Alpha and VAX Comparison

based on Industry-standard Benchmark Results

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Preface

This report contains many of the industry-standard benchmark results of Digital's Alpha and VAX systems measured by Digital Equipment Corporation. Because system performance is highly dependent upon application characteristics, you should consider industry-standard benchmark results as just one "data point" when evaluating different systems. You must carefully evaluate and understand individual work environments before making estimates of expected performance.

Please send any questions and comments about this report to: csgperf@zko.enet.dec.com.

Intended Audience

This report is for Digital's sales and sales support people, VARs (value-added resellers), OEMs (original equipment manufacturers), master resellers, industrial distributors, and customers who need to—

- understand what each industry-standard benchmark measures.
- know and compare the industry-standard benchmark results of Digital's Alpha and VAX systems.

Structure of this Report

The following list describes the organization of the report:

- Section 1 summarizes Alpha and VAX comparative system performance based on industry-standard benchmarks.
- Section 2 gives an overview of some key differences between the Alpha and VAX architectures and discusses how they affect system performance.
- Sections 3 through 5 describe individual industry-standard benchmarks and show Alpha and VAX industry-standard benchmark results by functional group, i.e., enterprise, department, and workgroup systems. Only comparisons for systems using VAX VMS™ and OpenVMS™ for Alpha and VAX and systems are shown in these sections.
- Section 6 lists selected references.
- Section 7 shows all of our available industry-standard benchmarks results for Digital's Alpha, VAX, and MIPS™ systems using VAX VMS, OpenVMS, DEC OSF/1™, or ULTRIX™ operating systems.

1 Executive Summary

Industry-standard benchmarks measure the speed of the various components that make up a system. I/O-intensive benchmarks show that Alpha systems run about 1.1 to 1.5 times faster than comparative VAX systems. TPC-A, a commercial benchmark, is a good example of this type of benchmark.

CPU-intensive or scientific benchmarks show that systems based on the Alpha architecture yield at least 4 times the performance of comparative systems based on the VAX architecture. Good examples of CPU-intensive benchmarks, which are representative of scientific and engineering environments, are SPEC and LINPACK.

Therefore, when comparing the system performance of Alpha and VAX systems, remember that the percentage of performance improvement achieved in one industry-standard benchmark may not be achieved in a different industry-standard benchmark due to the components exercised and measured by the benchmark.

The relative performance of Alpha and VAX varies across different types of benchmarks. The following data support this point.

Table 1-1 Relative Performance of Industry-standard Benchmarks on Comparative AlphaServer 2100 4/200 and VAX 4000 Model 50xA Systems

Benchmark (Type)	Systems	Ratio by which Alpha System is Faster
TPC-A (Commercial)	AlphaServer 2100 4/200 using OpenVMS and DEC Rdb vs. VAX 4000 Model 505A using OpenVMS and DEC Rdb	1.4
SPEC CFP92 (Scientific and Engineering)	AlphaServer 2100 4/200 vs. VAX 4000 Model 505A	4.1
LINPACK 100x100 Double-Precision (Scientific and Engineering)	AlphaServer 2100 4/200 vs. VAX 4000 Model 500A	6.3

Additional comparative Alpha and VAX systems' ratios are shown in Section 3 through Section 5; Section 7 contains all the results we have measured and collected for many of Digital's computers.

2 Alpha and VAX Architectures' Key Differences

In the 1970s, computer architects concentrated on designing hardware that could reduce software efforts. They designed hardware architectures, called CISC (Complex Instruction Set Computer), that provided high-level hardware support for languages. However, complex hardware increased the efforts to design, build, and maintain it.

In the 1980s, the emergence of sophisticated optimizing compilers and advanced integrated circuit technology allowed computer architects to concentrate on reducing the complexity of hardware. Simpler hardware architectures, called RISC (Reduced Instruction Set Computers), resulted in improved performance.

VAX systems are based on the CISC architecture, and Alpha systems are based on the RISC architecture. The rest of this section points out some of the key differences between Alpha and VAX systems and the effect these differences have on performance.

- Alpha is a 64-bit architecture; VAX is a 32-bit architecture.
- Alpha systems have 32 quadword (8 bytes) integer and 32 quadword floating-point registers; VAX has 16 longword registers.
- Alpha has fixed-length (32 bits) instructions; VAX has variable-length instructions.
  - You should align memory accesses on longword or quadword boundaries for Alpha systems. A misaligned memory access will take multiple aligned memory references and cause a performance penalty. Programs with aligned access run faster. Alpha, like all RISC architectures, relies on careful attention to data alignment and instruction scheduling to achieve high performance.
  - Because instructions on Alpha systems have the same length and all execute in one cycle, a streamlined instruction handling, particularly suited for pipelined implementation, is achieved and overall throughput increased.
  - Fixed-length instructions cannot cross word boundaries; thus, an instruction cannot be written to two separate pages in a virtual memory.
- Alpha is a load/store architecture (also called register-register); VAX is a memory-memory architecture.
  - Although the load/store machine requires more instructions, this does not imply anything about the relative performance of RISC machines.
  - More instructions cause the RISC code to be larger. Larger RISC programs require more memory locations for their storage.
- Alpha operations are performed on registers; a single VAX instruction can perform operations directly on memory
  - Registers are easier for a compiler to use and can be used more effectively than other forms of internal storage. Registers are faster than memory. Alpha systems contain many registers; VAX systems relatively few registers.

- On Alpha, all data is moved between registers and memory without computation; all computation is done between values in registers.
- Restricting operations to register operands allows the use of simple, uniform instruction set. The separation of memory access from arithmetic operations results in a performance gain in a system that can exploit pipelining, instruction scheduling, and parallel operational units.

- The RISC instruction set allows for optimal, customized, compiler-generated code to load registers and perform most operations in the registers before accessing memory.
  - RISC machines can usually optimize register usage to a greater extent than CISC machines because RISC instructions are lower-level instructions than CISC instructions.
  - Accessing memory can create memory bottlenecks.
- On Alpha, explicit tests are required to determine a given condition. On VAX, condition codes are set on each instruction.
  - Because there are no special registers and no condition codes on Alpha, the architecture can facilitate pipelining multiple instances of the same operations.
- Multiple Alpha instructions can enter the instruction pipeline; VAX systems issue one at a time.
- Generally, multiple Alpha instructions are required to perform the equivalent function of a VAX instruction. However, Alpha instructions may take fewer cycles than VAX instructions.

The time required to perform an application on a computer is determined by three factors.

*Time = (number of instructions) * (cycles per instruction) * (cycle time)*

Most RISC machines strive to execute one or more instructions per cycle. Due to factors such as multiple-cycle delays for memory data on a cache miss, pipeline conflicts, and pipeline startup delays on branches, real RISC machines do not achieve one cycle per instruction on the average. Depending on the application, the typical numbers are between 1.5 and 2. CISC machines such as the VAX often require 8 to 10 cycles per instruction.

Due to their inherent simplicity, RISC machines often achieve shorter cycle times than CISC machines.

On the down side, a RISC machine often requires more instructions to perform the same function as a CISC machine. Preliminary measurements show that typical RISC machines require 1.5 to 2.5 times the number of instructions required by a CISC machine. Obviously, this number is application-sensitive. Optimization techniques used by contemporary compilers for RISC machines help to reduce the number of required instructions.

Based on these factors, one would expect that a RISC machine could achieve a factor of 2 to 4 times higher performance than a CISC machine built with the same technology.

One way to compare the Alpha and VAX architectures is to compare results from running the same industry-standard benchmarks on each type. Digital has an archive of industry-standard benchmark results for many of Digital's systems using the Alpha and VAX architectures and shows them in the following sections.

3 TPC-A Benchmark

TPC-A™ is a Remote Terminal Emulator (RTE) on-line transaction processing (OLTP) benchmark. This benchmark exercises the following system-level components:

1. Processor speed
2. Memory size
3. Memory bandwidth
4. Operating system efficiency
5. Context switching speed
6. Optional OLTP monitor efficiency
7. Compiler effectiveness
8. I/O architecture
9. I/O bandwidth
10. Data caching
11. Database management system (DBMS) efficiency
12. Terminal handling
13. Network efficiency
14. Optional client/server architecture

Thus, TPC-A provides a fairly comprehensive measurement of system-level performance in the commercial transaction processing environment that emphasizes update-intensive database services. TPC-A is characterized by significant disk input/output, moderate system and application execution time, transaction integrity, and multiple on-line terminals.

3.1 Metrics

Response times are measured at the RTE. TPC defines the response time (*RT*) of a transaction as follows:

$RT = T2 - T1$

where *T1* and *T2* are measured at the RTE and defined as:

T1 is the time stamp taken before the first byte of the input message is sent from the RTE to the SUT (system-under-test).

T2 is the time stamp taken after the last byte of the output message from the SUT arrives at the RTE.

Ninety percent (90%) of all transactions started and completed during the measurement interval must have a response time of less than 2 seconds.

The reported tpsA is the total number of committed transactions that both started and completed at the RTE during the measurement interval, divided by the elapsed time of the interval.

Price/performance, $/tpsA, is calculated by dividing the total cost of ownership of the target configuration, including cost of all hardware, all software, and 5-year maintenance of the system required to achieve the reported performance by the throughput in tpsA.

Higher tpsA signifies better performance; lower $/tpsA signifies better price/performance.

