	22.6
020.nasa7	FP	15.6	23.6	28.4	29.1	10.6	64.5	57.7	72.6	30.5
022.li	INT	12.9	19.0	23.0	23.1	15.1	37.7	15.8	20.0	25.8
023.eqntott	INT	14.1	18.4	22.2	22.3	9.8	41.2	18.8	23.6	22.3
030.matrix300	FP	42.9	67.7	81.5	82.6	8.3	323.2	323.2	404.0	86.5
042.fpppp	FP	11.5	19.1	23.0	23.8	12.3	78.5	41.8	53.0	19.1
047.tomcatv	FP	11.9	19.7	23.8	24.9	8.2	66.4	60.9	76.6	23.6

[1] SPEC results recorded using Kuck and Associates' pre-compilers
[2] Integer benchmark written in C
[3] Floating-point benchmark written in FORTRAN

5 Dhrystone Integer Benchmark

5.1 Background

The Dhrystone benchmark was introduced in an ADA program in 1984 developed by Reinhold P. Weicker. It has since been translated into C and TURBO PASCAL.

This synthetic benchmark[1] measures processor and compiler efficiency. Its emphasis is on the type of data and operations encountered in a system rather than numerical programming. Dhrystones is CPU-intensive.

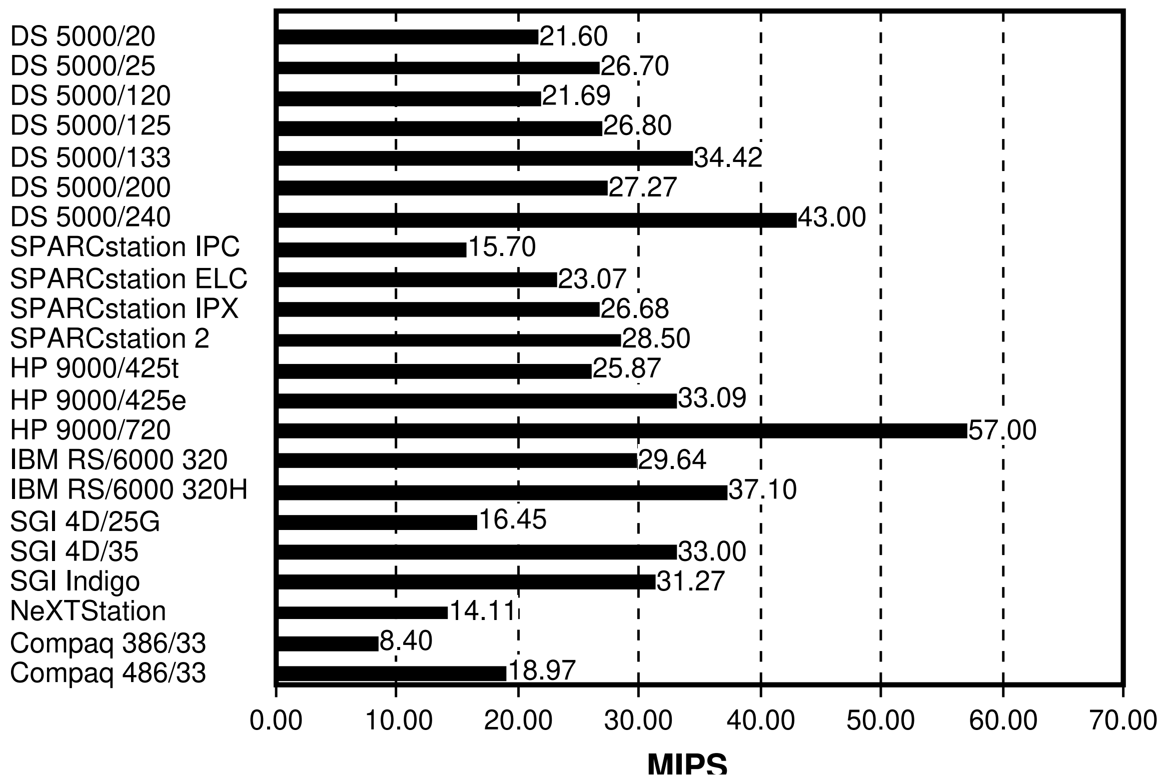
Dhrystones are most commonly expressed in Integer MIPS (Millions of Instructions Per Second) where 1 MIP is the number of Dhrystones per second that can be performed by a VAX 11/780 (1757 Dhrystones/second).

Dhrystone V1.1 was used to include as many target competitors as possible.

5.2 Results and Conclusion

Following are the results of the Dhrystone benchmark tests.

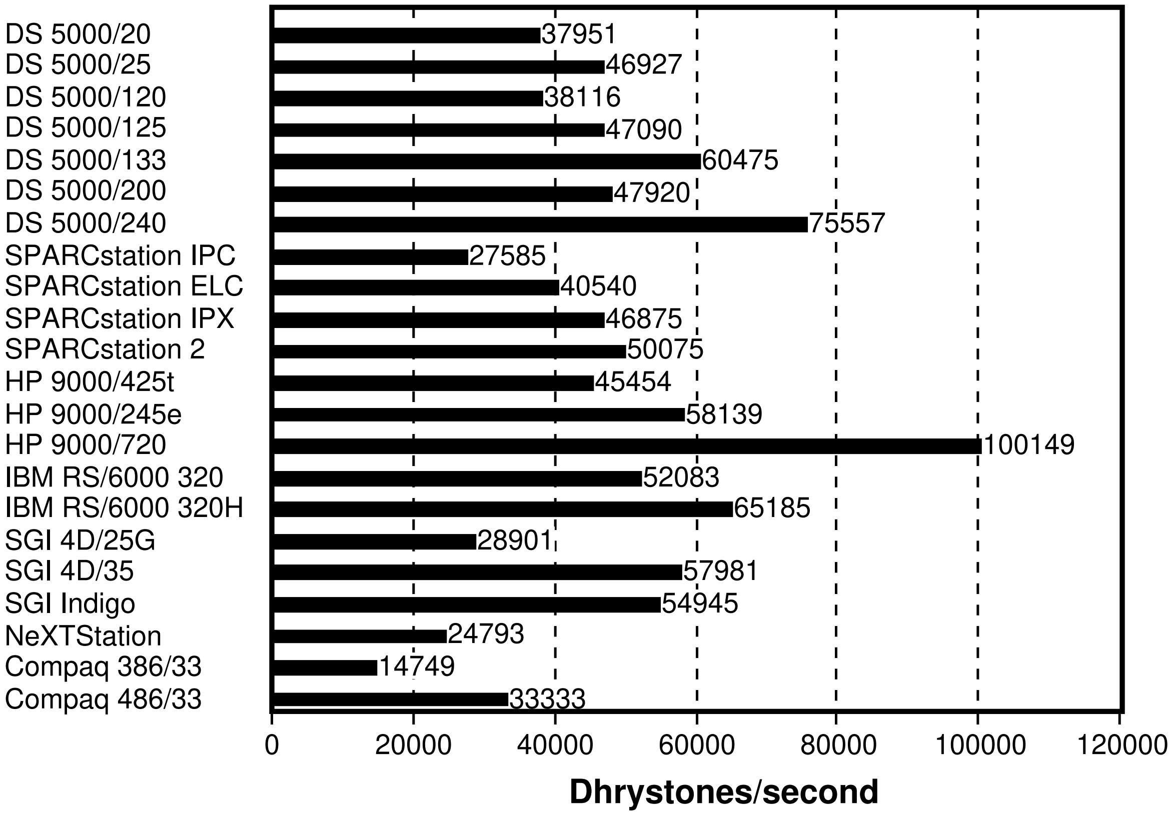
Figure 5-1: Dhrystones Benchmark Results (MIPS)



[1] Synthetic benchmarks are mostly loops which time different system calls and are not based on actual applications.

Dhrystones/second are shown in the following graph.

Figure 5-2: Dhrystone Benchmark Results (Dhrystones/second)



6 Linpack Benchmark

6.1 Background

Developed at Argonne National Laboratories, Linpack is a FORTRAN benchmark that solves a 100x100 system of linear equations. This benchmark is widely used to compare the performance of mathematical and scientific applications where floating point computations are prevalent. When running, this benchmark gives little weight to I/O.

The results are measured in millions of floating point operations per second (MFLOPS). Both single-precision and double-precision operations are reported.

6.2 Results and Conclusions

Charts containing MFLOPS results follow.

Note: SGI 4D/35 single-precision Linpack results were not available. IBM RS/6000 320H double-precision Linpack results were also unavailable.

