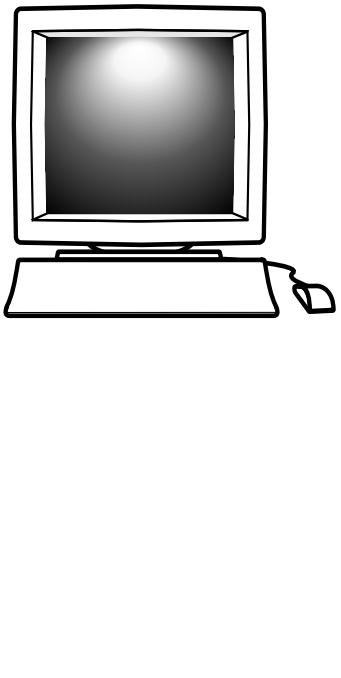
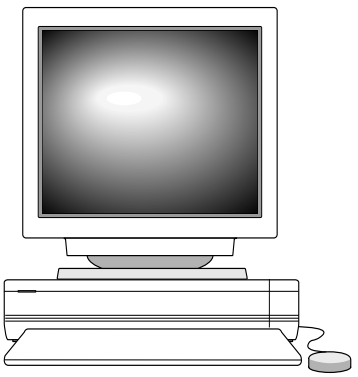
Alpha AXP Workstation Family
Performance Brief - DEC OSF/1 AXP



DEC 3000 Model 500 AXP Workstation



DEC 3000 Model 400 AXP Workstation

INSIDE

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- DN&R Labs CPU2
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Alpha AXP Workstation Family Performance Brief - DEC OSF/1 AXP

Introducing Digital's Alpha AXP Workstation Family

This document presents the results of industry-standard benchmarks on the DEC 3000 Model 400 AXP™ and DEC 3000 Model 500 AXP workstations in the DEC OSF/1 ™ AXP™ operating system environment. Both workstations are members of Digital's breakthrough 64-bit RISC architecture.

DEC 3000 Model 400 AXP Workstation

The DEC 3000 Model 400 AXP workstation is Digital's entry-level, desktop workstation, and it runs at a CPU clock speed of 133 MHz. This workstation allows for expansion of memory, storage, I/O, and graphics.

The DEC 3000 Model 400 AXP workstation satisfies the performance needs of technical users developing or deploying software and of commercial users doing financial analysis, network management, publishing, and database services.

DEC 3000 Model 500 AXP Workstation

The DEC 3000 Model 500 AXP workstation is the most powerful system in Digital's 64-bit Alpha AXP™ workstation family, and it runs at a CPU clock speed of 150 MHz. The DEC 3000 Model 500 AXP workstation uses advanced CPU, TURBOchannel, and graphics technologies. This workstation is available in a deskside or rackmountable configuration.

The DEC 3000 Model 500 AXP workstation is the system of choice for such high-performance technical and commercial applications as mechanical CAD, scientific analysis, medical imaging, animation and visualization, financial analysis, and insurance processing.

Digital's Alpha AXP Workstation Family Performance

The performance of the Alpha AXP workstation family was evaluated using industry-standard benchmarks. These benchmarks allow comparison across vendors. Performance characterization is one "data point" to be used in conjunction with other purchase criteria such as features, service, and price.

***Notes**: The performance information in this report is for guidance only. System performance is highly dependent upon application characteristics. Individual work environments must be carefully evaluated and understood before making estimates of expected performance. This report simply presents the data, based on specified benchmarks. Competitive information is based on the most current published data for those particular systems and has not been independently verified.*

Alpha AXP Workstation Family Performance Brief - DEC OSF/1 AXP

Table 1 Digital's Alpha AXP Workstation Family Benchmark Results

Benchmark	DEC 3000 Model 400 AXP	DEC 3000 Model 500 AXP
SPECint92	74.8	84.4
SPECfp92	112.5	127.7
SPECmark89	111.1	126.1
LINPACK 64-bit Double-Precision		
100X100 (MFLOPS)	26.0	29.6
1000x1000 (MFLOPS)	91.7	103.5
Dhrystone V1.1 (instructions/second)	235,939	266,487
V2.1 (instructions/second)	238,095	263,157
X11perf (2D Kvectors/second)	579	662
X11perf (2D Mpixels/second)	27.2	31.0
DN&R Labs CPU2 (MVUPs)	185.0	209.1

We chose the competitive systems (shown with the Alpha AXP workstations in the following charts and tables) based on comparable or close CPU performance, coupled with comparable expandability capacity (primarily memory and disk). Although we do not present price comparisons in this report, system price was a secondary factor in our competitive choices.

