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I. INTRODUCTION

The performance of seven computer platforms has been evaluated with the MCNP4A Monte Carlo radiation transport code.[1] For the first time we report timing results using MCNP4A and its new test set and libraries. Comparisons are made on platforms not available to us in previous MCNP timing studies. By using MCNP4A and its 25-problem test set, (1) a widely-used and readily-available physics production code is used; (2) the timing comparison is not limited to a single "typical" problem, demonstrating the problem dependence of timing results; (3) the results are reproducible at the more than 100 installations around the world using MCNP; (4) comparison of performance of other computer platforms to the ones tested in this study is possible because we present raw data rather than normalized results; and (5) a measure of the increase in performance of computer hardware and software over the past two years is possible.

The computer platforms reported are the Cray-YMP 8/64, IBM RS/6000-560, Sun Sparc10, Sun Sparc2, HP/9000-735, 4 processor 100 MHz Silicon Graphics ONYX, and Gateway 2000 model 4DX2-66V PC.

In 1991 a timing study[2,3] of MCNP4, the predecessor to MCNP4A, was conducted using ENDF/B-V cross-section libraries, which are export protected. The new study is based upon the new MCNP 25-problem test set which utilizes internationally available data. MCNP4A, its test problems, and the test data library are available from the Radiation Shielding and Information Center (RSIC) in Oak Ridge, Tennessee, or from the NEA Data Bank in Saclay, France. Anyone with the same workstation and compiler can get the same test problem sets, the same library files, and the same MCNP4A code from RSIC or NEA and replicate our results. And, because we report raw data, comparison of the performance of other computer platforms and compilers can be made.

II. THE MCNP COMPUTER CODE

MCNP is a general purpose Monte Carlo code for calculating the time-dependent continuous-energy transport of neutrons, photons, and/or electrons in three dimensional geometries.[1] The code has many applications: reactor design, criticality safety, shielding and safeguards, detector design and analysis, health and medical physics, aerospace and defense applications, radiotherapy, radiography, waste disposal, and decontamination and decommissioning.

The latest MCNP version is MCNP4A. MCNP4A differs from its predecessor, MCNP4, in that it has X-Windows graphics, PVM multitasking, dynamic memory adjustment on workstations, new sophisticated statistical analysis of answers, ENDF/B-VI physics, extended photon libraries, and many more new features. For this timing study the fastest options were chosen, such as no dynamic memory adjustment, and the fastest graphics for each system. All runs were in single processor mode, not exploiting the MCNP multitasking capabilities.

III. TIMING STUDY RESULTS

The running times for the twenty-five MCNP4A test problems on the seven machines are presented in Table 1. All runs are for a single processor.

The average running times for each system relative to the Cray are: IBM RS/6000-560 = 1.47, Sun Sparc10 = 1.51, Sun Sparc2 = 4.22, HP/9000-735 = .67, Silicon Graphics ONYX = 1.11, and Gateway PC = 3.66. These relative running times weight each of the 25 test problems equally. The ratios of the average running times (at the bottom of Table 1) weight the test problems according to how long they ran. These ratios are IBM RS/6000-560 = 1.43, Sun Sparc10 = 1.48, Sun Sparc2 = 4.06, HP/9000-735 = .66, Silicon Graphics ONYX = 1.08, and Gateway PC = 3.55.

Table 1 shows that MCNP runs 50% faster on the HP/9000-735 scientific workstation than on the Cray supercomputer, which indicates two things. First, workstation hardware has come a long way since the Cray YMP was delivered in 1988. Second, MCNP does not take advantage of the vector processing on the Cray. The Cray still significantly outperforms workstations with vectorized computer codes.

