A Performance Comparison of MSC/NASTRAN V68.2 Through V70.5 Across Multiple Hardware Platforms

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ABSTRACT

There have been enormous advances in both hardware and software technology in recent years. This paper illustrates MSC/NASTRAN performance using several types of analyses with several versions of MSC/NASTRAN on multiple hardware platforms. The purpose of this paper is to inform users of performance enhancements, which are a result of these advances in technology.

INTRODUCTION

This paper attempts to qualify various enhancements made to different systems since version 68.2. Hardware and software technology has been changing at a faster rate than ever before. Users of MSC/NASTRAN are often faced with decisions on upgrading hardware or software. This paper attempts to aid users in making those decisions.

PROBLEM DEFINITION:

Eight hardware platforms were chosen to perform the benchmark tests. These hardware platforms are listed below:

Vendor	Model	O/S Level	Memory	First Sold
CRAY	T90	UNICOS 10.0	1024 Mb	Q1 / 95
Digital	2300 5/300 EV5	UNIX V4.0	1024 Mb	≈ '95
HP	V2250	HP-UX 11.0	4096 Mb	Mar / 98
IBM	590 POWER2	AIX 4.1	128 Mb	≈ '94
Intel	P II/PC 100/350	NT 4.0	512 Mb	Apr / 98
NEC	SX-4	SuperUX 7.2	2048 Mb	Dec / 95
SGI	R10000	IRIX64 6.4	512 Mb	1996
SUN	UltraSPARC 2	SunOS 5.6	512 Mb	Sep / 97

The set of problems used vary in size and solution type. These tests were actual jobs given to MSC by clients. A summary of these tests is given below:

Test	DOF	Description	SOL[1]	N2-D[2]	N3-D[3]	mem	Disk[4]	I/O
smnmf	9,644	Block	111	1,852	7,057	56 Mb	230 Mb	12 Gb
smoop	366	Wedge	200	119	0	40 Mb	190 Mb	29 Gb
mddst	32,184	Wheel	101	6,840	7,632	40 Mb	3 Gb	1 Gb
mdest	30,934	Crank Shaft	101	0	8,888	40 Mb	210 Mb	2 Gb
mdemd	30,934	Crank Shaft	103	0	8,888	40 Mb	290 MB	1 Gb
lgast	68,000	Engine Block	101	8,696	2,469	56 Mb	820 Mb	5 Gb
lgbbk	66,000	Airplane Part	105	11,551	0	64 Mb	360 Mb	9 Gb
lgkmd	65,904	Satellite	103	15,218	0	48 Mb	4 Gb	53 Gb
lgmst	99,191	Gear	103	0	18,681	80 Mb	580 Mb	3 Gb
lgnas	71,559	Airplane Wing	144	14,820	0	400 Mb	830 Mb	3 Gb
vlgst	134,333	T-Joint	101	0	27,081	256 Mb	960 Mb	5 Gb
xldst	606,231	Transmission	101	0	122,284	400 Mb	4 Gb	62 Gb
xlnmd	331,468	Car Body	103	71,914	428	192 Mb	3 Gb	48 Gb
xxcmd	1,519,472	Car Body	103	271,437	0	400 Mb	45 Gb	2 Tb
xxdmd	1,920,855	Engine	103	0	402,441	120 Mw	45 Gb	500 Gb

[1] SOL 101:Linear Statics, 103:Normal Modes, 105:Buckling,
111:Modal Frequency Response, 144:Static Aeroelastic, 200:Design Optimization
[2] N2-D – Number of 2 dimensional elements.
[3] N3-D – Number of 3 dimensional elements.
[4] Hiwater Disk of DBALL, SCRATCH, and SCR300

ANALYSIS

MSC/NASTRAN aggressively pursues performance enhancements. Many of these enhancements are developed internally or purchased from outside companies. Many other enhancements are a result of collaboration with MSC's hardware partners. Enhancements made by each method will be described below:

MSC/NASTRAN Performance Enhancements listed by release of MSC/NASTRAN

V69 (Release Oct/96)

- Memory requirements for the direct sparse solver were greatly reduced in version 69. Many jobs which were limited by memory may now be solved faster (see figure 1).
- The SPARSE solver became the default solver.
- The iterative solver was introduced in version 69. This solver uses much less disk (but more memory) than the SPARSE solver (1).

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V69.1 (Released Jan/97)

- Enhancements were made to the frequency response solutions (SOL 111 / SOL 200).
- Enhancements were made for inertia release in SOL 200.

V70 (Released Jul/97)

- Enhancements were made to improve matrix multiplication methods.
- Enhancements were made to improve LANCZOS eigenvalue solutions.

V70.5 (Released May/98)

- Extreme and Metis reordering became available on all systems.
- Memory requirements for the iterative solver were reduced (2).
- BLAS and LAPACK kernels are being introduced.
- A DMAP modification improved the processing of the Frequency-Dependent Acoustic Absorber Element (CAABSF entry).
- Design optimization data recovery was significantly improved.
- SOL 144 (Static Aeroelastic) runs with more than 50,000 DOF will run faster than in previous versions.

Vendor Performance Enhancements:

Cray

- EAG FFIO was introduced in V68.2 to reduce elapsed time.
- Cray Optimized triple loop kernels in MPYAD in V69 (DOT3RD).
- Extreme reordering was introduced in V69.1. It became the default in V70.
- Cray/SGI **only** decomp/REIGL kernels were tuned in V70.
- Cray/SGI **only** changes were made to the new READ module in V70.5.

Digital

- Version 68.2 was compiled to optimize code for the EV-5 instead of the EV-4.

HP

- All kernels were rewritten in V69 to allow for better performance and to allow for parallel processing.
- Version 69 was compiled for S-Class systems.
- Version 69 was compiled for PA-RISC 1.1 OS 10.2 and PA-RISC 2.0 OS 10.2.
- Version 70 was also compiled for a PA-RISC 2.0 OS 11.0.
- Version 70 was compiled for V-Class systems.
- Metis reordering was introduced in V70.0.3 (but was not the default).

IBM (AIX)

- A separate POWER2 version became available starting with version 68.2.
- Large file support was added in V70.5 (not performance related).

Intel

- The Intel compilers were used starting with V69. This new compiler resulted in a direct performance improvement around 5-10%.
- Dynamic memory allocation was allowed in V70.5. Previous versions were limited to 100 Mb.

NEC

- V68.2 was compiled for scalar optimization. V69 was compiled for vector optimization. It is unknown if this change helped performance.
- V68.2 was compiled for the SX-3, V69.1 was compiled for the SX-4.
- HPIO was introduced in V69 to reduce elapsed time.
- NEC **only** changes were made to design optimization code (NVH) in V70.5.

SGI

- Extreme reordering was introduced in V69.1. It became the default in V70.
- Version 70 was compiled for the R10 (previously was R8).
- EAG FFIO was introduced in V70.5 to reduce elapsed time.
- Cray/SGI **only** changes were made to the new READ module in V70.5.

SUN

- All kernels were rewritten in V69 to allow for better performance and to allow for parallel processing.
- Compiler optimizations were increased in V69 (including an UltraSPARC as well as a SuperSPARC version).
- Metis reordering was introduced in V70.0.3 (but was not the default).
- Additional updates were made to complex parallel kernels in V70.0.0.
- Large file support was added in V70.5 (not performance related).