The Alpha AXP performance information presented in this brief is the latest measured results as of the date published. Digital has an ongoing program of performance engineering across all products. As system tuning and software optimizations continue, Digital expects the performance of its workstations to increase. As more benchmark results become available, Digital will publish reports containing the new and updated benchmark data.

For more information on Digital's Alpha AXP workstation family, please contact your local Digital sales representative.

SPEC Benchmark Suites

SPEC™ (Standard Performance Evaluation Corporation) was formed to identify and create objective sets of applications-oriented tests, which can serve as common reference points and be used to evaluate performance across multiple vendors' platforms.

SPEC CINT92 and CFP92

In January 1992, SPEC announced the availability of the CINT92 and CFP92 benchmark suites. CINT92, the integer suite, contains six real-world application benchmarks written in C. The geometric mean of the suite's six SPECratios is the SPECint92™ figure. CFP92 consists of fourteen real-world applications; two are written in C and twelve in FORTRAN. Five of the fourteen programs are single precision, and the rest are double precision. SPECfp92™ equals the geometric mean of this suite's fourteen SPECratios.

CINT92 and CFP92 have different workload characteristics. Each suite provides performance indicators for different market segments. SPECint92 is a good base indicator of CPU performance in a commercial environment. SPECfp92 may be used to compare floating-point intensive environments, typically engineering and scientific applications.

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Figure 1 SPEC CINT92 Results

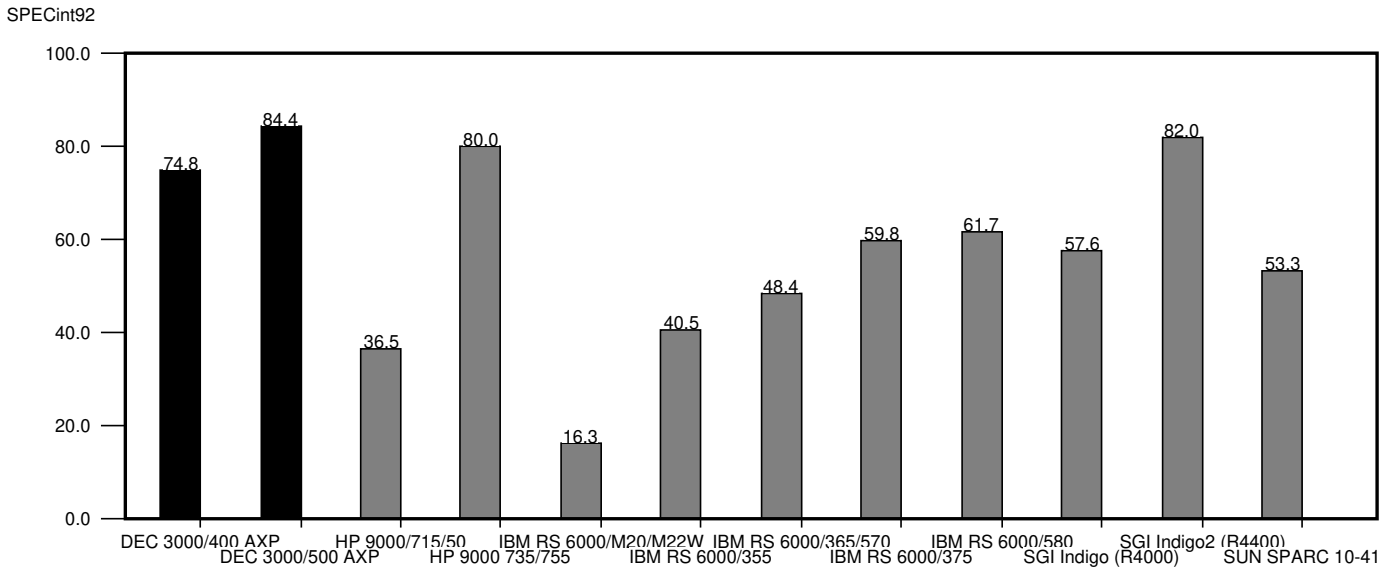
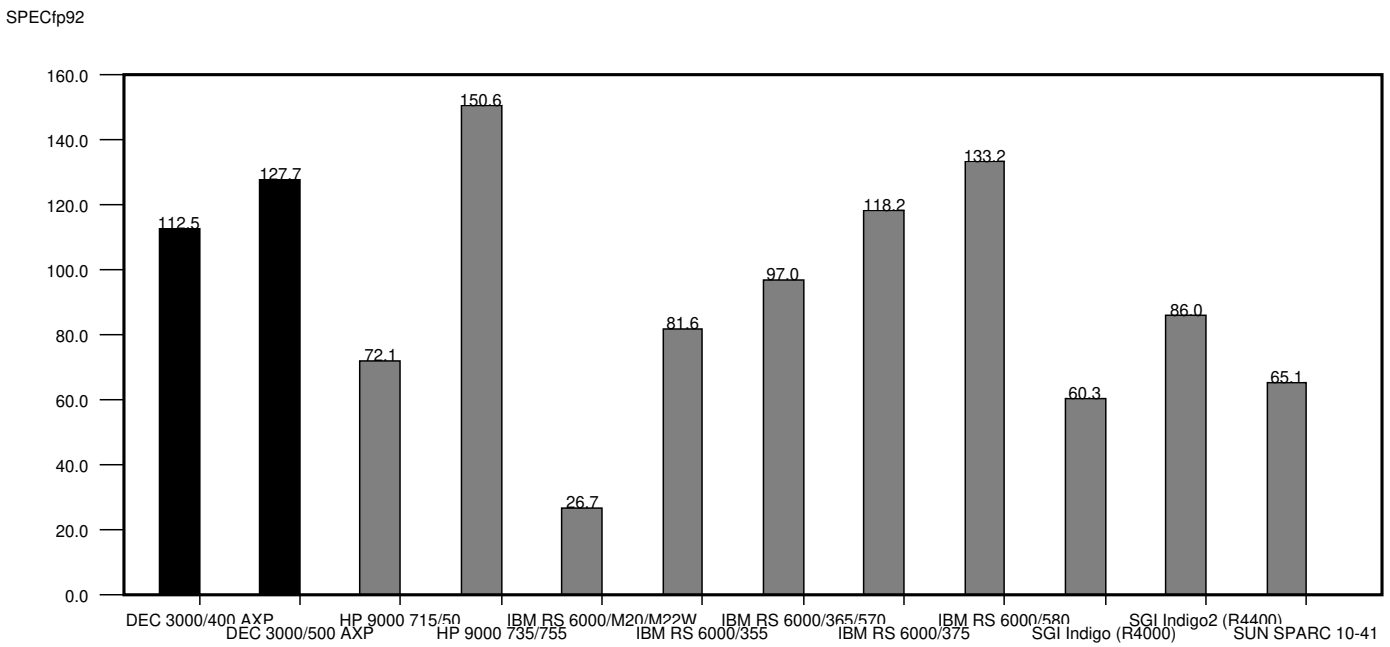