Figure 6-1: Linpack Single-Precision Benchmark Results

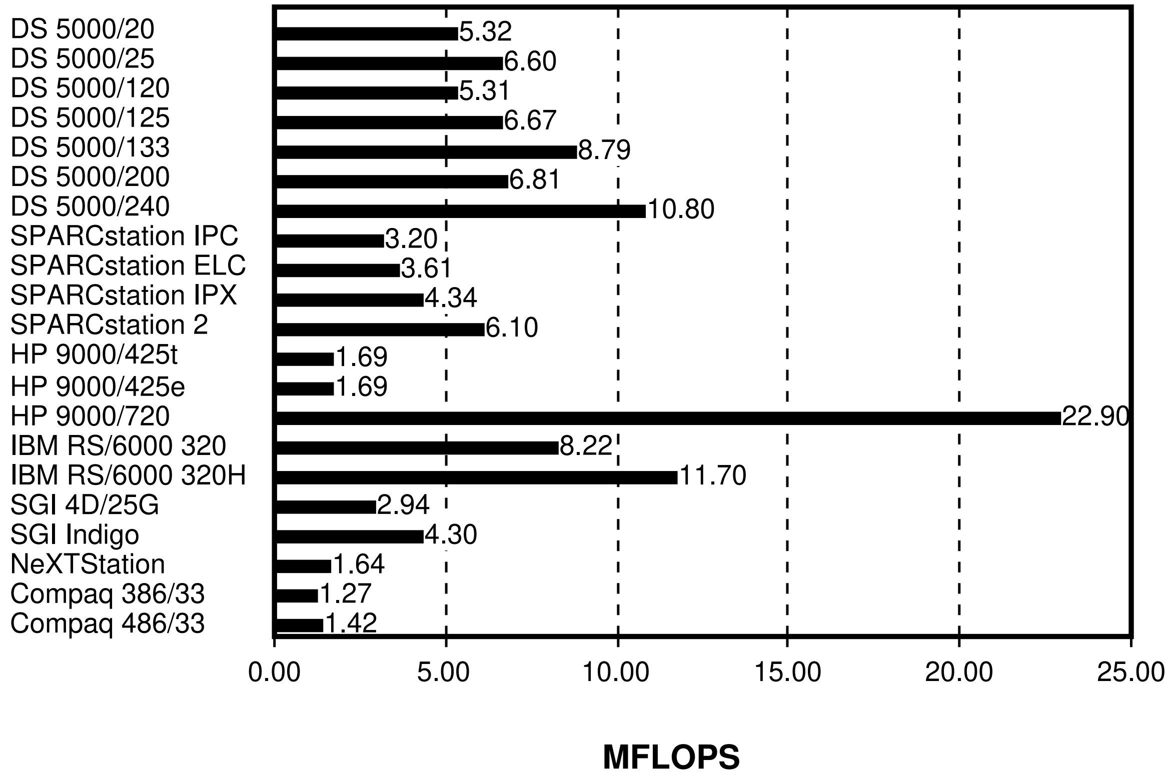
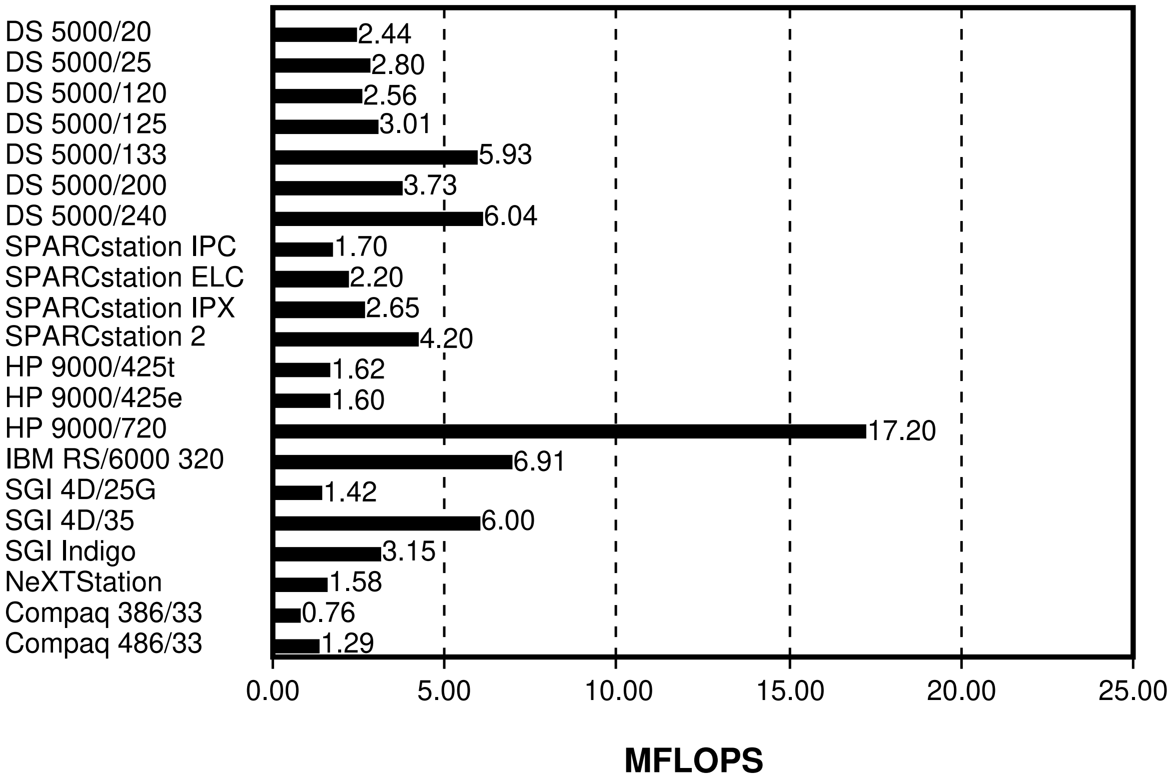


Figure 6-2: Linpack Double-Precision Benchmark Results



7 Whetstone Benchmark

7.1 Background

The Whetstone benchmark was developed in Great Britain's National Physical Laboratory in Whetstone, England in 1970. This synthetic benchmark was designed to represent small engineering/scientific programs.

The Whetstone benchmark has been implemented in single-precision and double-precision FORTRAN programs, each arranged to defeat most compiler optimizations. The results are measured in KWIPS (thousands of Whetstone Instructions Per Second).

7.2 Results and Conclusions

Shown below are the results of the Whetstone benchmark tests.

Note: IBM RS/6000 320H and SGI 4D/35 single- and double-precision Whetstone benchmark results were not available.

Figure 7-1: Whetstones Single-Precision Benchmark Results

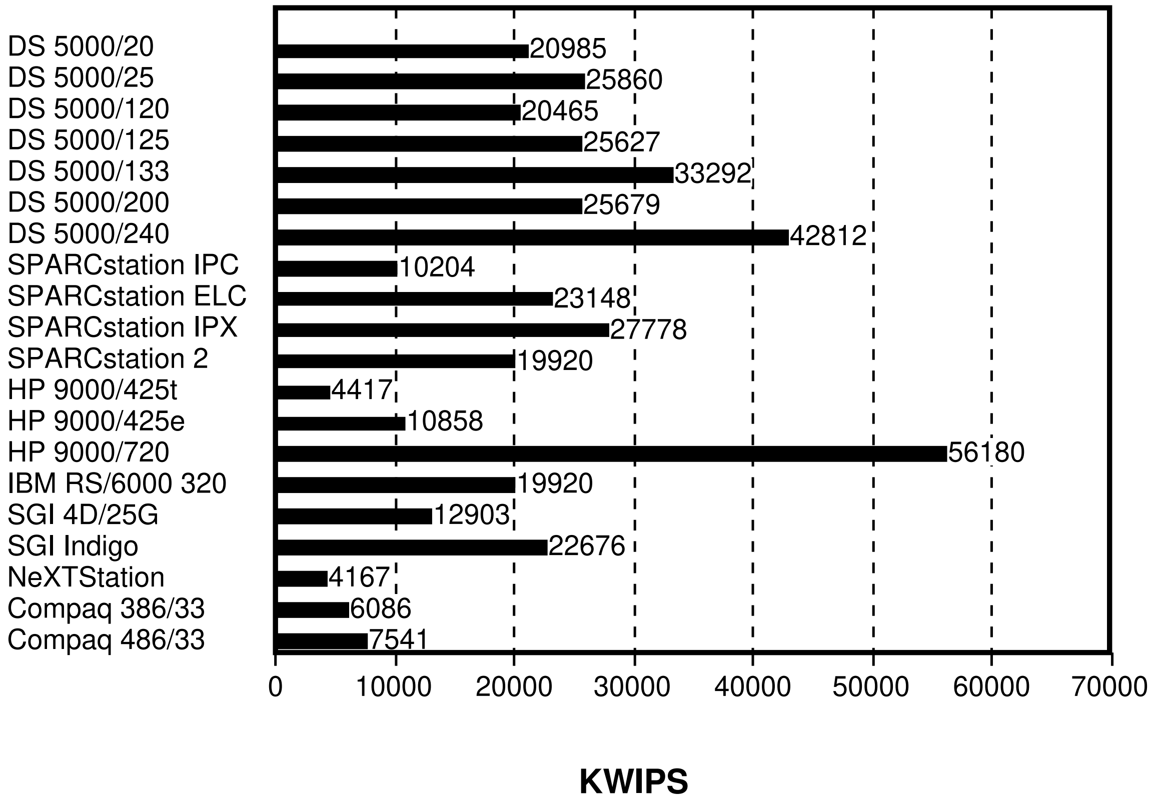
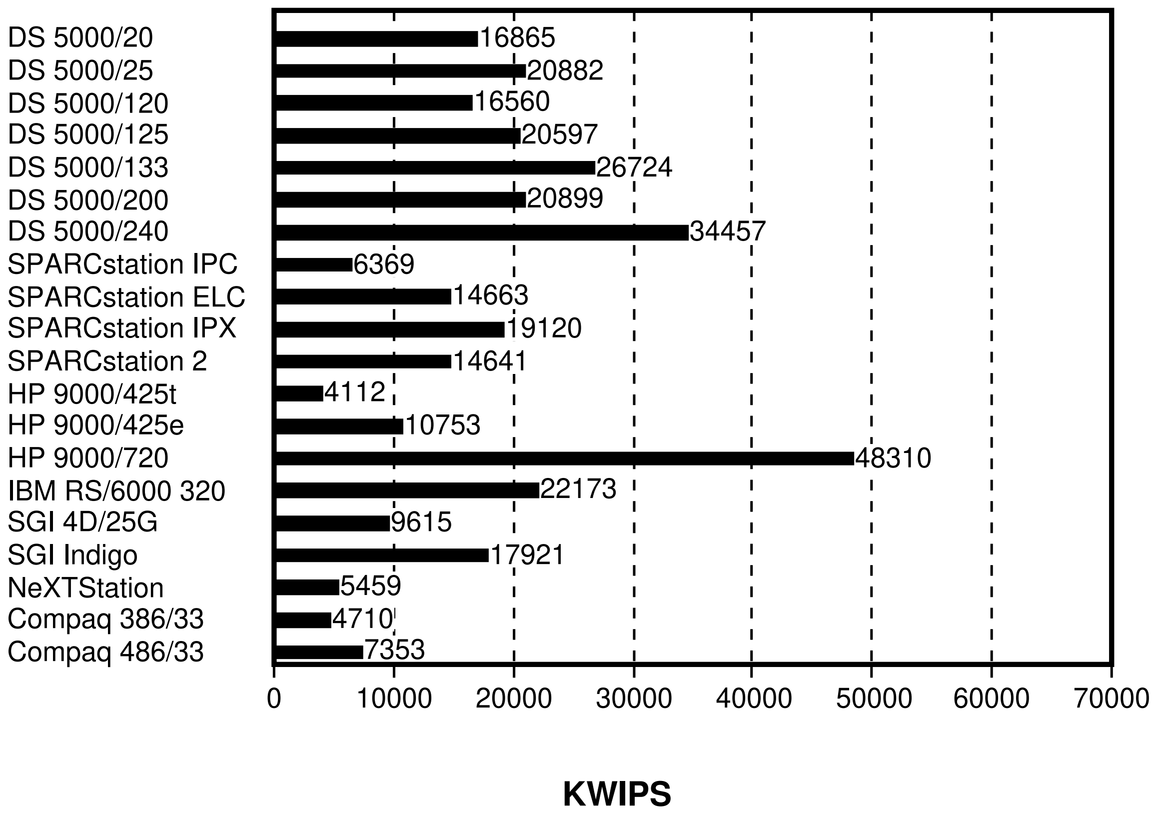


Figure 7-2: Whetstones Double-Precision Benchmark Results



8 DR Labs CPU2

8.1 Background

The DR Labs CPU2 benchmark, a public domain benchmark from *Digital Review Magazine,* is a floating-point intensive series of FORTRAN programs that include thirty-four separate tests. The results of the CPU2 suite reflect the raw compute speed of a processor, the efficiency of a system's FORTRAN compiler and, to a lesser degree, the speed of memory access. A system's I/O capabilities do not affect the results. The benchmark is most relevant in predicting the performance of engineering/scientific applications.

