Digital's DECstation Family Performance Summary

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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 are crucial for accurate performance prediction. *Digital's DECstation Family Performance Summary* provides performance information on the DECstation family of systems and competitive computers running standard industry benchmarks.

This revision of *Digital's DECstation Family Performance Summary* contains updated and new graphic benchmark results for both the DECstation family of systems and comparable, competitive systems.

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

2 Methodology

Wherever possible, we executed the same benchmark code on all our systems. Competitive 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 3-3 contain the benchmarking performance results of the DECstation family of systems and competitive systems.

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

Workstation	SPEC-mark	SPEC Integer	SPEC Floating Point	MIPS (Dhrystone Version 1.1)	Dhrystones per second (Version 1.1)	Dhrystones per second (Version 2)	Whetstone Single (WIPS)	Whetstone Double (WIPS)	Linpack Single Precision (MFLOPS)	Linpack Double Precision (MFLOPS)	DR Labs CPU2 (MVUPS)	Total Khorner-stones
DECstation 5000/20	16.3	13.5	18.4	21.60	37951	31847	20985	16865	5.32	2.44	22.78	26689
DECstation 5000/25	19.1	15.7	21.7	26.70	46927	38760	25860	20882	6.60	2.80	27.71	32822
DECstation 5000/120	16.4	13.8	18.4	21.69	38116	32051	20465	16560	5.31	2.56	22.00	29494
DECstation 5000/125	19.3	16.1	21.7	26.80	47090	38759	25627	20597	6.67	3.01	26.81	33731
DECstation 5000/133	25.5	20.9	29.1	34.42	60475	49020	33292	26724	8.79	5.93	37.10	39606
DECstation 5000/200	23.5	19.5	26.7	27.27	47920	38168	25679	20899	6.81	3.73	28.61	27604
DECstation 5000/240	32.4	27.9	35.8	43.00	75557	64103	42812	34457	10.80	6.04	47.16	50949
SPARCstation IPC	13.5	12.8	14.0	15.70	27585	22831	10204	6369	3.20	1.70	10.64	19030
SPARCstation ELC	20.3	18.0	22.0	23.07	40540	25063	23148	14663	3.61	2.20	18.52	23909
SPARCstation IPX	24.4	21.7	26.5	26.68	46875	43478	27778	19120	4.34	2.65	22.24	29111
SPARCstation 2	25.0	21.7	27.4	28.50	50075	35587	19920	14641	6.10	4.20	21.60	27142
HP 9000/425t	11.0	12.3	10.3	25.87	45454	38760	4417	4112	1.69	1.62	8.47	14512
HP 9000/425e	10.3	12.2	9.3	33.09	58139	39185	10858	10753	1.69	1.60	7.92	42753
HP 9000/705	34.6	24.6	43.4	35.00	61495	na	na	na	na	8.00	na	na
HP 9000/710	49.7	35.4	62.4	53.69	94339	58574	55556	34364	20.94	9.76	48.43	42881
HP 9000/720	59.5	39.5	78.5	57.00	100149	87000	56180	48310	22.90	17.20	55.51	44573
IBM RS/6000 220	25.9	17.5	33.7	36.48	64102	55127	17544	18868	4.79	5.22	28.07	62870
IBM RS/6000 320H	43.4	21.8	68.8	37.44	65789	57274	25000	27778	10.38	8.57	na	83582
IBM RS/6000 350	71.4	36.2	112.3	60.55	106382	95420	65789	65789	15.49	13.99	71.47	88038
SGI Personal Iris 4D/25G	12.2	14.0	11.1	16.45	28901	na	12903	9615	2.94	1.42	16.15	20727
SGI 4D/35	31.1	28.0	33.4	34.29	60240	56370	24331	19194	5.11	3.99	29.56	86327
SGI Indigo	26.3	23.6	28.4	31.27	54945	48544	22676	17921	4.30	3.15	26.14	92032

Table current as of April 1992 na = not available Refer to Appendix A for test configurations

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

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)[1]	2D Vectors X11perf. 10-pixel line (Kvectors/sec.)[2]	3D Graphics 3D Vectors (Kvectors/sec.)	3D Graphics 3D Polygons (Kpolygons/sec.)[3]	GPC Picture-Level Benchmarks				
					pc_board	sys_chassis	cyl_head	head	shuttle
Personal DECstation 5000/20 board	5.7	153.0	na	na	nr	nr	nr	nr	nr
Personal DECstation 5000/20 TX	4.1	137.0	na	na	nr	nr	nr	nr	nr
Personal DECstation 5000/25 board	6.4	183.0	na	na	nr	nr	nr	nr	nr
Personal DECstation 5000/25 HX	14.7	285.0	na	na	nr	nr	nr	nr	nr
Personal DECstation 5000/25 TX	4.3	156.0	na	na	nr	nr	nr	nr	nr
Personal DECstation 5000/25 PXG+	18.3	339.0	312	68	11.2:na	11.9:na	16.2:na	20.9:na	20.0:na
DECstation 5000/120 MX	7.9	108.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/120 HX	14.6	272.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/120 TX	4.1	137.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/120 PXG+	18.3	338.0	307	68	11.2:na	10.7:na	16.2:na	20.9:na	20.0:na
DECstation 5000/120 PXGT+	12.3	434.0	310	102	12.1:na	11.4:na	17.0:na	21.3:na	21.1:na
DECstation 5000/125 MX	8.0	114.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/125 HX	14.6	284.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/125 TX	4.3	156.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/125 PXG+	18.3	338.0	310	68	11.2:na	11.9:na	16.2:na	20.9:na	20.0:na
DECstation 5000/125 PXGT+	12.3	434.0	313	102	12.2:na	12.5:na	17.0:na	21.3:na	21.1:na
DECstation 5000/133 MX	8.1	124.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/133 HX	14.8	298.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/133 TX	5.1	158.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/133 PXG+	18.3	339.0	376	68	11.3:na	13.2:na	16.1:na	20.9:na	19.9:na
DECstation 5000/133 PXGT+	12.3	434.0	405	102	12.2:na	13.7:na	17.1:na	21.3:na	21.1:na

Table current as of April 1992
Refer to Appendix A for test configuration

na=not available or not applicable
nr=not reported

[1] Mpixels=1,048,576 pixels
[2] Kvectors=1,000 vectors
[3] Kpolygons=1,000 polygons

Table 3-2: DECstations and Competitive Workstations Graphics Benchmark Results (cont.)

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)[1]	2D Vectors X11perf. 10-pixel line (Kvectors/sec.)[2]	3D Graphics 3D Vectors (Kvectors/sec.)	3D Graphics 3D Polygons (Kpolygons/sec.)[3]	GPC Picture-Level Benchmarks				
					pc_board	sys_chassis	cyl_head	head	shuttle
DECstation 5000/200 MX	14.0	162.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/200 HX	30.3	510.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/200 PXG+	18.5	345.0	400	70	11.6:na	13.6:na	16.8:na	21.3:na	20.8:na
DECstation 5000/200 PXGT+	12.3	445.0	434	106	12.6:na	14.9:na	17.7:na	21.7:na	21.9:na
DECstation 5000/240 MX	20.3	248.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/240 HX	30.5	621.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/240 TX	8.1	278.0	na	na	nr	nr	nr	nr	nr
DECstation 5000/240 PXG+	18.5	345.0	401	70	11.6:na	13.8:na	16.7:na	21.3:na	20.7:na
DECstation 5000/240 PXGT+	12.3	445.0	436	106	12.7:na	15.3:na	17.6:na	21.7:na	21.9:na
SPARCstation IPC~	5.1	58.2	na	na	nr	nr	nr	nr	nr
SPARCstation ELC~	17.9	29.3	na	na	nr	nr	nr	nr	nr
SPARCstation IPX~	9.7	217.0	na	na	nr	nr	nr	nr	nr
SPARCstation IPX-SunPHIGS	na	na	na	na	14.3:14.3	10.7:10.7	nr	nr	nr
SPARCstation 2~	8.3	205.0	na	na	nr	nr	nr	nr	nr
SPARCstation 2 GX-SunPHIGS	na	na	na	na	14.6:14.6	10.8:10.8	nr	nr	nr
SPARCstation 2 GXplus-SunPHIGS	na	na	na	na	14.0:14.0	10.7:10.7	nr	nr	nr
SPARCstation 2 GS-SunPHIGS	na	na	na	na	3.6: 3.6	4.0: 4.0	7.2: 7.2	6.2: 6.2	9.2: 9.2
SPARCstation 2 GT-SunPHIGS	na	na	na	na	9.7: 9.7	18.6:18.6	15.1:15.1	29.3:29.3	17.2:17.2
HP 9000/425t Personal VRX~	.9	23.3	na	na	nr	nr	nr	nr	nr
HP 9000/425t~	1.5	69.1	na	na	nr	nr	nr	nr	nr
HP 9000/425e~	8.8	49.0	na	na	nr	nr	nr	nr	nr

Table current as of April 1992
Refer to Appendix A for test configuration

na=not available or not applicable
~ X11perf results from Workstation Laboratories, Inc.

nr=not reported
[1] Mpixels=1,048,576 pixels
[2] Kvectors=1,000 vectors

[3] Kpolygons=1,000 polygons

Table 3-2: DECstations and Competitive Workstations Graphics Benchmark Results (cont.)

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)[1]	2D Vectors X11perf. 10-pixel line (Kvectors/sec.)[2]	3D Graphics 3D Vectors (Kvectors/sec.)	3D Graphics 3D Polygons (Kpolygons/sec.)[3]	GPC Picture-Level Benchmarks				
					pc_board	sys_chassis	cyl_head	head	shuttle
HP 9000/710~	3.4	492.0	na	na	nr	nr	nr	nr	nr
HP 9000/710 C-HP-PHIGS	na	na	na	na	24.2:26.8	20.1:34.3	nr	nr	nr
HP 9000/720 CRX-HP-PHIGS~	22.8	868.0	na	na	27.6:31.6	21.1:37.1	11.4:na	14.3:15.8	15.6:na
HP 9000/720 CRX24-HP-PHIGS	na	na	na	na	29.7:34.3	21.5:40.3	18.9:na	14.4:16.0	15.7:na
HP 9000/720 CRX24Z-HP-PHIGS	na	na	na	na	28.4:33.0	20.9:38.0	31.9:na	32.6:42.5	21.1:na
IBM RS/6000 220 POWER GTO-graPHIGS	na	na	na	na	18.5:32.4	29.5:na	11.3:17.4	27.0:31.8	np:22.4
IBM RS/6000 320H POWER GTO-graPHIGS~	3.4	77.4	na	na	18.8:35.9	31.5:na	11.5:17.4	27.2:34.2	np:24.2
IBM RS/6000 350 POWER GTO-graPHIGS	na	na	na	na	18.8:41.0	31.5:na	11.3:17.4	27.4:35.5	np:25.3
SGI 4D/35	.9	11.3	na	na	nr	nr	nr	nr	nr
SGI 4D/RPC Indigo~	8.6	141.0	na	na	nr	nr	nr	nr	nr

Table current as of April 1992

Refer to Appendix A for test configuration

~ X11perf results from Workstation Laboratories, Inc.

na=not available or not applicable

np=not possible

nr=not reported

[1] Mpixels=1,048,576 pixels

[2] Kvectors=1,000 vectors

[3] Kpolygons=1,000 polygons

Table 3-3: 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	13.1	2806	3.2
DECstation 5000/25 HX @66Hz	12.5	2750	3.1
DECstation 5000/25 HX @72Hz	13.0	3193	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

Refer to Appendix A for test configuration

Table current as of April 1992

Part II

Benchmark Results

We ran a variety of benchmarks on a number of DECstations. The benchmarks were primarily CPU-intensive or graphics-intensive or both. Results from our benchmarking activity as well as benchmark results of competitive workstations are presented in this section. We encourage the reader to carefully consider the appropriateness of mapping these results into their own environments.