Figure 2 SPEC CFP92 Results

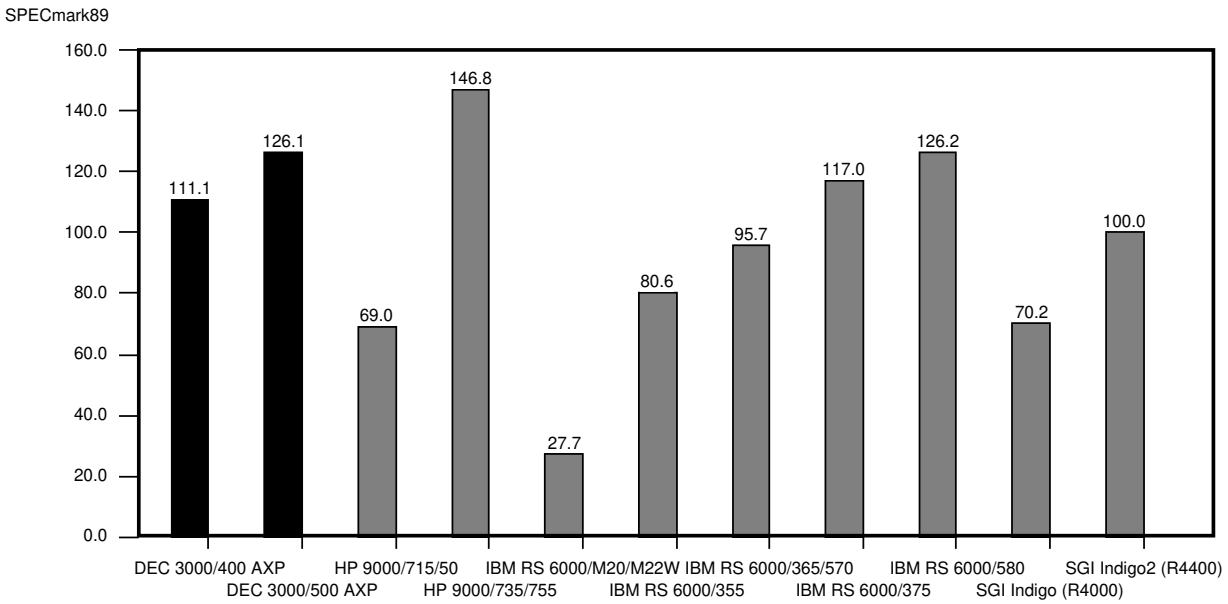


SPEC Release 1

In October 1989, SPEC introduced SPEC Release 1, a benchmark suite that measures CPU-intensive, single stream performance of uniprocessor systems. SPEC Release 1 consists of ten portable programs similar to those found in technical environments. Four programs are written in C and primarily test integer performance. The remaining six programs are written in FORTRAN and measure floating-point performance. SPECmark89™ is the metric for this suite.