Performance is expressed as a multiple of MicroVAX II Units of Performance (MVUPs).

8.2 Results and Conclusions

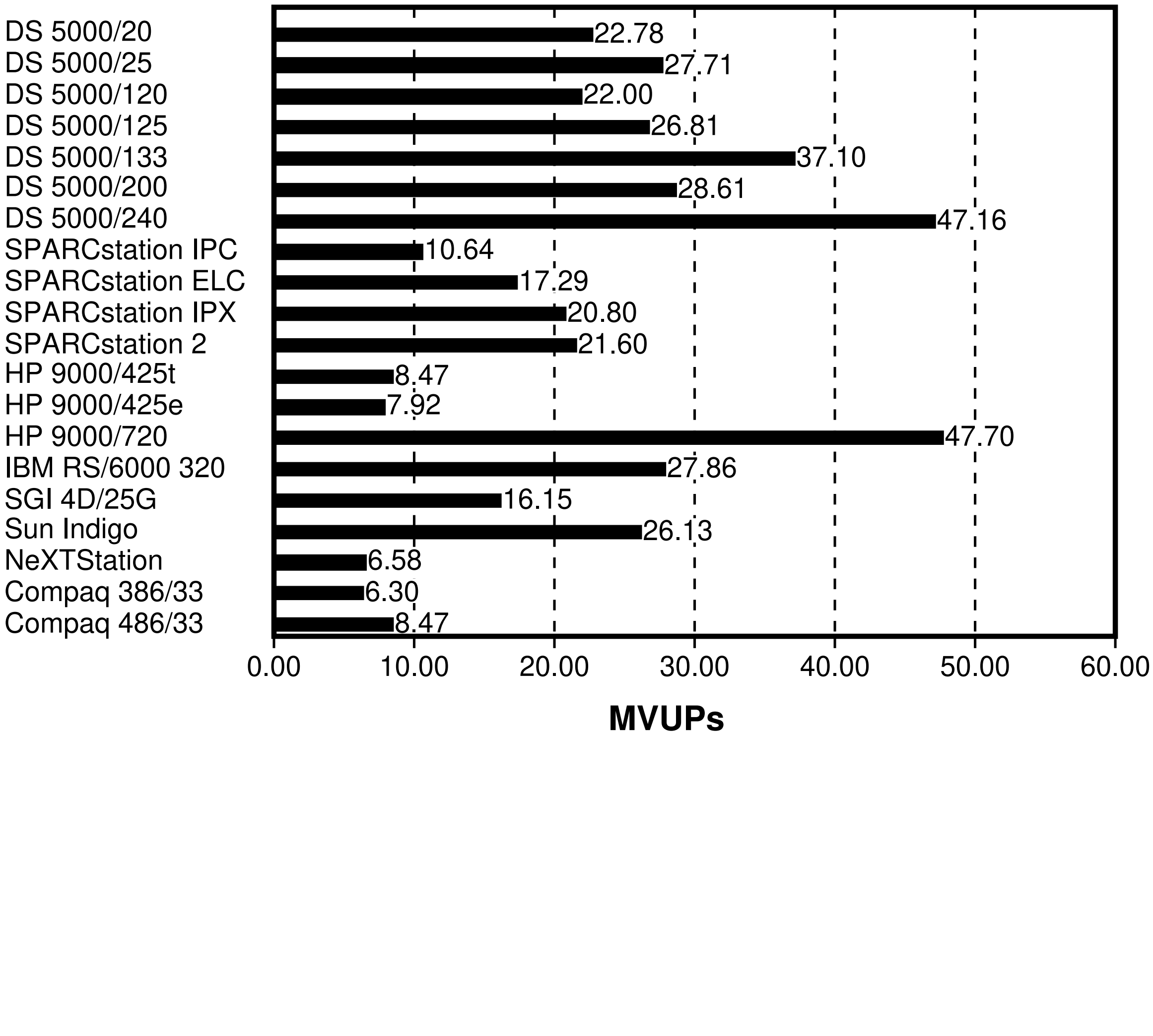
The results and conclusions of the DR Labs CPU2 benchmark tests are shown on the following page.

Note: IBM RS/6000 320H and SGI 4D/35 MVUPs results were not available.

For DR Lab's CPU2 benchmarks

- All DECstations, including the Personal DECstations, recorded faster MVUPs than all SPARCstations.
- The DECstation 5000 Model 240 is 99% MVUP performance of HP's 9000/720.
- The Personal DECstations are 2.5-3.5 times faster than the Compaq 386/33 and 486/33, the HP 9000 Models 425t and 425e, and the NeXTStation.

Figure 8-1: DR Labs CPU2 Benchmark Results



9 Khornerstone Benchmarks

9.1 Background

The Khornerstone and Khornerstone2 Benchmarks were developed by Workstation Laboratories, Irving, TX. Consisting of 21 separate tests, the benchmarks rate the overall performance of a system. The tests include both public domain (Whetstone, Dhrystone, Sieve, etc.) and proprietary routines. The purpose of these tests is to measure single-user loads on a system and to provide one number representing that load condition.

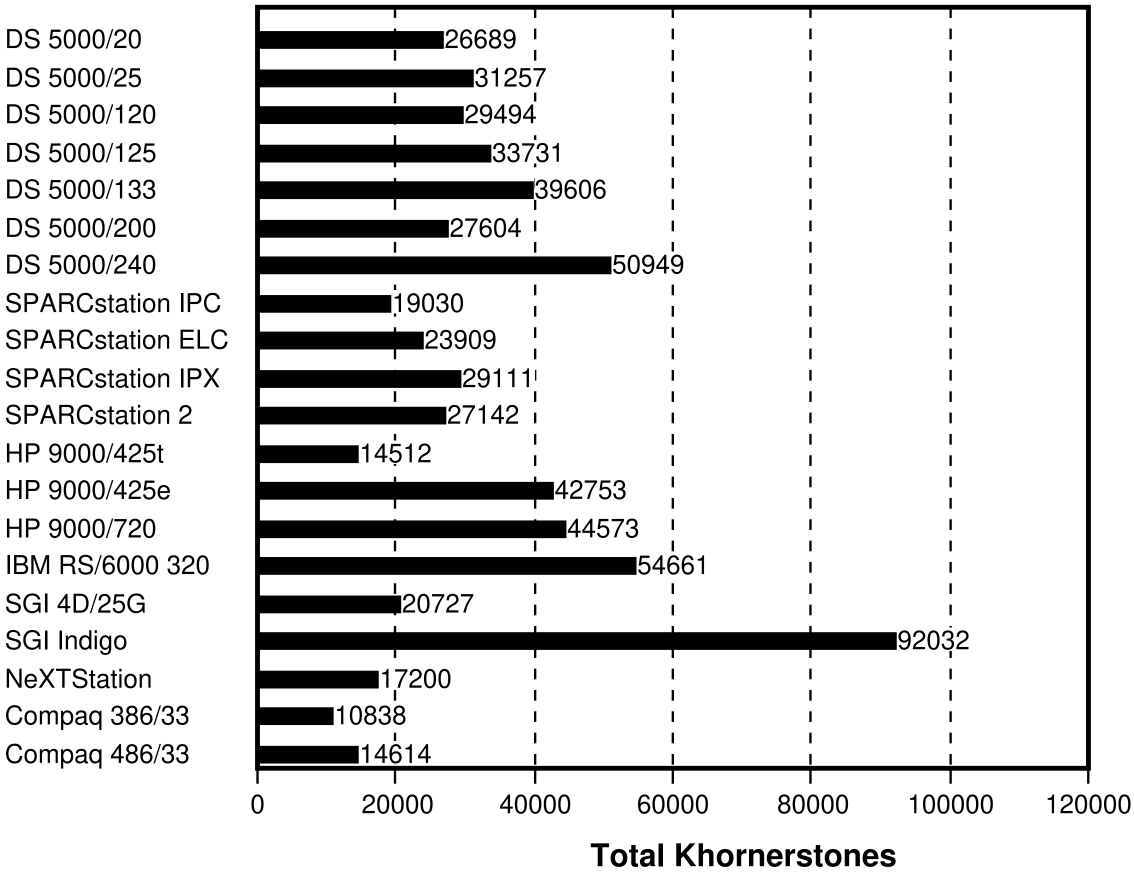
The Khornerstone and Khornerstone2 benchmarks differ in that the Khornerstone2 test runs 10 times as many repetitions of each test.

9.2 Results and Conclusions

The following graph has the Khornerstone and Khornerstone2 benchmark results.

Note: IBM RS/6000 320H and SGI 4D/35 Khornerstone results were not available. HP 9000/425e Khornerstone results were recorded using large buffer cache.

Figure 9-1: Khornerstones Benchmark Results



10 SoftPC for ULTRIX

10.1 Background

DEC SoftPC for ULTRIX provides the RISC user the ability to operate DOS based software. The SoftPC product emulates an IBM PC/AT system (real mode only) using standard hardware and software. A DOS application will function in the SoftPC environment as it functions on an IBM PC/AT so long as it does not require special hardware, protected mode, himem.sys or copy protected diskette.

10.2 Results and Conclusions

The performance of the DEC SoftPC facility is dependent upon the speed of the processor and the type of application being run. Performance of graphics applications will be slower than compute-intensive applications. The benchmark results shown below were derived by running ten cycles (on an average) of each of the following: Norton Speed Index (SI), Dhrystone Integer Benchmark, and *PC Magazine's* BENCH V4.0. The BENCH program gives an index number relative to an 8 MHz IBM PC/AT.