The table appearing on this page explains the system 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 3-4: 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 9000/705	Hewlett-Packard 9000 Model 705
HP 9000/720	Hewlett-Packard 9000 Model 710
HP 9000/720	Hewlett-Packard 9000 Model 720
IBM AT 80286	IBM AT 80286
IBM RS/6000 220	IBM RISC System/6000 POWERstation 220
IBM RS/6000 320H	IBM RISC System/6000 POWERstation 320H
IBM RS/6000 350	IBM RISC System/6000 POWERstation 350
SGI 4D/25G	Silicon Graphics Personal Iris 4D/25G
SGI 4D/35	Silicon Graphics 4D/35
SGI Indigo	Silicon Graphics 4D/RPC Indigo

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 in the following three charts are the SPEC R1.2 Benchmark Suite.

Figure 4-1: SPECmark Benchmark Results

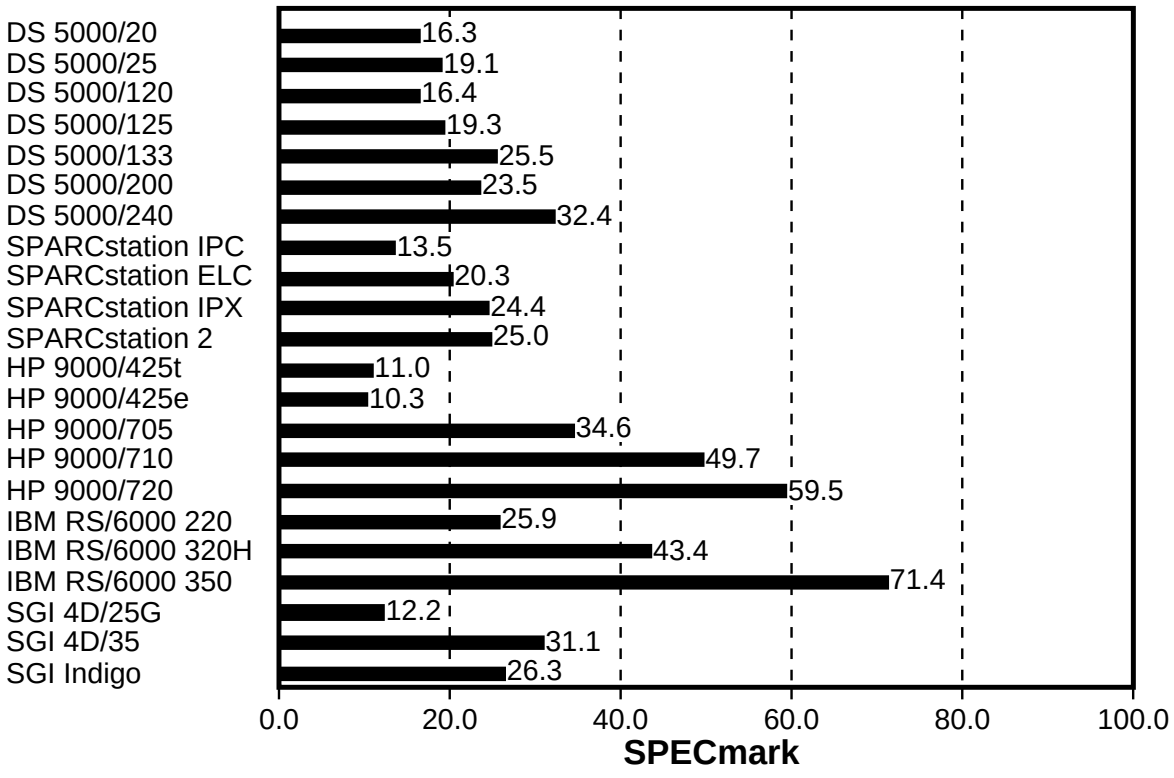


Figure 4-2: SPEC Integer Benchmark Results

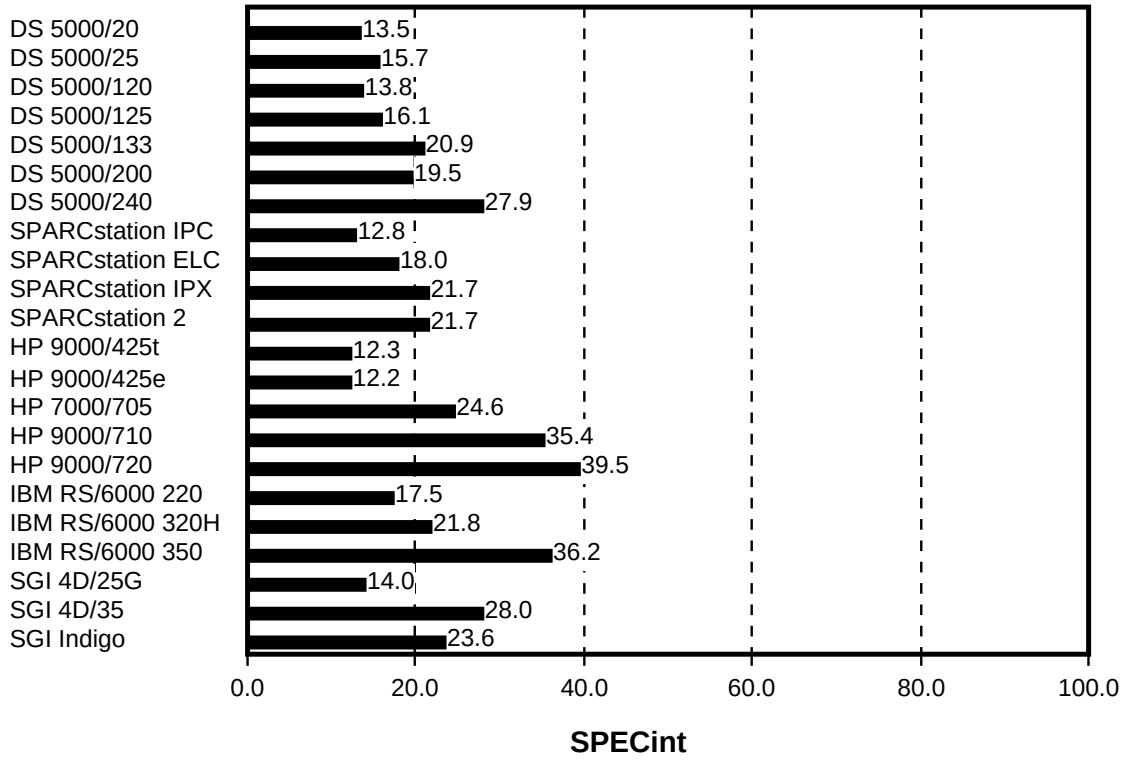
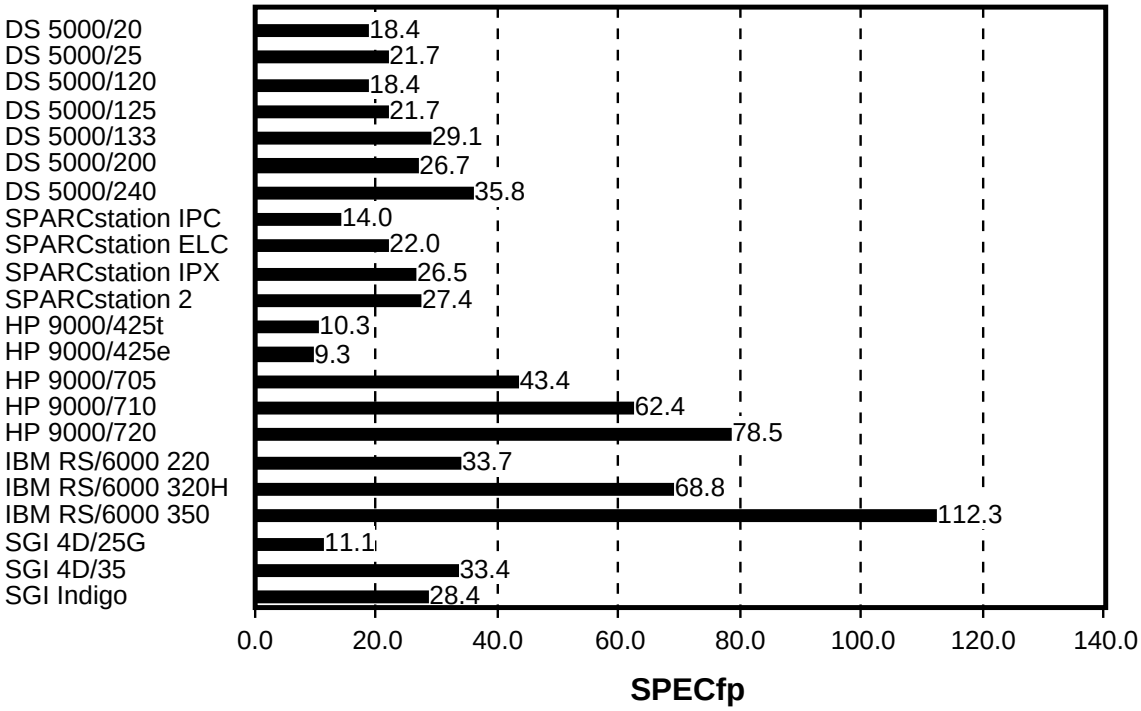


