Digital's VAXstation 4000 Family Performance Summary

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Executive Summary

1 Introduction

This revision of *Digital's VAXstation 4000 Family Performance Summary* introduces the SPXg and SPXgt, the new generation of graphics accelerators for the VAXstation 4000 Model 60. The SPXg and SPXgt provide high-resolution (1280 x 1024) 3D capability for the VAXstation 4000 Model 60.

The 8-plane SPXg is intended for design automation (CAD/CAE/CAM), molecular modeling, architectural design, and true-color imaging applications. The SPXg option provides support for full double buffering and 16-bit Z buffering. The higher performance 24-plane SPXgt is designed for 3D modeling and visualization applications. Again, full double buffering is supported along with 24-bit Z buffering. Both the SPXg and SPXgt contain hardware acceleration to support major industry standard graphics protocols including PHIGS (Programmers Hierarchical Interactive Graphical System) and GKS (Graphics Kernel System). PEX support provides the PHIGS link to the X Window System.

Digital's VAXstation 4000 Family Performance Summary is a technical reference document for Digital sales support personnel, customers, and other individuals who need to understand the performance characteristics of the VAXstation family.

This document provides information about the workstation and the system-level performance of the VAXstation family running standard industry benchmarks and workloads. The metrics for recording system performance vary according to the workload and focus on useful work done by the system.

The following sections briefly describe the workloads and graphically depict the results. Test configurations and sources of test results are shown in Appendix A. References are listed in Appendix B.

The VAXstation 4000 Model 60 SPXg and SPXgt tests were performed in February 1992.

2 New Product Highlights

- The SPXg and SPXgt provide much better graphics than a SPARCstation 2 GS, proving that raw CPU power doesn't necessarily provide the graphics performance needed for 3D.
- The VAXstation 4000 Model 60 with SPXgt (24-plane) offers better performance and costs less than the Hewlett Packard 9000/425t VRX (CISC, 16-plane).
- The SPXg and SPXgt offer pricing and graphics performance comparable to the DECstation PXG graphics adapter.

3 New Product Descriptions

VAXstation 4000 VLC and VAXstation 4000 Model 60 system features are shown in the following table.

Table 3-1: VAXstation 4000 VLC and VAXstation 4000 Model 60 System Features

	VAXstation 4000 VLC	VAXstation 4000 Model 60
System		
Packaging	Desktop	Desktop
CPU	SOC (System on a chip)	VAX CPU and FPU chipset
Clock Rate	25 MHz	55 MHz
Read or Write Cycle Time to Cache	40 ns	18 ns
Memory	8-24 MB	8 - 104 MB
Disks - Internal fixed	121 MB maximum	852 MB maximum
External fixed	6.1 GB maximum	6.4 GB maximum
Bus	Sync SCSI	Sync SCSI/ Turbochannel
Internal Options	None	Sync Communications
Ethernet	Thick (adapter to Thin)	Thick/Thin
Graphics		
	1024 x 768 1280 x 1024 8-plane color / 8-plane greyscale	1280 x 1024 Dual 1280 x 1024 8-plane color / 8-plane greyscale 8-plane 1280 x1024 3D SPXg graphics 24-plane 1280 x 1024 3D SPXgt graphics
Monitors		
1024 x 768 monochrome	17"	N/A
1024 x 768 color	13"	N/A
1280 x 1024 monochrome	19"	17" / 19"
1280 x 1024 color	16" / 19"	16" / 19"

4 Summary of Relative Performance and System Attributes

The following tables show relative application performance positioning only. It is important to consider other factors when selecting a system to solve a specific problem. Other factors include operating environment, expandability (such as expanded memory and storage), and price. Using this data, the most appropriate system can be selected based on system attributes, as well as performance characterization.

Table 4-1: Digital VAXstations and Competitive Systems Graphics & SoftPC Benchmark Results

Workstation	2D Fill Area X11perf Copy 500x500 from pixmap to windows (Mpixels/sec.)	2D Vectors X11perf 10-pixel line (Kvectors/sec.)	3D Graphics 3D Vectors (Kvectors/ sec.)	3D Graphics 3D Polygons (Kpolygons/ sec.)	SoftPC Norton SI	SoftPC Dhrystone	SoftPC *PC Magazine*'s Bench V4.0
VAXstation 3100 Model 38 GPX	7.7	24.0	n/a[1]	n/a	4.3	940	1.1
VAXstation 3100 Model 38 SPX	14.2	214.0	n/a	n/a	n/a	n/a	n/a
VAXstation 3100 Model 76 GPX	7.8	23.7	n/a	n/a	9.2	1915	2.2
VAXstation 3100 Model 76 SPX	14.2	183.0	57	6	n/a	n/a	n/a
VAXstation 4000 VLC	13.4	156.0	n/a	n/a	6.9	1149	1.6
VAXstation 4000 Model 60	14.6	216.0	n/a	n/a	14.0	3079	3.3
VAXstation 4000 Model 60 SPXg	24.8	365.0	295	30	n/a	n/a	n/a
VAXstation 4000 Model 60 SPXgt	10.4	371.0	300	33	n/a	n/a	n/a
DECstation 5000 Model 125 PXG	13.9	259.0	288	51	n/a	n/a	n/a
HP 9000/425t	1.5	69.1	206	29	n/a	n/a	n/a
HP 9000/720 CRX	22.8	868.0	820	23	n/a	n/a	n/a
SPARCstation IPC	5.1	58.2	n/a	n/a	n/a	n/a	n/a
SPARCstation ELC	17.9	29.3	n/a	n/a	n/a	n/a	n/a
SPARCstation IPX	9.7	217.0	n/a	n/a	n/a	n/a	n/a
SPARCstation 2 GS	8.3	205.0	150	20	n/a	n/a	n/a
SGI Indigo	26.3	141.0	250	60	n/a	n/a	n/a

[1]n/a = not available or not applicable
Refer to Appendix A for test configurations
Table current as of March 1992

Table 4-2: Digital VAXstations and Competitive Systems CPU and Floating Point Benchmark Results

Workstation	SPECmark	SPECint	SPECfp	Dhrystone MIPS	Dhrystone per second	Linpack Single MFLOPS	Linpack Double MFLOPS	Whetstone Single KWIPS	Whetstone Double KWIPS
VAXstation 3100 Model 38	3.7	3.5	3.8	6.14	10794	1.01	.49	3919	2514
VAXstation 3100 Model 76	6.8	7.1	6.6	12.65	22222	1.92	1.12	8216	5784
VAXstation 4000 VLC	6.2	5.8	6.3	10.87	19105	1.20	.75	6357	4070
VAXstation 4000 Model 60	12.0	11.1	12.6	17.14	30120	2.66	1.72	12774	8628
DECstation 5000 Model 125	19.3	16.1	21.7	26.80	47090	6.67	3.01	25627	20597
Compaq SystemPro 486-840	n/a[1]	n/a	n/a	18.97	33333	1.42	1.29	7541	7353
HP 9000/425t	11.0	12.3	10.3	25.87	45454	1.69	1.62	4417	4112
HP 9000/720	59.5	39.5	78.5	57.00	100149	22.90	17.20	56180	48310
SPARCstation IPC	13.5	12.8	14.0	15.70	27585	3.20	1.70	10204	6369
SPARCstation ELC	20.3	18.0	22.0	23.07	40540	3.61	2.20	23148	14663
SPARCstation IPX	24.4	21.7	26.5	26.68	46875	4.34	2.65	27778	19120
SPARCstation 2	25.0	21.7	27.4	28.50	50075	6.10	4.20	19920	14641
SGI Indigo	26.3	23.6	28.4	31.27	54945	4.30	3.15	22676	17921