DISCUSSION

CPU (User + System) times are plotted on figures 2 to 16. Below is a discussion of some of the peculiarities with the data.

SMNMF

· SMNMF is much faster in V70.5 than in V70 because of a DMAP (CAABSF) enhancement.
· An HP S-Class system with an OS level of 5.1 will be up to 5 times slower on this problem than on one running an OS level of 5.2 due to the large page enhancement in 5.2.

SMOOP

· SMOOP is much faster in V70.5 than in V70 because of the implementation of the design optimization data recovery enhancement.
· Most of the design optimization code is SCALAR. Cray and NEC (VECTOR machines) do not perform well with SCALAR code. Cray and NEC are reviewing this performance issue at this time.

MDDST

· 68.2 to 69 performance improvements were a result of the implementation of SPARSE Decomp.
· Most of the time was spent in SCALAR code on the NEC and Cray. Consider the following table of CPU time spent in various MODULES for the 70.5 runs:

Module	Cray	NEC	SGI
OFP	36	99	26
SDR2	27	46	20
EMG	19	30	9
DCMP	17	26	37

LGAST

· This test is a Superelement run. It is dominated by FBS (Forward Backward Substitution module).

LGBBK

· Although this problem is slower on several V70.5 systems when compared to the V70 version, the results for buckling overall have improved.

LGKMD

· READ and SMPYAD dominate this job. Therefore, VECTOR systems perform better.

LGNAS

- LGNAS is much faster in V70.5 than V70 because of the SOL 144 enhancement.
- The performance improvement occurred in DECOMP. This improvement occurs on the Cray and NEC, but the percentage improvement is less. Consider the following table of CPU times:

Module	CRAY V70	CRAY V70.5	SGI V70	SGI V70.5
DECOMP	96	1	3110	1
DCMP	23	27	71	74

XLDST

- Cray and SGI had EXTREME reordering in V70, while other systems did not get that enhancement until V70.5.

XLNMD

- This job was slower in V70.5 than in V70. V70.5 introduced changes in the real Lanczos algorithm. These changes improve reliability and in some cases performance. MSC has experienced slight performance degradation in a few models, while the general performance has improved.

XXCMD

- This job could only be run on a few systems. It has 2 **terabytes** of IO transferred.
- Intel times for this report were from an IBM Intellistation. A new DELL computer was received and numbers for this PC are below.
- Although elapsed times have not been discussed in this report, for small problems, the elapsed and CPU times are very similar. Elapsed times on PCs are much greater for larger problems.

System	User	System	Elapsed	Comments
Cray	12,772	751	16,514	Non Dry system
Nec	19,288	1,633	25,788	
HP	104,988	30,592	140,421	
Intel	213,083	17,639	466,773	IBM Intellistation PII/350 MHz 512 Mb
Intel	174,852	14,095	262,413	DELL WS 610 400MHz 1GB (fast disks)

MISC

- An IBM RS/6000 Model 590 system (5 years old) was used in these tests.
- Additional performance information may be found at: http://www.macsch.com/tech/performance.

CONCLUSIONS

MSC/NASTRAN has pursued performance improvements with each release. The impact of these improvements varies greatly depending on the user's application. The main focus of this paper was to compare performance of various versions of MSC/NASTRAN.

The results presented here are based on MSC's available resources. Performance is a function of the user's application and available resources and may vary compared to what is presented here. Elapsed time comparisons were also not presented. Users should consider their own requirements and resources when performing any comparisons.

ACKNOWLEDEMENTS

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References:

1. *MSC/NASTRAN Release Guide, Version 69,* The MacNeal-Schwendler Corporation, Los Angeles, CA, 1996.
2. *MSC/NASTRAN Release Guide, Version 70.5*, The MacNeal-Schwendler Corporation, Los Angeles, CA, 1998.

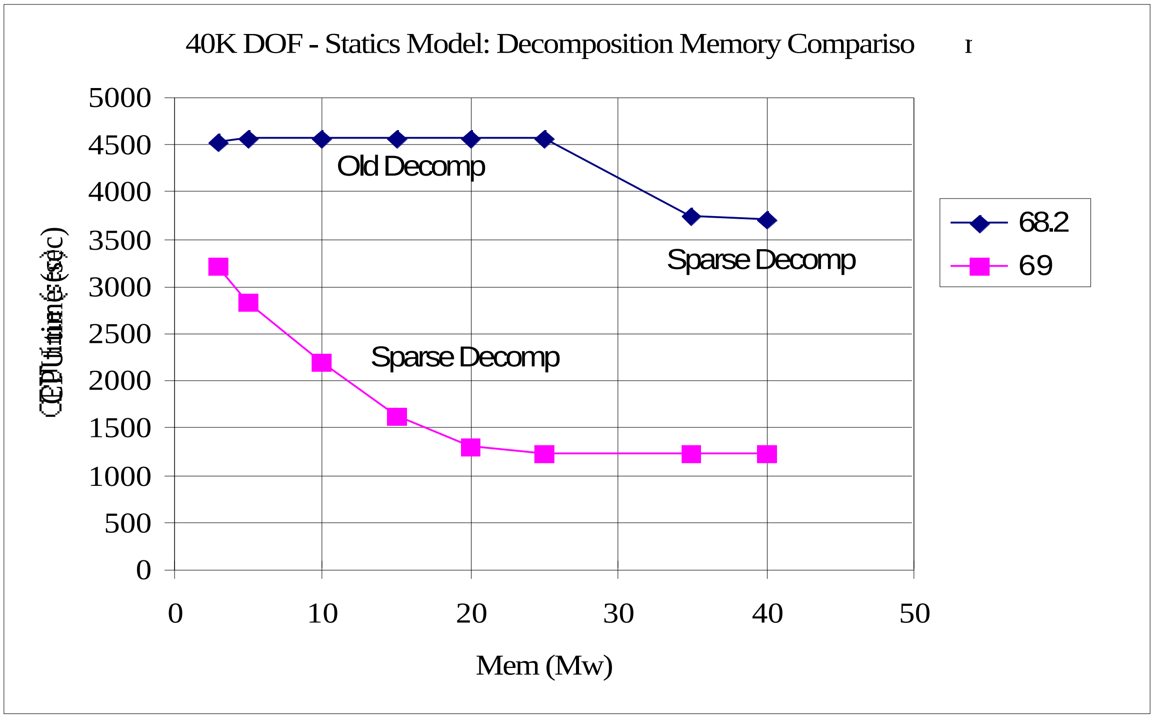

Figure 1. Comparison of CPU Times Varying Memory. *Effect of SPARSE Decomposition enhancements demonstrated. Version 68.2 required 35Mw for SPARSE decomposition. Version 69 allows SPARSE Decomposition over the entire curve.*