Figure 4-3: SPEC Floating Point Benchmark Results



4.2.1 SPEC Ratios

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	DS 5000/25	DS 5000/120	DS 5000/125	DS 5000/133	DS 5000/200	DS 5000/240
001.gcc	INT[1]	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[2]	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] Integer benchmark written in C
[2] Floating-point benchmark written in FORTRAN

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

Benchmark No. & Name	Type	SPARC-station ELC	SPARC-station IPX	SPARC-station 2	HP 9000/ 705	HP 9000/ 710	HP 9000/ 720	IBM 6000/ 220	IBM 6000/ 320H	IBM 6000/ 350	SGI Indigo
001.gcc	INT[1]	16.6	19.9	20.0	19.6	29.0	36.0	14.6	19.9	32.6	23.5
008.espresso	INT	18.0	21.7	21.7	28.3	39.8	43.4	19.7	20.5	34.1	22.8
013.spice 2g6	FP[2]	13.4	16.1	16.5	22.9	33.2	44.5	14.6	26.4	42.6	19.4
015.doduc	FP	14.0	16.6	18.2	29.7	42.5	47.6	18.1	29.5	48.9	22.6
020.nasa7	FP	23.6	28.4	29.1	35.6	51.7	64.5	32.3	81.3	129.5	30.5
022.li	INT	19.0	23.0	23.1	25.4	36.7	37.7	14.7	21.3	35.7	25.8
023.eqntott	INT	18.4	22.2	22.3	26.0	37.2	41.2	22.0	25.9	43.2	22.3
030.matrix300	FP	67.7	81.5	82.6	190.9	277.6	323.2	191.5	407.7	675.4	86.5
042.fpppp	FP	19.1	23.0	23.8	32.8	45.3	78.5	25.7	54.1	87.8	19.1
047.tomcatv	FP	19.7	23.8	24.9	43.9	64.1	66.4	34.7	76.1	124.9	23.6

[1] Integer benchmark written in C
[2] Floating-point benchmark written in FORTRAN

5 Dhrystone Integer Benchmark

5.1 Background

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

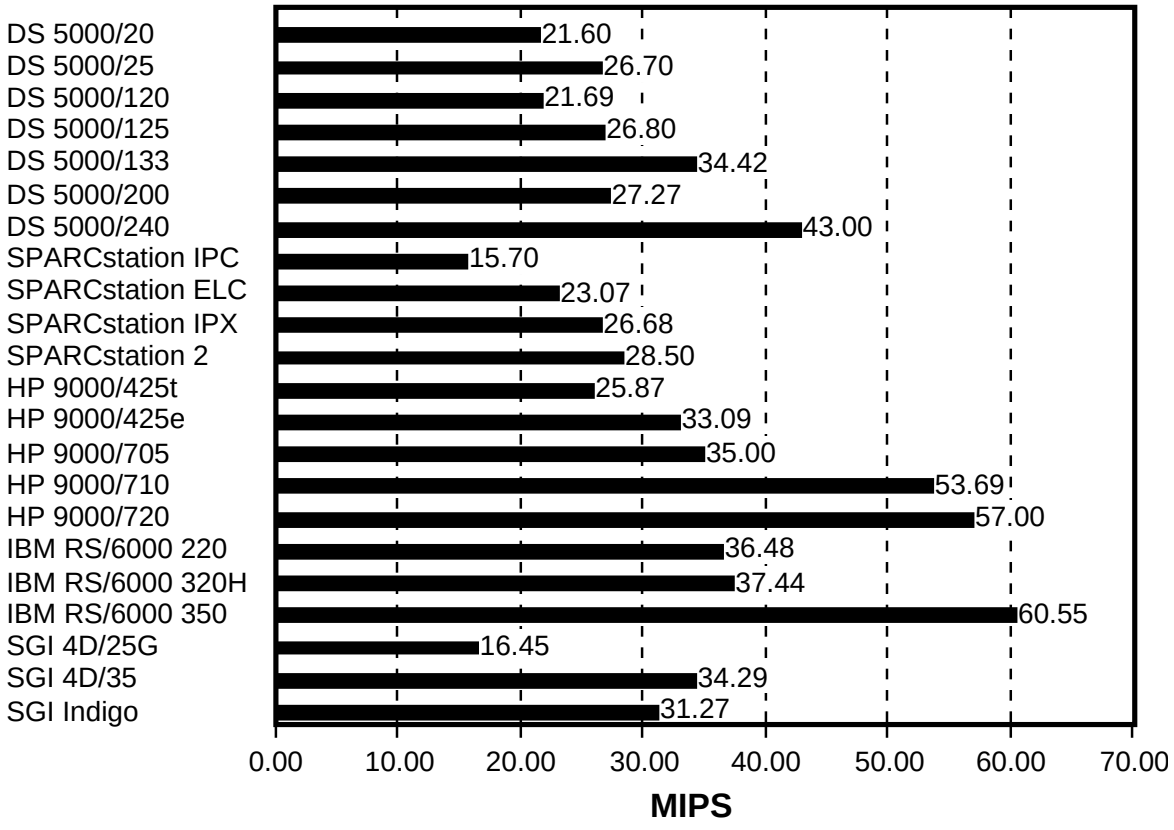
This synthetic benchmark[1] measures processor and compiler efficiency. Its emphasis is on the type of data and operations encountered in a system rather than numerical programming. Dhrystones is CPU-intensive.

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). Please note that not all vendors base their MIPS rating on the Dhrystone benchmark.

5.2 Results and Conclusion

Following are the results of the Dhrystone benchmark tests.

Figure 5-1: MIPS Results from Dhrystones V1.1 Benchmark

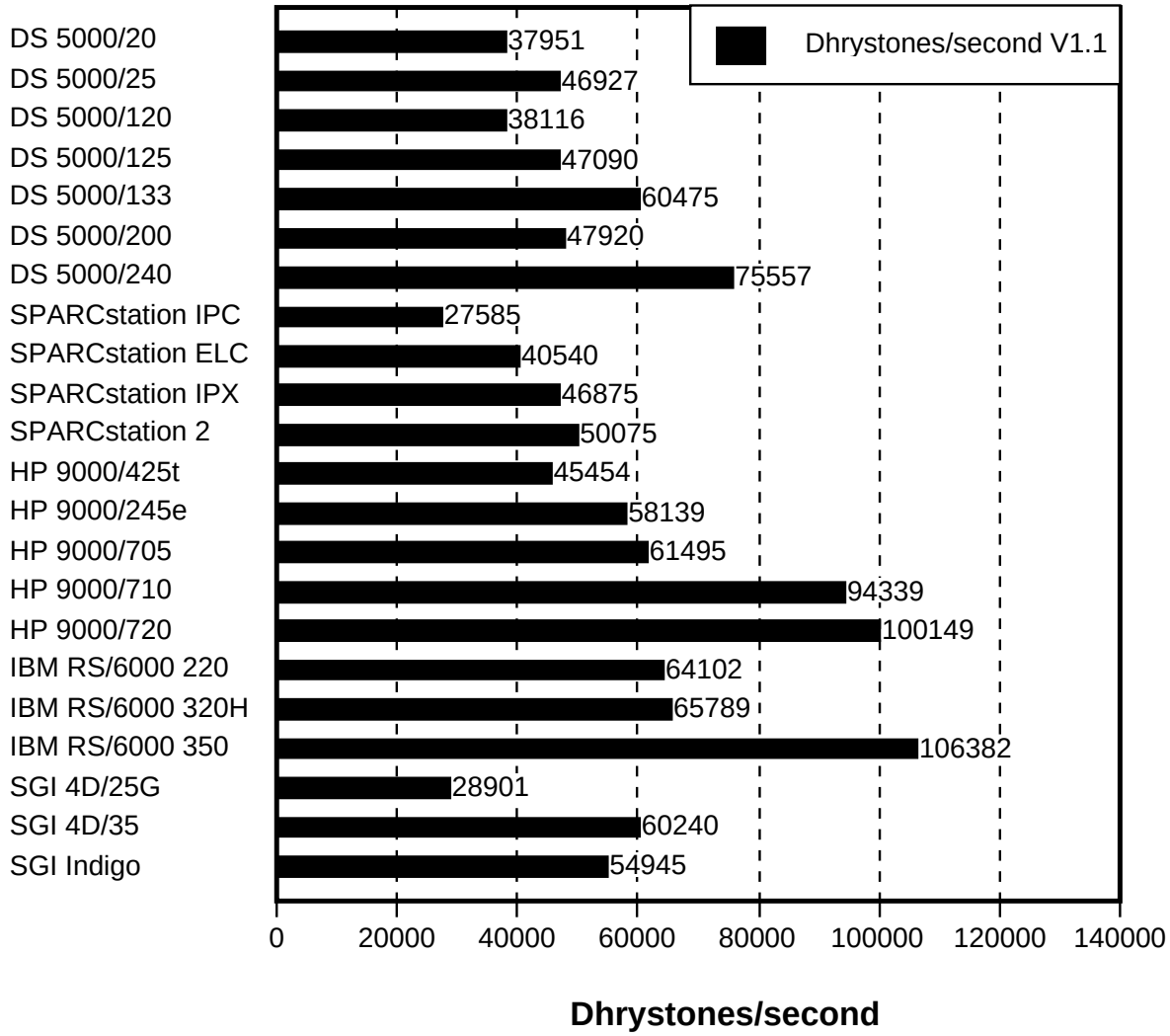


[1] Synthetic benchmarks are mostly loops which time different system calls and are not based on actual applications.

Dhrystone V1.x and V2.x vary considerably. Version 1.1. contains sequences of code segments that calculate results never used later in the program. These code segments are known as "dead code." Compilers able to identify the dead code can then eliminate those instruction sequences from the program. These compilers allow a system to complete the program in less time and result in a higher Dhrystone rating. Dhrystone V2.x has been modified to execute all instructions.