[1] n/a = not available
Refer to Appendix A for test configurations
Table current as of March 1992

Table 4-3: Digital VAXstations and Competitive Systems PLB Results

	PLBlit : PLBopt				
Workstation	pc_board	sys_chassis	cyl_head	head	shuttle
VAXstation 4000 Model 60 SPXg	11.9 : NR[1]	11.0: NR	NR	NR	NR
VAXstation 4000 Model 60 SPXgt	12.3 : NR	11.1 : NR	8.4 : NR	8.5 : NR	12.5 : NR
DECstation 5000 Model 125 PXG	9.8 : NR	10.5 : NR	14.4 : NR	18.8 : NR	17.6 : NR
HP 9000/720 CRX (HP-PHIGS)	34.0 : NR	22.1 : NR	14.3 : NR	13.8 : NR	16.4 : NR
SPARCstation IPX (XGL)	17.7 : 23.7	9.7 : 13.7	NR	NR	NR
SPARCstation IPX (SunPHIGS)	14.3 : 14.3	10.7 : 10.7	NR	NR	NR
SPARCstation 2 GX (XGL)	17.8 : 23.8	9.5 : 13.6	NR	NR	NR
SPARCstation 2 GX (SunPHIGS)	14.6 : 14.6	10.8 : 10.8	NR	NR	NR
SPARCstation 2 GS (XGL)	3.6 : 3.6	4.0 : 4.0	7.0 : 7.0	6.2 : 6.2	8.9 : 9.2
SPARCstation 2 GS (SunPHIGS)	3.6 : 3.6	4.0 : 4.0	7.2 : 7.2	6.2 : 6.2	9.2 : 9.2

[1] NR= Not Reported
Refer to Appendix A for test configurations
Table current as of March 1992

Part II

Benchmark Results

Results of individual benchmarks can be changed dramatically by the choice of operating system version, compiler version, level of optimization used, memory size, configuration, cache size, process scheduling, buffer management, and so on. Because some systems have more than one compiler available from the vendor, using different compilers can have a significant impact on benchmark performance.

The following table explains the abbreviations used in the graphs and tables contained in this section.

Table 4-4: Key to Graphs

Abbreviation	Full Product Description
VS 3100/38	Digital VAXstation 3100 Model 38
VS 3100/76	Digital VAXstation 3100 Model 76
VS4000 VLC	Digital VAXstation 4000 VLC
VS4000/60	Digital VAXstation 4000 Model 60
Compaq 486-840	Compaq SystemPro 486-840
HP 9000/425t	Hewlett-Packard 9000 Model 425t
HP 9000/720	Hewlett-Packard 9000 Model 720
SPARCstation IPC	Sun Microsystems SPARCstation (4/40) IPC
SPARCstation ELC	Sun Microsystems SPARCstation ELC
SPARCstation IPX	Sun Microsystems SPARCstation IPX
SPARCserver 2	Sun Microsystems SPARCserver 2
SGI Indigo	Silicon Graphics, Inc. Indigo

3D Graphics Benchmarks

4.1 Background

Digital's 3D graphics benchmarks measure 3D line and 3D polygon performance using a PEX server benchmark. For Digital systems, 3D vectors are 10-pixel, 10 lines/polyline, structure mode. 3D vector results are reported in kilovectors (Kvectors)/second or 1,000 lines/second. For Digital systems, 3D polygons are 100-pixel triangles, 10 triangles/triangle strip, Z-buffered, default+directional lighting. 3D polygon results are shown in kilo-polygon (Kpolygons)/second or 1,000 polygons/second. Refer to Appendix A for descriptions of competitive systems' 3D graphics benchmark measurements.

4.2 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.

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. Although comparing 3D graphics performance numbers quoted by one vendor to those of another is rarely a meaningful comparison and can be misleading, we are showing 3D graphic performances reported by our competitors. The text appearing below each chart explains what each vendor is measuring.

The following graph presents the 3D graphics kvectors/second.

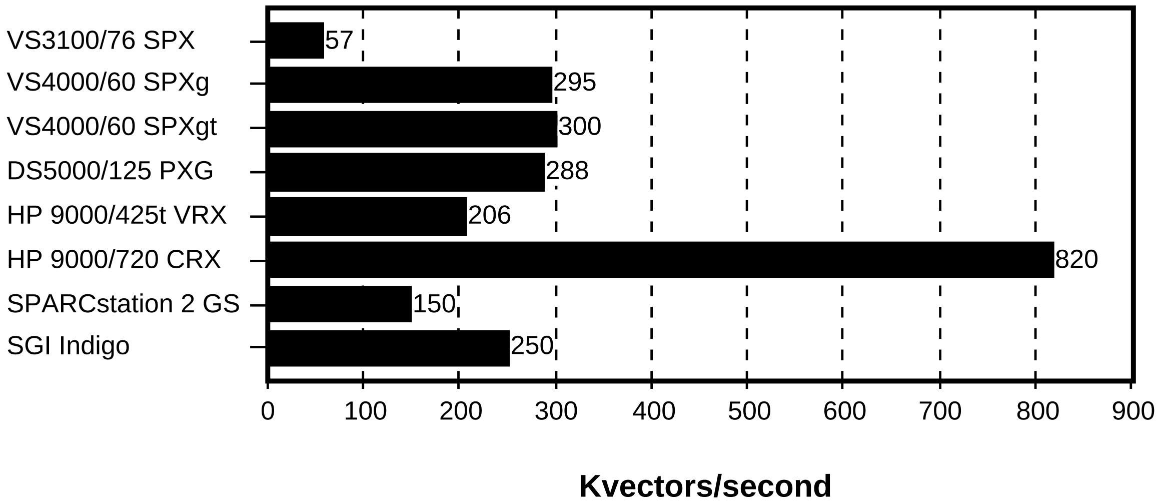

Figure 4-1: 3D Graphics Kvectors/second Results

Digital:	10 pixel lines, 10 lines/polyline, structure mode. From PEX server benchmark.
HP:	10 pixel, random orientation, clipping on perspective projection, and constant color. Through Starbase API.
Sun:	10 pixel vectors, transformed and clipped. API was not specified.
SGI:	10 pixel, connected, arbitrarily rotated.

The graph below shows the the 3D kpolygons/second results for the VAXstation 4000 Model 60 SPXgt and competitive systems.