SPECmark89 represents the geometric mean of the ten benchmark SPECratios™. The SPECratio for a benchmark is the quotient derived from dividing the SPEC Reference Time by a particular machine's corresponding run time. The SPEC Reference Time is the time that it takes a DEC VAX 11/780 to run each benchmark (in seconds).

Figure 3 SPECmark89 Results



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LINPACK 100x100 and 1000x1000 Benchmarks

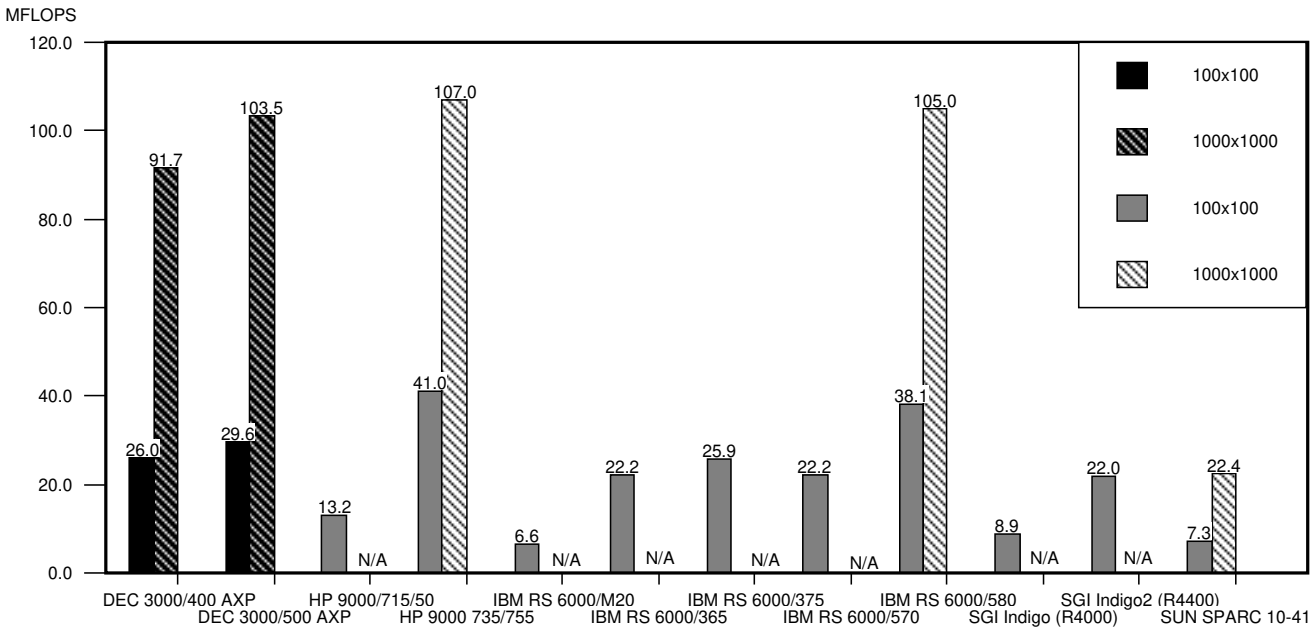
LINPACK is a linear equation solver written in FORTRAN. LINPACK programs consist of floating-point additions and multiplications of matrices. The LINPACK benchmark suite consists of two benchmarks.

1. 100x100 LINPACK solves a 100x100 matrix of simultaneous linear equations. Source code changes are not allowed so that the results may be used to evaluate the compiler's ability to optimize for the target system.

2. 1000x1000 LINPACK solves a 1000x1000 matrix of simultaneous linear equations. Vendor optimized algorithms are allowed.

The LINPACK benchmarks measure the execution rate in MFLOPS (millions of floating-point operations per second). When running, the benchmark depends on memory-bandwidth and gives little weight to I/O. Therefore, when LINPACK data fit into system cache, performance may be higher.