3.2 Results

The DEC 7000 Model 660 using OpenVMS and Oracle7 processed about 1.1 times the number of transactions per second than the VAX 7000 Model 760 using OpenVMS and DEC Rdb. TPC-A, a commercial benchmark, is characterized by significant disk input/output, moderate system and application execution time, transaction integrity, and multiple on-line terminals.

Figure 3-1 TPC-A tpsA Benchmark Results for Digital's Enterprise Systems as of 11/4/94

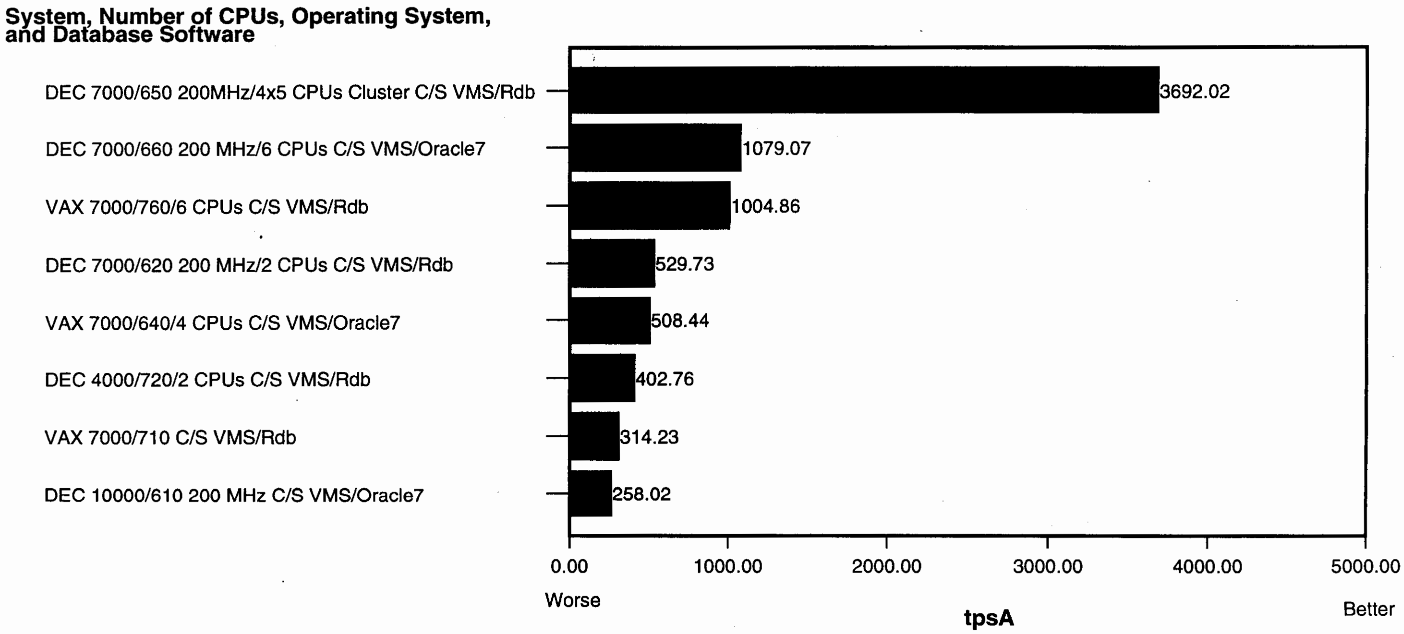
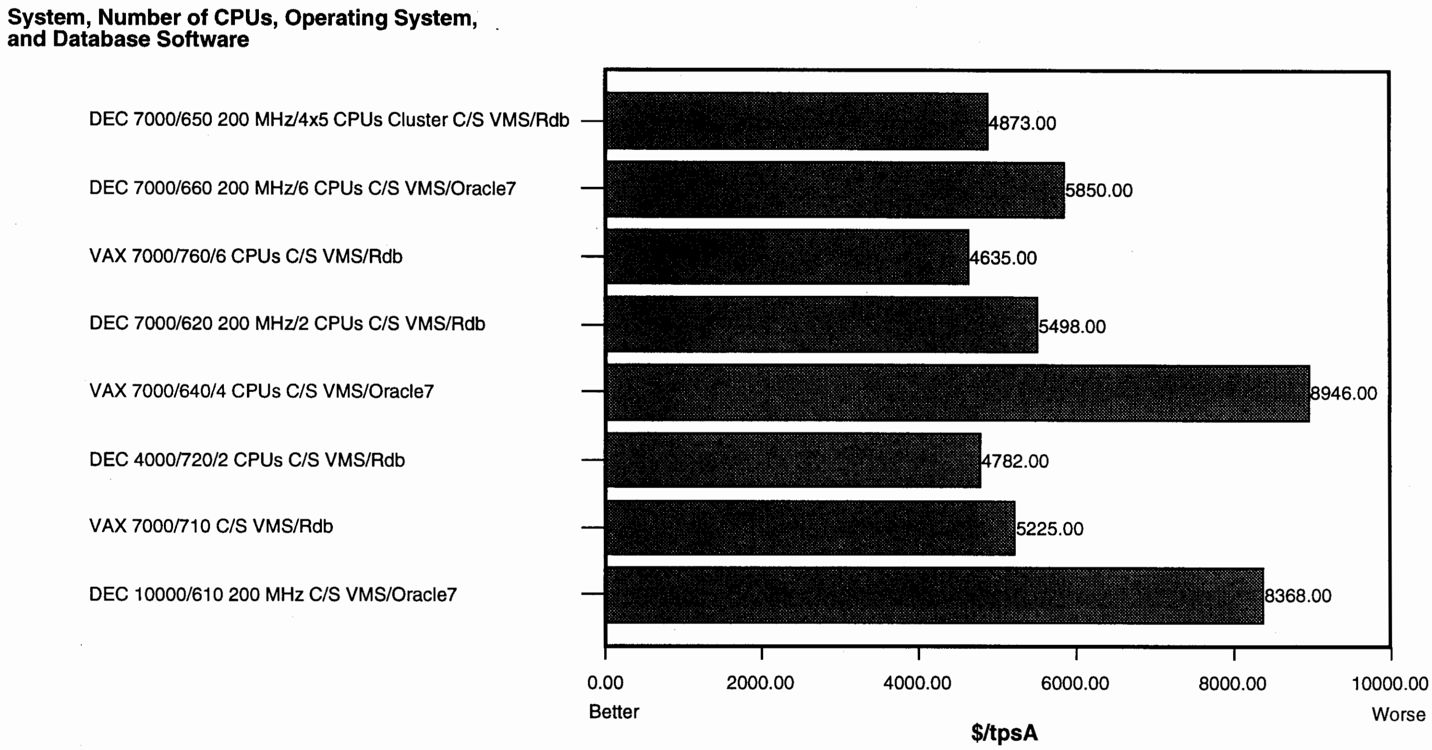


Figure 3-2 TPC-A $/tpsA Benchmark Results for Digital's Enterprise Systems as of 11/4/94



Shown in the next two figures are the TPC-A results measured on Digital's department systems using OpenVMS operating system and DEC Rdb for OpenVMS. The AlphaServer 2100 4/200 processed approximately 1.4 times the number of transactions per second than the VAX 4000 Model 505A.

Figure 3-3 TPC-A tpsA Benchmark Results for Digital's Department Systems as of 11/4/94

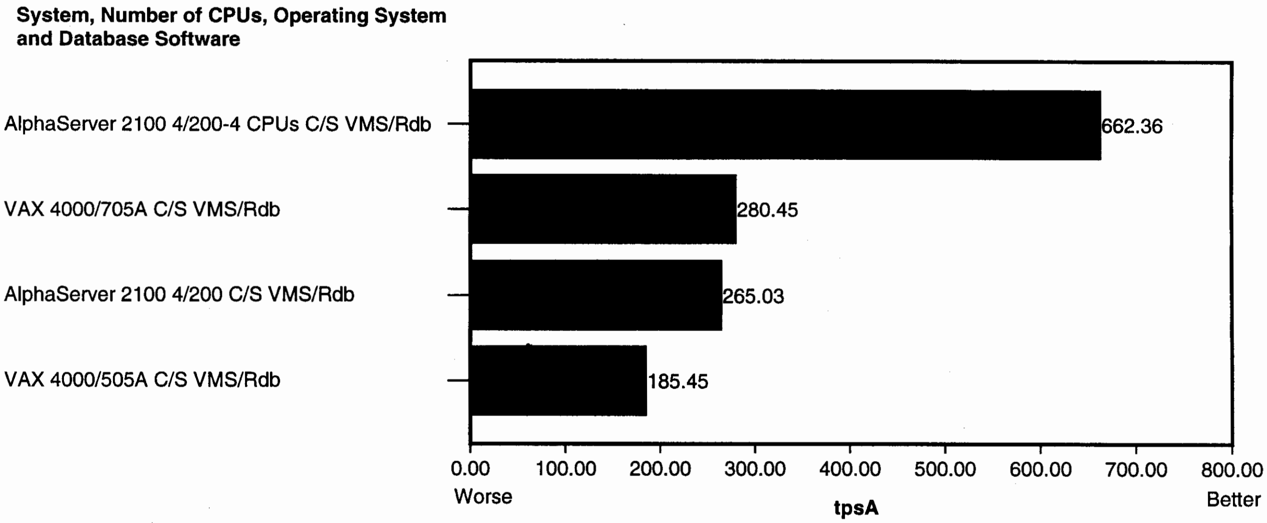
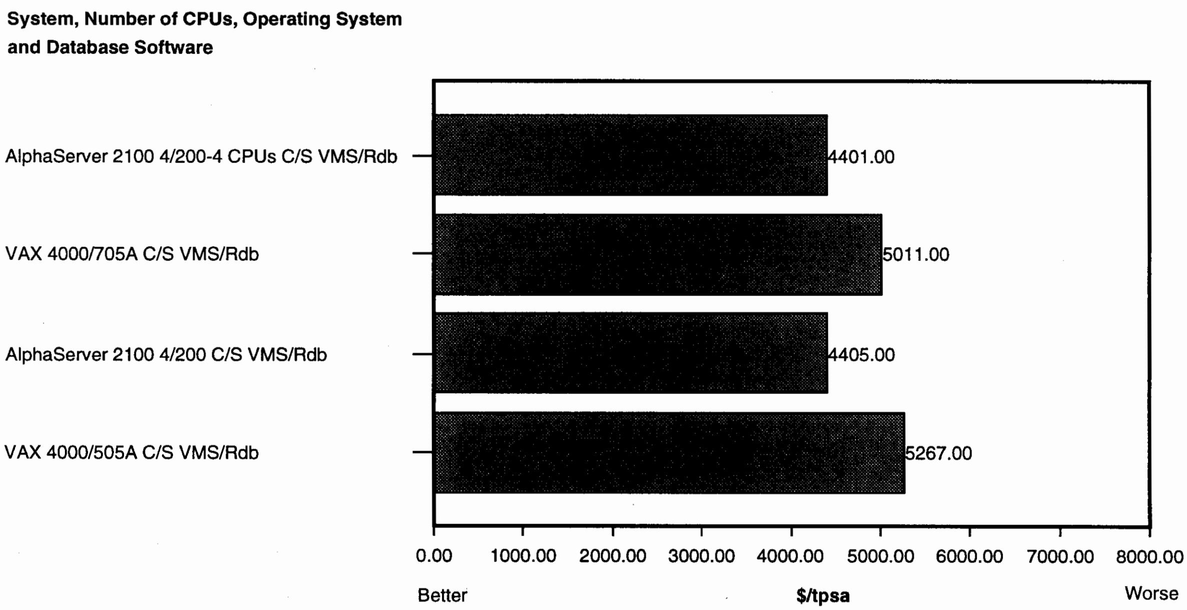