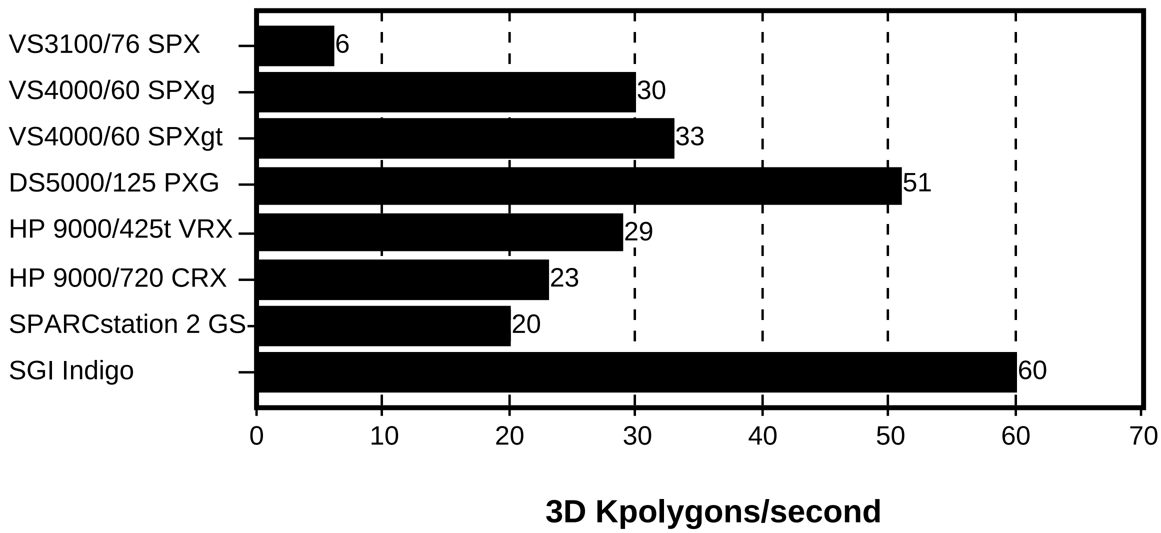

Figure 4-2: 3D Graphics Kpolygons/second Results

Digital:	100-pixel triangles, 10 triangles/triangle strip, Z-buffered, default+directional lighting. From PEX server benchmark.
HP:	10x10, 50 pixel triangles in triangular strips, random orientation, transformed, clipped checked, and Z-buffered.
Sun:	100 pixel triangles, gourand-shaded, clipped, through. Through SunPHIGS.
SGI:	Filled 10x10 pixels, 4-sided, independent quadrilaterals, arbitrarily rotated. Gourand Z, T-mesh.

Picture-Level Benchmarks

4.3 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.

4.4 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 PLB results for the VAXstation 4000 Model 60 and competitive systems. The competitors' results shown in the table were taken from *The GPC Quarterly Report*, Volume 1, Number 3, 4th Quarter 1991, except for HP 9000/720 CRX which came from Hewlett-Packard's 700 Series performance report.

Figure 4-3: PLB Benchmarks Results

System	PLB Benchmark PLBlit:PLBopt				
	pc_board	sys_chassis	cyl_head	head	shuttle
VS 4000/60 SPXg	11.9 : NR	11.0 : NR	NR	NR	NR
VS 4000/60 SPXgt	12.3 : NR	11.1 : NR	8.4 : NR	8.5 : NR	12:5 : NR
DS 5000/125 PXG	9.8 : NR	10.5 : NR	14.4 : NR	18.8 : NR	17.6 : NR
HP 9000/720 CRX (HP-PHIGS)	34.0 : NR	22.1 : NR	14.3 : NR	13.8 : NR	16.4 : NR
SPARCstation IPX (XGL)	17.7 : 23.7	9.7 : 13.7	NR	NR	NR
SPARCstation IPX (SunPHIGS)	14.3 : 14.3	10.7 : 10.7	NR	NR	NR
SPARCstation 2 GX (XGL)	17.8 : 23.8	9.5 : 13.6	NR	NR	NR
SPARCstation 2 GX (SunPHIGS)	14.6 : 14.6	10.8 : 10.8	NR	NR	NR
SPARCstation 2 GS (XGL)	3.6 : 3.6	4.0 : 4.0	7.0 : 7.0	6.2 : 6.2	8.9 : 9.2
SPARCstation 2 GS (SunPHIGS)	3.6 : 3.6	4.0 : 4.0	7.2 : 7.2	6.2 : 6.2	9.2 : 9.2

[1]Not Reported
PXG = 24-Plane with optional Z-buffer

2D Graphics X11perf Benchmarks

Developed by Digital and 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.

X11perf is a suite of X-window system display server tests. X11perf determines the number of operations/second that a X server can deliver for 222 client requests, plus 121 client requests with XOR writing mode, for a total of 343 different client requests. To test the server, there is a single client communicating exclusively with the server by one transport mechanism.

Measurements reported here are:

- 2D vector results from the X11perf *10-pixel lines* tests shown in units of kilo-vectors (Kvectors/second).
- 2D fill area results from the X11perf *Copy 500X500 from pixmap to window* tests shown in units of mega-pixels or Mpixels (mega-pixel=1,048,576 pixels).

4.5 X11perf Benchmark Results

X11perf results and conclusions for the VAXstation family and its comparable competitors are presented in the following pages and graphs.

Note: We believe that it is inappropriate to compare Compaq SystemPro 486-840 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 hardware performance would also be different. Therefore, Compaq X11perf results have not been included in the graphic graphs.

2D X11perf kvectors/second benchmark results are shown below.

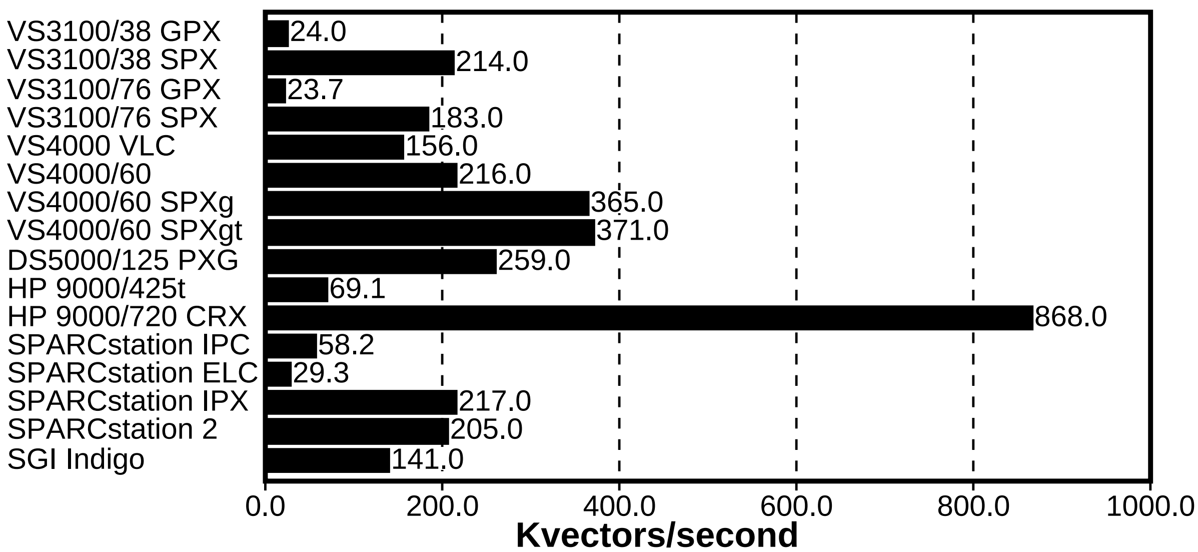

Figure 4-4: X11perf 2D Kvectors/second Benchmark Results

The following graph shows the 2D X11perf graphics Mpixels/second benchmark results.