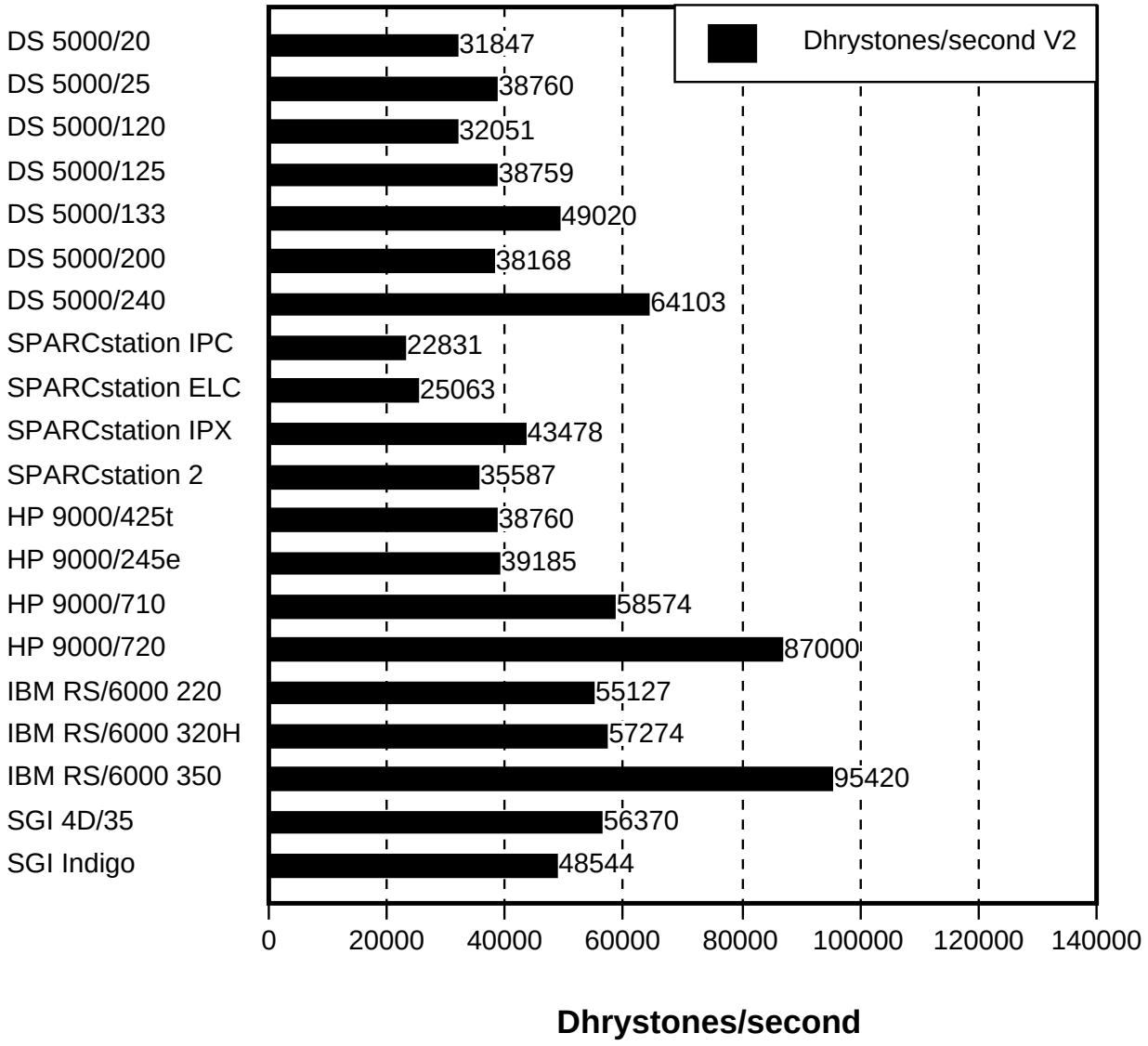
Dhrystones V1.1 results are shown in the following graph.

Figure 5-2: Dhrystone V1.1 Benchmark Results (Dhrystones/second)



Note: SGI 4D/25G V2 and HP 9000/705 Dhrystones V2.x results were not available.

Figure 5-3: Dhrystones V2.0 and V2.1 Benchmark Results (Dhrystones/second)



6 Whetstone Benchmark

6.1 Background

The Whetstone benchmark was developed in Great Britain's National Physical Laboratory 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 WIPS (Whetstone Instructions Per Second).

6.2 Results and Conclusions

The single- and double-precision Whetstone benchmark results are shown in the following two graphs.

Note: HP 9000/705 Whetstone benchmark results were not available.

Figure 6-1: Whetstones Single-precision Benchmark Results

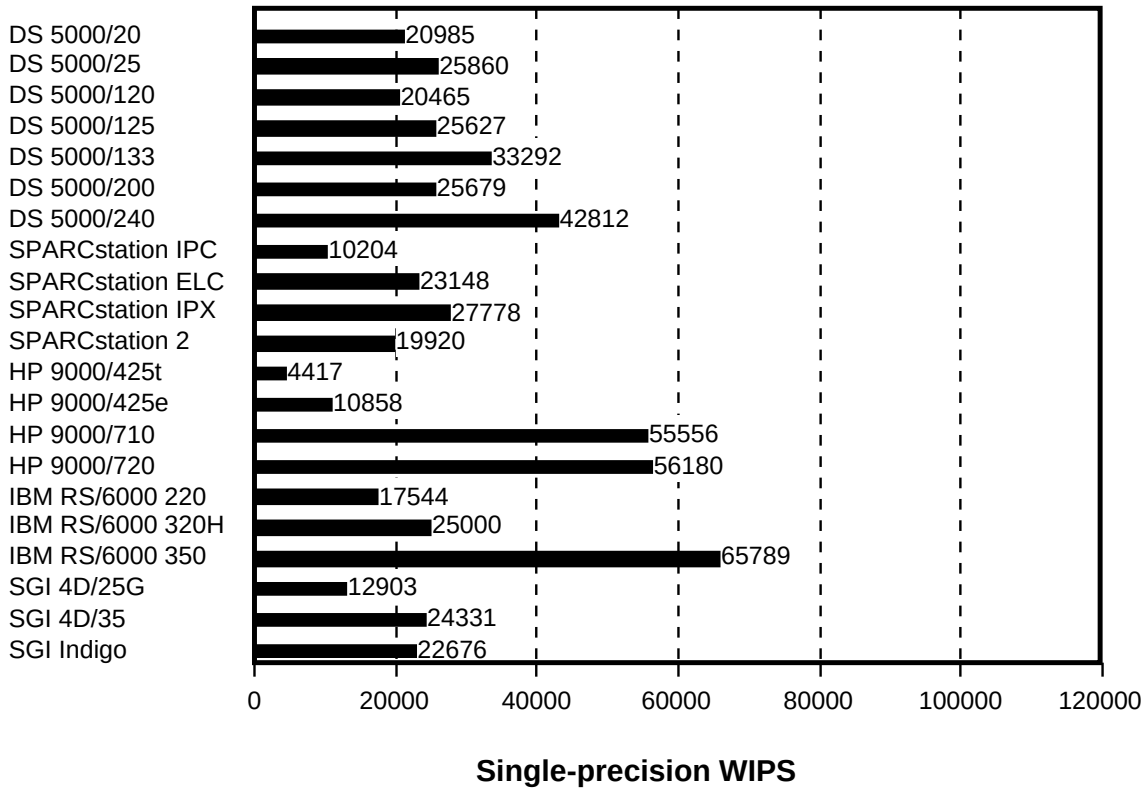
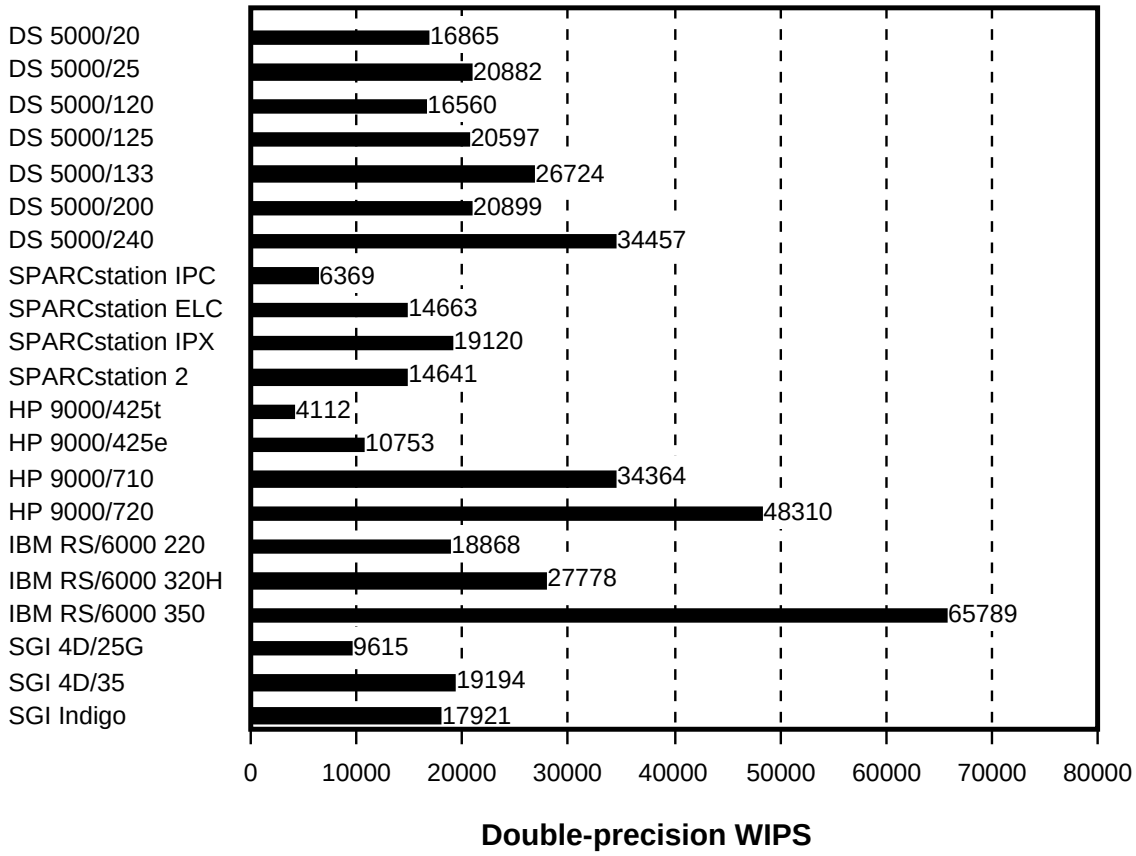


Figure 6-2: Whetstones Double-Precision Benchmark Results



7 Linpack Benchmark

7.1 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.

7.2 Results and Conclusions

The following two charts contain Linpack MFLOPS results.

Note: HP 9000/705 single-precision Linpack results were not available.