Figure 3-4 TPC-A $/tpsA Benchmark Results for Digital's Department Systems as of 11/4/94



Shown in the next two figures are the available TPC-A results measured on Digital's workgroup systems' using OpenVMS.

Note: These systems are not comparable.

Figure 3-5 TPC-A tpsA Benchmark Results for Digital's Workgroup Systems as of 11/4/94

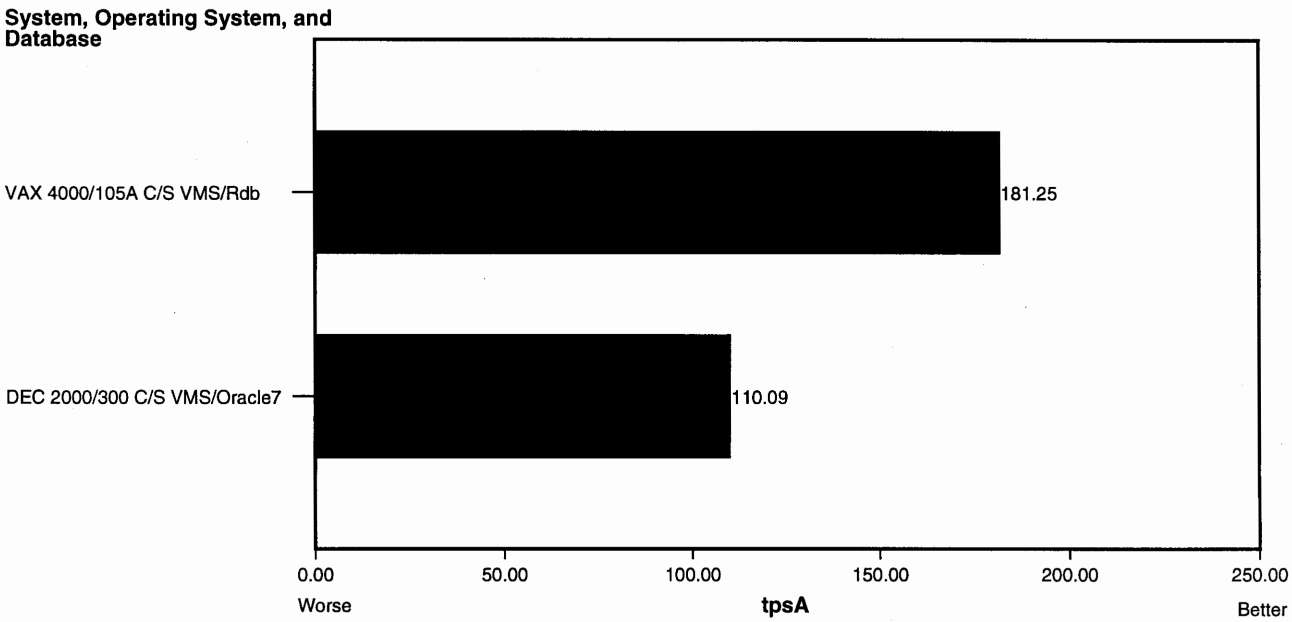
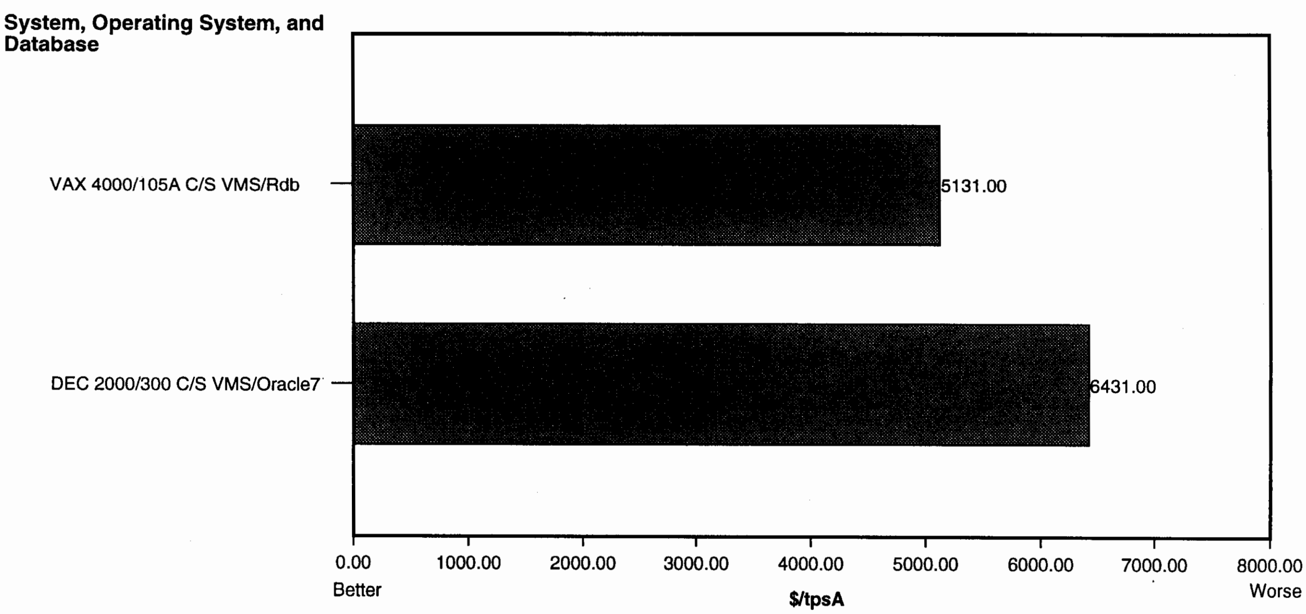


Figure 3-6 TPC-A $/tpsA Benchmark Results for Digital's Workgroup Systems as of 11/4/94



4 SPEC CFP92 Benchmark Suite

SPEC™ (System Performance Evaluation Cooperative) 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.

The SPEC CFP92 benchmark suite is comprised of a set of programs that measure CPU-intensive, floating-point, single-stream performance. SPEC CFP92 contains 14 floating-point benchmarks, 2 of which are written in C and the rest in FORTRAN. Five of the benchmarks are single-precision, the rest are double-precision.

The programs included in this suite are as follows:

1. 013.spice2g6—an analog circuit simulation tool. It is a CPU-intensive, floating-point, double-precision, FORTRAN application. It is a real application used heavily in the EDA markets.
2. 015.doduc—Monte Carlo simulation of the time evolution of a thermo-hydraulic model (hydrocode) for a nuclear reactor's component. Uses double-precision, floating-point numbers with 64-bit precision and is written in non-vectorizable FORTRAN. This is a synthetic benchmark that represents ECAD and high-energy physics applications.
3. 034.mdljpd2—a double-precision, FORTRAN benchmark that represents quantum chemistry applications.
4. 039.wave5—a large, FORTRAN, scientific benchmark with single-precision, floating-point arithmetic. A two-dimensional, relativistic, electromagnetic, particle-in-cell, simulation code used to study various plasma phenomena. It solves Maxwell's equations of motion cartesian mesh with a variety of field and particle boundary conditions. The benchmark problem involves 500,000 particles on 50,000 grid points for 5 time step.
5. 047.tomcatv—a highly (90%-98%) vectorizable, double-precision, FORTRAN program for the generation of two-dimensional boundary-fitted, coordinate systems around the general geometric domains such as airfoils and cars.
6. 048.ora—a CPU-intensive, double-precision, floating-point, scientific, FORTRAN benchmark. Traces rays through an optical system composed of spherical and plan surfaces. Double-precision is necessary on computers with 32-bit word length. Single-precision is adequate on computers with 48-bit or greater word length. This benchmark executes in double-precision mode.
7. 052.alvinn—a single-precision, robotic application program written in C. Trains a neural network called ALVINN (Autonomous Land Vehicle in a Neural Network) using back propagation. Designed to take as input sensory data from a video camera and a laser range finder and to give as output the direction for a vehicle to travel in order to stay on the road.
8. 056.ear—a single-precision, floating-point intensive, C benchmark. Simulates a human ear. Makes extensive use of complex Fast Fourier Transforms (FFTs) and other library functions (single-precision).