Figure 4 LINPACK 100x100 and 1000x1000 Double-Precision Results

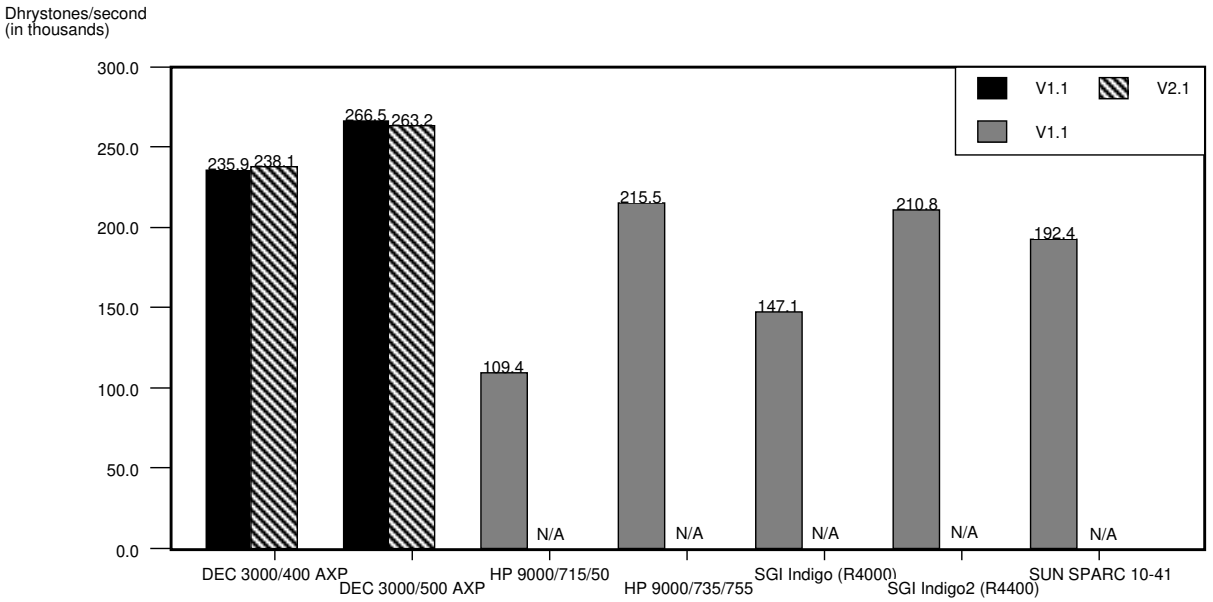


Dhrystone Benchmarks

Developed as an Ada program in 1984 by Dr. Reinhold Weicker, the Dhrystone benchmark was rewritten in C in 1986 by Rick Richardson. It measures processor and compiler efficiency and is representative of systems programming environments. Dhrystones are most commonly expressed in Dhrystone instructions per second.

Dhrystone V1 and V2 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 eliminate these instruction sequences from the program. These compilers allow a system to complete the program in less time and result in a higher Dhrystones rating. Dhrystones V2 was modified to execute all instructions.

Figure 5 Dhrystone Results



***Note**: Hewlett-Packard has reported Dhrystone V2.0 results, but not V2.1. The other vendors have not reported Dhrystone V2.0 or V2.1 results.*

X11perf Benchmark

X11perf tests various aspects of X server performance including simple 2D graphics, window management functions, and X-specific operations. Other non-traditional graphics include CopyPlane and various stipples and tiles.

X11perf employs an accurate client-server synchronization technique to measure graphics operations' completion times. X11perf tests both graphics primitive drawing speeds and window environment manipulation.

Table 2 contains the two most commonly requested performance metrics from X11perf tests for 2D graphics systems: X11perf *10-pixel line* tests and X11perf *Copy 500x500 from pixmap to window* tests. The *10-pixel line* results are shown in units of 2D Kvectors/second drawing rate, and the *Copy 500x500 from pixmap to window* are shown in units of 2D Mpixels/second fill rate (1 Mpixel equals 1,048,576 pixels).