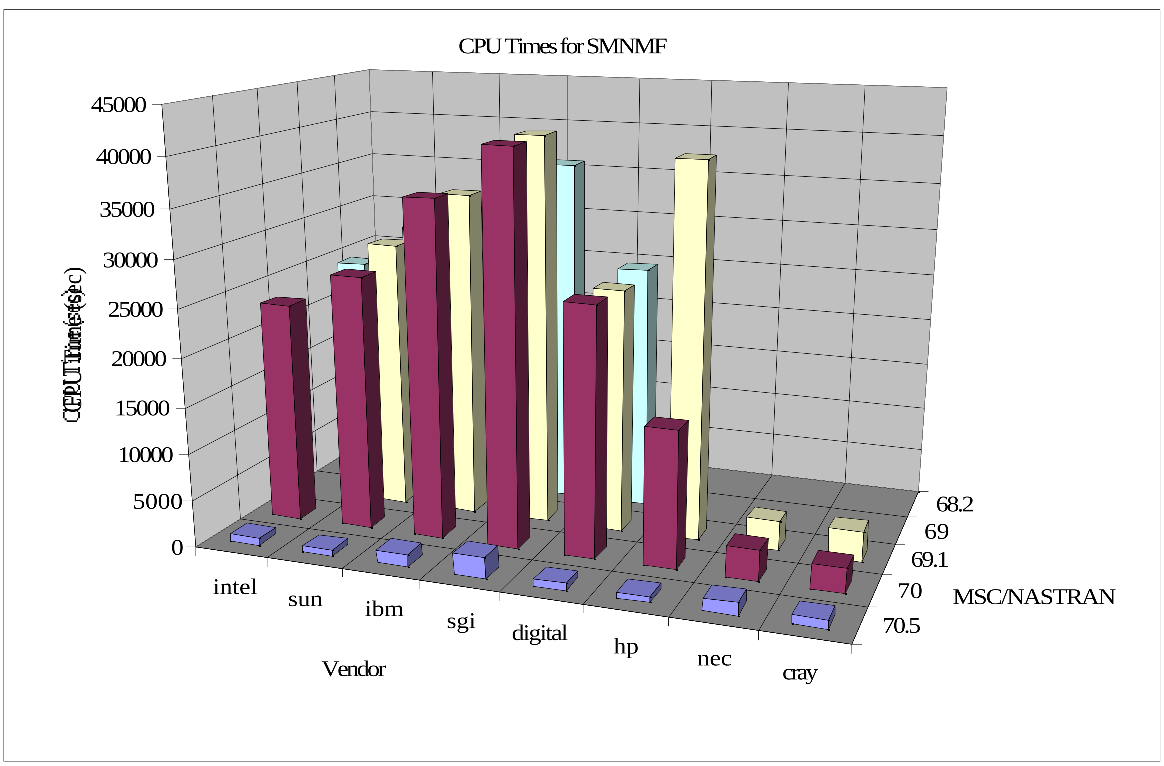

Figure 2. CPU times for SMNMF. *This test illustrates the Frequency-Dependent Acoustic Absorber Element (CAABSF) enhancement introduced in V70.5.*

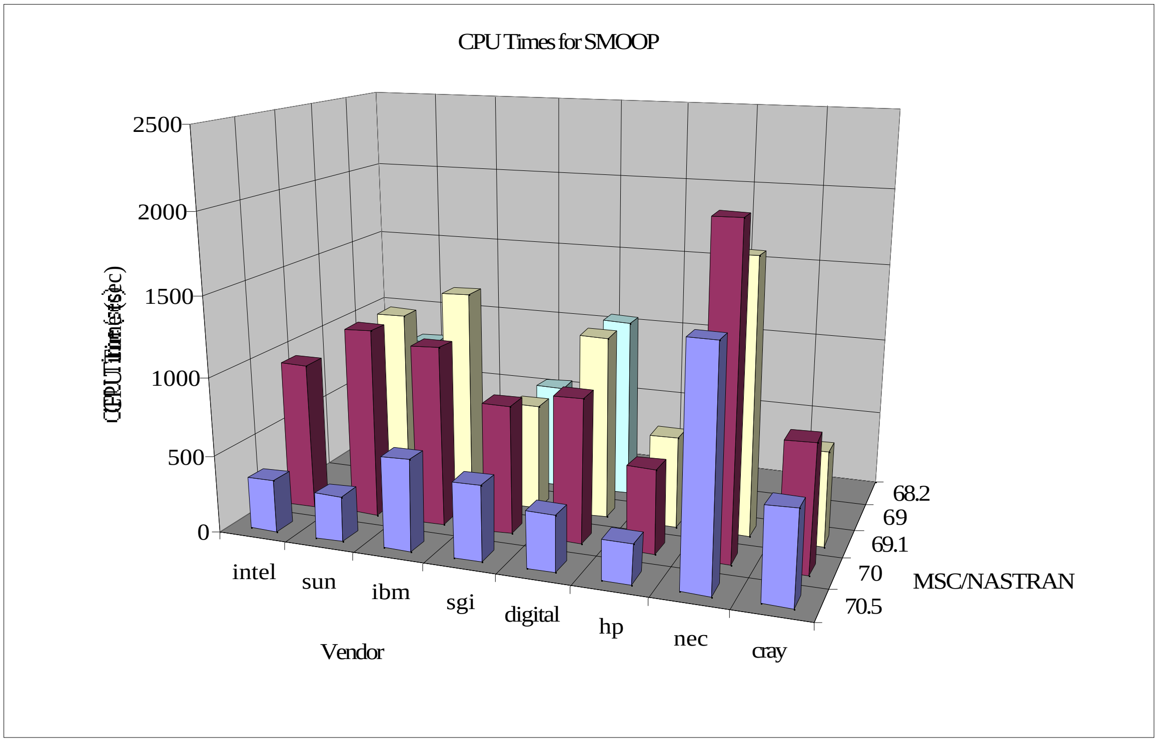

Figure 3. CPU times for SMOOP. *This test illustrates the design optimization enhancement introduced in V70.5.*

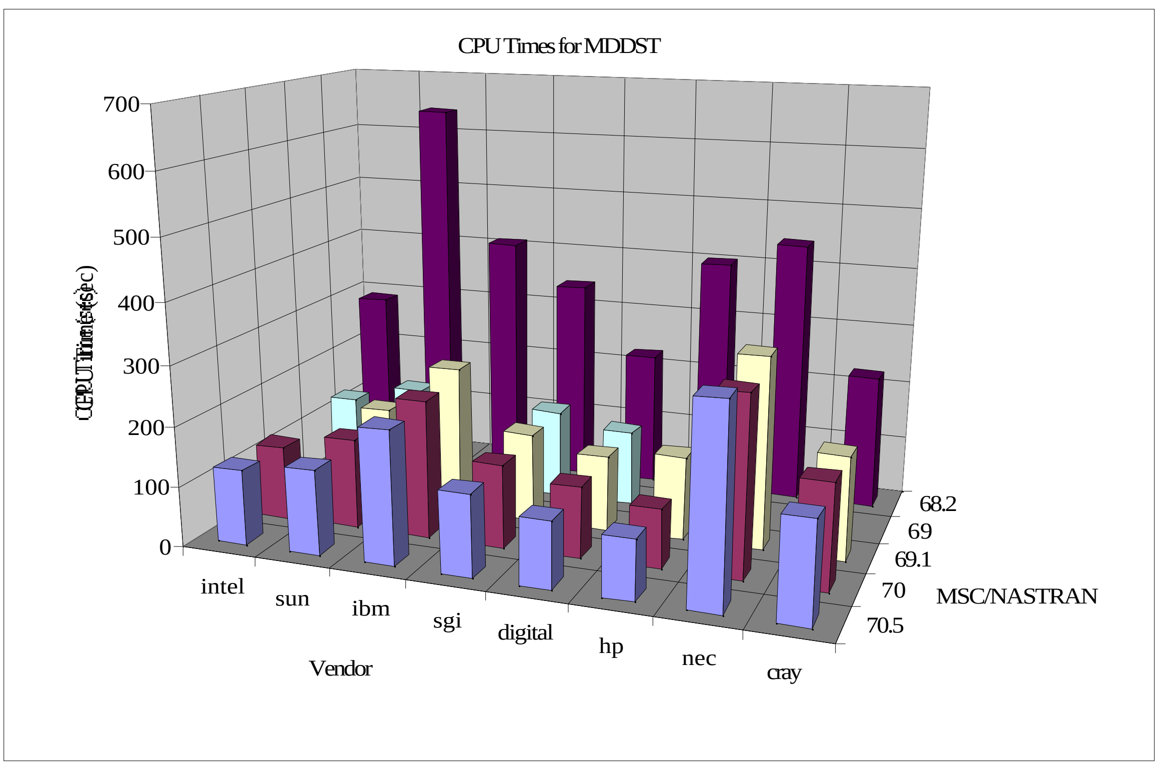

Figure 4. CPU times for MDDST. *This test has lots of output requests to the F06 file.*