9. 077.mdljsp2—a single-precision, FORTRAN benchmark representative of quantum chemistry applications. Solves the equations of motion for a model of 500 atoms interacting through the idealize Lennard-Jonet potential.

10. 078.swm256—a scientific benchmark written in FORTRAN with single-precision, floating-point arithmetic. Solves the system of shallow water equations using finite difference approximations on a 256x256 grid.

11. 089.su2cor—a vectorizable FORTRAN program with double-precision computation in quantum physics. Masses of elementary particles are computed in the framework of the Quark-Gluon theory. Computed with the Monte Carlo method. Configuration is generated by the warm bath method. Most code is highly vectorizable.

12. 090.hydro2d—a vectorizable FORTRAN program with double-precision, floating-point computations. From the area of astrophysics, hydrodynamical Navier Stokes equations are solved to compute galactical jets.

13. 093.nasa7—a FORTRAN program with double-precision computations in applications used by NASA such as matrix multiply operations, Cholsky decomposition in parallel on a set of input matrices and block tridagonal matrix solution.

14. 094.fpppp—a double-precision, floating-point, FORTRAN benchmark. It is a quantum chemistry program that measures performance on one style of computation (two electron integral derivative), which occurs in the Gaussian series of programs.

4.1 Metric

The following metrics are used to report the results of SPEC CFP92 benchmark testing:

1. SPEC Reference Time—time it took Digital's VAX 11/780 system to run each benchmark in the suite.

2. SPECratio™—the ratio of the time it took to run a benchmark on the system-under-test relative to SPEC reference time.

3. SPECfp92™—the geometric mean of the SPECratios of the 14 benchmarks contained in the suite

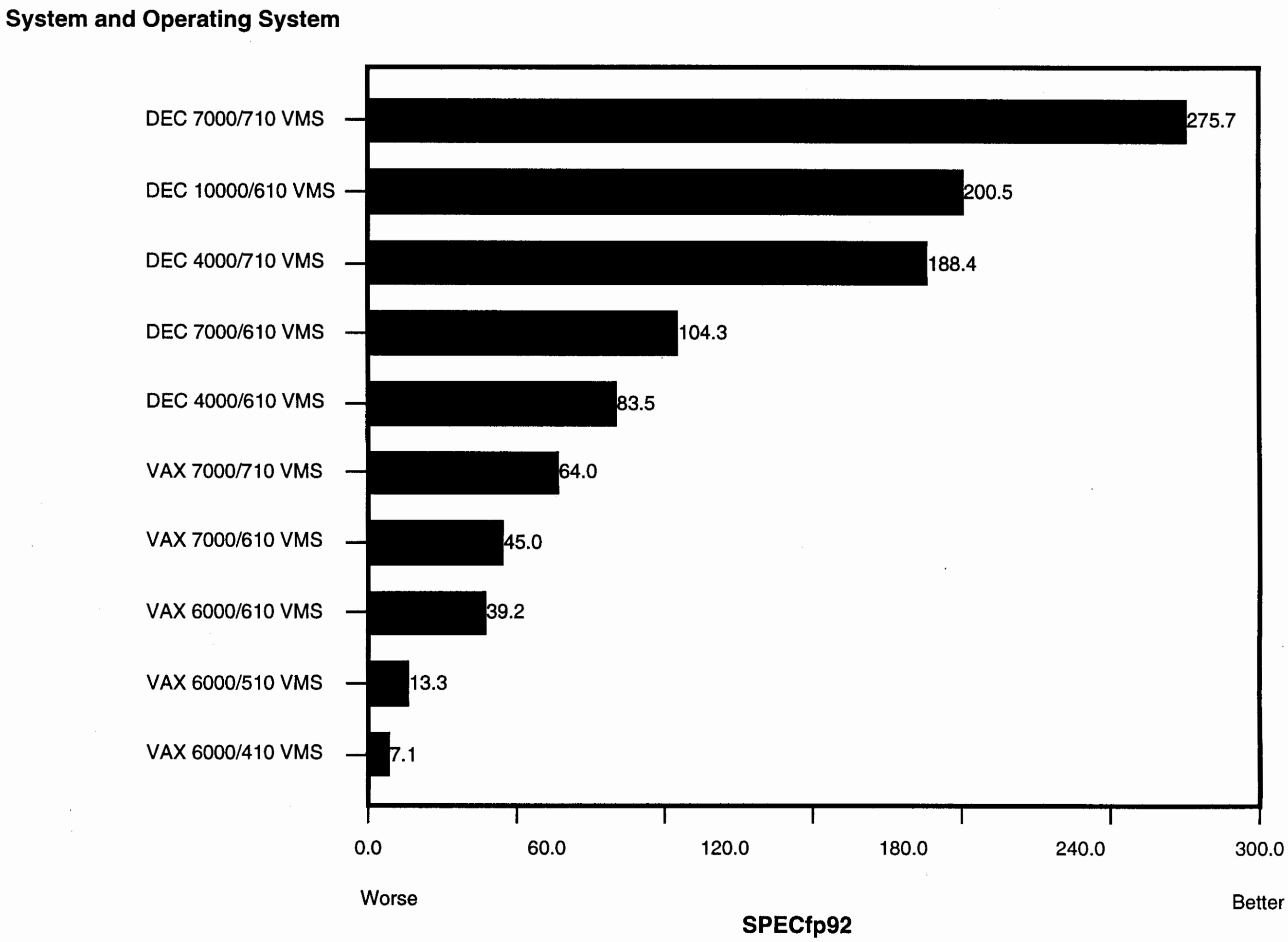
The higher the SPECfp92 result, the better the result.

4.2 Results

Shown in the following figures are the peak SPECfp92 ratings for the Alpha and VAX enterprise, department, and workgroup systems using VAX VMS or OpenVMS operating system. Available SPECbase_fp92 results are shown in Section 7.

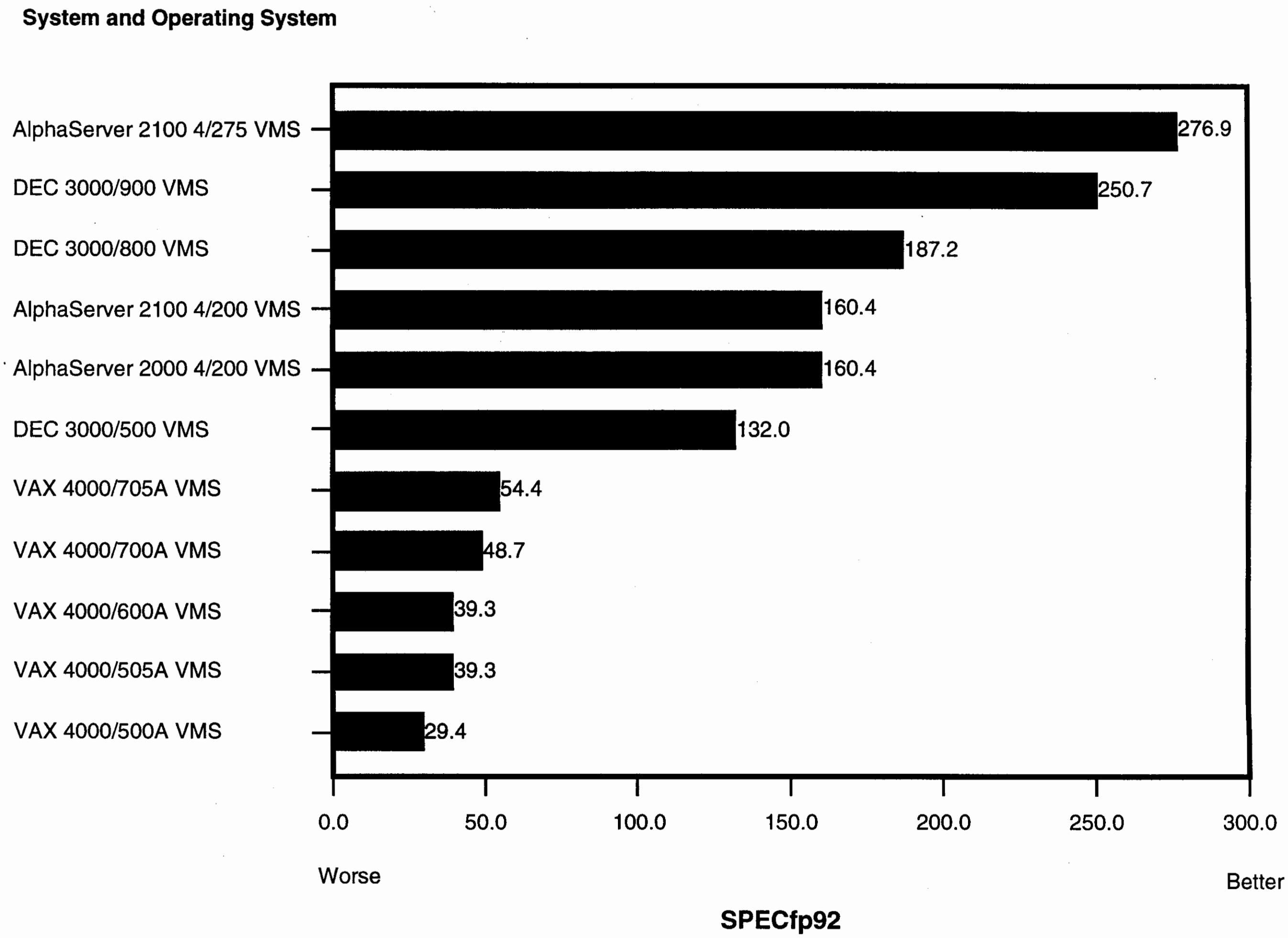
SPEC CFP92 is a CPU-intensive benchmark (i.e., operates only on the architecture); therefore, it is not surprising that DEC 7000 Model 710 is about 4.3 times faster than the VAX 7000 Model 710.