Figure 7-1: Linpack Single-precision Benchmark Results

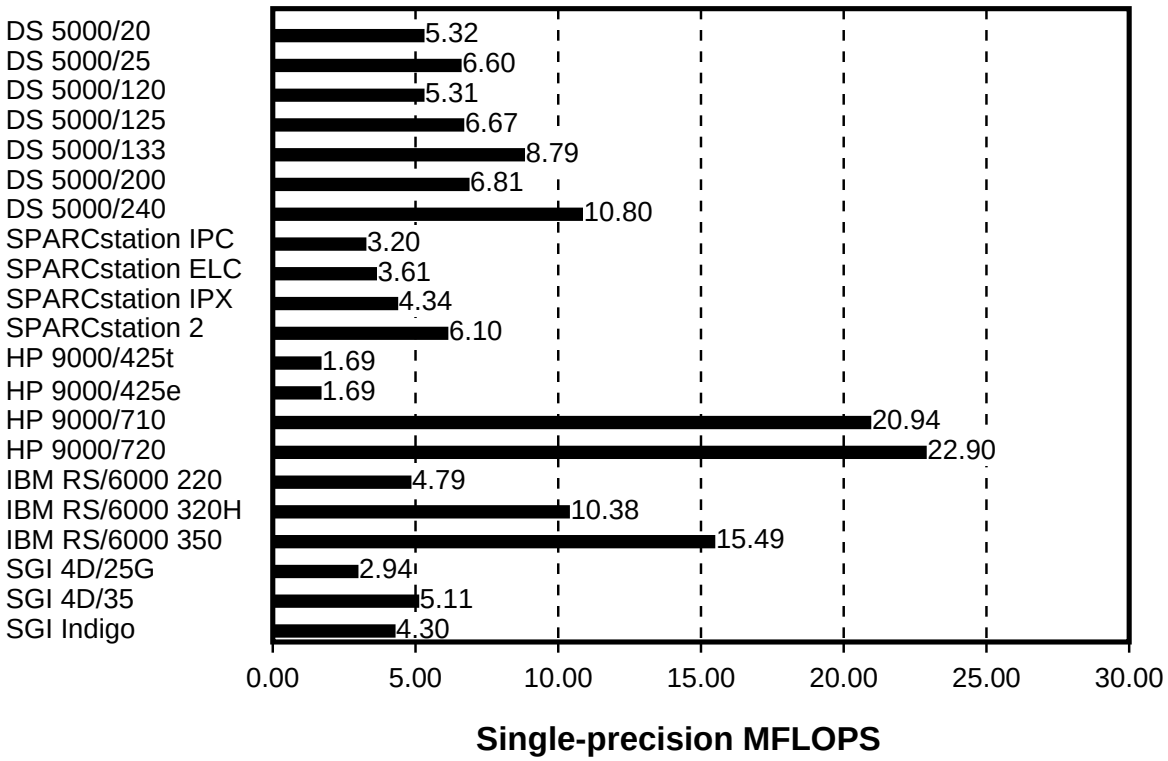
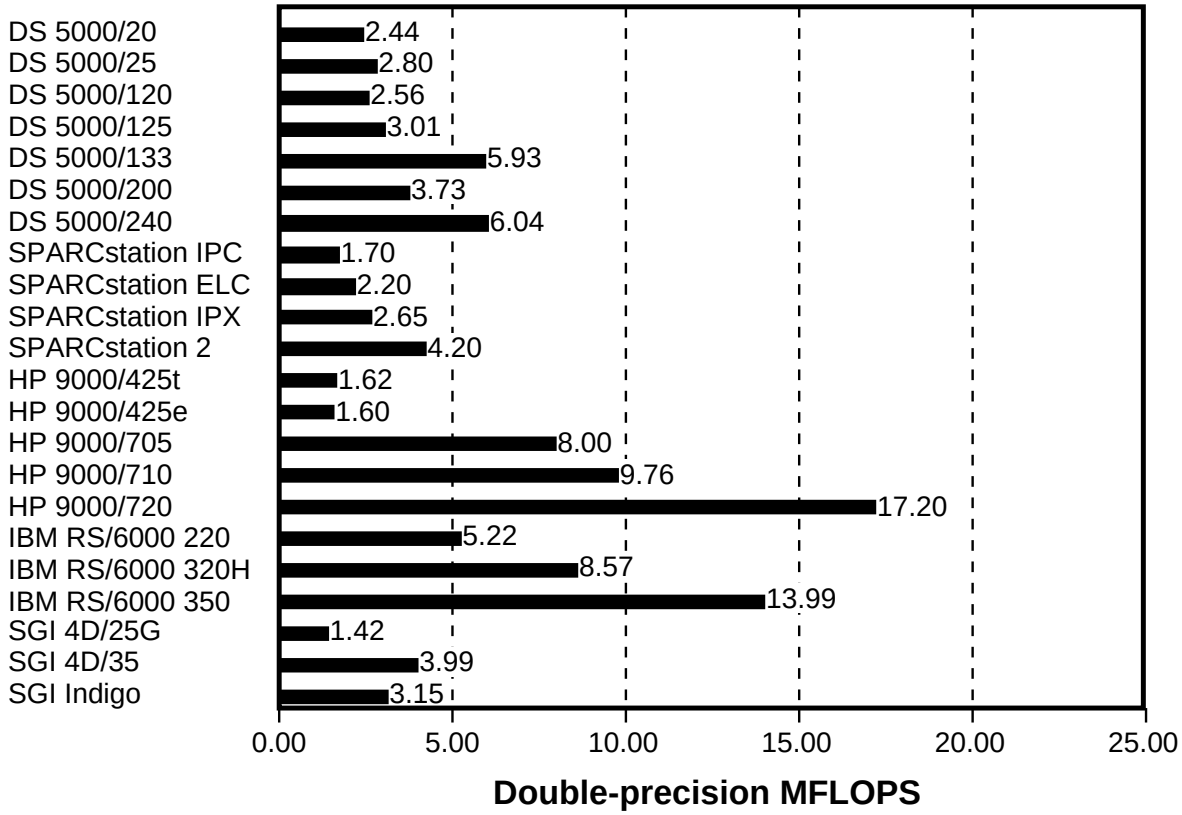


Figure 7-2: Linpack Double-precision Benchmark Results



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 and scientific applications.

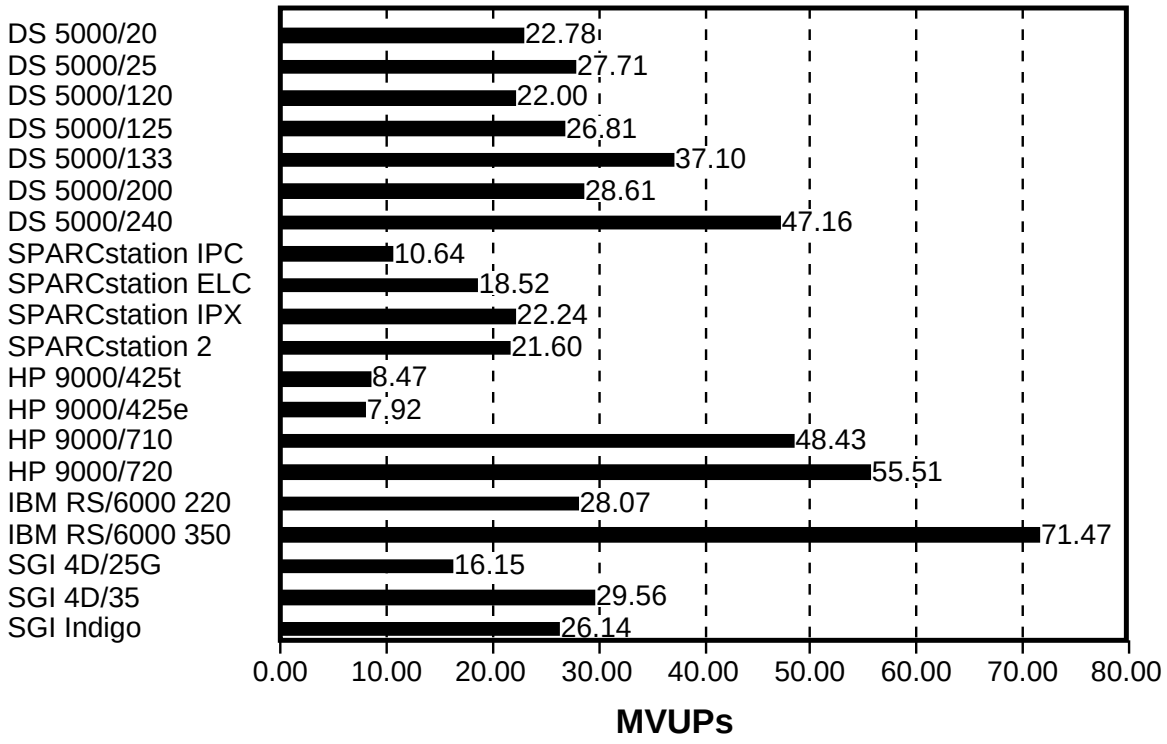
Performance is expressed as a multiple of MicroVAX II Units of Performance (MVUPs).

8.2 Results and Conclusions

The results of the DR Labs CPU2 benchmarks are shown in the following graph.

Note: HP 9000/705 and IBM RS/6000 320H MVUPs results were not available.

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 (e.g., 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.

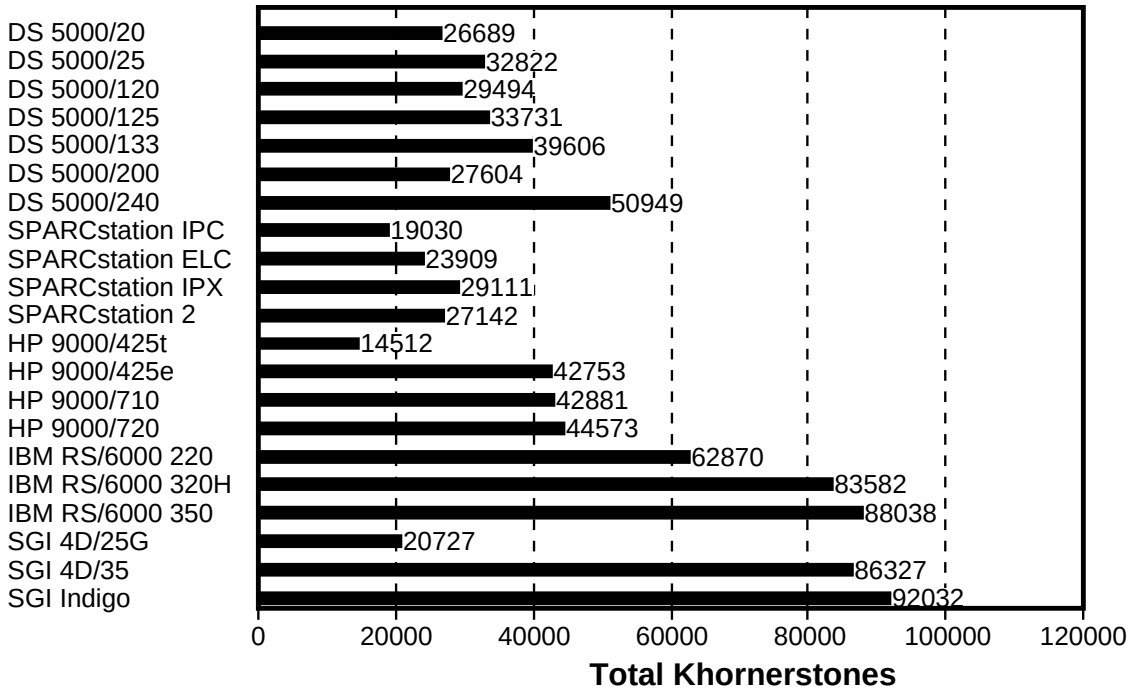
The Khornerstone and Khornerstone2 benchmarks differ in that the Khornerstone2 test runs 10 times as many repetitions of each test.