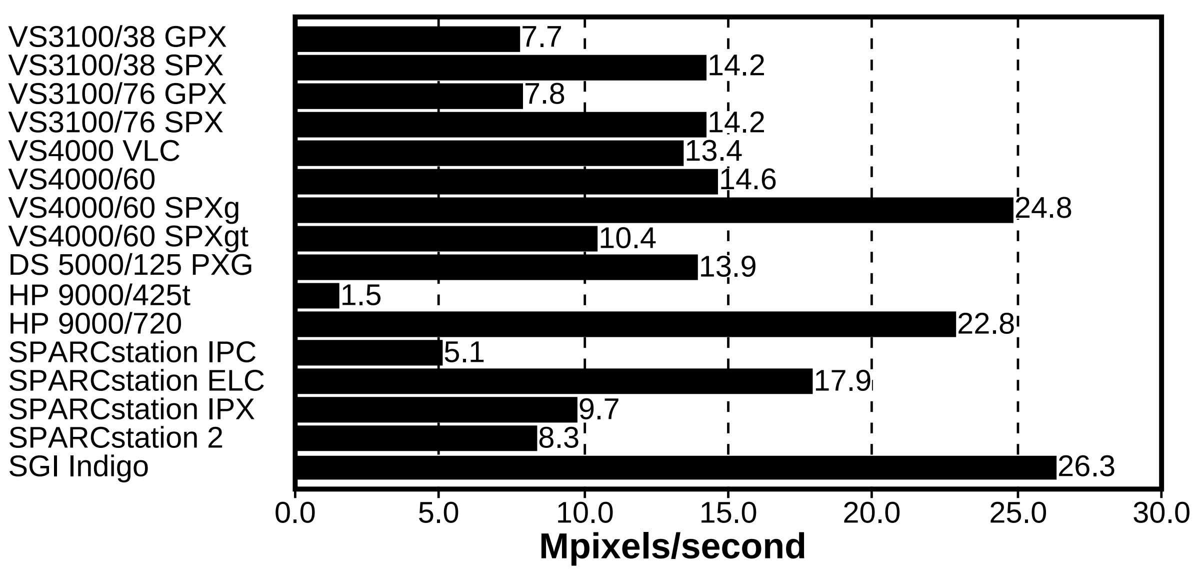

Figure 4-5: X11perf Mpixels/second Benchmark Results

SoftPC for VMS

The SoftPC for VMS software product provides the VAXstation user the ability to operate DOS based software. The SoftPC product emulates an IBM PC AT system (real mode only) using standard VAX VMS hardware and software.

The SoftPC for VMS product is a VMS layered product. It supports both DECwindows as well as the VT220 terminal. As such, it can be executed on any VAX VMS system and can be displayed on a VT220, or either a local or remote DECwindows X windows display station.

The performance of the SoftPC facility is dependent upon a number of factors as well as the speed of the processor upon which it executes.

4.6 SoftPC Benchmark Results

The benchmark results shown below are the averages of ten runs of each of the following: Norton SI V3.1.0, Dhrystone V1.1, and *PC Magazine*'s BENCH 4.0.1.

Peter Norton SI (System Information) benchmark measures overall system performance. Dhrystone is an integer benchmark that measures the efficiency of both the CPU and the C compiler. The CPU test partition of *PC Magazine*'s BENCH test was run. The BENCH program gives an index number relative to a 8MHz IBM AT.

Digital performed the SoftPC benchmarking. SoftPC was run emulating the 286 instruction set (8 MHz).

As shown in the results below, the VAXstation 4000 VLC running SoftPC offers similar performance to an IBM AT. The VAXstation 4000 Model 60 running SoftPC offers twice the performance of the IBM AT.

Table 4-5: Comparison of SoftPC Software Benchmarking

	VS 3100/38	VS 3100/76	VS 4000 VLC	VS 4000/60	IBM AT 80286
Norton SI	4.3	9.2	6.9	14.0	6.9
Dhrystone	940	1915	1149	3079	1716
BENCH Average	1.1	2.2	1.6	3.3	1.0

The SPEC Benchmark Suite

This section presents the results of System Performance Evaluation Cooperative (SPEC) Benchmark Suite. SPEC is a nonprofit organization formed to develop a standard suite of benchmark programs that characterize system performance.

The release suite consists of ten codes/programs, four of which are written in C and considered to be compute intensive. The geometric mean of these make up the SPEC metric called SPECint and are classified as integer benchmarks. The remaining six programs are FORTRAN based and floating point intensive. They make up the SPECfp rating. The SPECmark is the geometric mean of the ten programs' elapsed times normalized to the VAX 11/780.

4.7 SPEC Results

SPEC ratings for the VAXstation 4000 VLC and VAXstation 4000 Model 60 are shown in the following three charts.

Note: The SPECmark, SPECint, and SPECfp ratings for the Compaq SystemPro 386-840 were unavailable.

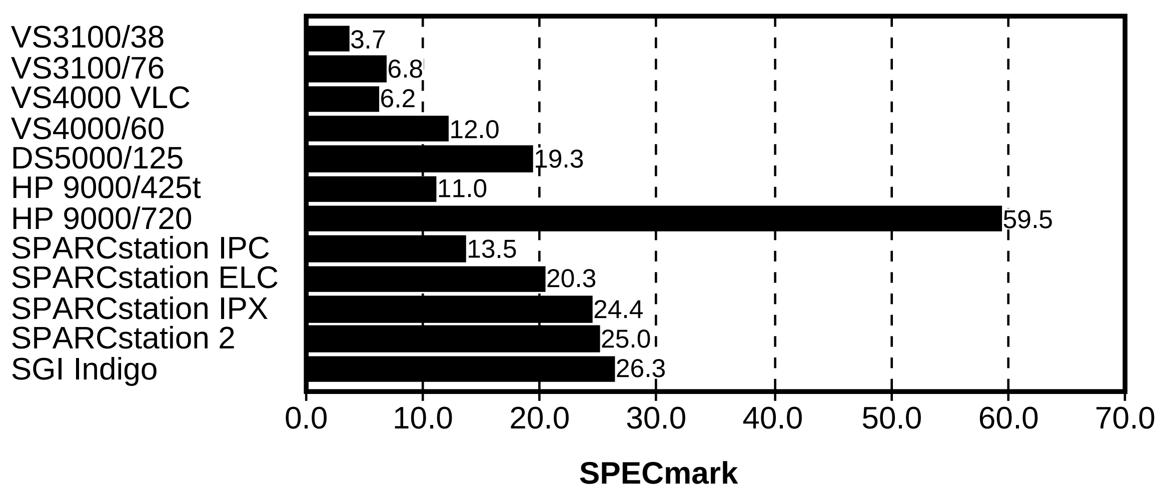

Figure 4-6: SPECmark Ratings

The SPECint ratings for the comparable systems are shown below

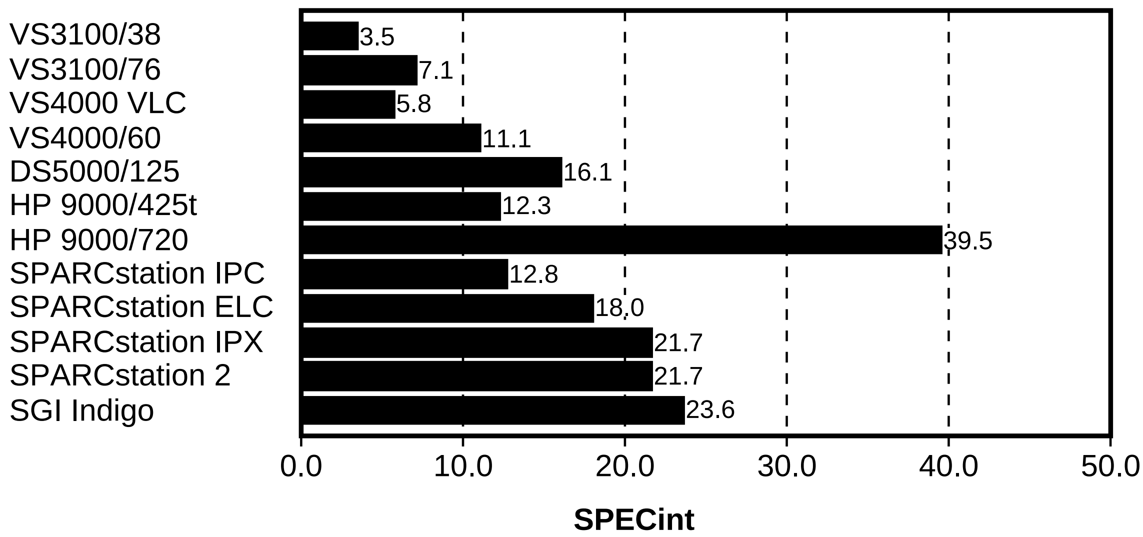

Figure 4-7: SPECint Ratings

The following graph presents the SPECfp measurements.