Figure 4-1 Peak SPEC CFP92 Benchmark Results for Enterprise Systems



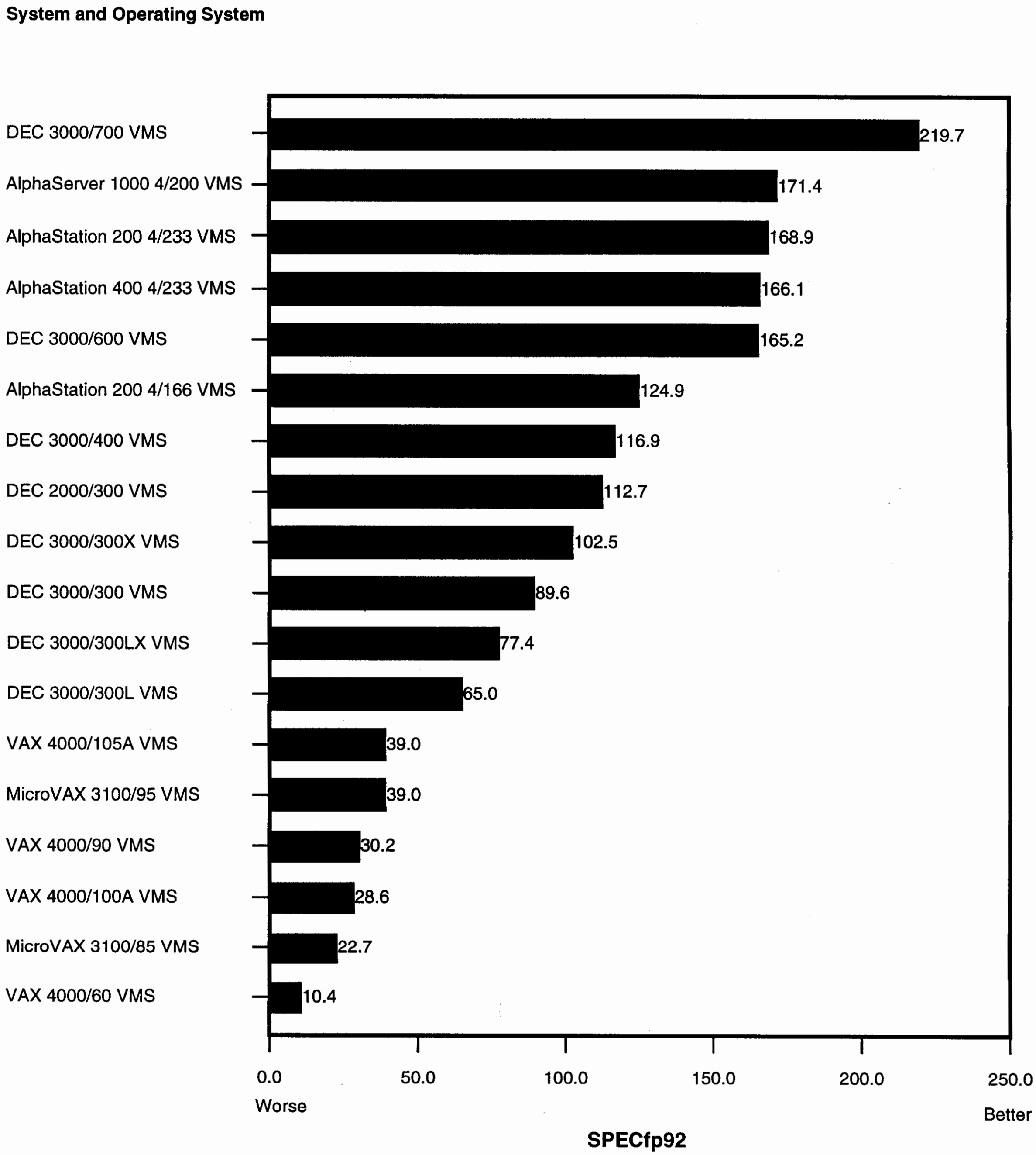
The AlphaServer 2100 4/275, Digital's fastest Alpha department server, is 5.1 times faster than the VAX 4000 Model 705A, Digital's fastest VAX department server.

Figure 4-2 Peak SPEC CFP92 Benchmark Results for Department Systems



The AlphaServer 1000 4/200 is 4.4 times faster than the VAX 4000 Model 105A.

Figure 4-3 Peak SPEC CFP92 Benchmark Results for Workgroup Systems



5 LINPACK 100x100 Benchmark

Argonne National Labs developed the LINPACK 100x100 benchmark to measure and compare the performance of different computers solving dense systems of linear equations. LINPACK 100x100 is written in FORTRAN and can be characterized as having a high percentage of double-precision, floating-point arithmetic operations. Most of these operations occur in a small set of subprograms called the Basic Linear Algebra Subprograms (BLAS), which are called repeatedly throughout the calculations. The BLAS routines reference one-dimensional arrays.

LINPACK 100x100 benchmark addresses a problem size that is relatively small, i.e., a matrix of order 100. You cannot make any changes to the LINPACK 100x100 software. Only compiler optimizations are allowed to tune the problem.

5.1 Metrics

LINPACK 100x100 reports the number of floating-point operations, i.e., MFLOPS (millions of floating-point operations per second), executed by the system to solve the LINPACK 100x100 problem. LINPACK 100x100's load driving program generates this number.

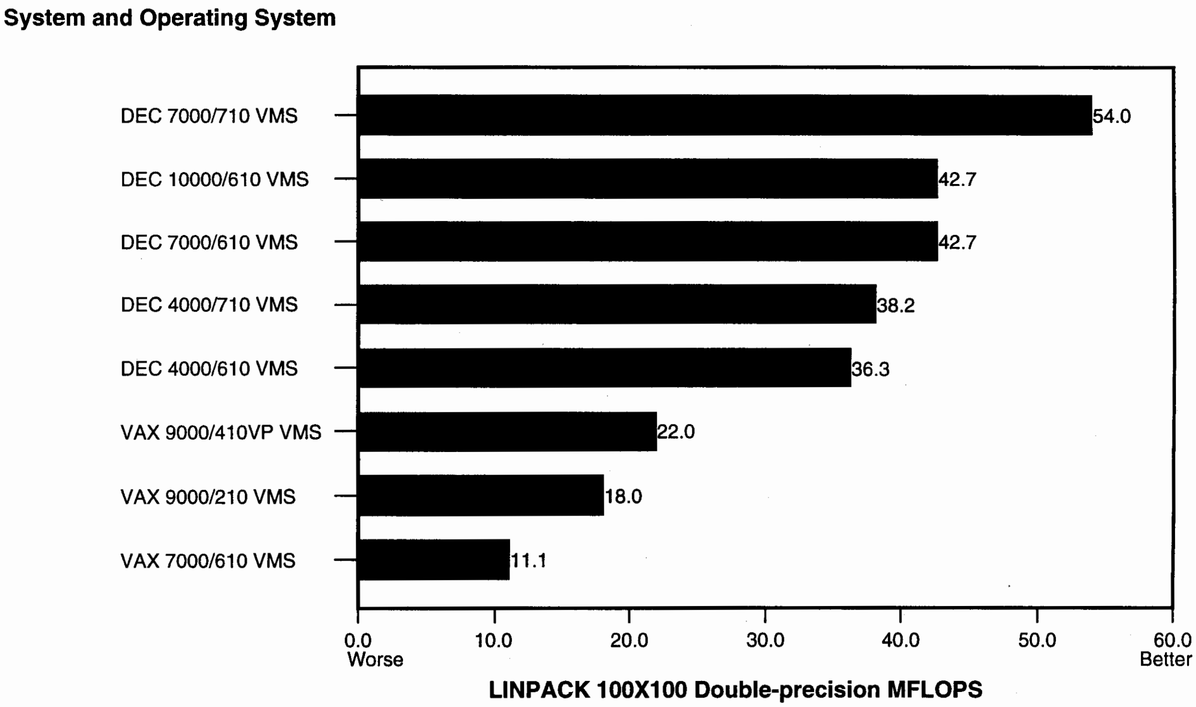
The higher the MFLOPS result, the better the result.

5.2 Results

Shown next are the LINPACK 100x100 double-precision results for Digital's enterprise systems.