As shown in the following table, the DECstation 5000 Model 25 running SoftPC is approximately twice as fast as an IBM PC/AT.

Table 10-1: SoftPC Benchmarks Results

Computers	SoftPC Norton SI	SoftPC Dhrystone per second	SoftPC *PC Magazine*'s Bench 4.0
DECstation 5000/25 board @66Hz	13.1	2,806	3.2
DECstation 5000/25 HX @66Hz	12.5	2,750	3.1
DECstation 5000/25 HX @72Hz	13.0	3,193	3.2
DECstation 5000/120 MX	9.8	2,528	2.5
DECstation 5000/125 PXG	13.0	2,517	3.1
DECstation 5000/200 CX	13.1	3,479	3.3
IBM PC/AT (8MHz)	6.9	1,761	1.0
NeXTStation	n/a	1,949	n/a

n/a = not available

11 DECstations Graphic Options

Abbreviations used for the DECstation computer systems included in the graphics benchmarks sections are shown in the following table.

Table 11-1: Key to DECstations Graphic Options

Key to Graphic Options			
Abbreviation	**Full Graphics Description**	**Options**	**Tested**
board	On-board 8-Plane Frame Buffer	(1024x768@72Hz)	Yes
MX	1-Plane Monochrome Frame Buffer	(1280x1024@72Hz)	Yes
HX	8-Plane Color Smart Frame 2D Graphics	(1024x768@72Hz)	No
HX	8-Plane Color Smart Frame 2D Graphics	(1024x864@60Hz)	No
HX	8-Plane Color Smart Frame 2D Graphics	(1280x1024@66Hz)	No
HX	8-Plane Color Smart Frame 2D Graphics	(1280x1024@72Hz)	Yes
PXG	8- or 24-Plane 3D Graphics w/wo Z-Buffer	(1280x1024@66Hz)	Yes
PXG+	8- or 24-Plane Dual-Width 3D Graphics	(1280x1024@66Hz)	Yes
PXG+	8- or 24-Plane Dual-Width 3D Graphics	(1280x1024@72Hz)	No
PXGT	24-Plane 3D Graphics w/wo Z-Buffer	(1280x1024@66Hz)	Yes
PXGT+	24-Plane 3D Graphics	(1280x1024@66Hz)	Yes
PXGT+	24-Plane 3D Graphics	(1280x1024@72Hz)	No

12 2D Graphics X11perf Benchmarks

12.1 Background

Developed by Digital and submitted to the X consortium at the Massachusetts Institute of Technology, X11perf tests various aspects of X server performance including simple 2D graphics, window management functions, and X-specific operations. Other non-traditional graphics included are CopyPlane,and various stipples and tiles.

X11perf employs an accurate client-server synchronization technique to measure graphics operations completion time. Both graphics primitive drawing speeds and window environment manipulation are tested.

Measurements reported in this section are:

- 2D vector results from X11perf *10-pixel line* tests; shown in units of kilovectors (Kvectors/second)
- 2D fill area results from X11perf *Copy 500x500 from pixmap to window* tests; shown in units of mega-pixels or Mpixels (mega-pixel=1,048,576 pixels)

12.2 Results and Conclusions

The following table and graphs contain excerpts from the X11perf results of the two most commonly requested performance metrics for 2D graphics systems, *10-pixel lines* and *Copy 500x500 from pixmap to window*. Results are shown in units of 2D Kvectors/second drawing rate and Mpixels/second fill rate.

Note: We believe that it is inappropriate to compare Compaq systems X11perf results with the other systems shown here. There are several X11 server software packages available that will turn the Compaq into a X11 terminal. Each one would probably produce different X11perf results because each has different performance characteristics (one might do lines really well and another might do windows really well). You would not be able to directly map the results because other vendors of 486 systems' hardware would be different and their performance would also be different. Therefore, Compaq X11perf results have not been included in the table nor graphic graphs.

Note: 2D X11perf results were not available for the IBM RS/6000 320, IBM RS/6000 320H, and SGI 4D/25G.

Table 12-1: DECstations' 2D Graphics X11perf Benchmark Results

Workstations	2D Kvectors/second[2]	2D Mpixels/second[3]
DS 5000/20 Board	153.0	5.7
DS 5000/20 HX	274.0	14.6
DS 5000/25 Board	183.0	6.4
DS 5000/25 MX	115.0	8.0
DS 5000/25 HX	285.0	14.7
DS 5000/25 PXG	260.0	13.9
DS 5000/25 PXG+	339.0	18.3
DS 5000/120 MX	108.0	7.9
DS 5000/120 HX	272.0	14.6
DS 5000/120 PXG	259.0	13.9
DS 5000/120 PXG+	338.0	18.3
DS 5000/120 PXGT	434.0	12.3
DS 5000/120 PXGT+[1]	434.0	12.3
DS 5000/125 MX	114.0	8.0
DS 5000/125 HX	284.0	14.6
DS 5000/125 PXG	259.0	13.9
DS 5000/125 PXG+	338.0	18.3
DS 5000/125 PXGT	434.0	12.3
DS 5000/125 PXGT+[1]	434.0	12.3
DS 5000/133 MX	124.0	8.1
DS 5000/133 HX	298.0	14.8
DS 5000/133 PXG	260.0	13.9
DS 5000/133 PXG+	339.0	18.3
DS 5000/133 PXGT	434.0	12.3
DS 5000/133 PXGT+[1]	434.0	12.3
DS 5000/200 MX	162.0	14.0
DS 5000/200 HX	510.0	30.3
DS 5000/200 PXG	263.0	13.9
DS 5000/200 PXG+	345.0	18.5
DS 5000/200 PXGT	445.0	12.3
DS 5000/200 PXGT+[1]	445.0	12.3
DS 5000/240 MX	248.0	20.3
DS 5000/240 HX	621.0	30.5
DS 5000/240 PXG	263.0	13.9
DS 5000/240 PXG+	345.0	18.5
DS 5000/240 PXGT	445.0	12.3
DS 5000/240 PXGT+	445.0	12.3

[1] Not tested; expected results [2] Kvectors=1,000 vectors [3] Mpixels=1,048,576 pixels

Table 12-2: Competitors' 2D Graphics X11perf Benchmark Results

Workstations	2D Kvectors/second[2]	2D Mpixels/second[3]
SPARCstation IPC[1]	58.2	5.1
SPARCstation ELC[1]	29.3	17.9
SPARCstation IPX[1]	217.0	9.7
SPARCstation 2[1]	205.0	8.3
HP 9000/425t Personal VRX[1]	23.3	.9
HP 9000/425t[1]	69.1	1.5
HP 9000/425e[1]	49.0	8.8
HP 9000/720 CRX[1]	868.0	22.8
SGI 4D/RPC Indigo[1]	141.0	8.6

[1] X11perf results from Workstation Laboratories benchmarking
[2] Kvectors=1,000 vectors
[3] Mpixels=1,048,576 pixels

In 2D vector drawing

- The Personal DECstation Models 20 and 25 with no graphics accelerations outperform all competitors in their class. They are more than twice as fast as the SPARCstation IPC and the HP 9000 Models 425t and 425e; they are 5 times faster than the SPARCstation ELC.
- With HX, the 2D graphics accelerator, the Personal DECstation 5000 Model 25 is faster than the SPARCstation 2 and SPARCstation IPX at a much lower entry price.
- Both the Personal DECstation 5000 Model 25 and DECstation 5000 Model 133 with PXG+ 3D graphics acceleration are 14 times faster than the HP 9000 Model 425t with Personal VRX, also a 3D graphics accelerator.
- With HX, the 2D graphics accelerator, the DECstation 5000 Model 133 is faster than the SPARCstation IPX, SPARCstation 2, and SGI's Iris Indigo.
- The DECstation 5000 Model 240 offers over 2.8 times the performance of the SPARCstation IPX and SPARCstation 2, and over 4.4 times the performance of SGI's Iris Indigo.

Figure 12-1: Personal DECstations' and Competitors' 2D Graphics X11perf Benchmark Results

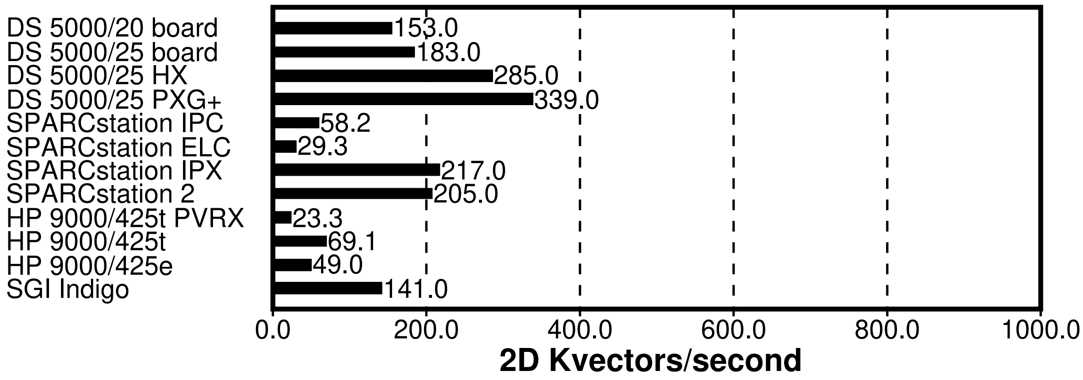


Figure 12-2: DECstation 5000/133's and Competitors' 2D Graphics X11perf Benchmark Results