Table 2 X11perf Results

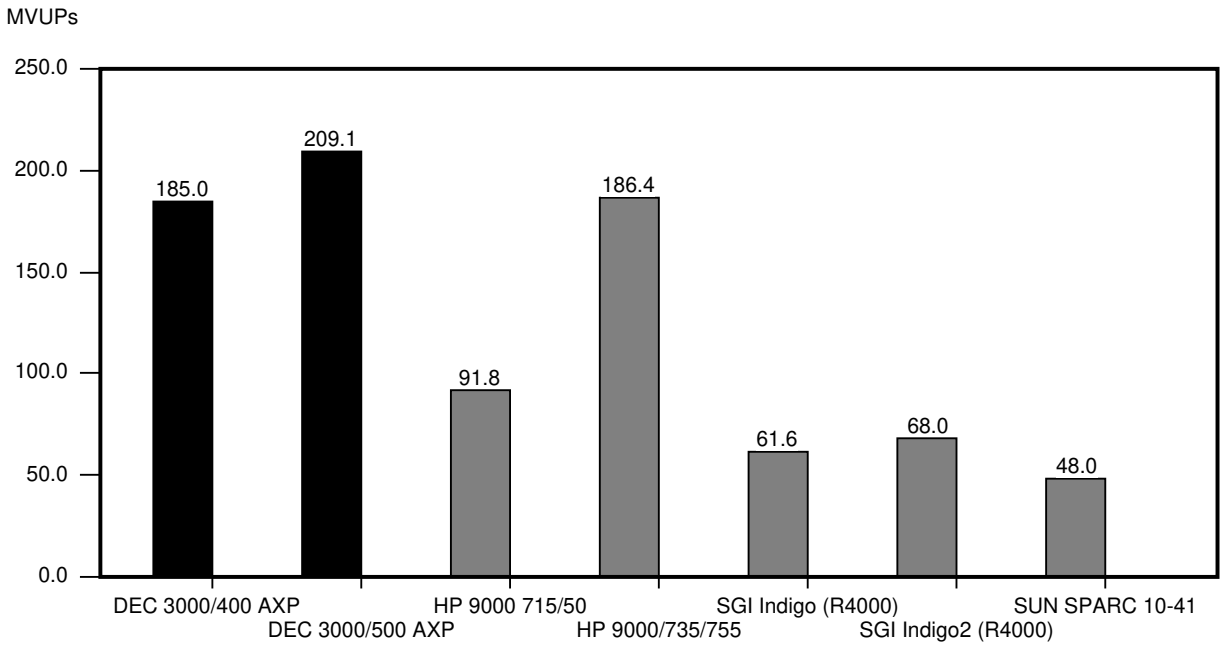
Workstation	2D Kvectors/second	2D Mpixels/second
DEC 3000 Model 500 AXP	662	31.0
DEC 3000 Model 400 AXP	579	27.2
HP 9000 Model 735/755 CRX	970	39.1
HP 9000 Model 715/50 C	860	np
SGI Crimson Elan (R4000)	389	9.3
SGI Indigo2 Extreme Graphics (R4000)	291	23.3
SGI Indigo (R4000)	241	26.2
SUN SPARC 10-41 GX	273	7.8

np = not published

DN&R Labs CPU2 Benchmark

DN&R Labs CPU2, a benchmark from *Digital Review & News* magazine, is a floating-point intensive series of FORTRAN programs and consists of thirty-four separate tests. 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).

Figure 6 DN&R Labs CPU2 Results



Basic Real-Time Primitives

Measuring basic real-time primitives such as process dispatch latency and interrupt response latency enhances our understanding of the responsiveness of the DEC OSF/1 AXP Real-Time kernel.

Process Dispatch Latency is the time it takes the system to recognize an external event and switch control of the system from a running, lower-priority process to a higher-priority process that is blocked waiting for notification of the external event.

Interrupt Response Latency (ISR latency) is defined as the amount of elapsed time from when the kernel receives an interrupt until execution of the first instruction of the interrupt service routine.

The DEC 3000 Model 500 AXP's Basic Real-Time Primitives results appear in the following table.

Table 3 Basic Real-Time Primitives Results

Metric	Minimum (µsec)	Maximum (µsec)	Mean (µsec)
Process Dispatch Latency	62.5	187.7	68.9
Interrupt Response Latency	7.0	50.4	8.4

Test configuration: DEC 3000 Model 500 AXP, 256 MB memory, DEC OSF/1 AXP RT operating system, Ver 1.2.
Test conditions: Single user mode, no network.

Shown next are histograms of the process dispatch latency times and the interrupt response latency times of a DEC 3000 Model 500 AXP system running in the DEC OSF/1 AXP Real-Time operating system environment.