The DEC 7000 Model 610 is about 3.9 times faster than the VAX 7000 Model 610 in this CPU-intensive benchmark, which is consistent with the other CPU-intensive benchmarks we have shown.

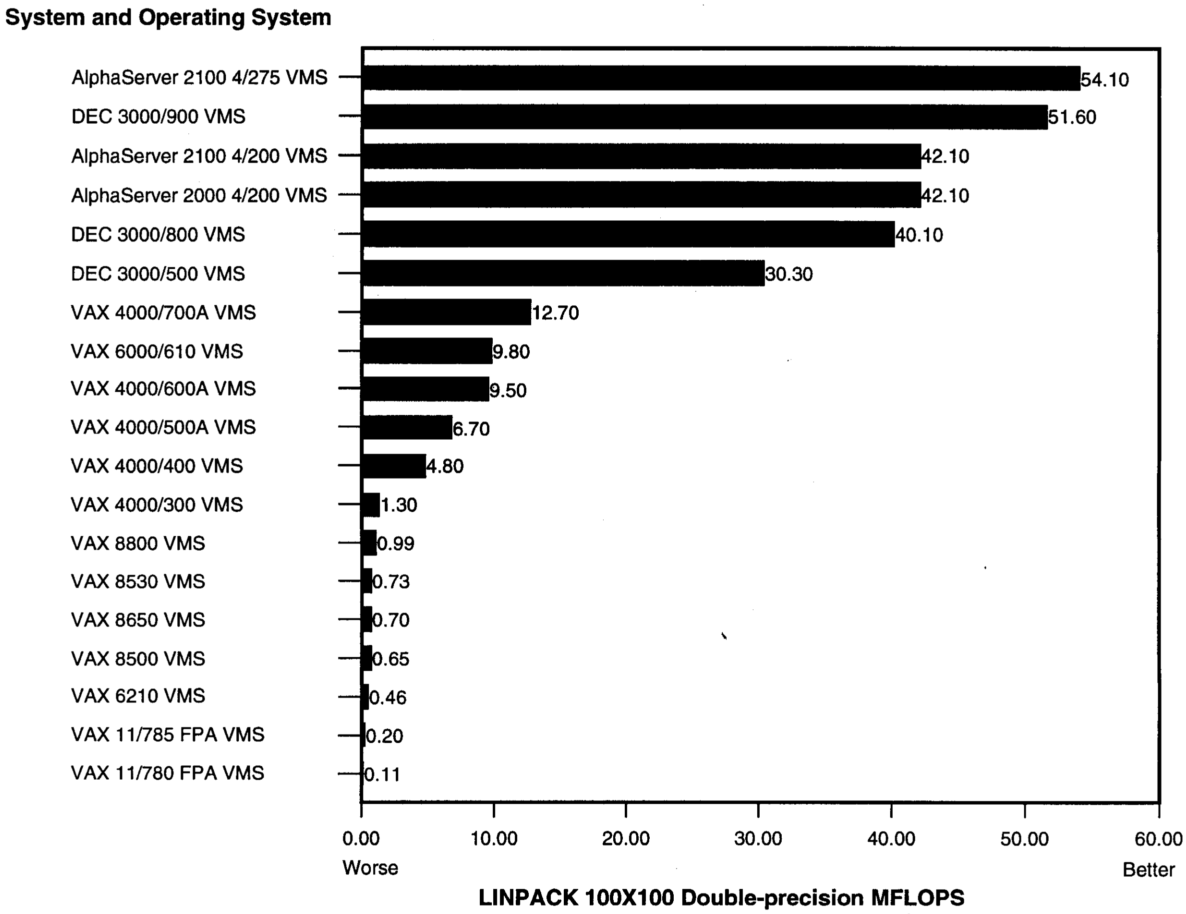
Figure 5-1 LINPACK 100x100 Double-precision Benchmark Results for Enterprise Systems



The following figure contains LINPACK 100x100 double-precision benchmark results for Digital's department systems.

The AlphaServer 2100 4/275 is 4.3 times faster than the VAX 4000 Model 700A; the AlphaServer 2100 4/200 is about 6.3 times faster than the VAX 4000 Model 500A.

Figure 5-2 LINPACK 100x100 Double-precision Benchmark Results for Department Systems

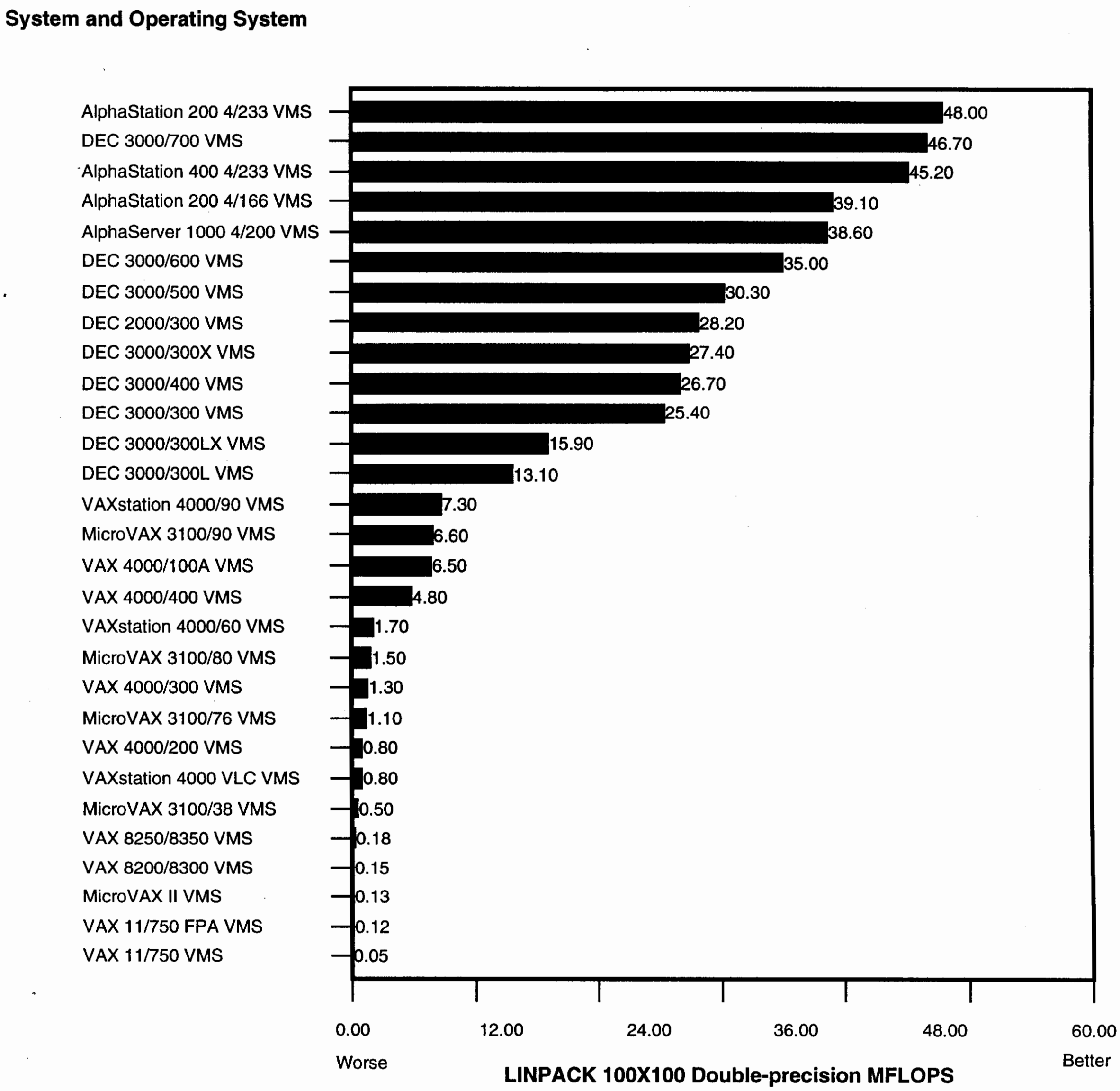


FPA = Floating-point Accelerator

The following figure contains LINPACK 100x100 double-precision benchmark results for Digital's workgroup systems.

The AlphaServer 1000 4/200 is about 5.9 times faster than both the MicroVAX 3100 Model 90 and the VAX 4000 Model 100A.

Figure 5-3 LINPACK 100x100 Double-precision Benchmark Results for Workgroup Systems



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7 Summary of Industry-standard Benchmark Ratings for Digital's Computers

The tables contained in this section show all of our available industry-standard benchmarks results for Digital's Alpha, VAX, and MIPS systems using DEC OSF/1, OpenVMS, VAX VMS, and ULTRIX.