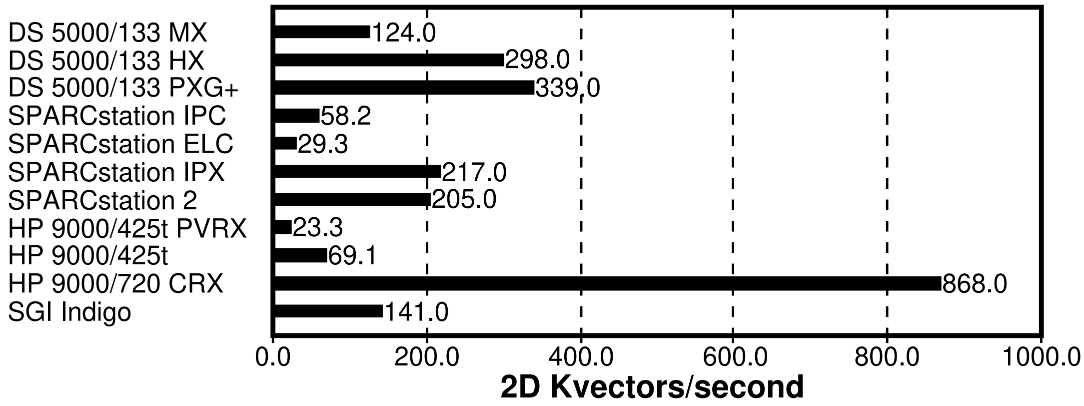
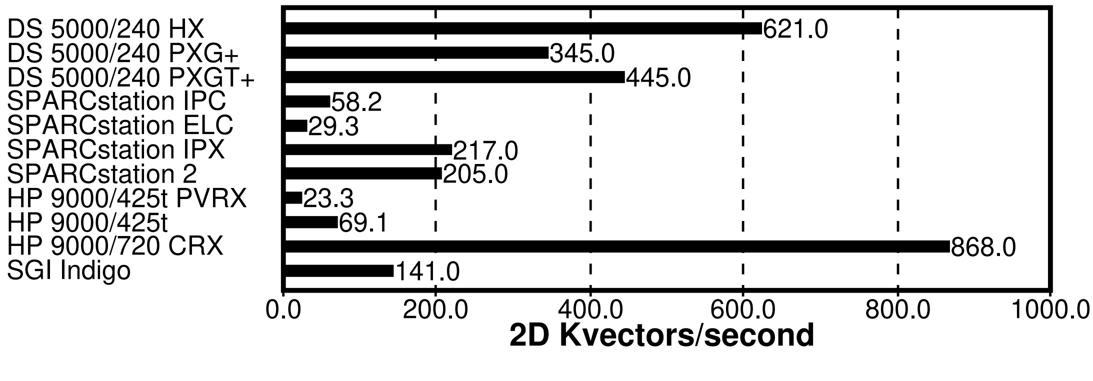


Figure 12-3: DECstation 5000/240's and Competitors' 2D Graphics X11perf Benchmark Results



2D fill area measures the copy of a pixmap to a window which is very important for image applications and double-buffer animation techniques. All DECstations listed in the following charts use full 8-bit planes.

The results of 2D fill area tests indicate

- The Personal DECstation 5000 Models 20 and 25 with no graphics acceleration are over five times faster than the HP 9000 Model 425t. Note that the SPARCstation ELC is displaying a single-bit monochrome image, which makes it faster than most other systems shown in Figure 12-4.
- With HX, the 2D graphics accelerator, the Personal DECstation 5000 Model 25 is faster than the SPARCstations 2 and IPX at a much lower entry price.
- Both the Personal DECstation 5000 Model 25 and DECstation 5000 Model 133 with PXG+ 3D graphics acceleration are 14 times faster than the HP 9000 Model 425t with Personal VRX, also a 3D graphics accelerator.
- The DECstation 5000 Model 240 MX is over twice as fast as the SPARCstation 2.
- The DECstation 5000 Model 240 with HX graphics accelerator outperforms the HP 9000 Model 720. At 30.5 Mpixels/second, the DECstation 5000 Model 240 can achieve real-time image animation.

Figure 12-4: Personal DECstations' and Competitors 2D Fill Area Graphics X11perf Benchmark Results

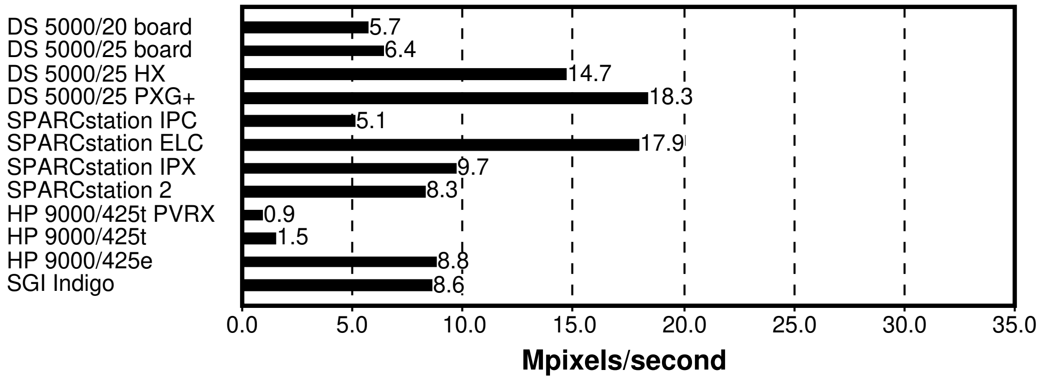


Figure 12-5: DECstation 5000/133's and Competitors' 2D Fill Area Graphics X11perf Benchmark Results

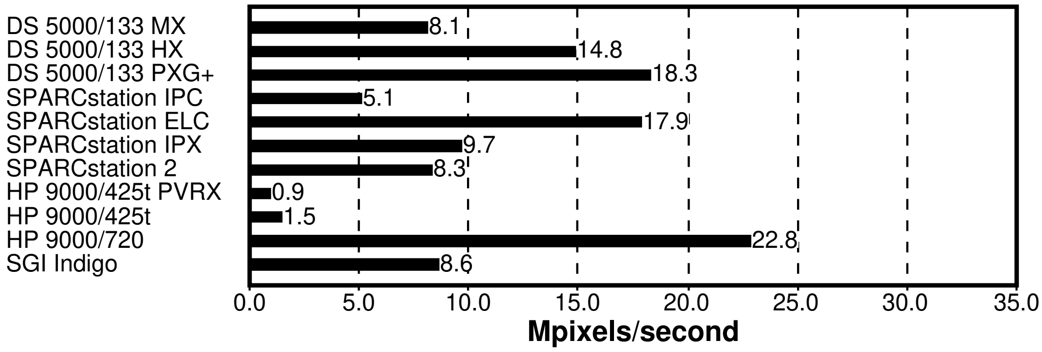
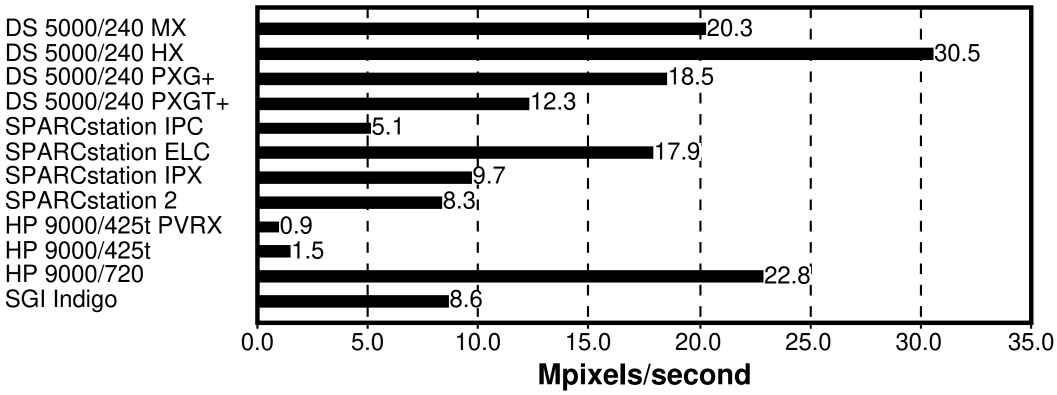


Figure 12-6: DECstation 5000/240's and Competitors 2D Fill Area Graphics X11perf Benchmark Results



13 3D Graphics Benchmarks

13.1 Background

Digital has developed several proprietary benchmarks to test the 3D primitive level performance of our PEX servers. This consists of building the appropriate 3D structures on the server, and then measuring the time to complete drawing these structures a number of times. We use the same accurate client-server synchronization technique to insure graphics operation completion time that is used in X11perf. The transport mechanism reported in this report is local:0.0 (shared memory transport).

These benchmarks measure 3D vector and 3D polygon performance. 3D vectors are 10-pixel, 10-segment polylines, random orientation, and clip checked. 3D vector results are reported in kilo-vectors (Kvectors)/second or 1,000 vectors/second. 3D polygons are 100-pixel, 10-triangle strip, shaded, default, and directional lighted, Z-buffered, and clip checked. 3D polygon results are shown in kilo-polygon (Kpolygons)/second or 1,000 polygons/second.

13.2 Results and Conclusions

In general, when evaluating graphics performance, it is important to fully understand the benchmarking being quoted. One should refrain from comparing one primitive performance number to another without first understanding how the entities are defined and measured. In addition, primitive-level benchmarks are good for measuring drawing rates for particular entities, but do not take into account other operations that an application may perform (such as picking or structure editing), or characteristics of the entire system (such as typical background load or disk I/O). Therefore, the best way to evaluate a system is to run the actual application itself. Because the DECstation 5000 family exhibits excellent balanced performance, graphics applications may see greater throughput on this workstation type than on others with the same graphics primitive performance.

Characterizing graphics performance is a complex task. How the application is written, the characteristics of the system the application is running on, and the nature of the graphics data itself are all factors that affect graphics performance. In addition, it is possible to measure graphics performance at several different levels. For example, you could measure how long it takes to draw an individual primitive at peak hardware rates, or you could measure how long it takes to set up and draw an entire picture using a high-level Application Programming Interface (API).

Because of the complexity of the problem, there are widely varying approaches within the industry for generating graphics metrics. While X11perf offers some standardization in the realm of 2D benchmarks, examination of commonly-quoted 3D numbers show that there is little uniformity regarding what is being measured, and at what level it is measured. As a result, comparing 3D graphics performance numbers quoted by one vendor to those of another is rarely a meaningful comparison, and can be misleading. (And it is for this reason that we are not offering comparisons with competitive systems in this section).

The following table and graphs present the 3D vectors and 3D polygons results for the DECstation systems.