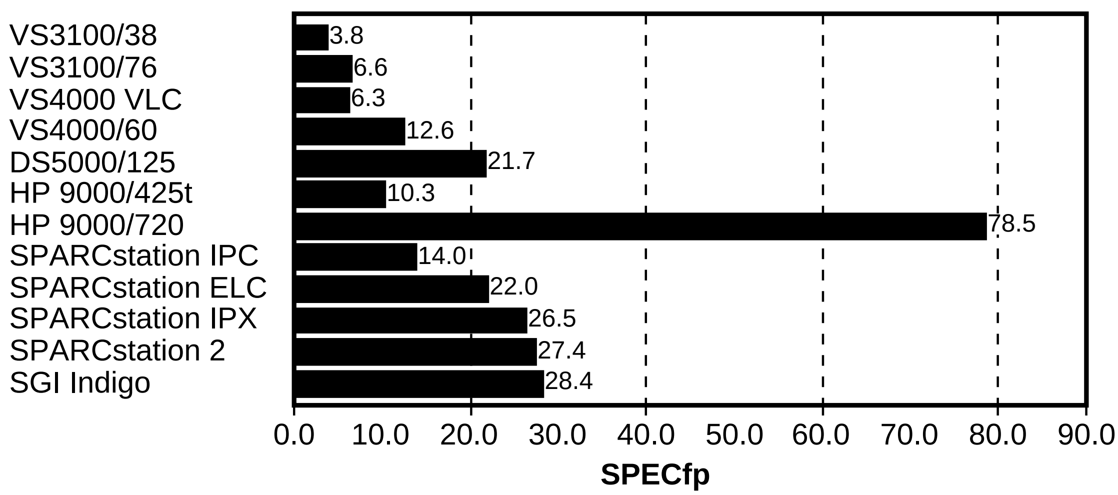

Figure 4-8: SPECfp Ratings

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 4-6: SPEC Ratios for VAXstations

Benchmark No. & Name	Type	VS 3100/ 38	VS 3100/ 76	VS 4000/ VLC[1]	VS 4000/ 60
001.gcc	Integer	3.3	7.5	6.3	11.2
008.espresso	Integer	3.3	6.7	5.3	9.9
013.spice 2g6	Floating point	3.8	8.2	5.7	10.6
015.doduc	Floating point	3.3	7.0	5.2	10.5
020.nasa7	Floating point	4.3	5.6	7.4	12.7
022.li	Integer	3.5	7.6	6.2	10.5
023.eqntott	Integer	3.5	6.5	6.7	12.9
030.matrix300	Floating point	4.6	6.6	11.7	23.6
042.fpppp	Floating point	3.2	7.3	3.9	11.0
047.tomcatv	Floating point	3.8	5.4	6.1	11.1

Table 4-7: SPEC Ratios for RISC-based Systems

Benchmark No. & Name	Type	DS 5000/ 125	HP 9000/ 425t	HP 9000/ 720	SPARC station IPC	SPARC station ELC	SPARC station IPX	SPARC station 2	SGI Indigo
001.gcc	Integer	13.7	12.4	36.0	11.3	16.6	19.9	20.0	23.5
008.espresso	Integer	17.4	12.8	43.4	13.1	18.0	21.7	21.7	22.8
013.spice 2g6	Floating point	11.4	11.8	44.5	10.3	13.4	16.1	16.5	19.4
015.doduc	Floating point	18.8	7.7	47.6	8.1	14.0	16.6	18.2	22.6
020.nasa7	Floating point	20.0	11.5	64.5	15.6	23.6	28.4	29.1	30.5
022.li	Integer	17.4	14.9	37.7	12.9	19.0	23.0	23.1	25.8
023.eqntott	Integer	16.4	9.7	41.2	14.1	18.4	22.2	22.3	22.3
030.matrix300	Floating point	57.0	10.8	323.2	42.9	67.7	81.5	82.6	86.5
042.fpppp	Floating point	21.9	12.1	78.5	11.5	19.1	23.0	23.8	19.1
047.tomcatv	Floating point	19.5	8.4	66.4	11.9	19.7	23.8	24.9	23.6

Dhrystone Integer Benchmark

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

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

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

4.8 Dhrystone Results

The following graph shows the MIPS ratings for the VAXstation family and comparable, competitive workstations.

Note: Both "Inlined" and "Standard" Dhrystone results are provided. "Inlined" results can be one of the following:

- The compiler takes modules that are called and placed them "inline", removing the overhead of the call to the module and the overhead with the register set-up in the Dhrystone code.
- The loader uses "inline" string functions that are called in Dhrystone code.

We have presented the competitors' Dhrystone results without labels because that is how the vendor or benchmarking service has reported them. Some manufacturers may include inline string libraries in the standard "c" library or some string manipulation instructions in their instruction sets. We were unable to verify or determine if the competitive results shown here were "Standard" or "Inlined".

The chart below shows Dhrystone MIPS ratings for the VAXstation family and comparable, competitive systems.

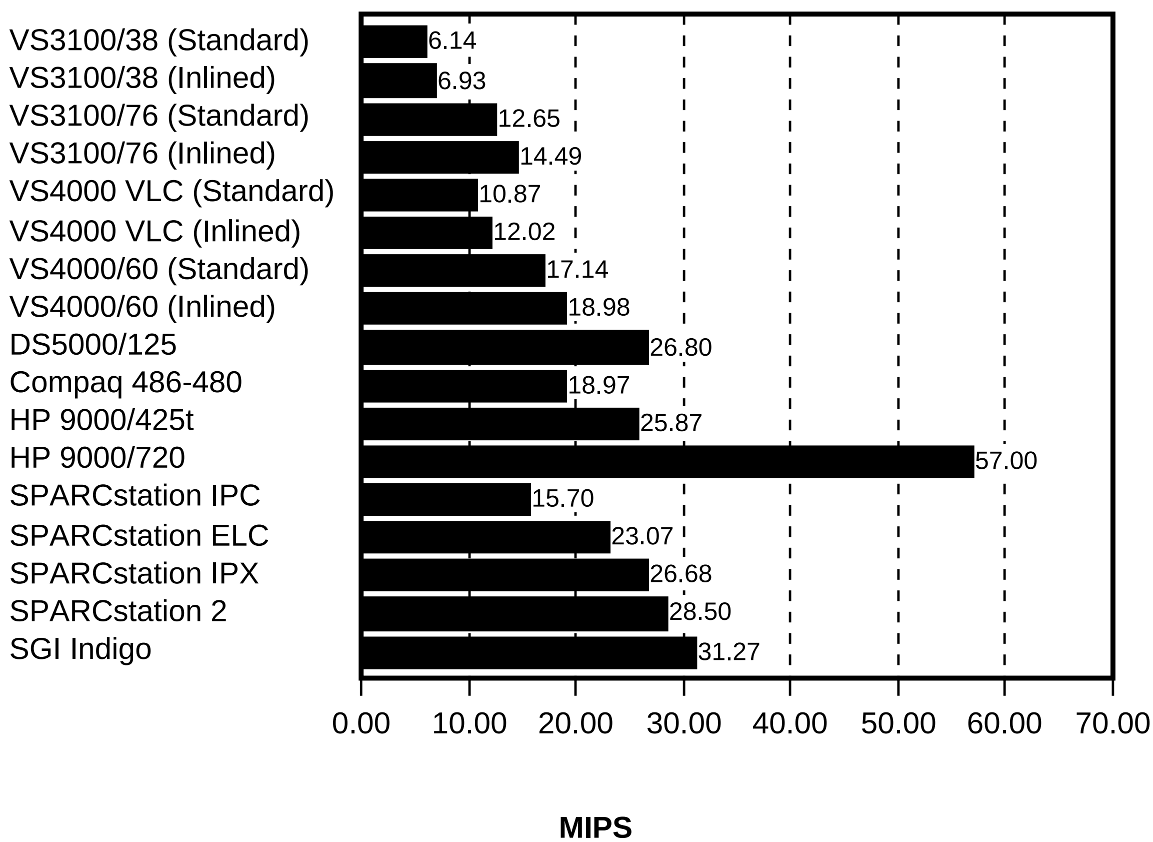

Figure 4-9: Dhrystones MIPS Ratings

Dhrystones per second are charted below.