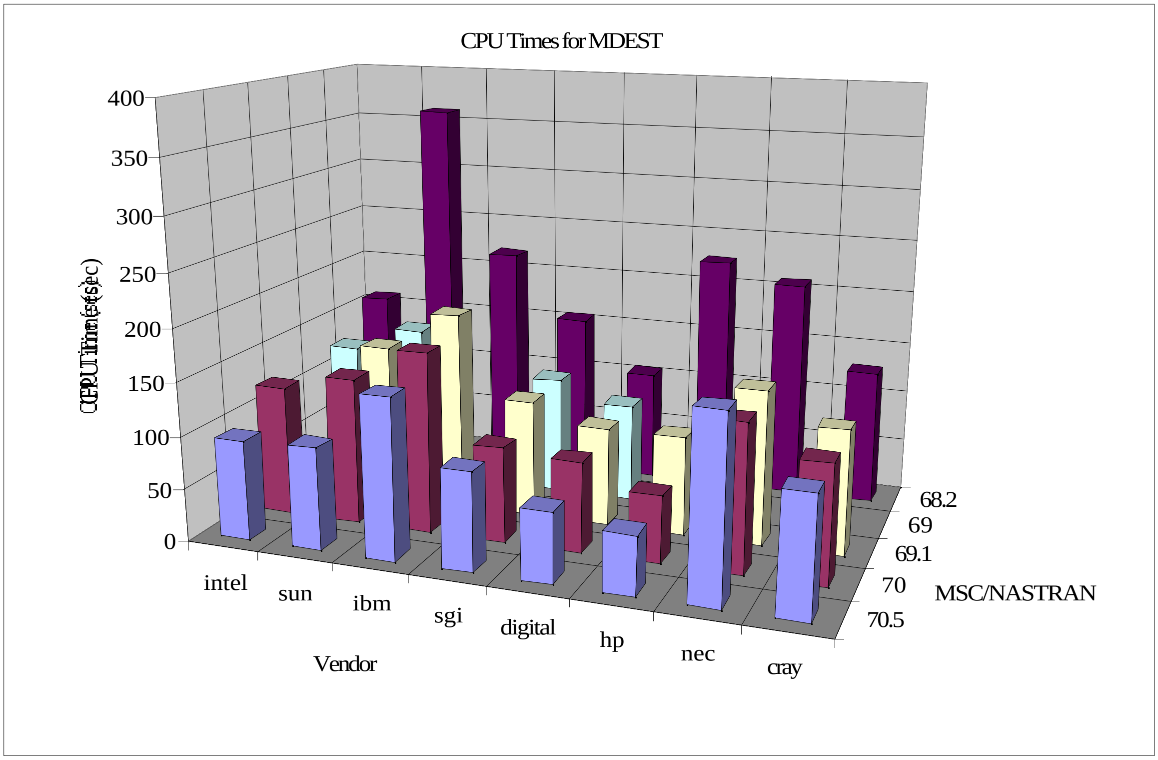

Figure 5. CPU Times for MDEST.

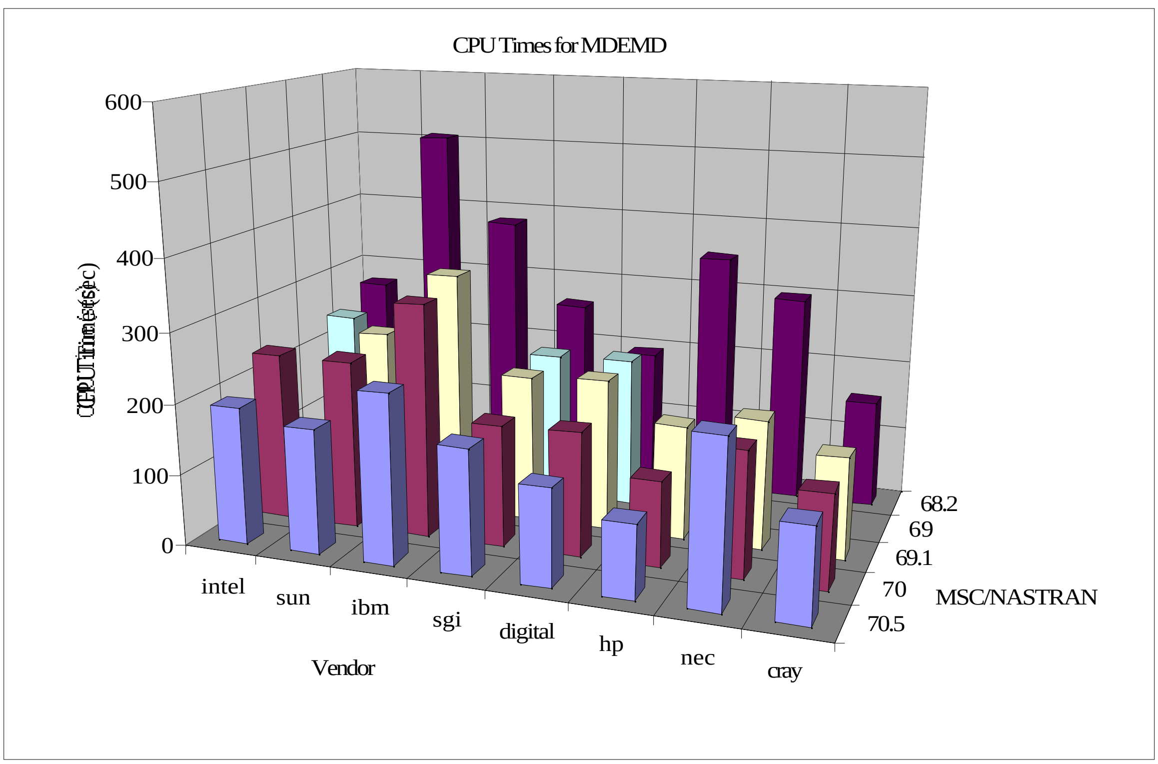

Figure 6. CPU Times for MDEMD.