9.2 Results and Conclusions

The following graph has the Khornerstone and Khornerstone2 benchmark results.

Note: HP 9000/705 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

11 DECstations Graphic Options

Abbreviations used for the DECstation computer systems appearing in the following 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
TX	24-Plane TrueColor Frame 2D Graphics	(1280x1024@66Hz)	Yes
TX	24-Plane TrueColor Frame 2D Graphics	(1280x1024@72Hz)	No
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 kilo-vectors (Kvectors/second)
- 2D fill area results from X11perf *Copy 500x500 from pixmap to window* tests; shown in units of megapixels or Mpixels (megapixel = 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.

All DECstation graphic measurements reported in this section with the following default visual types:

- StaticGray: MX
- PseudoColor: HX, TX
- TrueColor: PXG, PXG+, PXGT+

Note: 2D X11perf results were not available for the HP 9000/705, IBM RS/6000 220, IBM RS/6000 350, and SGI 4D/25G.

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

Workstation	2D Kvectors/second[1]	2D Mpixels/second[2]
DS 5000/20 Board	153.0	5.7
DS 5000/20 HX	274.0	14.6
DS 5000 /20 TX[3]	137.0	4.1
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 TX[3]	156.0	4.3
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 TX[3]	137.0	4.1
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+	434.0	12.3
DS 5000/125 MX	114.0	8.0
DS 5000/125 HX	284.0	14.6
DS 5000/125 TX[3]	156.0	4.3
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+	434.0	12.3
DS 5000/133 MX	124.0	8.1
DS 5000/133 HX	298.0	14.8
DS 5000/133 TX[3]	158.0	5.1
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+	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+	445.0	12.3

(continued on next page)

[1] Kvectors=1,000 vectors [2] Mpixels=1,048,576 pixels [3] PseudoColor

Table 12-1: DECstations 2D Graphics X11perf Benchmark Results (continued)

Workstation	2D Kvectors/second[1]	2D Mpixels/second[2]
DS 5000/240 MX	248.0	20.3
DS 5000/240 HX	621.0	30.5
DS 5000/240 TX[3]	278.0	8.1
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] Kvectors=1,000 vectors [2] Mpixels=1,048,576 pixels [3] PseudoColor

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

Workstation	2D Kvectors/second[1]	2D Mpixels/second[2]
SPARCstation IPC	58.2	5.1
SPARCstation ELC	29.3	17.9
SPARCstation IPX	217.0	9.7
SPARCstation 2	205.0	8.3
HP 9000/425t Personal VRX	23.3	.9
HP 9000/425t	69.1	1.5
HP 9000/425e	49.0	8.8
HP 9000/710	492.0	3.4
HP 9000/720 CRX	868.0	22.8
IBM RS/6000 320H	77.4	3.4
SGI 4D/35	11.3	.9
SGI 4D/RPC Indigo	141.0	8.6

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

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

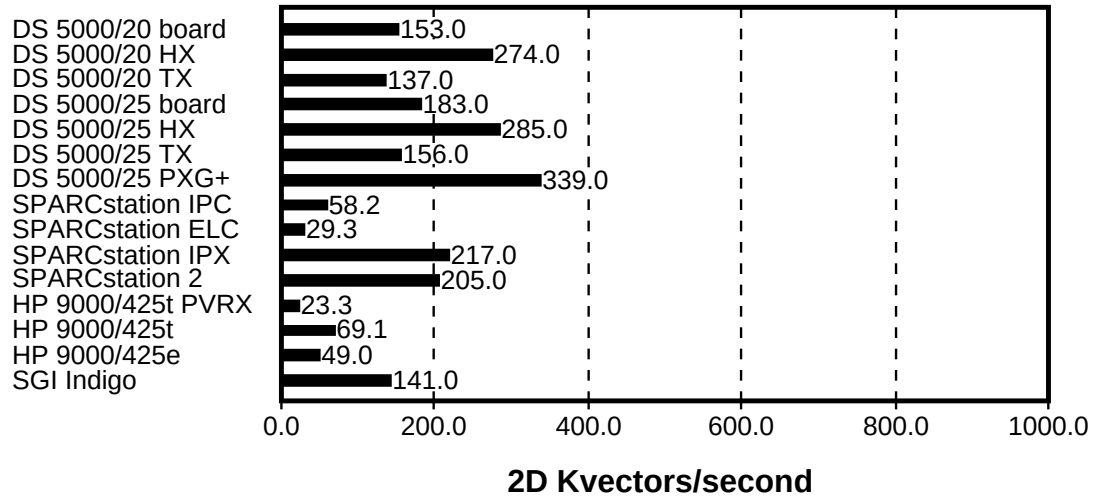


Figure 12-2: DECstation 5000/120, 125, & 133 and Competitors 2D Graphics X11perf Benchmark Results

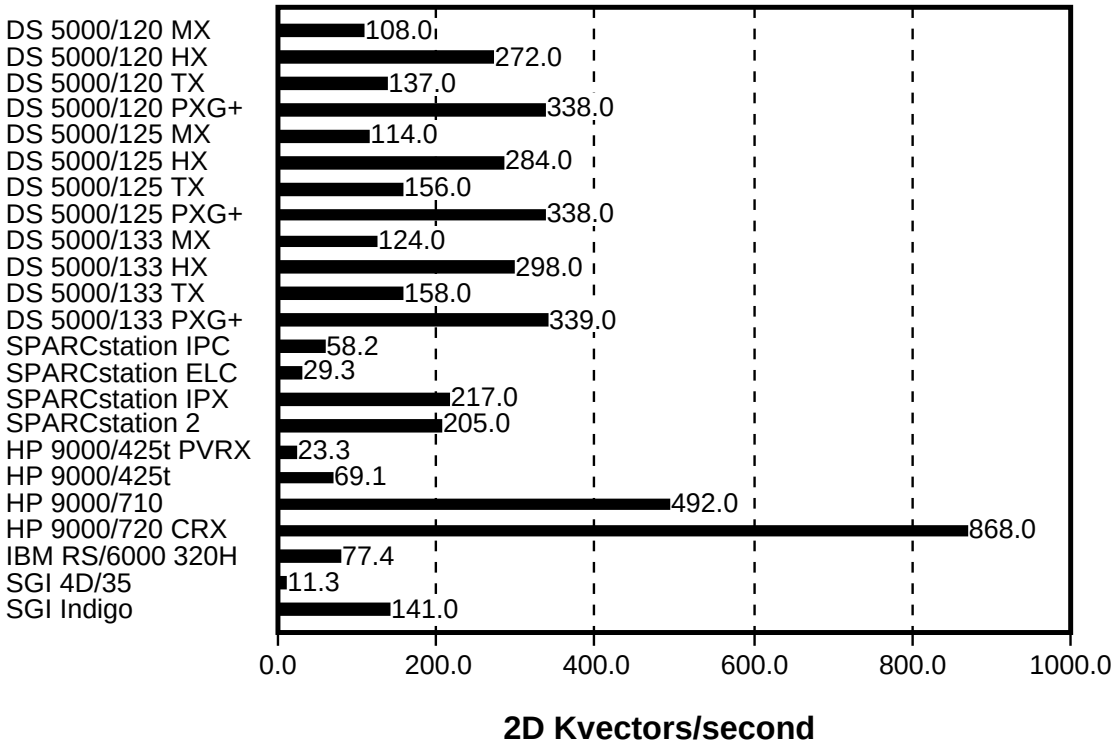


Figure 12-3: DECstation 5000/200 & 240 and Competitors 2D Graphics X11perf Benchmark Results

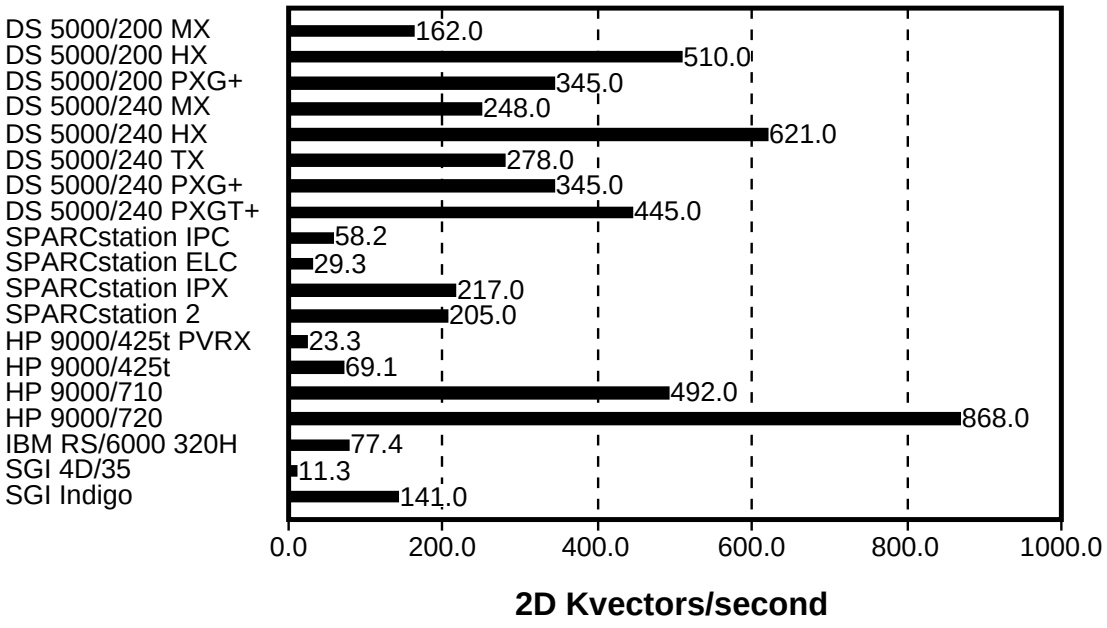


Figure 12-4: Personal DECstations and Competitors 2D Fill Area Graphics X11perf Benchmark Results