Table 13-1: 3D Graphics Benchmark Results

Workstations	3D Kvectors/second[2]	3D Kpolygons/second[3]
DS 5000/25 PXG	288	51
DS 5000/25 PXG+	312	68
DS 5000/120 PXG	288	51
DS 5000/120 PXG+	307	68
DS 5000/120 PXGT	310	102
DS 5000/120 PXGT+[1]	310	102
DS 5000/125 PXG	288	51
DS 5000/125 PXG+	310	68
DS 5000/125 PXGT	313	102
DS 5000/125 PXGT+[1]	313	102
DS 5000/133 PXG	288	51
DS 5000/133 PXG+	376	68
DS 5000/133 PXGT	405	102
DS 5000/133 PXGT+[1]	405	102
DS 5000/200 PXG	302	52
DS 5000/200 PXG+	400	70
DS 5000/200 PXGT	434	106
DS 5000/200 PXGT+[1]	434	106
DS 5000/240 PXG	302	52
DS 5000/240 PXG+	401	70
DS 5000/240 PXGT	436	106
DS 5000/240 PXGT+	436	106

[1] Not tested; expected results
[2] Kvectors=1,000 vectors
[3] Kpolygons=1,000 polygons

14 Picture-Level Benchmarks

14.1 Background

Picture-Level Benchmark (PLB) is software that allows comparisons to be made of graphics display performance for different hardware platforms. It is the first product from the Graphics Performance Characterization (GPC) committee, a volunteer group of vendors, users, and consultants that provide and support standardized benchmarks for measuring graphics performance as related to specific applications. The National Computer Graphics Association (NCGA) is administrator for the committee.

PLB is designed to measure the performance of CRT-based display systems such as engineering workstations, personal computers, and special-purpose attached display systems. Two requirements exist for the PLB to work. The geometry must be presented to the system in a specified format and the PLB code must have been ported to the device under test.

The five major components of the PLB are:

1. Benchmark Interchange Format (BIF), the file format for specifying the geometry.
2. Benchmark Timing Methodology (BTM) which provides a standardized performance measurement.
3. Benchmark Reporting Format (BRF), for standardized reporting of test results.
4. Picture-Level Benchmark (PLB) program which implements BIF file processing and runs the test.
5. A suite of standard tests and a report summary sheet.

In order to run BIF files, the PLB code must be customized for each hardware configuration.

To date, five application files have been approved by the GPC committee for use. They are:

- "pc_board" - a typical 2-D electrical CAD application
- "sys_chassis" - a 3-D wire frame model of a computer chassis
- "cyl_head" -a 3-D solid model of an automobile engine's cylinder head
- "head" - depicts a 3-D human head modeled using data generated by a laser scanner
- "shuttle" - an example of low-end 3-D simulation

Note: Although the PLB allows buyers to compare performance, it does not address the issue of display quality. It is the user's responsibility to look at the image on the screen and determine superiority.

14.2 Results and Conclusions

PLB performance results are reported using a measure called the "GPCmarks". The GPCmarks is a ratio determined by dividing a normalizing constant by the elapsed time in seconds required to perform the test. The higher the number, the better the performance.

Each benchmark generates two GPCmarks; the "PLBlit" (PLB Literal) and the "PLBopt" (PLB Optimized). The PLBlit results of the GPC are most useful for users who know how their applications draw pictures. They select the benchmarks which most closely approximates the software they use, or they develop BIF files for benchmarks. They want to know what the performance of the workstation will be if the picture is drawn "as is".

PLBopt results are for the users who may make whatever changes necessary to their applications to get the *best possible* performance for the workstation. The picture will not be drawn "as is". Instead, the drawing may be re-ordered, or it might use different primitives, or additional information such as surface normals may be provided.

The GPCmarks are reported in the format:

PLBlit: PLBopt

The following table contains the PLBlit (PLB Literal) results for the DECstation family of systems. *The GPC Quarterly Report,* coming out in December 1991, will contain the competitors' and some of these DECstation PLB results.

Figure 14-1: PLB Benchmarks Results

System	PLB Benchmark PLBlit:PLBopt pc_board	sys_chassis	cyl_head	head	shuttle
DS 5000/20 PXG	9.8:nr[1]	10.2:nr	14.4:nr	18.8:nr	17.6:nr
DS 5000/20 PXG+	11.2:nr	10.8:nr	16.2:nr	20.9:nr	20.0:nr
DS 5000/25 PXG	9.8:nr	10.5:nr	14.4:nr	18.8:nr	17.6:nr
DS 5000/25 PXG+	11.2:nr	11.9:nr	16.2:nr	20.9:nr	20.0:nr
DS 5000/120 PXG	9.8:nr	10.2:nr	14.4:nr	18.8:nr	17.6:nr
DS 5000/120 PXG+	11.2:nr	10.7:nr	16.2:nr	20.9:nr	20.0:nr
DS 5000/120 PXGT	12.1:nr	11.4:nr	17.0:nr	21.3:nr	21.1:nr
DS 5000/120 PXGT+[3]	12.1:nr	11.4:nr	17.0:nr	21.3:nr	21.1:nr
DS 5000/125 PXG8	9.8:nr	10.5:nr	np[2]	np	np
DS 5000/125 PXG	9.8:nr	10.5:nr	14.4:nr	18.8:nr	17.6:nr
DS 5000/125 PXG+	11.2:nr	11.9:nr	16.2:nr	20.9:nr	20.0:nr
DS 5000/125 PXGT	12.2:nr	12.5:nr	17.0:nr	21.3:nr	21.1:nr
DS 5000/125 PXGT+[3]	12.2:nr	12.5:nr	17.0:nr	21.3:nr	21.1:nr
DS 5000/133 PXG	9.8:nr	11.3:nr	14.4:nr	18.8:nr	17.8:nr
DS 5000/133 PXG+	11.3:nr	13.0:nr	16.2:nr	20.9:nr	20.1:nr
DS 5000/133 PXGT	12.2:nr	13.7:nr	17.1:nr	21.3:nr	21.2:nr
DS 5000/133 PXGT+[3]	12.2:nr	13.7:nr	17.1:nr	21.3:nr	21.2:nr
DS 5000/200 PXG8	10.0:nr	11.7:nr	np	np	np
DS 5000/200 PXG	10.0:nr	11.7:nr	14.9:nr	19.2:nr	18.3:nr
DS 5000/200 PXG+	11.6:nr	13.6:nr	16.8:nr	21.3:nr	20.8:nr
DS 5000/200 PXGT	12.6:nr	14.9:nr	17.7:nr	21.7:nr	21.9:nr
DS 5000/200 PXGT+[3]	12.6:nr	14.9:nr	17.7:nr	21.7:nr	21.9:nr
DS 5000/240 PXG	10.0:nr	11.7:nr	14.9:nr	19.2:nr	18.3:nr
DS 5000/240 PXG+	11.6:nr	13.8:nr	16.8:nr	21.3:nr	20.9:nr
DS 5000/240 PXGT	12.6:nr	15.3:nr	17.8:nr	21.7:nr	22.1:nr
DS 5000/240 PXGT+[3]	12.6:nr	15.3:nr	17.8:nr	21.7:nr	22.1:nr

[1] not reported
[2] not possible
[3] not actually tested; expected results

PXG8 = 8-Plane
PXG = 24-Plane with optional Z-buffer
PXG+ = 24-Plane with Z-buffer
PXGT = 24-Plane with Z-buffer
PXGT+ = 24-Plane with Z-buffer

A

Test Configurations

Test Configurations

The benchmarks were run on systems with the following configurations. Source of benchmark results follow configuration listing.

Compaq Deskpro 386/33:

Processor Type & Frequency	80386 - 33 MHz
Floating Point Unix & Frequency	80387 - 33 MHz & Weitek 3167 - 33 MHz
Cache Memory Size & Speed	64 Kbytes - ? ns
RAM Memory Size & Speed	8 MB
Display Size & Type	Compaq Color VGA
Display Resolution	640 - 480
Hardfile Brands & Model Numbers	5.25" half-high
Hardfile Size(s) (Unformatted/For.)	380 / 320 MB
Operating System Name & Level	ISC Unix Version 2.0
Compilers and Switches	Microway Fortran 1.4e -OLM -n4, Microway C 1.4e -OLM -n4

Dhrystone, Whetstone, Linpack, Khornerstone, and DR Labs CPU2 benchmark results from *Workstation Laboratories,* 9/1/89, Volume 8, Chapter 9, page V8-9-Config.

Compaq SystemPro 486-840:

Processor Type & Frequency	80486 - 33 MHz (one processor)
Floating Point Unix & Frequency	Built into 80486
Cache Memory Size & Speed	8 Kb on 80486 / 512 Kb external cache
RAM Memory Size & Speed	10 MB
Display Size & Type	14" Color VGA Monitor
Hardfile Brands & Model Numbers	Conners 210 MB
Hardfile Quantity/Interface	4 drives / IDE on each drive
Hardfile Size(s) (Unformatted/For.)	840 MB total / 240 MB per disk drive
Operating System	SCO Unix 3.2v2.0s
Compilers and Switches	Microway Fortran 2.0.6 -n2 -OLM, Microway C 2.0.6 -n2 -OLM

Dhrystone, Whetstone, Khornerstone, DR Labs CPU2, and Linpack benchmark results from *Workstation Laboratories,* 6/1/91, Volume 13, Chapter 5, page V13-5-Config.

Personal DECstation 5000 Model 20 MX, CS, PXG+ Workstations:

CPU chipset	R3000A
CPU MHz	20 MHz
FPU chipset	R3010A
FPU MHz	20 MHz
Memory (MB)	16 MB
Disk	SCSI 426MB RZ25, 665 MB RZ56
Cache Size	64KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX X4.2A-4 (Rev. 20)
Compilers	DEC Fortran T3.1 (ft2), DEC C V1.0
File System	Berkeley FFS
Tuning Parameters	10% bufcache, delay_wbuffers=1, cache_bufcache=1

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992. Khornerstone2 tests used 10% buffer cache.

All benchmark testing was performed by Digital Equipment Corporation.

Personal DECstation 5000 Model 25:

CPU chipset	R3000A
CPU MHz	25 MHz
FPU chipset	R3010A
FPU MHz	25 MHz
Memory (MB)	16 MB
Disk	SCSI 426MB RZ25. 665 MB RZ56
Cache Size	64KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX X4.2A-4 (Rev. 20)
Compilers	DEC Fortran T3.1 (ft2), DEC C V1.0
File System	Berkeley FFS
Tuning Parameters	0% bufcache, delay_wbuffers=1, cache_bufcache=1

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992. Khornerstone 2 tests used 10% buffer cache.

All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 120 MX, HX, PXG+,PXG Turbo+ Workstations:

CPU chipset	R3000A
CPU MHz	20
FPU chipset	R3010
FPU MHz	20
Memory (MB)	16
Disk	665 MB RZ56
Cache Size	64KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX V4.2 (Rev. 85)
Compilers	DEC FORTRAN, DEC C
File System	Berkeley FFS
Tuning Parameters	Unlimited Stack Size , cache_bufcache=1 , delay_wbuffers=1
Background Load	none
System State	single-user

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992.