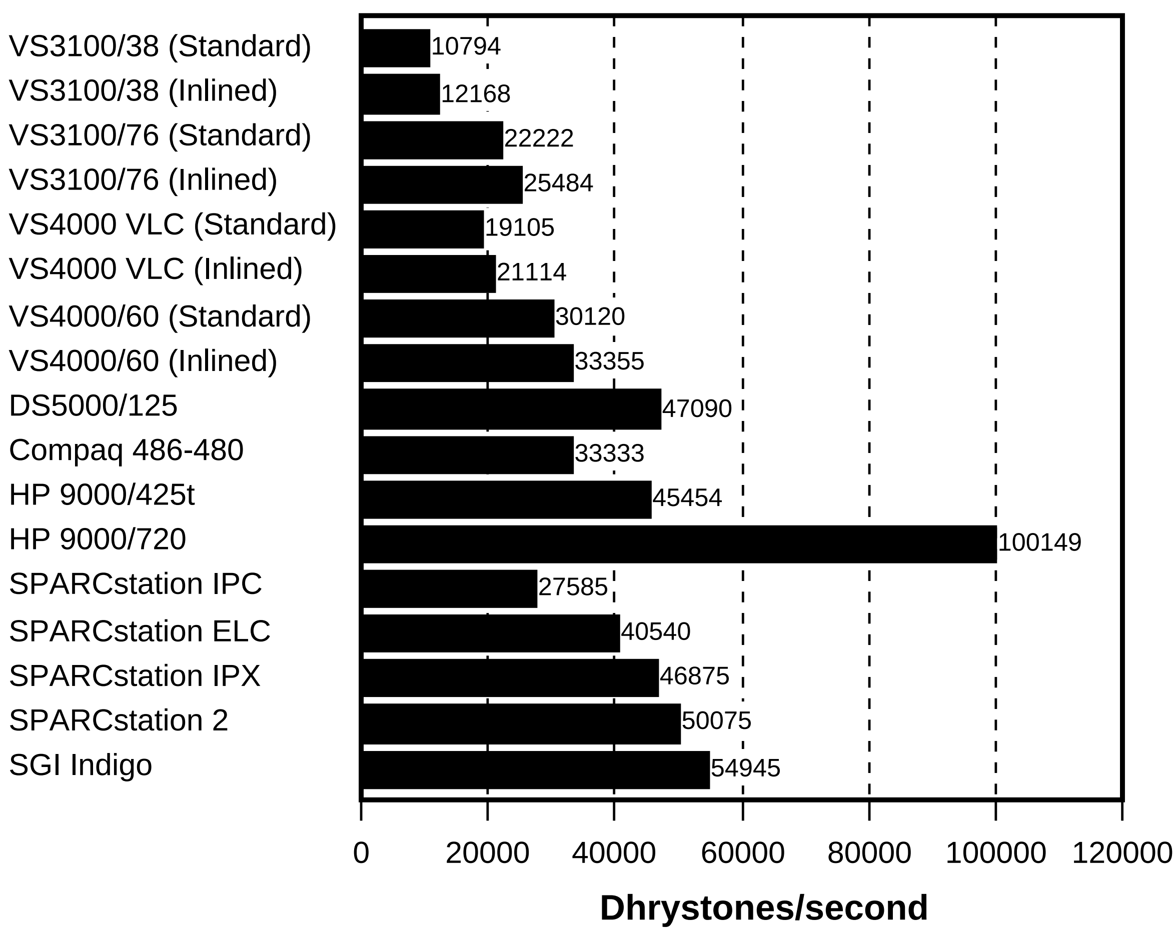

Figure 4-10: Dhrystones/second Benchmark Results

Linpack Benchmark

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

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

4.9 Linpack Results

Single precision MFLOPS ratings are shown in the following graph.

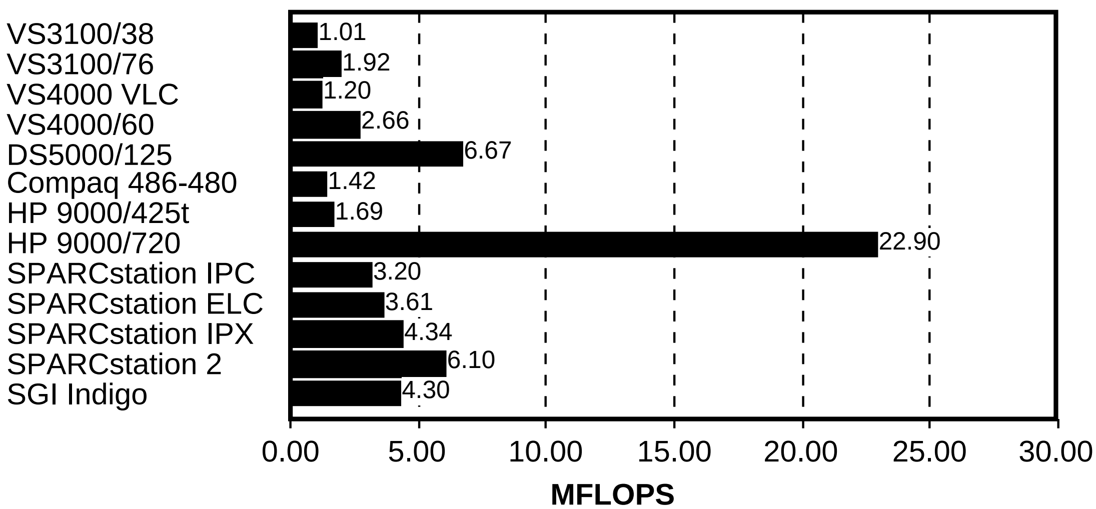

Figure 4-11: Linpack Single Precision MFLOPS Ratings

The following chart contains the double precision MFLOPS results.

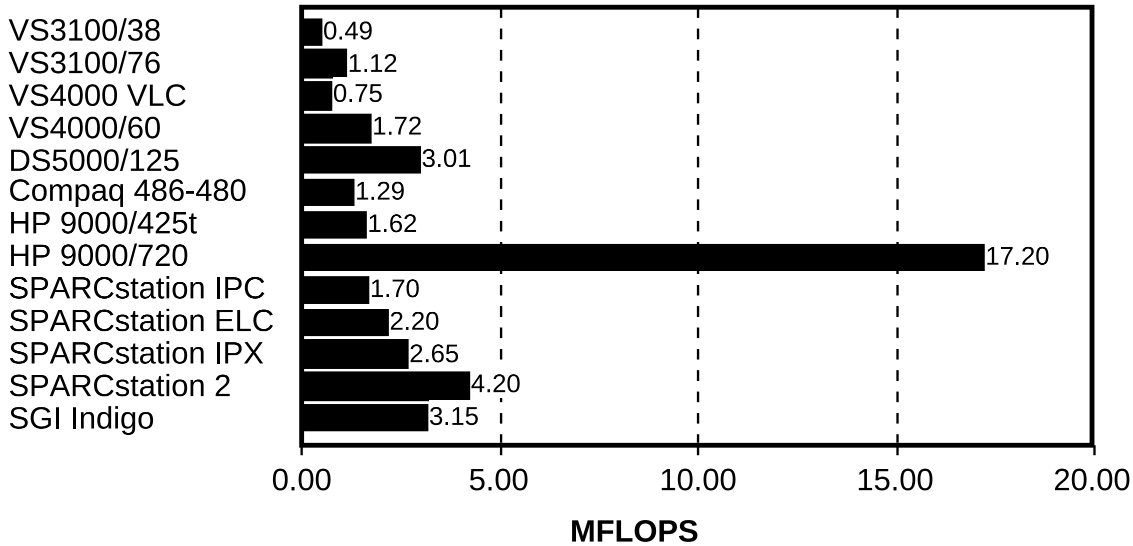

Figure 4-12: Linpack Double Precision MFLOPS Ratings

Whetstone Benchmark

The Whetstone benchmark was developed at Great Britain's National Physical Laboratory in Whetstone, England in 1970. It is a synthetic benchmark designed to represent small engineering and 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).