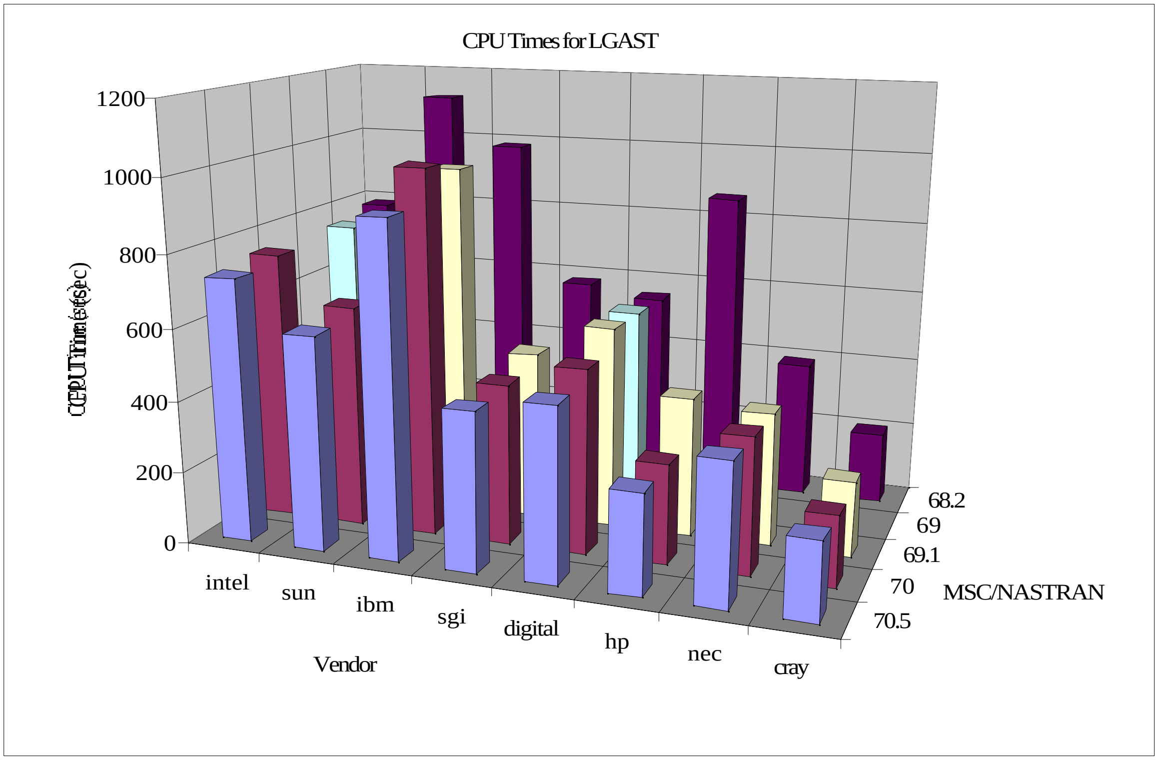

Figure 7. CPU Times for LGAST. *This test is a superelement test case*

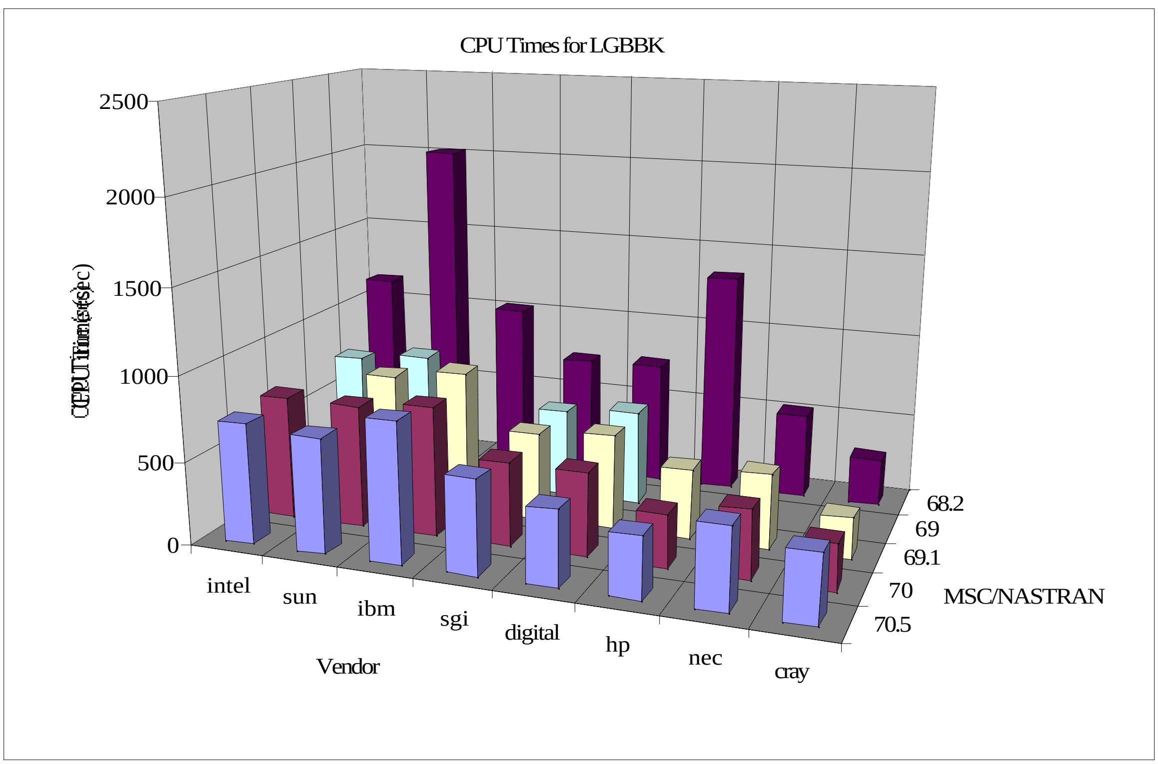

Figure 8. CPU Times for LGBBK.