All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 125 MX, HX, PXG+, and PXG Turbo+ Workstations:

CPU chipset:	R3000A
CPU MHz:	25
FPU chipset:	R3010
FPU MHz	25
Memory (MB)	16
Disk	665 MB RZ56
Cache Size	64KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX V4.2 (Rev. 85)
Compilers	DEC FORTRAN EFT5, DEC C
File System	Berkeley FFS
Tuning Parameters	Unlimited Stack Size, cache_bufcache=1, delay_wbuffers=1
Background Load	none
System State	single-user

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992.

All benchmark testing was performed by Digital Equipment Corporation.

Test Configurations

DECstation 5000 Model 133 MX, HX, PXG+, and PXG Turbo+ Workstations:

CPU Chipset	R3000A
CPU MHz	33
FPU chipset	R3010A
FPU MHz	33
Memory	64 MB
Disk	2 209 MB RZ24, 1 332 MB RZ55
Cache Size	128KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX T4.2A-5
Compilers	DEC FORTRAN T3.1, DEC C V1.0
File System	Berkeley FFS
Tuning Parameters	10% bufcache, cache_bufcache=1, delay_wbuffers=1
Background Load	none
System State	single-user

Khornerstone2 results used 10% buffer cache.

All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 200 MX, HX, PXG+, and PXG Turbo+ Workstations:

CPU chipset	R3000
CPU MHz	25
FPU chipset	R3010
FPU MHz	25
Memory (MB)	16
Disk	665 MB RZ56
Cache Size	64KB data/64KB instruction
Network Interface	Ethernet
Operating System	ULTRIX T4.2 (Rev. 54)
Compilers	DEC FORTRAN EFT5, DEC C
File System	Berkeley FFS
Tuning Parameters	Unlimited Stack Size , cache_bufcache=1, delay_wbuffers=1
Background Load	none
System State	single-user

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992. Khornerstone2 tests results shown.

All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 240 MX, HX, PXG+, and PXG Turbo+ Workstations:

CPU chipset	R3000A
CPU MHz	40 MHz
FPU chipset	R3010A
FPU MHz	40 MHz
Memory (MB)	64 MB
Disk	SCSI 1.0 GB RZ57
Cache Size	64KB data/64 KB instruction
Network Interface	Ethernet
Operating System	ULTRIX X4.2A-1 (Rev. 25)
Compilers	DEC Fortran T3.1 (ft2), DEC C V1.0
File System	
Tuning Parameters	10% bufcache, delay_wbuffers=1, cache_bufcache=1

The SPEC benchmarks were recorded using advanced compiler technology which will be available in the Spring 1992. Khornerstone2 test used 10% buffer cache.

All benchmark testing was performed by Digital Equipment Corporation.

Hewlett-Packard 9000/425t with Personal VRX Graphics Workstation:

Processor Type & Frequency	68040 - 25 MHz
Floating Point Unix & Frequency	built-in
Cache Memory Size & Speed	8 Kb Total (4 Kb each I & D)
RAM Memory and Speed	32 MB
Hardfile Brands & Model Numbers	HP 200 Mb 3.5" internal disk/Rodime
Hardfile Quantity/Interface	2/SCSI
Hardfile Size(s) (Unformatted/For.)	?/200 MB
Operating System	HP-UX Version 7.03
Compilers & Switches	HP Fortran -O3, HP C -O3
Graphics Libraries Used	X11

X11perf benchmarking numbers from *Workstation Laboratories,* 2/1/91, Volume 12, page V12-28-Config.

Hewlett-Packard 9000/425t Workstation:

Processor Type & Frequency	68040 - 25 MHz
Floating Point Unix & Frequency	built-in
Cache Memory Size & Speed	8 Kb Total (4 Kb each I & D)
RAM Memory Size & Speed	32 MB
Disk Buffer Sizes	
Hardfile Brands & Model Numbers	HP 200 Mb 3.5" internal disk/Rodime
Hardfile Quantity/Interface	2/SCSI
Hardfile Size(s) (Unformatted/For.)	?/200 MB
Operating System	HP-UX Version 7.03
Compilers	HP Fortran -O3, HP C -O3
Graphic Libraries Used	X11

SPEC numbers from *SPEC Newsletter,* Volume 3, Issue 1 Winter 1991 ,page 18. Dhrystone, Whetstone, Linpack, Khornerstone, and X11perf benchmarking numbers from Workstations Laboratories, 2/1/91, Volume 12, page V12-20-Config. DR Labs CPU2 MVUPS from Digital Review, 3/4/91, page 19, running HP-UX Version 8.0.

Hewlett-Packard 9000 Model 425e:

Processor Type & Frequency	68040 - 25MHz
Floating Point Unix & Frequency	built-in
Cache Memory Size & Speed	8 Kb Total (4 Kb each I & D)
RAM Memory Size & Speed	32 MB
Disk Buffer Sizes	9.3 MB except where indicated (small=2.3 MB)
Display Size & Type	HP 16" Color
Display Resolution	1280 x 1024 pixels
Hardfile Brands & Model Numbers	HP 200 MB 3.5" internal disk/Rodime
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	?/200 MB
For Network Tests: "Remote" or "Local"	Both
For Network Tests: Server Type	MIPS RC3240
For Network Tests: Network Type	Ethernet NFS
For Network Tests: Network Speed	10 MB/second
Operating System Name & Level	HP-UX Version 8.05
Fortran Supplier & Version	HP Fortran
Fortran Compiler Switches Used	+O3
C Compiler & Version	HP C
Compiler Switches Used	+O3
Graphics Libraries Used	X11

SPEC, Dhrystone, Whetstone, Linpack, Khornerstone (with large buffer cache) , DR Labs CPU2, and X11perf benchmark results from *Workstation Laboratories*, 6/1/91, Volume 14, Chapter 5.

Hewlett-Packard 9000 Model 720 Workstation:

SPU	HP720
Memory	16 MB
Disk Size and Type	210 MB internal
Operating System	HP-UX 8.05M (available in June 1991)
Compilers & Switches	HP-UX FORTRAN/9000s 700 optimizing prep-processor (avail able in June 1991); HP C Compiler HP92453-01 a.08.53 SPEC - optimized with -O; linked with archive libraries by setting the environment variable LDOPTS to -a archive; floating point compiled with +OP or +OP4; Dhrystone LDOPTS set to -a and +O3; Linpack LDOPTS set to -a and compiled with +OP3; Whet stone LDOPTS to -a and optimization level -O; Khornerstone 10% default buffer cache, LDOPTS set to -a and optimization +O.

SPEC benchmarking numbers from *SPEC Newsletter,* Volume 3, Issue 2, Spring 1991, page 20. Dhrystones, Whetstones , Khornerstone 2 , and Linpack benchmark numbers from *HP Apollo Series 700 Workstations Performance Overview,* March 1991. DR Labs CPU2 and X11perf benchmarks numbers from *Workstation Laboratories*, 4/1/91, Volume 13, Chapter 10. Configuration used by WSL was HP 9000 Model 720 CRX.

IBM RS/6000 Model 320 Workstation:

Processor Type & Frequency	Custom RISC Processor - 20 MHz
Floating Point Unix & Frequency	Integrated in CPU
Cache Memory Size & Speed	8 Kb Instruction + 32 Kb Data
RAM Memory Size & Speed	16 MB
Disk Buffer Sizes	Mapped Files
Hardfile Brands & Model Numbers	IBM 320 MB SCSI 3.5"
Network Type	Ethernet NFS
Operating System	AIX 3.1
Compilers & Switches	IBM XLF Fortran -O, AIX C Version 3.1 -O
Graphic Libraries Used	X11, graPHIGS, DPS & GSL

SPEC benchmark numbers as announced by IBM on 5/7/91 using Fortran compiler V2 R2 (available in September 1991). Dhrystones, Whetstones, Khornerstones , and Linpack benchmark numbers from *Workstation Laboratories*, 8/1/90, Volume 11, page V11-10-Config. DR Labs CPU2 MVUPS number from *Digital Review*, 3/11/91, page 19, running AIX 3.0.

IBM RISC System/6000 POWERstation 320H Computer:

CPU	25MHz IBM 2564
FPU	Integrated
Memory	16MB
Disk Controller	DBA/SCSI
Disk	320MB
Cache Size	64KB data/8 KB instruction
Network Interface	Ethernet
Operating System	AIX
Compilers	C, FORTRAN
File System	AIX

SPEC results from S*PEC Newsletter,* Volume 3, Issue 3, September 1991, page 14.

Dhrystone and Linpack ratings from IBM information dated March 1991.

NeXTStation:

Processor Type & Frequency	68040 - 25 MHz
Floating Point Unix & Frequency	builtin to 68040
Cache Memory Size & Speed	8 Kb Total / 4 Kb in I & D 68040 chip
RAM Memory Size & Speed	16 MB
Display Size & Type	17 " Monochrome
Display Resolution	1120 x 832 pixels
Hardfile Brands & Model Numbers	? Manufacturer / 3.5"
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	480 / 400 MB each
For Network Tests: "Remote" or "Local"	Local and Remote
For Network Tests: Server Type	Mips RC3240 running NFS
For Network Tests: Network Type	Ethernet
For Network Tests: Network Speed	10 MB/second
Operating System Name & Level	NeXT OS 2.0
Compilers & Switches	Oasys GF68kB Fortran 1.8.5 -OLM, NeXT (Gnu C) C Compiler 2.0 -O

Dhrystone. Whetstone, Linpack, Khornerstones, and DR Labs CPU2 results from *Workstation Laboratories,* 6/1/91, Volume 13, Chapter 19, page V13-19-Config.

SoftPC Dhrystone results from *Workstation Laboratories*, 6/191, Volume 13, Chapter 20, page V13-20-Config. Operating system was SoftPC MS/DOS 3.30 under NestOS. Compilers were Microsoft Fortran 5.0 /G2 /AL /FPi87 /OX, Microsoft C 6.0 /G2 /AL /FPi87 /Ox.

SPEC benchmark results from NeXT Computer, Inc., 10/6/91. Configuration used 330 MB internal SCSI disk, NeXTstep 2.1 OS operating system, GNU C 1.36 C compiler, Absoft FORTRAN 77 3.1 Greenhills Fortran-68000 1.8.5 (Grh) fortran compilers, default tuning parameters, multi-user, normal background load, and no source code changes to benchmarks.