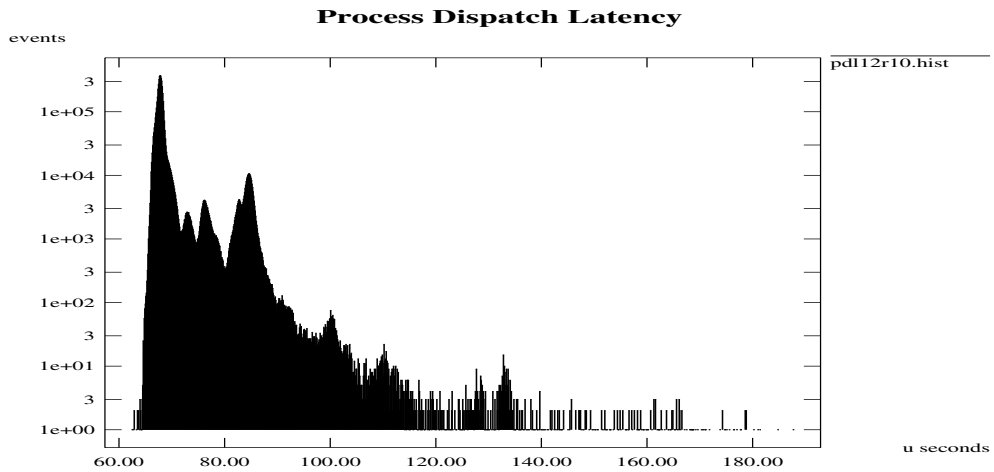


Figure 7 Basic Real-Time Primitives Process Dispatch Latency Results

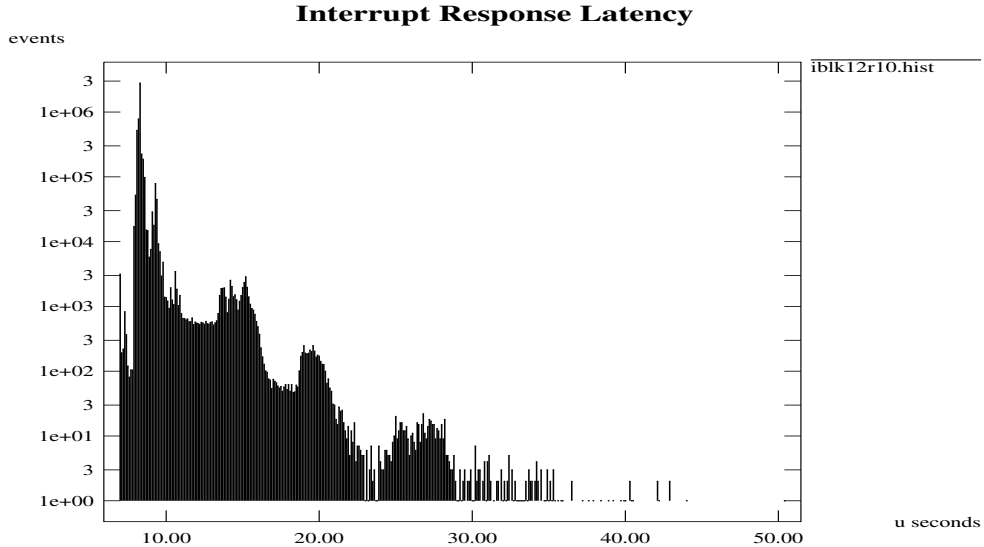


Figure 8 Basic Real-Time Primitives Interrupt Response Latency Results

Rhealstone Benchmark

The Rhealstone Real-time Benchmark is a definition for a synthetic test that measures the real-time performance of multitasking systems. It is unique in that "the verbal and graphical specifications, not the C programs, are the essential core of the benchmark" (Kar 1990). We implemented the following components of the Rhealstone Benchmark, which measure the critical features of a real-time system:

1. Task switch time—the average time to switch between two active tasks of equal priority.
2. Preemption time—the average time for a high-priority task to preempt a running low-priority task.
3. Interrupt latency time—the average delay between the CPU's receipt of an interrupt request and the execution of the first instruction in an interrupt service routine.

   Semaphore shuffle time—the delay within the kernel between a task's request and its receipt of a semaphore, which is held by another task (excluding the runtime of the holding task before it relinquishes the semaphore).

   ***Note**: We report the delays associated with* `sem_wait` *as well as* `sem_post` *plus the two corresponding context switches.*

4. Intertask message latency —the delay within the kernel when a non-zero-length data message is sent from one task to another.

Deadlock-break time is not applicable to DEC OSF/1 AXP Real-Time.

The following figures show the four components of the Rhealstone benchmark we implemented.