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	AlphaServer 1000 4/200 OSF	AlphaServer 2000 4/200 OSF	AlphaServer 2100 4/275 OSF	DEC 7000 700 OSF	AlphaServer 1000 4/200 VMS	AlphaServer 2000 4/200 VMS	AlphaServer 2100 4/275 VMS	DEC 7000 700 VMS
SPECint92	135.8	131.8	200.1	200.5	100.4	97.4	148.3	148.2
SPECbase_int92	123.3	117.5	176.5	180.0	89.9		134.4	134.3
SPECfp92	177.0	160.5	291.1	292.6	171.4	160.4	276.9	275.7
SPECbase_fp92	165.7	152.0	259.5	265.8	150.5		243.7	242.6
SPECrate_int92	3,136	3,123	4,412	4,522	2,385	2,319	3,562	3,563
SPECrate_fp92	4,230	3,835	6,827	6,684	4,065	3,822	6,640	6,605
SPECnfs_A93 ops/sec								
SPEC SFS avg resp time								
SPECnfs_A93 users								
LINPACK 100x100 dp	38.6	41.4	51.5	53.3	38.6	42.1	54.1	54.0
LINPACK 1000x1000 dp	147.4	128.5	204.8	208.2	137.6	127.2	196.8	198.6
Dhrystone 1.1 instr/sec	364K	325K	456K	471K	347K	320K	474K	471K
Dhrystone 2.1 instr/sec	333K	313K	455K	455K	282K	363K	522K	520K
DN&R Labs MVUPs	283.7	269.9	367.6	373.8	269.5	265.0	373.0	378.0
AIM Perf Rating								
AIM Max User Load								
AIM Max Throughput								
Livermore Loops geo m	26.4	25.5	40.5	40.5	27.0	25.9	42.4	42.8
CERN	32.7		53.1	53.4				
SLALOM Patches	7,906	6,932	8,814	8,848	7,134	6,932	8,908	8,908
SLALOM MFLOPs	62.7	59.9	95.7	99.5	63.5	58.8	99.4	99.5
Perfect geo m MFLOPS	30.2		49.5	50.1				
TPC-A tpsA								
TPC-A $/tpc-A								
Xmark93								
Whetstone KWIPS sp	189.4	156.2	259.4	258.0	200.0	170.8	333.3	333.3
Whetstone KWIPS dp	177.6	140.2	240.0	226.6	142.8	142.1	250.0	250.0

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	AlphaStation 200 4/166 OSF	AlphaStation 200 4/233 OSF	AlphaStation 400 4/233 OSF	DEC 3000 700 OSF	DEC 3000 900 OSF	AlphaStation 200 4/166 VMS	AlphaStation 200 4/233 VMS	AlphaStation 400 4/233 VMS	DEC 3000 700 VMS	DEC 3000 900 VMS
SPECint92	116.2	157.7	155.2	162.6	200.6	82.9	114.1	113.0	128.2	146.0
SPECbase_int92	100.1	137.4	136.2	153.4	180.6	74.4	102.9	101.9	115.1	133.0
SPECfp92	134.8	183.9	181.2	230.6	264.1	124.9	168.9	166.1	219.7	250.7
SPECbase_fp92	128.4	174.6	168.1	213.3	244.6	112.2	153.8	151.1	195.9	224.6
SPECrate_int92	2,779	3,772	3,767	3,944	4,702	1,973	2685	2,696	3,031	3,488
SPECrate_fp92	3,160	4,415	4,251	5,482	6,293	2,960	4012	3,960	5,233	5,966
SPECnfs_A93 ops/sec				1,387	1,817					
SPEC SFS avg resp time				28.8	26.3					
SPECnfs_A93 users				139	182					
LINPACK 100x100 dp	32.5	45.1	43.3	44.5	52.0	39.1	48.1	45.2	46.7	51.6
LINPACK 1000x1000 dp	99.6	138.0	137.3	163.8	192.6	102.1	130.9	128.1	160.0	186.9
Dhrystone 1.1 instr/sec	330K	435K	424K	401K	456K	303K	409K	402K	404K	468K
Dhrystone 2.1 instr/sec	278K	417K	417K	385K	545K	189K	443K	444K	424K	514K
DN&R Labs MVUPs	241.6	350.3	350.7	333.8	394.9	224.5	324.7	321.8	345.8	374.0
AIM Perf Rating										
AIM Max User Load										
AIM Max Throughput										
Livermore Loops geo m	23.2	35.5	35.3	34.7	40.6	23.7	36.6	36.0	34.5	42.5
CERN	28.4	41.0	40.0	42.5	51.7					
SLALOM Patches	6,640	7,948	7,948	8,032	8,814	6,668	8,120	8,070	7,998	8,908
SLALOM MFLOPs	54.5	79.8	79.4	81.1	95.6	55.5	81.8	81.7	79.2	97.7
Perfect geo m MFLOPS	26.3	41.3	41.3	42.4	49.5					
TPC-A tpsA										
TPC-A $/tpc-A										
Xmark93	11.93	15.04	14.66	16.72	18.06	11.71	14.46	13.69	15.75	17.09
Whetstone KWIPS sp	154.3	227.2	226.7	213.5	249.3	166.7	333.0	250.0	250.0	333.3
Whetstone KWIPS dp	135.9	206.6	207.4	197.4	227.2	111.1	200.0	200.0	200.0	250.0

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	DEC 2000/ 300 OSF	DEC 3000/ 300LX OSF	DEC 3000/ 300X OSF	DEC 3000/ 600 OSF	DEC 3000/ 800 OSF	AlphaServer 2100 4/200 OSF	DEC 4000/ 710 OSF	DEC 2000/ 300 VMS	DEC 3000/ 300LX VMS	DEC 3000/ 300X VMS	DEC 3000/ 600 VMS	DEC 3000/ 800 VMS	AlphaServer 2100 4/200 VMS	DEC 4000/ 710 VMS
SPECmark89											151.1	171.5		
SPECint92	80.9	63.5	84.4	114.1	130.2	131.8	122.4	65.3	48.9	64.2	87.6	99.3	97.4	94.0
SPECfp92	110.2	75.5	100.5	162.1	184.0	161.0	185.4	112.7	77.4	102.5	165.2	187.2	160.4	188.4
SPECrate_int92	1930	1501	1925	2722	3137	3,123	2900	1551	1166	1526	2096	2387	2,319	2201
SPECrate_fp92	2634	1788	2374	3857	4377	3,835	4340	2655	1836	2433	3905	4417	3,822	4414
SPECnfs_A93 ops/sec				1059	1196									
SPEC SFS avg resp time				22.4	41.1									
SPECnfs_A93 users				106	123									
LINPACK 100x100 dp	27.9	15.7	26.9	35.6	40.6	41.4	37.1	28.2	15.9	27.4	35.0	40.1	42.1	38.2
LINPACK 1000x1000 dp	88.3	62.9	80.1	129.7	147.1	128.5	143.4	90.3	64.2	80.6	130.1	148.3	127.2	145.6
Dhrystone 1.1 instr/sec	248K	213	295	296K	339K	325K	332K	277K	200	271	292K	334K	320K	317K
Dhrystone 2.1 instr/sec	227K	208	294	294K	333K	313K	333K	286K	198	279	303K	344K	363K	317K
DN&R Labs MVUPs	161.6	163.8	231.3	258.5	294.8	269.9	264.6	172.5	133.0	190.6	256.5	295.5	265.0	273.9
AIM Perf Rating	68.6			93.8	119.3	310.6 (4 cpus)	105.1							
AIM Max User Load	178			537	902	2,552 (4 cpus)	776							
AIM Max Throughput	672.5			919.2	1169.4	3,044.3 (4 cpus)	1029.9							
Livermore Loops geo m	19.1	15.1	21.4	23.7	27.2	25.5	25.6	22.2	15.2	20.8	24.3	27.9	25.9	26.4
CERN	20.5	15.1	20.7	26.1	30.0		27.8							
SLALOM Patches	5950	4992	6084	6668	7134	6,932	6932	5920	5022	6068	6784	7198	6,932	7050
SLALOM MFLOPs	44.6	31.5	46.3	56.3	63.9	59.9	61.2	44.2	31.8	45.5	58.2	64.0	58.8	62.3
Perfect geo m MFLOPS	20.6	12.4	16.6	24.1	27.6		27.8	20.1			23.9	27.1	25.1	25.8
TPC-A tpsA	94.43 o			172.16 o	186.02 o			110.09 o					265.03r	
TPC-A $/tpc-A	7082 o			6072 o	6503 o			6431 o					4405r	
X11perf Kvectors/sec		510	521	677	683				547	578	665	670		
X11perf Mpixels/sec		30.5	30.8	31.0	31.0				29.3	30.8	31.0	31.0		
Whetstone KWIPS sp	122.4	102	143	144.3	165.3	156.2	156.4	111	91	160	140	158	170.8	150
Whetstone KWIPS dp	108.9	92	129	129.0	147.9	140.2	140.1	100	125	145	121	137	142.1	130