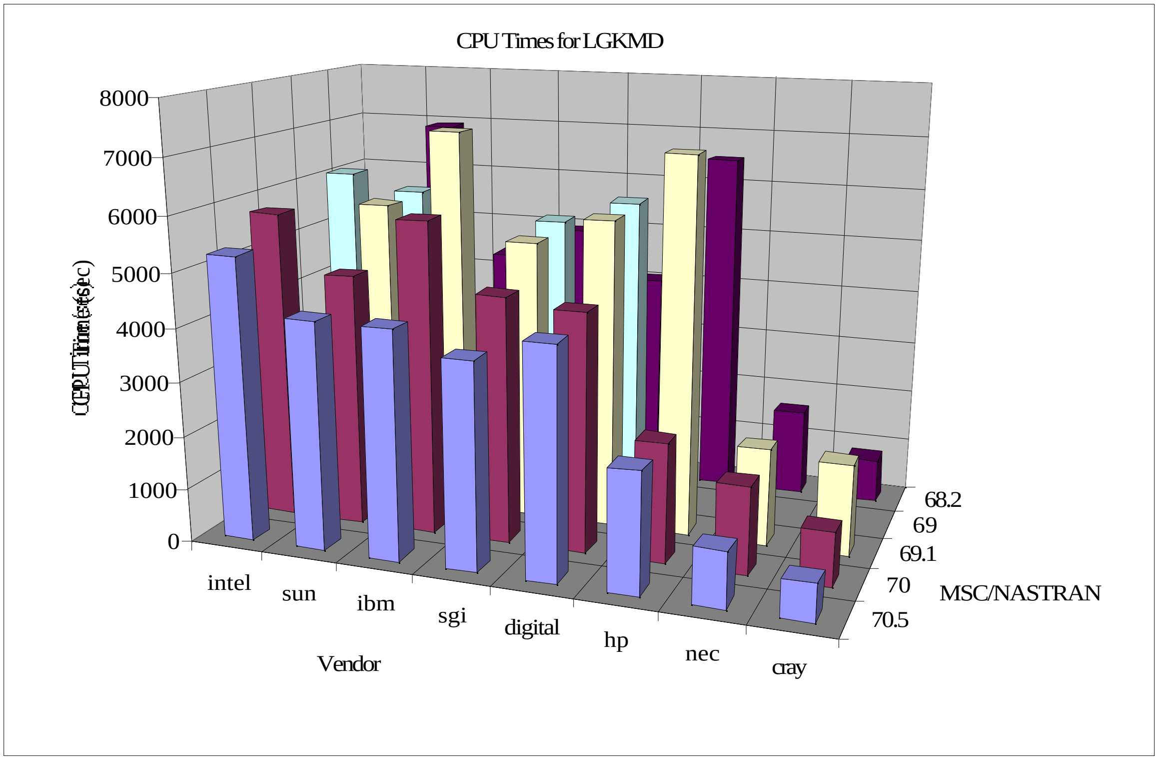

Figure 9. CPU Times for LGKMD. *The READ and SMPYAD modules dominate this test.*

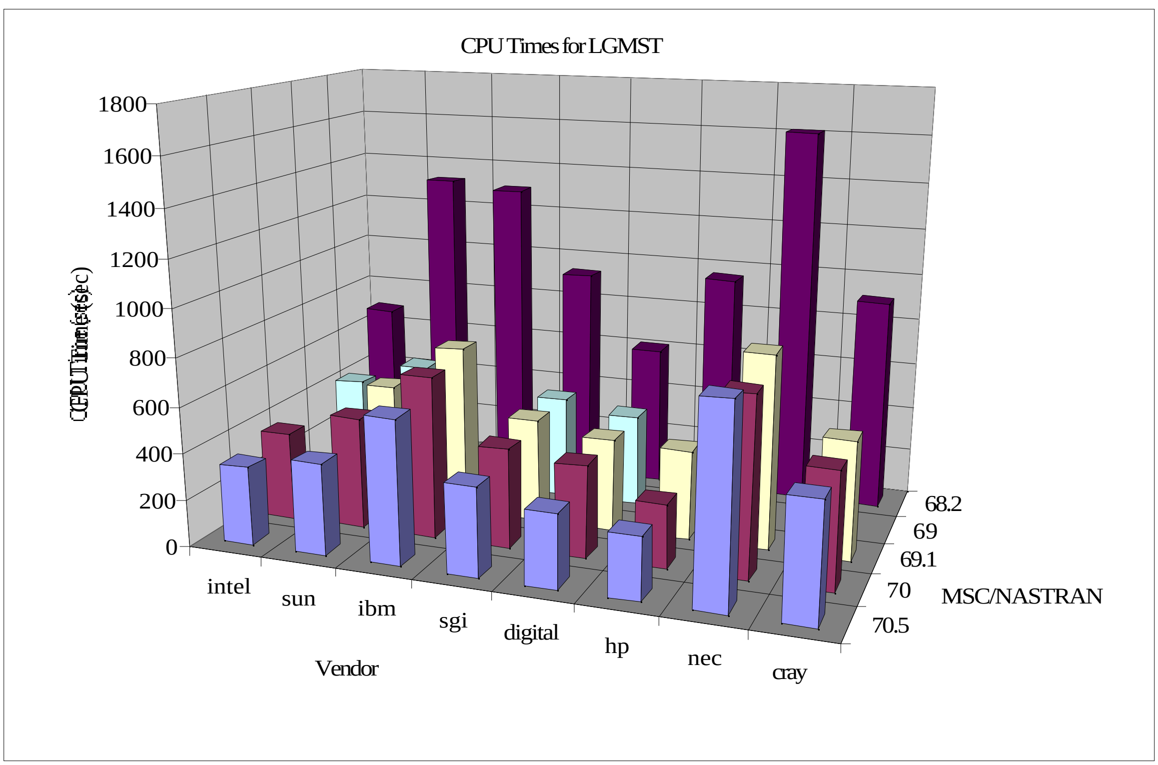

Figure 10. CPU Times for LGMST.

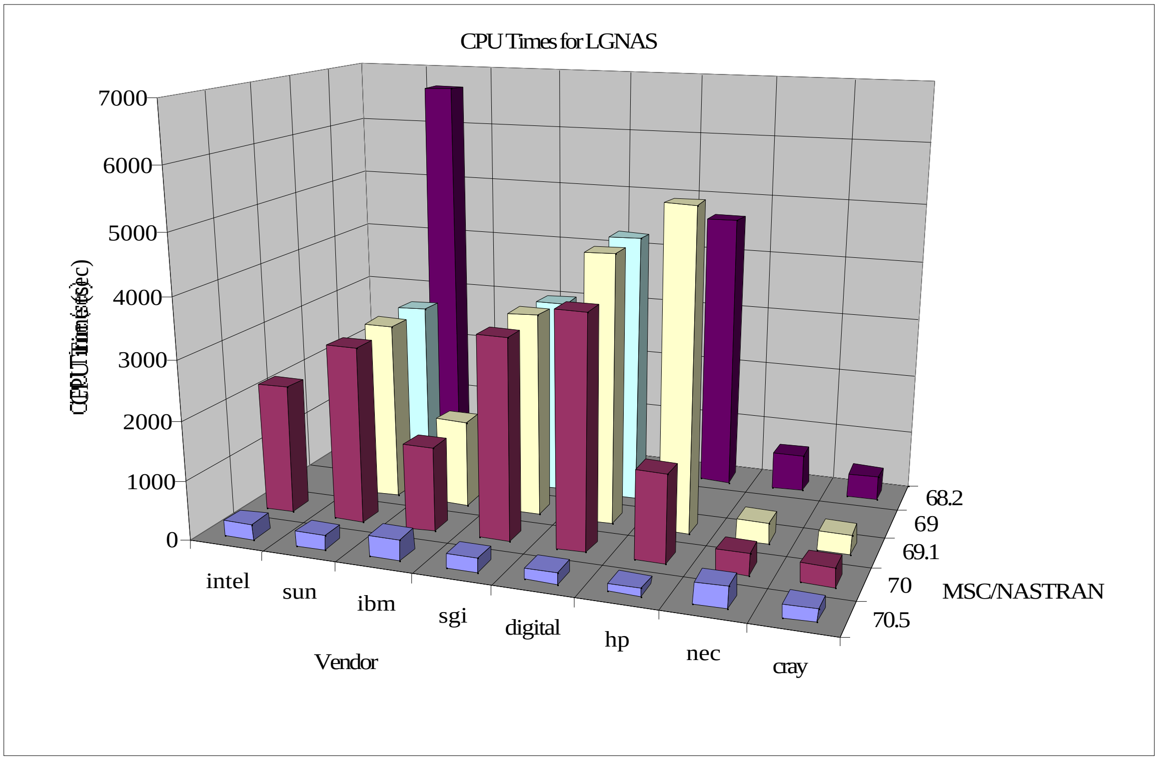

Figure 11. CPU Times for LGNAS. *This test illustrates the SOL 144 performance enhancements.*