4.10 Whetstone Results

Charted below are the Whetstone single and double precision benchmark tests results.

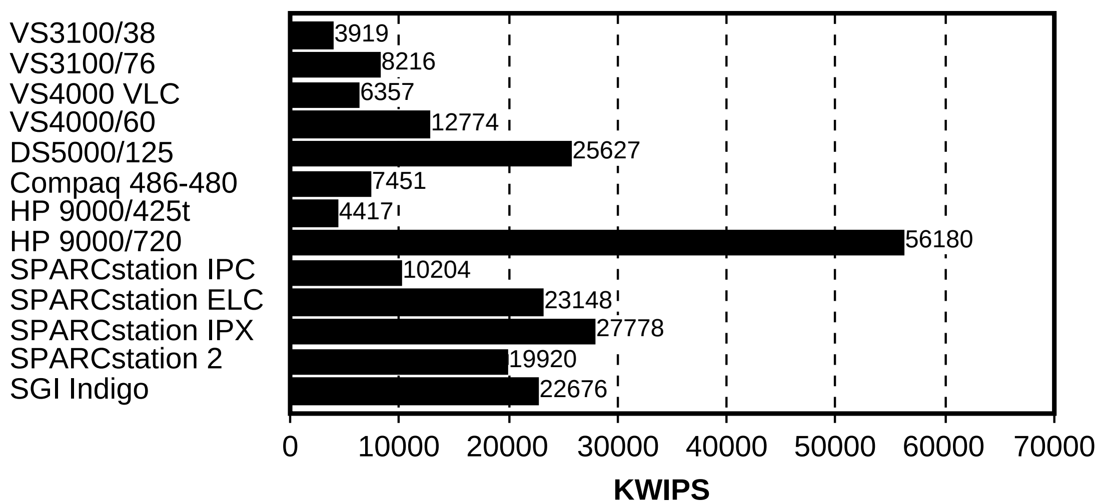

Figure 4-13: Whetstone Single Precision KWIPS Ratings

Whetstone double precision KWIPS ratings appear in the following chart.

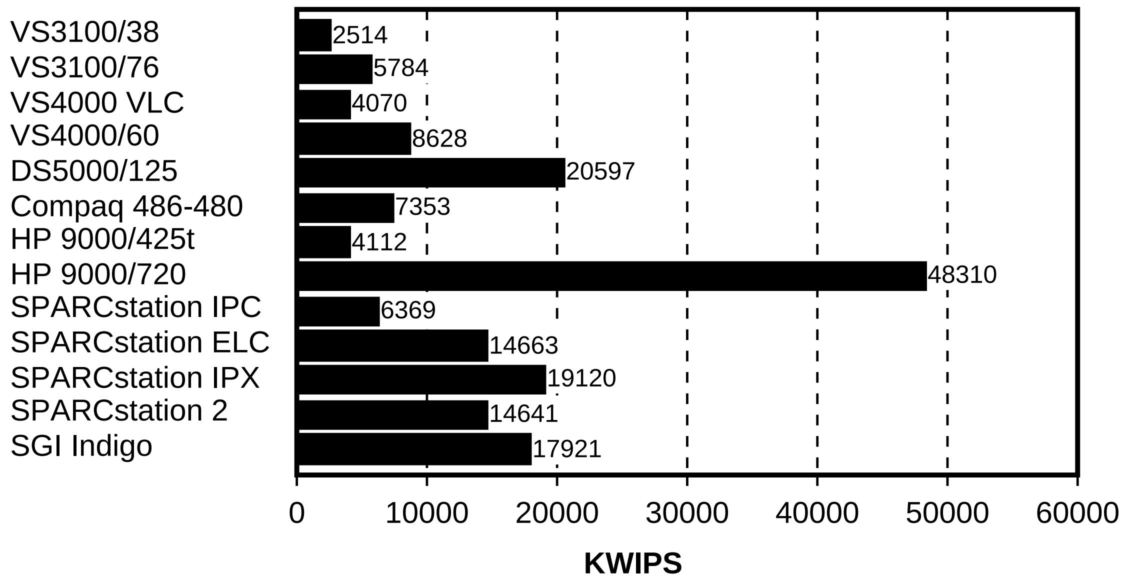

Figure 4-14: Whetstone Double Precision KWIPS Ratings

A

Test Configurations

The benchmarks were run on the following system configurations:

VAXstation 3100 Model 38 Workstation:

Memory	16 MB
Disk Controller	SCSI
Disks	2 104MB RZ23
Display Device	VRT19 (1280x1024)
Network Interface	Ethernet
Operating System	VAX/VMS V5.4
Compilers	VAX FORTRAN, VAX C

Linpack, and Whetstones tests used 1 665MB RZ56 disk. X11perf benchmarks used VR299 (1024x864) display device. All tests were performed by Digital.

VAXstation 3100 Model 76 Workstation:

CPU	REX520
FPU	DC523
Number of CPUs	1
Cache Per CPU	128KB
Memory	16 MB
Disk Controller	SCSI
Disk	2 332 MB RZ55
Network Interface	Ethernet
Operating System	VAX/VMS V5.4
Compilers	VAX FORTRAN V5.2, VAX C V3.1
Tuning Parameters	WSEXTENT=16384, WSQUO=8192, WSDEFAULT=1024
Background Load	None
System State	single user

SPEC benchmark results from *Spec Newsletter,* Volume 3, Issue 1, Winter 1991, page 34. Linpack and Whetstone benchmarks used 1 665MB RZ56 disk. X11perf benchmarks used VR299 (1024x864) display device and 2 104MB RZ23 MB disks. All tests were performed by Digital.

VAXstation 4000 VLC Workstation:

VAX CPU/FPU	SOC (System on a chip)
Clock Speed	25 MHz
Memory	24 MB / 80 nanosecond RAM
Read or write cycle to cache	40 nanosecond
Display Size and Type	Digital VRT13
Disk Controller	Sync SCSI
Disk	1 121 MB RZ23, 1 332 MB RZ55
Network Interface	Ethernet
Operating System	VAX/VMS T5.5-4x6
Compilers	VAX FORTRAN 5.6, VAX C 3.2
Tuning Parameters	WSMAX=16400, WSQUO=16400, WSEXTENT=16400
Background Load	None
System State	Standalone

System was booted minimum for all benchmarks except for X11perf. DECwindows was running for X11perf tests. All tests were performed by Digital.