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	DEC 3000/ 300L OSF	DEC 3000/ 300 OSF	DEC 3000/ 400 OSF	DEC 3000/ 500 OSF	DEC 3000/ 500X OSF	DEC 4000/ 610 OSF	DEC 7000/ 610 OSF	DEC 10000/ 610 OSF	DEC 3000/ 300L VMS	DEC 3000/ 300 VMS	DEC 3000/ 400 VMS	DEC 3000/ 500 VMS	DEC 3000/ 500X VMS	DEC 4000/ 610 VMS	DEC 7000/ 610 VMS	DEC 10000/ 610 VMS
SPECmark89			111.1	126.1		137.3	192.1	192.1			108.1	121.5		136.2	184.1	184.1
SPECint92	45.9	66.2	74.7	84.4	110.9	94.6	132.7	132.7	40.2	58.2	65.5	71.9	92.6	83.5	104.3	104.3
SPECfp92	63.6	91.5	112.5	127.7	164.1	137.6	200.1	200.1	65.0	89.6	116.9	132.0	168.2	143.1	200.5	200.5
SPECrate_int92	1081	1535	1763	1997	2611	2198	3179	3179	953	1380	1553	1705	2202	1986	2392	2392
SPECrate_fp92	1480	2137	2662	3023	3910	3247	4699	4699	1541	2126	2773	3131	3990	3317	4336	4336
SPECnfs_A93 ops/sec			537	601			1417									
SPEC SFS avg resp time			26	21.6			36.9									
SPECnfs_A93 users			54	60			142									
LINPACK 100x100 dp	12.3	24.5	26.0	29.6	39.8	35.0	43.1	43.1	13.1	25.4	26.7	30.3	40.2	36.3	42.7	42.7
LINPACK 1000x1000 dp	52.8	72.3	91.7	103.5	133.2	110.1	152.3	152.3	55.0	75.0	95.0	107.0	136.3	86.4	154.5	154.5
Dhrystone 1.1 instr/sec	176K	266K	235K	267K	350K	297K	344K	344K	220K	327K	287K	330K	441K	279K	339K	339K
Dhrystone 2.1 instr/sec	152K	238K	238K	263K	333K	294K	357K	357K	190K	288K	257K	289K	386K	304K	338K	338K
DN&R Labs MVUPs	134.4	207.4	185.0	209.1	284.7	225.6	289.9	289.9	134.0	205.9	187.9	211.5	282.3	216.5	295.2	295.2
AIM Perf Rating	42	58.7	70.3	82.9	110.4	92	117.8									
AIM Max User Load	225	216	485	649	805	655	977									
AIM Max Throughput	411.7	575.5	688.7	812.9	1082.4	901.7	1154.4									
Livermore Loops geo m	11.5	18.1	17.4	19.5	26.3	22.3	27.5	27.5	11.8	19.0	18.2	20.4	26.9	24.0	28.5	28.5
CERN			18.8	21.3	28.9	23.2	27.5	27.5						21.0	26.0	28.6
SLALOM Patches	4488	5844	5776	6084	7134	6496	7248	7248	4444	5844	5776	6084	7050	4072	7134	7134
SLALOM MFLOPs							66.7	66.7							63.3	63.3
Perfect geo m MFLOPS			18.4	20.7		23.1	28.4	28.4							28.6	28.6
TPC-A tpsA																258.02 o
TPC-A $/tpc-A																8368 o
X11perf Kvectors/sec	512	517	579	662	670				564	575	572	649	664			
X11perf Mpixels/sec	30.5	30.8	27.2	31	31				27.2	29.8	27.4	31	31			
Whetstone KWIPS sp															158.2	158.2
Whetstone KWIPS dp															137.5	137.5

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	VAX 3100/ 80 VMS	VAX 3100/ 90 VMS	VAX 4000/ 100A VMS	VAX 4000/ 200 VMS	VAX 4000/ 300 VMS	VAX 4000/ 400 VMS	VAX 4000/ 500A VMS	VAX 4000/ 600A VMS	VAX 4000/ 700A VMS	VAX 6000/ 610 VMS	VAX 7000/ 610 VMS	DECsys 5000/ 25 ULTRIX	DECsys 5000/ 33 ULTRIX	DECsys 5100 ULTRIX	DECsys 5000/ 133 ULTRIX	DECsys 5000/ 240 ULTRIX	DECsys 5500 ULTRIX	DECsys 5900 ULTRIX
SPECmark89	10.5	31.2	31.1	5.6	9.2	22.3	30.7	41.1	51.6	42.1	46.6	19.1	26.5	18.9	25.5	32.4	27.3	32.8
SPECint92												15.8	20.9		20.1	27.3		27.3
SPECfp92			28.6				29.4	39.3	48.7	39.2	45.0	17.5	23.4		23.5	29.9		29.9
SPEC SDM SDET S												62.3		131.2	90.6	222.5	195	233.2
SPEC SDM SDET W												6		10	6	3	4	4
SPEC SDM KENBUS1 S												566.3		965.4	703.7	1212.5	1261.1	1299.3
SPEC SDM KENBUS1 W												64		120	112	150	160	150
LINPACK 100x100 dp	1.5	6.6	6.5	0.8	1.3	4.8	6.7	9.5	12.65	9.8	11.1	2.8	6.0	3.0	5.9	6.0	4.3	6.0
Dhrystone 1.1 instr/sec	14K	33K	33K	9K	16K	25K	33K	39K	46K	39K	42K	47K	60K	38K	61K	76K	57K	76K
Dhrystone 2.1 instr/sec												39K	49K		49K	64K		64K
DN&R Labs MVUPs	16	49.9	50.5	7.7	10.0	36.2	50.9	60.2	73.7	60.3	64.8	27.7	37	22.7	37.1	47.2	33.9	46.9
AIM Perf Rating												15.3		17.5	16.6	33.1	25.9	33.2
AIM Max User Load												136		153	146	249	229	281
Livermore Loops geo m	1.8	6.0	5.9			4.1	6.8	7.1	8.9	7.4	7.8							
SLALOM Patches	377	578	578	274	312	511	583	635	731	647	723							
SLALOM MFLOPS			4.1	0.6	0.8	3.0	4.3	5.3	7.9	5.6	7.6							
Perfect geo m MFLOPS	1.7	4.6	4.7			3.1	4.7	6.1		6.1	7.2							
Whetstone KWIPS sp	21.7	71.4	71.4	66.7	89.3	47.6	71.4	83.3	90.9	88.3	90.9	25.9	33.3	20.6	33.3	42.8	30.9	42.7
Whetstone KWIPS dp	13.9	45.5	45.5	42.7	62.5	32.2	45.5	52.6	66.7	52.6	58.8	20.9	26.6	16.7	26.7	34.5	25.2	34.4
Accessworks # clients	98	151	157	50	85		171	249		252	307							
Khornerstone												32822		29511	39606	53579	82650	50949

Benchmark	VAX 3100 85 VMS	VAX 3100 95 VMS	VAX 4000 105A VMS	VAX 4000 505A VMS	VAX 4000 705A VMS	VAX 6000 410 VMS	VAX 6000 510 VMS	VAX 7000 710 VMS
SPECmark89		41.2	41.2	41.1	57	8.5	15.6	66.6
SPECint92								
SPECfp92	22.7	39	39	39.3	54.4	7.1	13.3	64
SPECrate_fp92	538	926	926	932	1,289			1,483
LINPACK 100x100 dp								
Dhrystone 1.1 instr/sec								
Dhrystone 2.1 instr/sec								
DN&R Labs MVUPs								
AIM Perf Rating								
AIM Max User Load								
Livermore Loops geo m								
SLALOM Patches								
SLALOM MFLOPS								
Perfect geo m MFLOPS								
TPC-A tpsA-Local			181.25 r	185.45 r	280.45 r			314.23 r
TPC-A $/tpc-A-Local			5131 r	5267 r	5011 r			5255 r
Whetstone KWIPS sp								
Whetstone KWIPS dp								
Accessworks # clients								
TPC-B tpsB								
TPC-B $/tpsB								
Khornerstone								

Industry-standard Benchmark Ratings for Digital Equipment Corporation Computers

Benchmark	VAXsta 3100/ 38 VMS	VAXsta 3100/ 76 VMS	VAXsta 4000 VLC VMS	VAXsta 4000/ 60 VMS	VAXsta 4000/ 90 VMS	DECsta 5000/ 20 ULTRIX	DECsta 5000/ 25 ULTRIX	DECsta 5000/ 33 ULTRIX	DECsta 5000/ 50 ULTRIX	DECsta 5000/ 125 ULTRIX	DECsta 5000/ 133 ULTRIX	DECsta 5000/ 150 ULTRIX	DECsta 5000/ 240 ULTRIX	DECsta 5000/ 260 ULTRIX
SPECmark89	3.7	6.8	6.2	12.0	32.7	16.3	19.1	26.5		19.3	25.5		32.4	
SPECint92						13.7	15.8	20.9	43.2	16.0	20.1	43.2	27.3	56.9
SPECfp92				10.4	30.2	14.8	17.5	23.4	42.1	17.5	23.5	42.1	29.9	55.6
LINPACK 100x100 dp	0.5	1.1	0.8	1.7	7.3	2.4	2.8	6.0	10.8	3.0	5.9	10.8	6.0	14.2
Dhrystone 1.1 instr/sec	11K	22K	19K	30K	66K	38K	47K	60K	151K	47K	61K	151K	76K	182K
Dhrystone 2.1 instr/sec						32K	39K	49K	135K	39K	49K	135K	64K	161K
DN&R Labs MVUPs		10.1	7.4	15.2	57.4	22.8	27.7	37	79.7	26.8	37.1	79.7	47.2	102.3
X11perf Kvectors/sec	214	183	156	365	365	153	339	253	291	434	434	291	445	613
X11perf Mpixels/sec	14.2	14.2	13.4	24.8	24.3	5.7	18.3	8.6	7.9	12.3	12.3	7.9	12.3	30.8
Whetstone KWIPS sp	3.9	8.2	6.4	12.8	31.4	21.0	25.9	73.3	81.8	25.6	33.3	81.8	42.8	98.1
Whetstone KWIPS dp	2.5	5.8	4.1	8.6	22.6	16.9	20.9	26.6	69.0	20.6	26.7	69.0	34.5	83.1
Khornerstone						26689	32822			33731	39606		50949	

Legend: r=rdb, i=informix, s=sybase, o=oracle, K=thousands, M=millions, geo m=geometric mean, sp=single precision, dp=double precision
OSF=DEC OSF/1, VMS=OpenVMS or VAX VMS

Blank cells signify NO AVAILABLE DATA