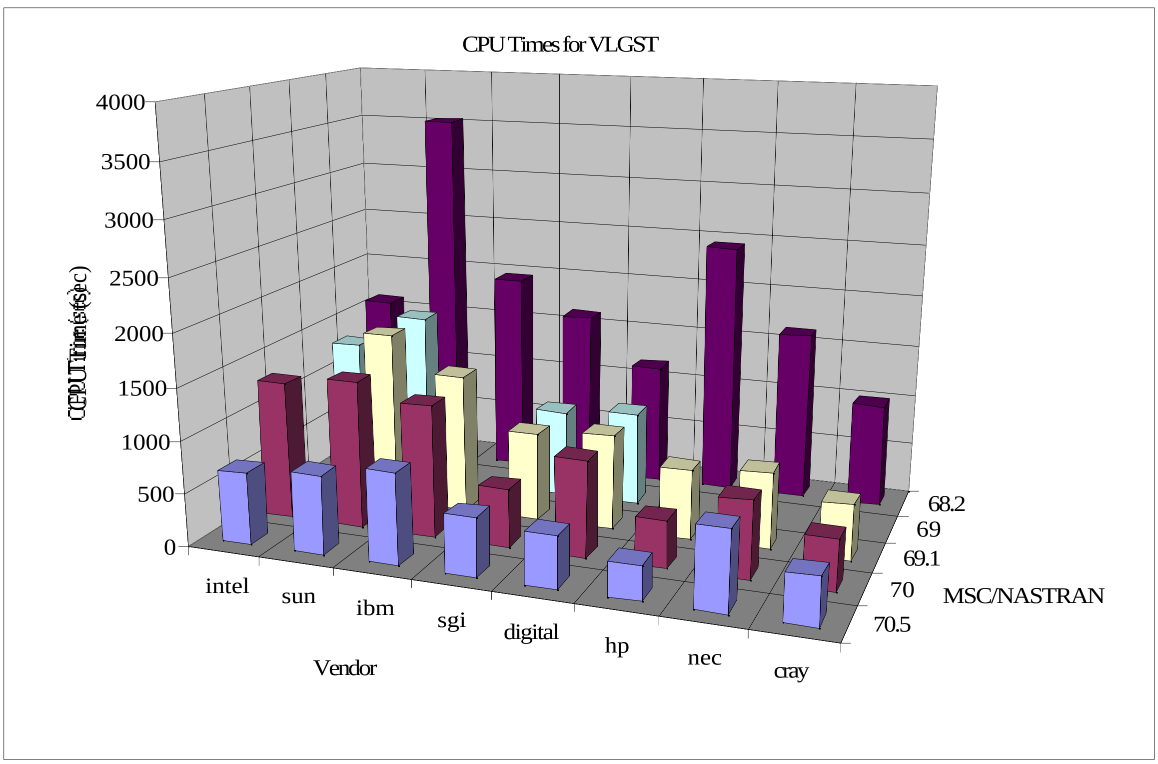

Figure 12. CPU Times for VLGST. *This test is used in the Iterative Solver presentation.*