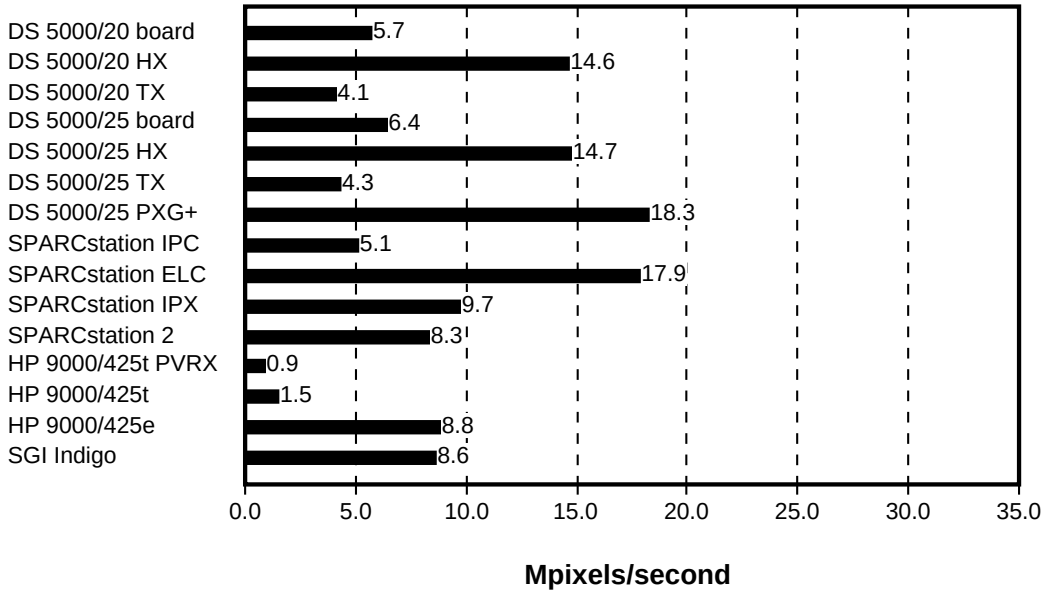


Figure 12-5: DECstation 5000/120, 125, & 133 and Competitors 2D Fill Area Graphics X11perf Benchmark Results

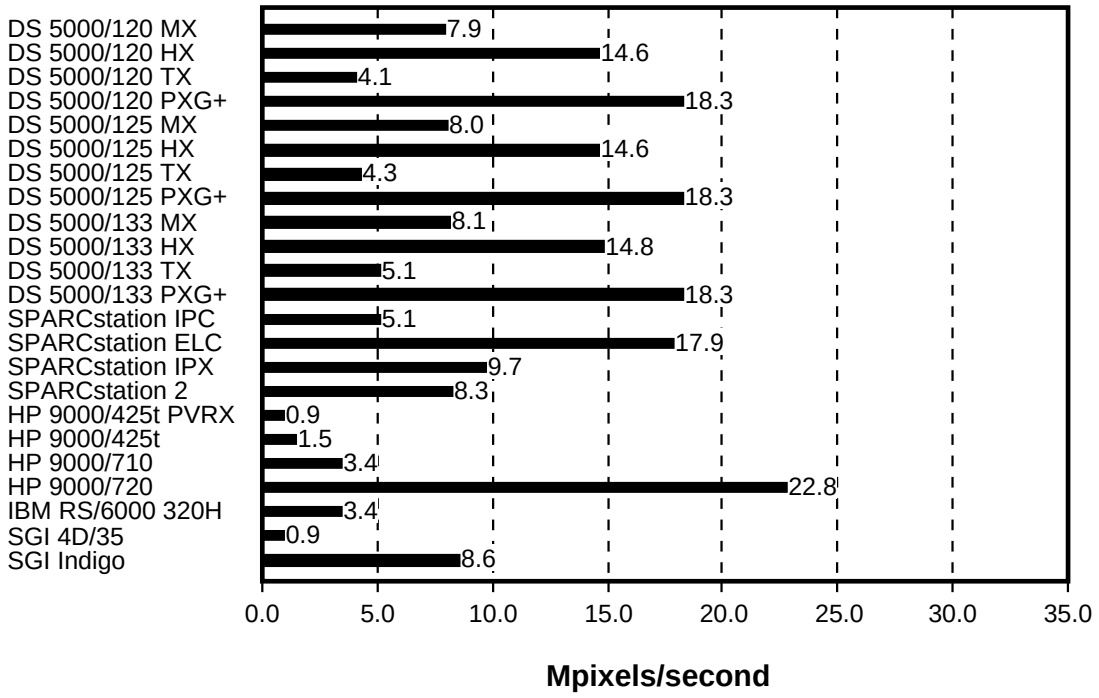
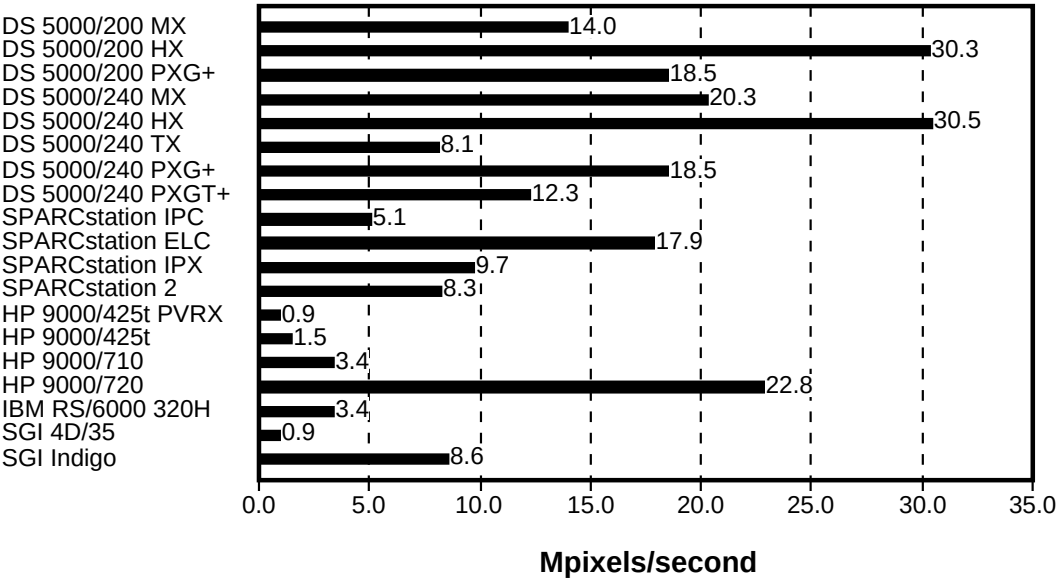


Figure 12-6: DECstation 5000/200 & 240 and Competitors 2D Fill Area Graphics X11perf Benchmark Results



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. You 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. 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[1]	3D Kpolygons/second[2]
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+	310	102
DS 5000/125 PXG	288	51
DS 5000/125 PXG+	310	68
DS 5000/125 PXGT	313	102
DS 5000/125 PXGT+	313	102
DS 5000/133 PXG	288	51
DS 5000/133 PXG+	376	68
DS 5000/133 PXGT	405	102
DS 5000/133 PXGT+	405	102
DS 5000/200 PXG	302	52
DS 5000/200 PXG+	400	70
DS 5000/200 PXGT	434	106
DS 5000/200 PXGT+	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] Kvectors=1,000 vectors
[2] 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 as follows:

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 as follows:

- "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 approximate 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 GPCmarks for the DECstation family of systems and comparable, competitive workstations.

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:na[1]	10.2:na	14.4:na	18.8:na	17.6:na
DS 5000/20 PXG+	11.2:na	10.8:na	16.2:na	20.9:na	20.0:na
DS 5000/25 PXG8	9.7:na	10.8:na	nr[2]	nr	nr
DS 5000/25 PXG	9.8:nr	10.5:na	14.4:na	18.8:na	17.6:na
DS 5000/25 PXG+8	11.2:na	12.0:na	nr	nr	nr
DS 5000/25 PXG+	11.2:nr	11.9:na	16.2:na	20.9:na	20.0:na
DS 5000/120 PXG	9.8:na	10.2:na	14.4:na	18.8:na	17.6:na
DS 5000/120 PXG+	11.2:na	10.7:na	16.2:na	20.9:na	20.0:na
DS 5000/120 PXGT	12.1:na	11.4:na	17.0:na	21.3:na	21.1:na
DS 5000/120 PXGT+	12.1:na	11.4:na	17.0:na	21.3:na	21.1:na
DS 5000/125 PXG8	9.7:na	10.8:na	np[3]	np	np
DS 5000/125 PXG	9.8:na	10.5:na	14.4:na	18.8:na	17.6:na
DS 5000/125 PXG+8	11.2:na	12.0:na	nr	nr	nr
DS 5000/125 PXG+	11.2:na	11.9:na	16.2:na	20.9:na	20.0:na
DS 5000/125 PXGT	12.2:na	12.5:na	17.0:na	21.3:na	21.1:na
DS 5000/125 PXGT+	12.2:na	12.5:na	17.0:na	21.3:na	21.1:na
DS 5000/133 PXG8	9.8:na	11.3:na	nr	nr	nr
DS 5000/133 PXG	9.9:na	11.4:na	14.3:na	18.8:na	17.6:na
DS 5000/133 PXG+8	11.2:na	13.2:na	nr	nr	nr
DS 5000/133 PXG+	11.3:na	13.2:na	16.1:na	20.9:na	19.9:na
DS 5000/133 PXGT	12.2:na	13.7:na	17.1:na	21.3:na	21.1:na
DS 5000/133 PXGT+	12.2:na	13.7:na	17.1:na	21.3:na	21.1:na
DS 5000/200 PXG8	10.0:na	11.7:na	np	np	np
DS 5000/200 PXG	10.0:na	11.7:na	14.9:na	19.2:na	18.3:na
DS 5000/200 PXG+	11.6:na	13.6:na	16.8:na	21.3:na	20.8:na
DS 5000/200 PXGT	12.6:na	14.9:na	17.7:na	21.7:na	21.9:na
DS 5000/200 PXGT+	12.6:na	14.9:na	17.7:na	21.7:na	21.9:na
DS 5000/240 PXG8	11.5:na	13.7:na	nr	nr	nr
DS 5000/240 PXG	10.0:na	11.7:na	14.9:na	19.2:na	18.3:na
DS 5000/240 PXG+	11.6:na	13.8:na	16.7:na	21.3:na	20.7:na
DS 5000/240 PXGT	12.6:na	15.3:na	17.8:na	21.7:na	22.1:na
DS 5000/240 PXGT+	12.7:na	15.3:na	17.6:na	21.7:na	21.9:na