Silicon Graphics Personal Iris (4D/25G) Workstation:

Processor Type & Frequency	R3000 Mips RISC CPU - 20 MHz
Floating Point Unix & Frequency	R3000 Mips RISC FPU - 20 MHz
Cache Memory Size & Speed	96 Kbytes Total - 32 Kb Data/64 Kb Instruction
RAM Memory Size & Speed	16 MB
Hardfile Brands	Control Data SCSI
Hardfile Size(s) (Unformatted/For.)	380/170 MB
Operating System Name & Level	Silicon Graphics Unix Operating System - 4D1-3.2
Compilers & Switches	Silicon Graphics Fortran (Mips) version 4D1-3.2-O, Silicon Graphics C (Mips) version 4D1-3.2 -O
Graphics Libraries Used	X11 and GL Graphics Libraries

SPEC benchmark numbers from *SPEC Newsletter,*Volume 3, Issue 1 Winter 1991, page 4. Dhrystones, Whetstones, Khornerstones, and Linpack benchmark numbers from *Workstation Laboratories,* 2/1/90, Volume 9, page V9-19-Config. DR Labs CPU2 MVUPS from *Digital Review,* 3/11/91, page 19, Silicon Graphics Personal Iris 4D/25 running IRIX 3.3.1.

Silicon Graphics 4D/35 Workstation:

SPEC benchmark numbers from Silicon Graphics.
Dhrystone and Linpack rating from *UNIX WORLD.*

Test Configurations

Silicon Graphics 4D/RPC Indigo Workstation:

Processor Type & Frequency	R3000 Mips RISC CPU - 33 MHz
Floating Point Unix & Frequency	R3010 Mips RISC FPU - 33 MHz
Cache Memory Size & Speed	64 Kbytes Total - 32 Kbytes each I & D
RAM Memory Size & Speed	56 MB
Display Size & Type	16" Color
Display Resolution	1024 x 768 Pixels
Hardfile Brands & Model Numbers	Seagate 3.5" ST1480N / SCSI
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	480/400 MB
For Network Tests: "Remote" or "Local"	Remote, using Mips RC3240 server, Ethernet, 10 MB/second
Operating System Name & Level	Silicon Graphics Unix OS - 4D1-4.0
Fortran Compiler, Version, & Switches	Silicon Graphics (Mips) version 4D1-4.0 -O3 or -O2
C Compiler, Version, & Switches	Silicon Graphics (Mips) version 4D1-4.0 -O3 or -O2
Graphics Libraries Used	X11 and GL Graphics Libraries

Dhrystone, Whetstone, Linpack, Khornerstone, and X11perf benchmark results from *Workstation Laboratories,* 9/1/91, Volume 15, Chapter 23, page V15-23-Config.

SPEC benchmark results from Silicon Graphics Computer Systems, *INTRODUCING IRIS INDIGO Competitive Analysis,* July 22, 1991, page 27. Configuration used was 33 MHz MIPS R3000A CPU, 32 MB memory, Ethernet network, IRIX 4.0 version 240, Beta software operating system, IRIX system daemons, xdm background load, network daemons for remotely-run-clients test case, and system state was multi-user, single-user login.

Sun SPARCstation 2 Workstation:

Processor Type & Frequency	SPARC - 40 MHz
Floating Point Unix & Frequency	SPARC (TI) - 40 MHz
Cache Memory Size & Speed	65 Kb
RAM Memory Size & Speed	16 MB
Disk Buffer Sizes	(14,901 available)
Hardfile Brands & Model Numbers	Quantum 210S & Conners CP3200F
Hardfile Quantity/Interface	2/SCSI
Network Interface	Ethernet
Operating System	Sun OS 4.1.1
Compilers & Switches	Optional Sun Fortran Compiler -O3, Optional Sun C Compiler -O3
Graphics Libraries Used	X11 (xnews)

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 21. Whetstones, DR Labs COU2 MVUPS, and X11perf benchmark numbers from *Workstation Laboratories,* 2/1/91, Volume 12, page V12-23-Config. Linpack and Dhrystone numbers form *SPARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990, page 17. Volume 12, page V12-23-Config. Linpack and Dhrystone numbers from S*PARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990, page 17.

Khornerstones benchmarks were performed by Digital Equipment Corporation. System tested disk configuration was 1 Quantum 210s and 1 Conners CP3200F, 207MB each formatted capacity.

AIM benchmarks were performed by Digital Equipment Corporation. A CPU 4/75 and 1 203MB SUN0207 disk were used. File system was F.S. Type 4.2. System state was full multi-user and no windows. Compile flags were -fast, -O4.

Sun SPARCstation (4/40) IPC Workstation:

Processor Type & Frequency	SPARC- 25 MHz
Floating Point Unix & Frequency	SPARC (TI) - 25 MHz
Cache Memory Size & Speed	64 Kb
RAM Memory Size & Speed	8MB
Hardfile Brands & Model Numbers	Maxtor 3.5"
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	?/206
Network Interface	Ethernet
Operating System Name & Level	Sun OS 4.1
Compilers & Switches	Sun Fortran 4.1 -O3
Graphics Libraries Used	X11

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 26. Dhrystones and Linpack numbers from *SPARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990, page 17. Whetstones benchmark numbers from *Workstation Laboratories*, 11/1/90, Volume 11, page V11-21-Config. DR Labs CPU2 MVUPS number from *Digital Review,* April 15, 1991 page 24 .

Khornerstones benchmarks were performed by Digital Equipment Corporation with 24MB of memory, Sun OS 4.1.1, 1 Quantum 210s, 207 MB formatted, and Sun C compiler and Sun Fortran Compiler.

Aim benchmarks were performed by Digital Equipment Corporation. CPU was a 4/40 and FPU was WEITEK 3172. Memory was 24MB and the disk configuration was 1 203MB SUN0207 and 1 653MB SUN 0669. The operating system was SUN O.S. 4.1.1 and File system F.S. type 4.2. System state was full multi-user, no windows. Compile flags were -fast, -O4.

Sun SPARCstation ELC Workstation:

Processor Type & Frequency	SPARC (LSI) - 33MHz
Floating Point Unix & Frequency	SPARC (Fujitsu) - 33 MHz
Cache Memory Size & Speed	64 Kilobytes
RAM Memory Size & Speed	8 Megabytes / 80 ns (except khorner1 @ 16Mb)
Hardfile Brands & Model Numbers	CDC (Imprimis) 94191
Hardfile Quantity/Interface	1 / SCSI
Hardfile Size(s) (Unformatted/for.)	760 / 680 MB
Operating System Name & Level	Sun OS 4.1.1
Fortran Supplier & Version	Sun Fortran 1.4
Fortran Compiler Switches Used	-O4
C supplier & Version	Sun C 1.1
Compiler Switches Used	-O4
Graphics Libraries Used	X11

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 24. Memory configured 16MB, Disk subsystem 207 MB SCSI, other software KAP/SUN pre-processor. System state single user, no tuning parameters in use, and no background load.

Dhrystones, Whetstones, Khornerstone, Linpack, DR Labs CPU2, and X11perf benchmark numbers from *Workstation Laboratories*, 9/1/1991, Volume 15, Chapter 21.

Sun SPARCstation IPX Workstation:

Processor Type & Frequency	SPARC (LSI) - 40MHz
Floating Point Unix & Frequency	SPARC (Fujitsu) - 40MHz
Cache Memory Size & Speed	64 Kilobytes
RAM Memory Size & Speed	16 Megabytes / 80 ns
Hardfile Brands & Model Numbers	Maxtor 3.5" SCSI
Hardfile Quantity/Interface	1 SCSI
Hardfile Size(s) (Unformatted/for.)	? / 207 Mb
Operating System Name & Level	Sun OS 4.1.1
Fortran Supplier & Version	Sun Fortran 1.4
Fortran Compiler Switches Used	-O4
C Supplier & Version	Sun C 1.1
Compiler Switches Used	-O4
Graphics Libraries Used	X11

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 22. Other software used was KAP/SUN pre-processor. Disk Subsystem was 424 MB SCSI. No tuning parameters in use, no background load and system state was single user.

Dhrystones, Whetstones, Khornerstone, Linpack, DR Labs CPU2, and X11perf benchmark numbers from *Workstation Laboratories*, 9/1/91, Volume 15, Chapter 22.

B

References

Digital Equipment Corporation, *DECstation 5000/100 Series Technical Overview*, Version 2.0, Order number: EC-N0580-51, 1991.

Digital Equipment Corporation, *Digital RISC Family Performance Summary,* April 2, 1990.

Digital Review, *Digital Review,* Product Review/Workstations, March 4, 1991.

Digital Review, *Digital Review,* Product Review/Workstations, March 11, 1991.

Digital Review, *Digital Review,* Product Review/Workstations, April 15, 1991.

Hewlett-Packard, *Hewlett-Packard Series 700 Performance Brief*, March 1991.

Norcott, Bill. *Review of Industry Standard UNIX Benchmarks*, Digital Equipment Corporation, May 1, 1990.

Silicon Graphics Computer Systems, *INTRODUCING IRIS INDIGO Competitive Analysis,* July 22, 1991.

SPEC, *SPEC Newsletter,* Volume 3, Issue 1, Winter 1991.

SPEC, *SPEC Newsletter,* Volume 3, Issue 2, Spring 1991.

SPEC, *SPEC Newsletter*, Volume 3, Issue 3, September 1991.

Sun Microsystems, Inc., *SPARCstation 2 Performance Brief,* November 1990.

Sun Microsystems, Inc., *SunFLASH,* Volume 31, Issue 14, July 1991.

Workstation Laboratories, *Workstation Laboratories Benchmark Test Directories*, Version of 4/1/90.

Workstation Laboratories, *Workstation Laboratories,* Volume 8, Chapter 9.

Workstation Laboratories, *Workstation Laboratories*, Volume 9, Chapter 19.

Workstation Laboratories, *Workstation Laboratories*, Volume 11, Chapters 10 and 11.

Workstation Laboratories, *Workstation Laboratories*, Volume 11, Chapters 20 and 21.

Workstation Laboratories, *Workstation Laboratories*, Volume 12, Chapters 2, 3, 11, 20, 23, and 28.

Workstation Laboratories, *Workstation Laboratories*, Volume 13, Chapters 5, 10 and 19.

Workstation Laboratories, *Workstation Laboratories*, Volume 14, Chapter 5.

Workstation Laboratories, *Workstation Laboratories*, Volume 15, Chapters 21 and 22.

Workstation Laboratories, *Workstation Laboratories*, Volume 23, Chapter 23.