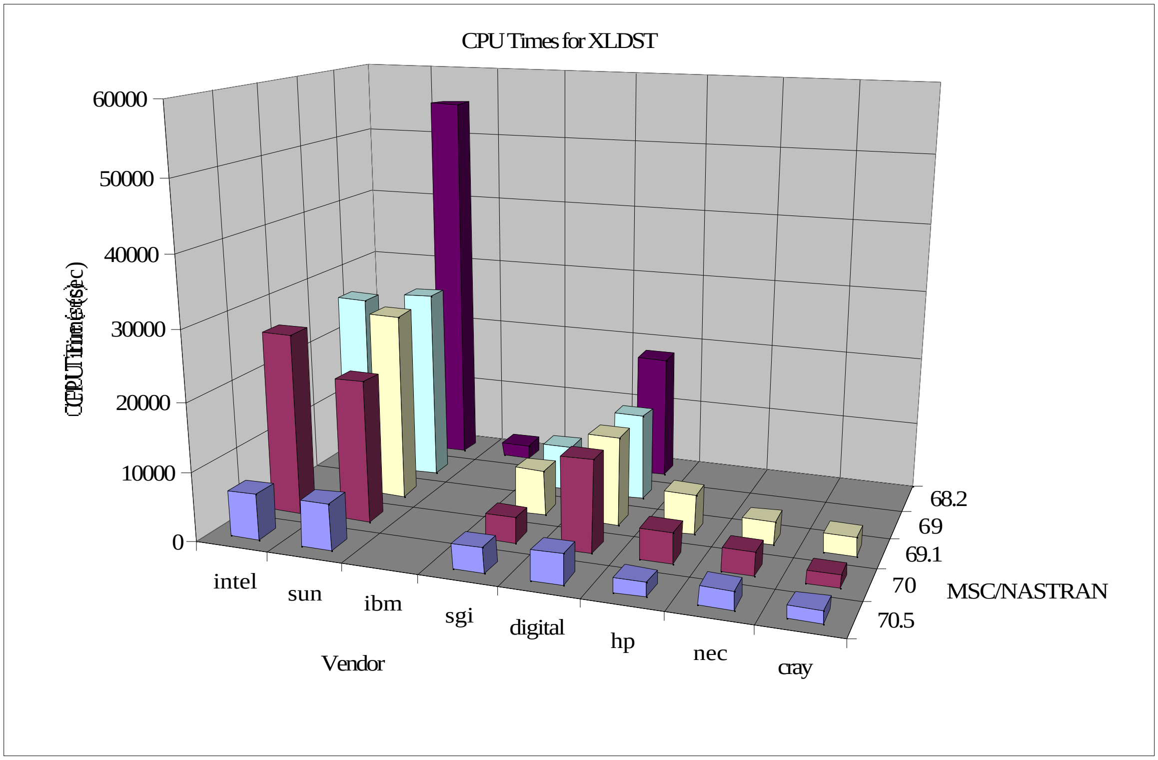

Figure 13. CPU Times for XLDST. *This test illustrates EXTREME reordering.*

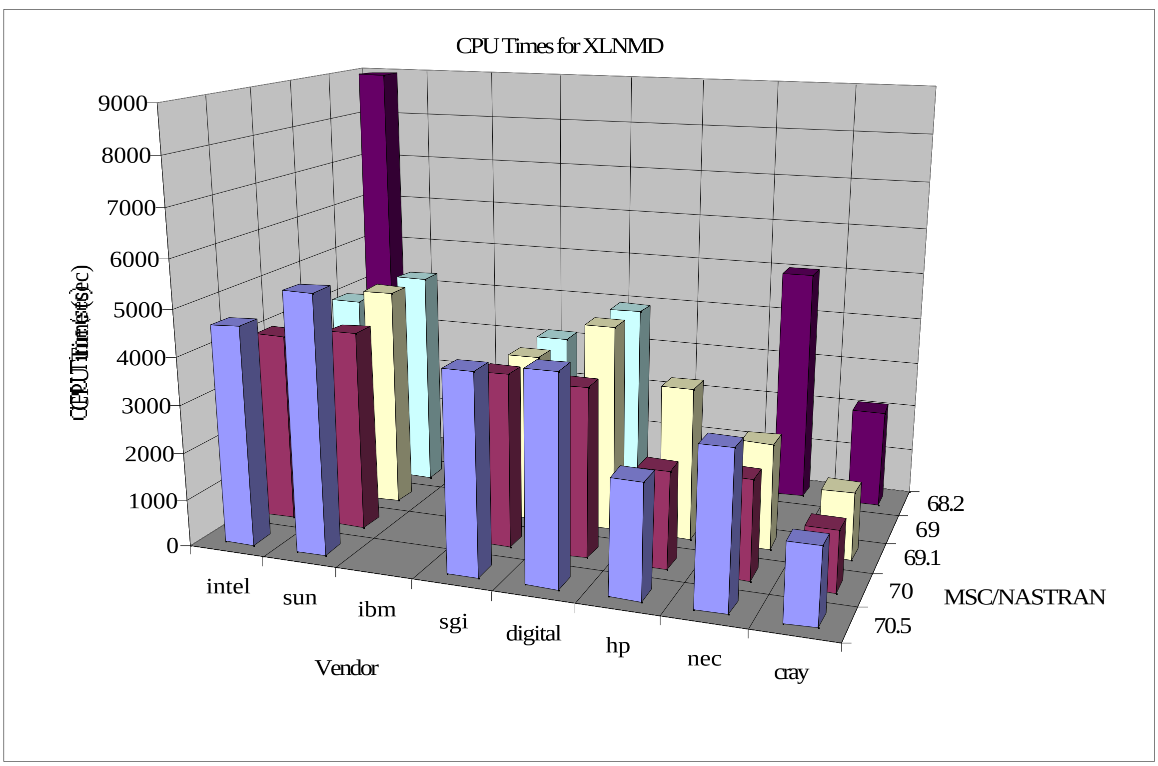

Figure 14. CPU Times for XLNMD.

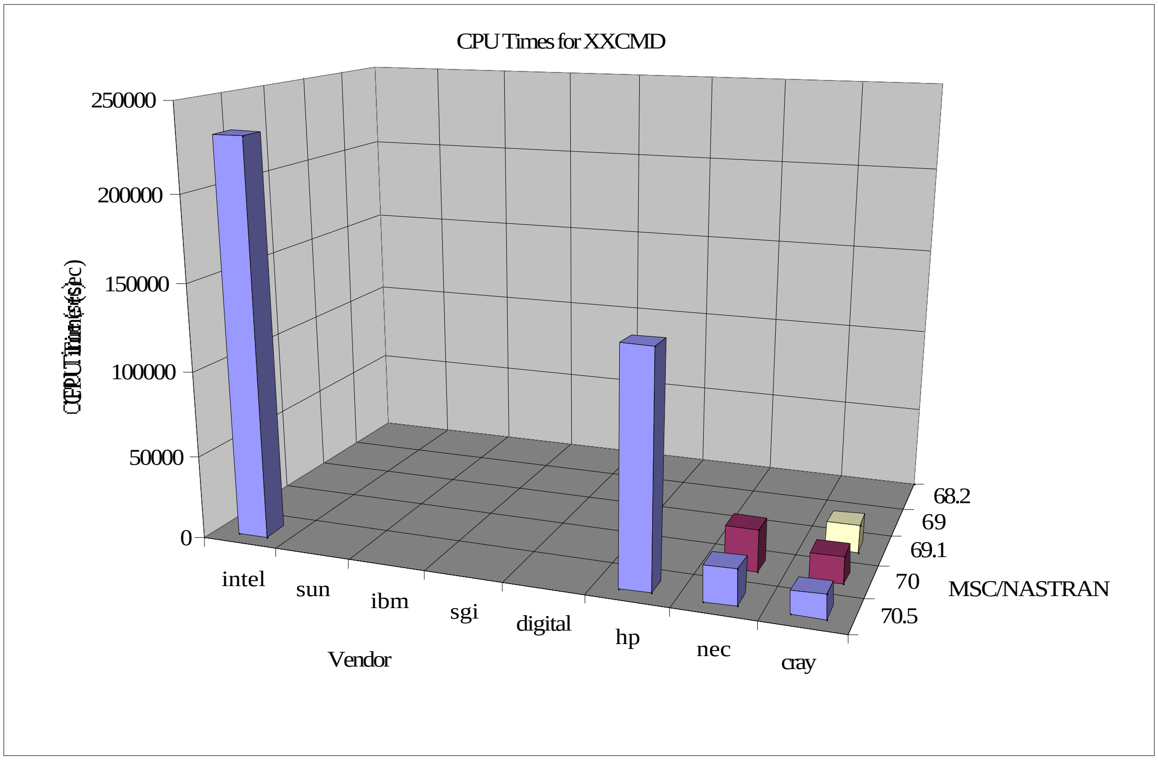

Figure 15. CPU Times for XXCMD. *This test is a large SOL 103 run with 1076 modes.*

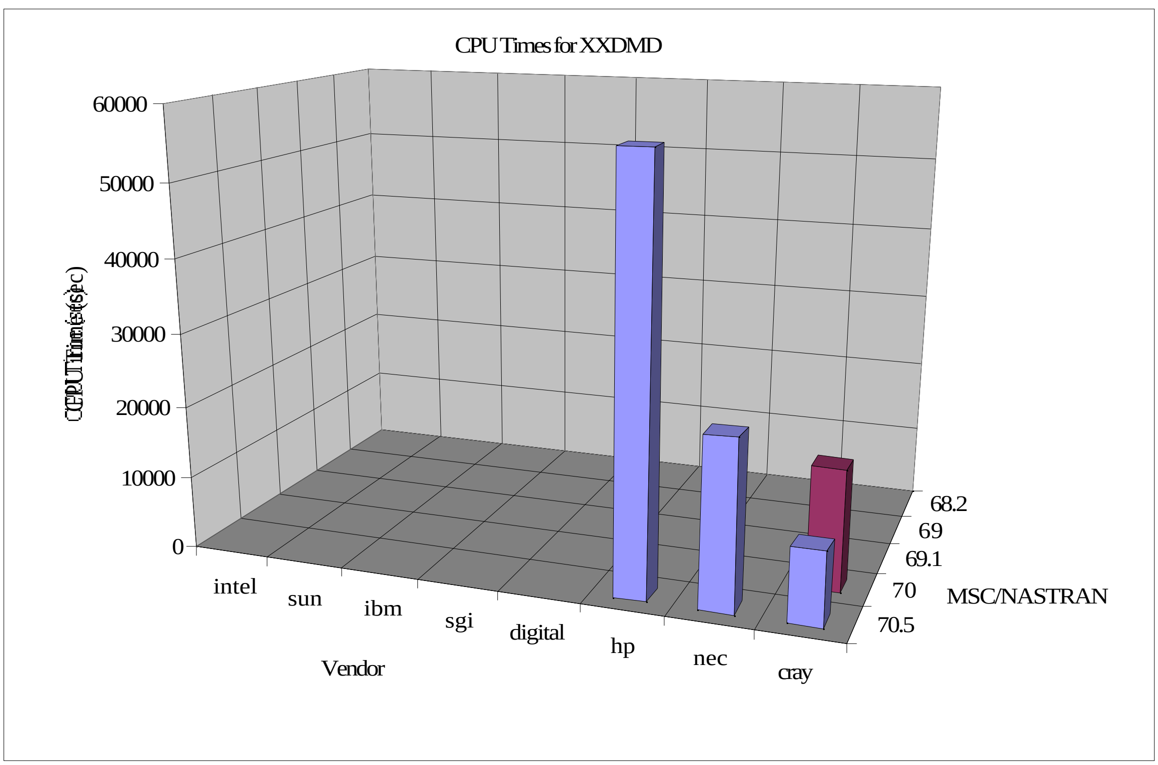

Figure 16. CPU Times for XXDMD. *This test is a large SOL 103 run with 17 modes.*