(continued on next page)

System	PLB Benchmark PLBlit:PLBopt				
	pc_board	sys_chassis	cyl_head	head	shuttle
HP 9000/710	24.2:26.8	20.1:34.3	nr	nr	nr
HP 9000/720 CRX	27.6:31.6	21.1:37.1	11.4:na	14.3:15.8	15.6:na
HP 9000/720 CRX24	29.7:34.3	21.5:40.3	18.9:na	14.4:16.0	15.7:na
HP 9000/720 CRX24Z	28.4:33.0	20.9:38.0	31.9:na	32.6:42.5	21.1:na
IBM RS/6000 220 GTO	18.5:32.4	29.5:na	11.3:17.4	27.0:31.8	np:22.4
IBM RS/6000 320H GTO	18.8:35.9	31.5:na	11.5:17.4	27.2:34.2	np:24.2
IBM RS/6000 350 GTO	18.8:41.0	31.5:na	11.3:17.4	27.4:35.5	np:25.3
SPARCstation IPX	14.3:14.3	10.7:10.7	nr	nr	nr
SPARCstation 2 GX	14.6:14.6	10.8:10.8	nr	nr	nr
SPARCstation 2 GXplus	14.0:14.0	10.7:10.7	nr	nr	nr
SPARCstation 2 GS	3.6:3.6	4.0:4.0	7.2:7.2	6.2:6.2	9.2:9.2
SPARCstation 2 GT	9.7:9.7	18.6:18.6	15.1:15.1	29.3:29.3	17.2:17.2

[1] not available
[2] not reported
[3] not possible
Digital used DEC PHIGS
HP used HP-PHIGS
IBM used graPHIGS
SPARCstations used SunPHIGS

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

A

Test Configurations

The benchmarks ran on systems with the following configurations. Sources of benchmark results follow configuration listing.

Personal DECstation 5000 Model 20 Board, TX, HX 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

Version 1.1 and Version 2.1 Dhrystones/second reported. Khornerstone2 tests used 10% buffer cache. All benchmark testing was performed by Digital Equipment Corporation.

Personal DECstation 5000 Model 25 Board, MX, TX, HX, PXG, PXG+ Workstations:

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

Version 1.1 and Version 2.1 Dhrystones/second reported. Khornerstone 2 tests used 10% buffer cache. All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 120 MX, TX, HX, PXG, PXG+,PXG Turbo, 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

Version 1.1 and V2.1 Dhrystones/second reported. All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 125 MX, TX, HX, PXG, PXG+, PXG Turbo, 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

Version 1.1 and V2.1 Dhrystones/second reported. All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 133 MX, TX, HX, PXG, PXG+, PXG Turbo, 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

Version 1.1 and Version 2.1 Dhrystones/second reported. Khornerstone2 results used 10% buffer cache. All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 200 MX, HX, PXG, PXG+, PXG Turbo, 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

Version 1.1 and Version 2.0 Dhrystones/second reported. Khornerstone2 tests results shown. All benchmark testing was performed by Digital Equipment Corporation.

DECstation 5000 Model 240 MX, TX, HX, PXG, PXG+, PXG Turbo, 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

Version 1.1 and Version 2.1 Dhrystones/second reported. 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
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 results from *SPEC Newsletter,* Volume 3, Issue 1 Winter 1991, page 18. Dhrystone Versions 1.1 and 2.0, 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 Versions 1.1 and 2.0, 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 705 Workstation:

Processor Type & Frequency	PA-RISC 1.1 - 35 MHz
Floating Point Unit	35 MHz Custom
Cache Memory Size & Speed	32 KB Instruction / 64 Kb Data
RAM Memory Size & Speed	16 MB
Display Size & Type	19" Grayscale
Display Resolution	1280 x 1024, 72 MHz refresh
Disk Subsystem	2-SCSI HP C2235A 420 MB
Operating System	HP-UX 8.05
Compilers & Versions	HP C A.08.53, HP Fortran A.08.05
Network Type	Ethernet

SPEC benchmark results from *SPEC Newsletter*, Volume 4, Issue 1, March 1992, page 90. Dhrystone Version 1.1,and Linpack ratings from HP January 1992 announcement.

Hewlett-Packard 9000 Model 710 Workstation:

Processor Type & Frequency	HP/PA 1.1-50 MHz
Floating Point Unix & Frequency	built-in
Cache Memory Size & Speed	32 Kb Instruction/64 Kb Data
RAM Memory Size & Speed	16 MB - 80 ns DRAM
Disk Buffer Sizes	10% of memory
Display Size & Type	19" Color
Display Resolution	1280 x 1024 pixels
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	?/425 MB
Network Type	Ethernet
Operating System	HP/UX 8.07
Compilers and Switches	HP Fortran 8.05 +O3 (+OP4 used for some tests), HP C 8.07 +O3

Dhrystone Version 1.1 and Version 2.0, Whetstone, Linpack, Khornerstone, and X11perf ratings from *Workstation Laboratories,* 3/1/92, Volume 16, page V16-17-Config. SPEC benchmark numbers from *SPEC Newsletter,* Volume 4, Issue 1, March 1992, page 90, running HP-UX 8.05, HP C A.08.53, and HP Fortran A.08.05 and using 2-SCSI HP C2235A 420 MB. DR Labs CPU2 from *Digital Review,* 2/3/92, page 26. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 12.

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. Dhrystone, Whetstone, Khornerstone 2 , and Linpack benchmark numbers from *HP Apollo Series 700 Workstations Performance Overview,* March 1991. X11perf benchmarks numbers from *Workstation Laboratories*, 4/1/91, Volume 13, Chapter 10. Configuration used by WSL was HP 9000 Model 720 CRX. DR Labs CPU2 rating from *Digital Review,* 1/20/92, page 47. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 12.

IBM RISC System/6000 POWERstation 220 Workstation:

Processor Type & Frequency	IBM RISC - 33MHz
Floating Point Unix & Frequency	built into CPU chip set
Cache Memory Size & Speed	8 Kb data + instruction
RAM Memory Size & Speed	32 MB
Hardfile Brands & Model Numbers	IBM 400 MB SCSI 3.5"
Operating System	AIX 3.2
Compilers & Switches	AIX XL FORTRAN Ver. 2.2, AIX XL C Ver. 1.2
Graphic Libraries Used	X11 and graPHIGS

SPEC benchmark numbers from *SPEC Newsletter,* Volume 4, Issue 1, March 1992, page 91. Dhrystone Versions 1.1 and 2.0, Whetstone, Khornerstone , DR Labs CPU2, and Linpack benchmark numbers from *Workstation Laboratories*, 3/1/92, Volume 16, page V16-19-Config. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 13.

IBM RISC System/6000 POWERstation 320H Computer:

CPU	IBM Power RISC - 25MHz
FPU	Integrated
Memory	16MB
Disk Controller	DBA/SCSI
Disk	400 MB
Cache Size	32KB data/8 KB instruction
Network Interface	Ethernet
Operating System	AIX 3.2
Compilers	AIX XL Fortran Ver. 2.2, AIX XL C Ver. 1.2
File System	AIX

SPEC results from S*PEC Newsletter,* Volume 4, Issue 1, March 1992, page 92. Dhrystone Versions 1.1 and 2.0, Linpack, Whetstone, Khornerstone, and X11perf ratings from *Workstation Laboratories,* 3/1/92, Volume 16, page V16-9-Config. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 13.

IBM RISC System/6000 POWERstation 350 Workstation:

Processor Type & Frequency	IBM RISC- 42 MHz
Floating Point Unix & Frequency	built into CPU chip set
Cache Memory Size & Speed	32 Kb Data / 8 Kb Instruction
RAM Memory Size & Speed	32 MB
Hardfile Brands & Model Numbers	IBM 400 MB SCSI 3.5"
Operating System	AIX 3.2
Compilers & Switches	IBM Fortran 3.2 -O, IBM C 3.2 -O
Graphic Libraries Used	X11 and graPHIGS

SPEC benchmark numbers from *SPEC Newsletter,* Volume 4, Issue 1, March 1992, page 94, using AIX XL C/6000 Ver. 1.2 and AIX XL FORTRAN Ver. 2.2. Dhrystone V1.1 and V2.0, Whetstone, Khornerstone , DR Labs CPU2, and Linpack benchmark numbers from *Workstation Laboratories*, 3/1/92, Volume 16, page V16-20-Config. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 13.

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. Dhrystone V1.1, Whetstone, Khornerstone, 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:

Processor Type & Frequency	R3000 - 36 MHz
Floating Point Unix & Frequency	R3010 - 36 MHz
Cache Memory Size & Speed	128 Kb total / 64 Kb Instruction / 64 Kb Data
RAM Memory Size & Speed	32 MB - 80 ns DRAM
Hardfile Brands & Model Numbers	Seagate (CDC) 5.25" SCSI
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	?/320 MB
Operating System Name & Level	IRIS 3.31
Compilers & Switches	Silicon Graphics Fortran -O3 (-O2 on some), Silicon Graphics C -O3 (-O2 on some)

SPEC benchmark numbers from Silicon Graphics. Dhrystone V1.1 and V2.0, Linpack , Whetstone, DR Labs CPU2, Khornerstone, and X11perf ratings from *Workstation Laboratories,* 3/1/92, Volume 16, page V16-13-Config.

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 V1.1 and V2.0, Whetstone, Linpack, Khornerstone, and X11perf benchmark results from *Workstation Laboratories,* 9/1/91, Volume 15, Chapter 23, page V15-23-Config. DR Labs CPU from *Digital Review,* 1/20/92, page 47. 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. Whetstone, DR Labs CPU2 MVUPS, Dhrystone V2.0, and X11perf benchmark numbers from *Workstation Laboratories,* 2/1/91, Volume 12, page V12-23-Config. Linpack and Dhrystone V1.1 numbers from S*PARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990, page 17. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 13.

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 at 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. Dhrystone V1.1 and V2.0, Whetstone, Khornerstone, Linpack, and X11perf benchmark numbers from *Workstation Laboratories*, 9/1/1991, Volume 15, Chapter 21. DR Labs CPU2 rating from *Digital Review,* 2/3/92, page 26.

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. Dhrystone V1.1 and Linpack numbers from *SPARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990, page 17. Dhrystone V2.0 and Whetstone 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 .

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. Dhrystone V1.1 and V2.0, Whetstone, Khornerstone, Linpack, and X11perf benchmark numbers from *Workstation Laboratories*, 9/1/91, Volume 15, Chapter 22. DR Labs CPU2 from *Digital Review,* 2/3/92, page 26. GPCmarks from *The GPC Quarterly Report,* Vol. 2, No. 1, 1st Qtr 1992, page 13.

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