TABLE 1

MCNP4A RUNNING TIMES USING MCNP4A TEST SET (cpu minutes)

Test Problem	Cray YMP	IBM RS/6000	Sun Sparc10	Sun Sparc2	HP-735	SG ONYX	Gateway PC
01	0.07	0.12	0.14	0.36	0.05	0.10	0.30
02	0.24	0.40	0.47	1.17	0.17	0.31	0.97
03	0.56	0.73	0.67	1.92	0.33	0.48	1.68
04	0.53	0.86	0.97	2.86	0.36	0.74	2.46
05	0.31	0.56	0.49	1.80	0.28	0.42	1.31
06	0.16	0.25	0.26	0.74	0.10	0.20	0.62
07	0.53	0.77	0.73	2.05	0.35	0.56	1.78
08	0.26	0.42	0.42	1.25	0.22	0.33	1.13
09	0.28	0.37	0.41	0.96	0.16	0.25	0.86
10	0.14	0.25	0.23	0.73	0.12	0.19	0.63
11	0.32	0.41	0.47	1.27	0.18	0.37	1.17
12	0.85	1.30	1.29	3.44	0.62	1.03	3.16
13	0.36	0.41	0.45	1.30	0.17	0.29	1.07
14	0.43	0.46	0.51	1.18	0.21	0.34	1.11
15	0.09	0.13	0.11	0.33	0.05	0.08	0.31
16	0.61	0.84	0.95	2.19	0.36	0.52	1.71
17	0.24	0.37	0.37	0.97	0.18	0.28	0.94
18	0.87	1.03	1.00	2.73	0.43	0.73	2.62
19	0.36	0.66	0.53	1.62	0.27	0.52	1.34
20	0.49	0.70	0.78	2.44	0.44	0.64	2.02
21	0.31	0.47	0.52	1.45	0.19	0.31	1.27
22	0.33	0.49	0.40	1.43	0.20	0.30	1.29
23	0.38	0.58	0.63	1.87	0.35	0.49	1.61
24	0.66	0.85	1.03	2.13	0.37	0.66	1.98
25	0.18	0.24	0.27	0.62	0.10	0.18	0.55
Total	9.55	13.67	14.10	38.83	6.27	10.33	33.89

The Sparc10 model 41 results were run with both the Solaris 2.2 operating system with the F77-2.0.1 compiler (shown in Table 1) and the older 4.1.3 operating system with the F77-1.4 compiler (not shown). Performance was 9% - 14% better with the newer operating system and compiler. A 2% improvement in performance on the Cray YMP was also observed due to newer compiler and UNICOS operating system versions.

The Sun Sparc2 was included for comparison to the 1991 timing study.[3] Table 1 shows that the Cray YMP was 4.2 times faster than the Sun Sparc2. In 1991 it was 3.8 times faster.[2] The difference in relative performance is due to differences in the test problems used. The differences in relative performance are not due to MCNP4A/MCNP4 differences, changes in compilers, optimizers, operating systems, or other software, or the choice of data libraries as can be shown by using the old MCNP4 test set and libraries and comparing the results to the published 1991 results.[2]

Problem dependence is further demonstrated in Table 1. For example, on problem 14 the IBM RS/6000-560 is almost as fast as the Cray YMP, but on problem 19 it is almost twice as slow. The Sun Sparc10 is 25% faster than the IBM RS/6000-560 on problem 19 but 21% slower on problem 24. The HP/9000-735 is 2.6 times faster than the IBM RS/6000-560 on problem 15 but only 1.6 times faster on problem 20.

IV. SUMMARY

Scientific workstations continue to improve in quality and performance in comparison to supercomputers, which dominated the industry only a few years ago. The performance ranking from fastest to slowest for MCNP is HP/9000-735, Cray YMP, Silicon Graphics ONYX, IBM RS/6000-560, Sun Sparc10, Gateway 2000 PC, and Sun Sparc2.

The improvements in hardware over the past two years appear modest — only a factor of about 3. Performance enhancements from new compilers and operating systems were less than 15%.

Performance was very problem dependent. The relative performance of two computer systems can change by a factor of two depending upon the problem selected. Clearly computer performance studies that use only a single "typical" problem for a given code can be very misleading.

As computer performance continues to improve and ever cheaper systems like the Gateway 2000 PC become available, the Monte Carlo method will be ever more accessible and useful for solving a wide variety of important science and engineering problems.

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