VAXstation 4000 Model 60 Workstation:

VAX CPU/FPU	VAX CPU/FPU
Clock Speed	222MHz
Memory	104 MB / 80 nanosecond RAM
Read or write cycle time to cache	18 nanosecond
Display Size and Type	Digital VRT19
Disk Controller	Sync SCSI
Disk	2 209MB RZ24
Network Interface	Ethernet
Operating System	VAX/VMS T5.5-4x6
Compilers	VAX FORTRAN V5.6, VAX C V3.2
Tuning Parameters	WSMAX=53200, WSQUO=25000, WSEXTENT=25000
Background Load	None
System State	Standalone

System was booted minimum for all benchmarks except for X11perf. DECwindows was running for X11perf tests. All tests were performed by Digital.

DECstation 5000 Model 125 PXG Workstation:

CPU chipset	R3000A
CPU MHz	25
FPU chipset	R3010
FPU MHz	25
Memory (MB)	16
Disk	665 MB RZ56
Cache Size	64KB data/65KB 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

All benchmark testing was performed by Digital Equipment Corporation.

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 Kbytes 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
Fortran Supplier & Version	Microway Fortran 2.0.6
Fortran Compiler Switches Used	-n2, -OLM
C Supplier & Version	Microway C 2.0.6
C Compiler Switches Used	-n2, -OLM

Dhrystone, Whetstone, and Linpack benchmark results from Workstation Laboratories, Volume 13, Chapter 5, page V13-5-Config., June 1, 1991.

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 numbers from *SPEC Newsletter,* Volume 3, Issue 1 Winter 1991, page 18. Dhrystone, Whetstone, and Linpack benchmark results from Workstation Laboratories, 2/1/21, Volume 12, page V12-20-Config.

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 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

X11perf benchmarking numbers from Workstation Laboratories, February 1, 1991, Volume 12, Chapter 28, page V12-28-Config. 3D graphics tests run on HP 9000/425t P VRX/

Hewlett Packard 9000/720 CRX

Processor Type & Frequency	PA-RISC/50 MHz
Number of CPUs	1
Floating Point	Yes
Memory	16 MB
Network Interface	Ethernet
Operating System/Rel.	HP/UX 8.07
Windows System/Rel.	X11R4
Graphics Library	HP-PHIGS 2.2

SPEC benchmarking numbers from *SPEC Newsletter,* Volume 3, Issue 2, Spring 1991, page 20. Dhrystones, Whetstones, and Linpack numbers from *HP Apollo Series 700 Workstations Performance Overview,* March 1991. 2D graphics results (X11perf) from *Workstation Laboratories,* 4/1/91, Volume 13, Chapter 10. Model used by Workstation Laboratories was HP 9000 Model 720 CRX. 3D graphic results from *HP Apollo 9000 Series 700 System Performance,* 2nd Edition, November 1991, pages 24-25. Configuration used 420 MB disk and shared memory transport. HP nominal vectors: 10 pixel, random orientation, clipping on perspective projection, and constant color. Through Starbase API. 3D Triangles/second benchmark conditions were 10x10, 50 pixel triangles in trianglular strips, random orientation, transformed, clipped checked, and Z-buffered. PLB results from *HP Apollo 9000 Series 700 System Performance,* 2nd Edition, November 1991, page 2.

Silicon Graphics (SGI) 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" ST140N/SCSI
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s)/(Unformatted/Formatted)	480/400 MB
For Network Tests: "Remote" or "Local"	Remote, using Mips RC3240 server, Ethernet, 10MB/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 or 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 as 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. 3D graphics tests run on SGI Indigo XS24, CPU R3000, Geom. Engines 1, Screen Ref. 60/72 Hz, Z buffer optional, Color planes 24-bit, planes 4/4, Screen resolution 1280 x 1024. 3D lines were 10-pixel, connected, arbitrarily rotated. 3D polygons were 50-pixel triangles, arbitrarily rotated. Per Silicon Graphics, Inc., 1/31/92.

Sun SPARCserver 2 Computer:

CPU Processor	SPARC
CPU MHz	40 MHz
FPU	SPARC (TI)
FPU MHz	40 MHz
Memory	16 MB
Disk Buffer Sizes	(14,901 available)
Disk Controller	2/SCSI
Disk	Quantum 210S & Conners CP3200F
Cache Size	64 KB data/64 KB instruction
Network Interface	Ethernet
Operating System	Sun OS 4.1.1
Compilers	Optional Sun Fortran, Optional Sun C
Compiler Switches	-O3

SPEC benchmark ratings from *SPEC Newsletter,* Volume 3, Issue 1, Winter 1991, page 10. Linpack and Dhrystone benchmark ratings from *SPARCstation 2 Performance Brief,* Sun Microsystems, Inc., November 1990. Tested configuration was SPARCstation 2 running SunOS 4.1.1beta, Sun FORTRAN 1.4beta and Sun C1.1beta. Whetstone and X11perf results from Workstation Laboratories, Inc., Volume 12, Chapter 23, page V12-23-Config. 3D graphics results from *HP Apollo 9000 Series 700 System Performance,* 2nd Edition, November 1991, pages 24-25. 3D vector benchmark conditions were 10 pixel vectors, transformed and clipped. API was not specified. 3D triangles/second benchmark conditions were 100 pixel triangles, gourand-shaded, clipped, through SunPHIGS. Tests run on SPARCstation 2GS. PLB results from *The GPC Quarterly Report,* Volume 1, Number 1, 4th Quarter 1991, pages 37-38, 41-42. Floating point SPARC IEEE 754, 424 MB disk, 32 MB of memory, operating system SunOS4.1.1revB GFXrev2, windows system OpenWindows Version 3, and graphics library XGL2.0. Graphics subsystem was 24 or 12+12 DB, 6 window planes, 16 Z-buffer, resolution 1152x900, 19" CRT, and 76 Hz CRT refresh rate.

Sun SPARCstation ELC Workstation:

Processor Type & Frequency	SPARC (LSI) - 33MHz
Floating Point Unix & Frequency	SPARC (Fujitsu) - 33MHz
Cache Memory Size & Speed	64Kb
RAM Memory Size & Speed	8 Mb/80 ns
Hardfile Brands * Model Numbers	CDC (Imprimis) 94191
Hardfile Quantity/Interface	1/SCSI
Hardfile Size(s) (Unformatted/For.)	760/680MB
Operating System Name and Level	Sun OS 4.1.1
Fortran Supplier, Version & Switches	Sun Fortran 1.4 -O4
C Supplier, Version & Switches	Sun C1.1 -O4
Graphics Libraries Used	X11

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 24. Memory configured was 16MB, disk subsystem 207 MB SCSI, other software KAP/SUN preprocessor. System state: single user, no tuning parameters, and no background load. Dhrystones, Whetstones, and X11perf benchmarks results from Workstation Laboratories, 9/1/91, Volume 15, Chapter 21.

SPARCstation 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	8 MB
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 7. Whetstones and X11perf benchmark numbers from Workstation Laboratories, 11/1/90, Volume 11, page V11-21-Config.

SPARCstation IPX Workstation:

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

SPEC benchmark numbers from *SPEC Newsletter,* Volume 3, Issue 3, September 1991, page 22. Memory configured was 16MB, disk subsystem 424 MB SCSI, other software KAP/SUN preprocessor. System state: single user, no tuning parameters, and no background load. Dhrystones, Whetstones, and X11perf benchmarks results from Workstation Laboratories, 9/1/91, Volume 15, Chapter 22. PLB results from *The GPC Quarterly Report,* Volume 1, Number 3, 4th Quarter 1991, pages 35-36. Floating point SPARC IEEE 754, 16 MB of memory, operating system SunOS4.1.1revB GFX rev2, windows system Open Windows Version 3, and graphics library XGL2.0. Graphics subsystem was 8 total bit planes, 8 image no overlay/underlay, no window planes, 1152 x 900 resolution, 16" CRT size, and 76 Hz CRT refresh rate.

B

References

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