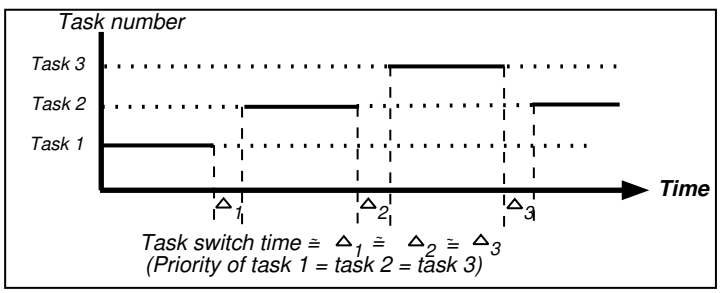


Figure 9 Rhealstone Component–Task-switch Time

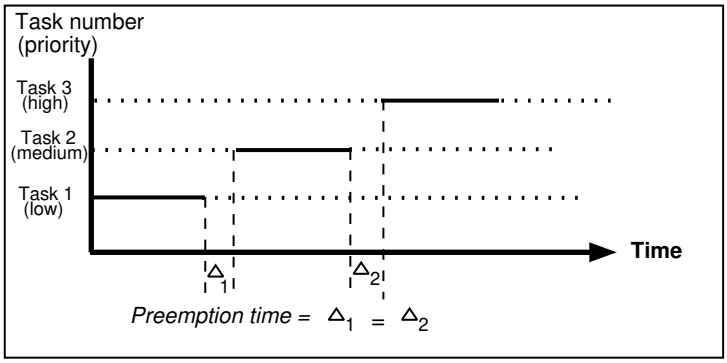


Figure 10 Rhealstone Component–Preemption Time

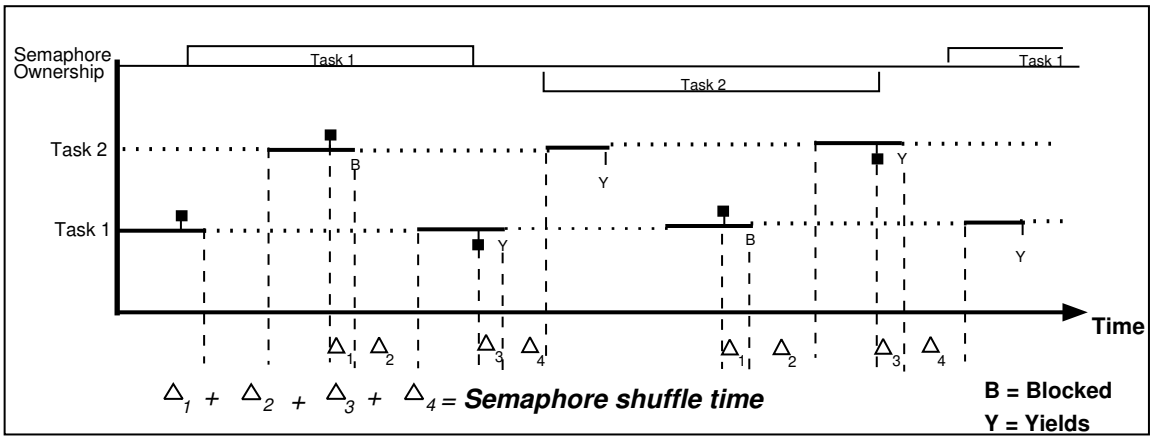


Figure 11 Rhealstone Component–Semaphore-shuffle Time

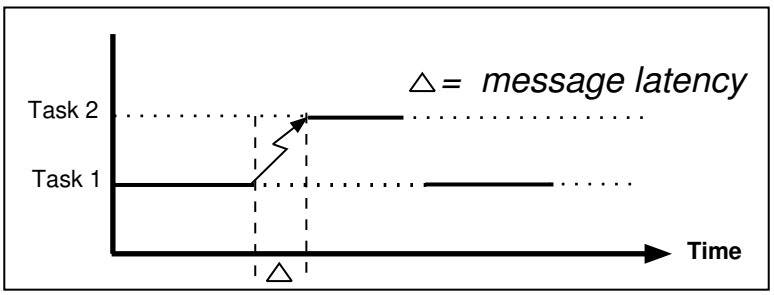


Figure 12 Rhealstone Component–Intertask Message Latency

Source: Figures 9, 10, and 12 largely taken from Kar, Rabindra, P., "Implementing the Rhealstone Real-Time Benchmark" *(Dr. Dobb's Journal*, April 1990).

Rhealstone results measured on a DEC 3000 Model 500 AXP are shown in the following table.

Table 4 Rhealstone Benchmark Results

Metric	Mean (µsec)
Task Switch Time	18.1
Preemption Time	33.1
Interrupt Latency Time	8.4 (Range: 7.0–50.4)
Intertask Message Time	92.8
Semaphore Shuffle Time	152.2

Test configuration: DEC 3000 Model 500 AXP, 256 MB memory, DEC OSF/1 AXP RT operating system, Ver 1.2.
Test conditions: Single user mode, no network.

Alpha AXP Workstation Family Performance Brief - DEC OSF/1 AXP

References

System and Vendor	Sources
DEC 3000 Model 400 AXP Workstation	All benchmarking performed by Digital Equipment Corporation.
DEC 3000 Model 500 AXP Workstation	All benchmarking performed by Digital Equipment Corporation.
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SGI Crimson Elan (R4000)	X11perf benchmark results reported in Workstation Laboratories Inc., Volume 17, Chapter 21 (5/1/92).
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Articles

Kar, Rabindra P., "Implementing the Rhealstone Real-Time Benchmark" (*Dr. Dobb's Journal*, April 1990).