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Retrospective Study of Performance and Power Consumption of Computer Systems

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Power consumption has become an important factor in the design of high-performance computer systems. The power consumption of newer systems is now published but is unknown for many older systems. Data for only two or three generations of systems are insufficient for projecting the performance/power of future systems. We measured the performance and power consumption of 70 computer systems from 1989 to 2011. Our collection of computers included desktop and laptop personal computers, workstations, handheld devices and supercomputers. This is the first paper reporting the performance and power consumption of systems over twenty years, using a uniform method. The primary benchmark we used was Dhrystone. We also used NAS Parallel Benchmarks and CPU2006 suite. The Dhrystone/power ratio was found to be growing exponentially. The data we obtained indicates that the Dhrystone result and the CINT2006 in SPEC CPU2006 correlate closely. The NAS Parallel Benchmarks and CFP2006 results also correlate. Using the trend of Dhrystone/power that we obtained, we predict that the Dhrystone/power ratio will reach 2,963 VAX MIPS/Watt in 2018, when exaflops machines are expected to appear.

1. Introduction

To predict the performance and power consumption of future systems, it is important to study that of past and present systems. The performance of computer systems was measured using benchmark software that was popular around the time the computer was manufactured. We can compare the performance of systems in the same generation using published benchmark results. However, because the popular benchmark software changes over time, it is difficult to compare systems across generations. In recent years, power consumption has become an important factor in computing. The power consumption of older systems was not measured because it was not considered critical in the design of computer systems until recently.

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We examined 70 computer systems that were manufactured in the years 1989 to 2011 and that include handheld devices, workstations, and a vector supercomputer. We used Dhrystone[31], NAS Parallel Benchmarks[2] (NPB) and CPU2006[16] benchmarks. The power consumption of the systems was measured using electrical testers. This is the first paper to report the power consumption of as many as 70 computers spanning the course of 20 years.

Cooper, Bell, Lin and Rasmussen benchmarked four microprocessors using exactly the same circuitry outside the processor[8]. Our focus is on system performance and system power consumption, rather than those of processor alone. Bailey, Barszcz, Dagum and Simon measured the result of NPB on supercomputers at NASA Ames Research Center in 1993[3]. Our list includes a more recent and a wider range of systems. The power consumption of recent systems has been published using SPECpower benchmarks[26]. However, the published results only include systems marketed recently. As the workload of the SPECpower benchmark runs on a Java virtual machine, it cannot measure the power consumption of systems where Java is not available (e.g., Human68K). Moreover, the optimization levels of Java virtual machine largely depends on the architecture where it runs. We used Dhrystone to measure the power consumption. A comparison of performance/watt on three generations of Google servers has been published[5]. The systems that we tested span many more generations than the servers at Google do. It has been observed that the older versions of SPEC and Dhrystone show similar results[20]. By running them on many configurations, both old and new we found this to be true for latest version of the SPEC benchmark.

We found that the power consumption of desktop and workstation systems has not changed as much as the performance. We also found a close correlation among the results of Dhrystone, NPB and SPEC CPU2006. Finally, we have forecasted the performance-per-watt in the exaflop era.

2. Materials and Methods

2.1 Computers

We examined computers that were available in years from 1989 to 2011. The year of a computer is defined as the year when the configuration of the computer system was made possible. For example, NEC PC-9801RA system was available in 1988 but was upgraded with a Cyrix Cx486DLC processor that was not available until 1992. Hence, the year of the system is 1992. The exact year of availability of systems or components was unclear for some computers so we estimated the year using advertisements in magazine archives.

The processors we benchmarked include Motorola/Freescale 68000 [30], 68030, MPC7447A, MPC7450, i.MX515, IBM PPC601 [6], PPC750 [23], POWER5 [21], Cell BE [7], HP PA-7100LC [25], MIPS R4000 [29], R5000, R12000 [15], DEC EV45 [27], EV56 [4], EV67 [24], Sun microSPARC, microSPARC II, UltraSPARC II [14], UltraSPARC III [18], Intel 80286, 80386, i486 [9], Pentium [1], Pentium III, Pentium D, Core 2 [12], Atom, Core i7, Itanium 2 [28], AMD Am5x86, K6-III [11], K7 [13], K8 [22], K10 [10], Renesas SH-4A, Cyrix Cx486DLC, VIA C3, NEC SX-9, Marvell Feroceon and NVIDIA Tegra 2. Detailed information on the system configurations is available in the Appendix.

2.2 Measuring Power Consumption

The power consumption was measured with a Fluke 336 clamp meter, a Sanwa Supply TAP-TST7 tester or a Metaprotocol UbiWattMeter. The Fluke 336 clamp meter is rated at 2% precision for the voltages we measured. The Sanwa Supply TAP-TST7 is rated at 0.2% and 0.3% precision for the voltage and current. The electrical testers were connected to the AC input of the computer systems.

We measured the power consumption at two states in each system. The first state is the idle state, where the power consumption of the system stabilizes after the computer is turned on. The other state is the running state, where the system is running the Dhrystone benchmark. On laptop systems, the display backlight was turned off during this experiment.

2.3 Performance Benchmarks

We used several benchmark software suites to evaluate the performance of each system. The first benchmark is Dhrystone version 2.1 in C language. This benchmark runs on systems with a smaller amount of memory. On most systems, Dhrystone runs inside the cache memory [32]. Therefore, the resulting measurements of power consumption are based on that of the processor core alone, and the power that is required to communicate with memory chips outside the processor is not measured. A DEC VAX 11/780 is supposed to perform at 1,757 runs/s. We normalized our Dhrystone results to that performance to get *VAX MIPS* equivalent performance metrics.

NPB is a collection of numerical benchmark programs. We used version 3.3.1 to estimate the floating-point performance of the systems. On all systems, we consistently used size A. We found that around 512 MB of memory is required for this problem size in order to obtain any useful results. The NPB figures we used for comparison are geometric means of normalized results (*NPB base ratio*) of individual benchmarks to the results on the Sun Ultra60 (UltraSPARC-II 360 MHz).

The last benchmark suite we used is SPEC CPU2006. These benchmarks share the workload kernel with real applications, and have a larger memory footprint than Dhrystone. CPU2006 requires 1,024 megabytes on 32-bit pointer machines [17]. The large memory footprint prevents the CPU2006 from running on older machines, so our CPU2006 results are limited to machines where sufficient amount of memory was available. The rules for running CPU2006 are defined by SPEC, which we followed on most of the systems. However, on NEC SX-9, we used 'specinvoke' to directly run each benchmark in order to use the job queue on the system.

3. Results

3.1 Dhrystone and Power Consumption

The Dhrystone benchmark confirmed that the processor performance is still increasing over the years (**Fig. 1**). Because Dhrystone runs inside the cache memory on most processors with caches, this improvement is due to the improvement in processor cores and not the supporting circuitry like memory controllers and caches.

The power consumption of mainstream systems is slightly higher on newer systems than on older ones (**Fig. 2**). Larger SMP systems with power consumption higher than 400 W are not plotted. Power consumption of NEC SX-9 is an estimate using one fourth of the power consumption of another SX-9 with 16 processors. We could not measure the power consumption of some machines in the method we used because they operate on batteries or they stopped working during this experiment. The power consumption in the idle state and in the

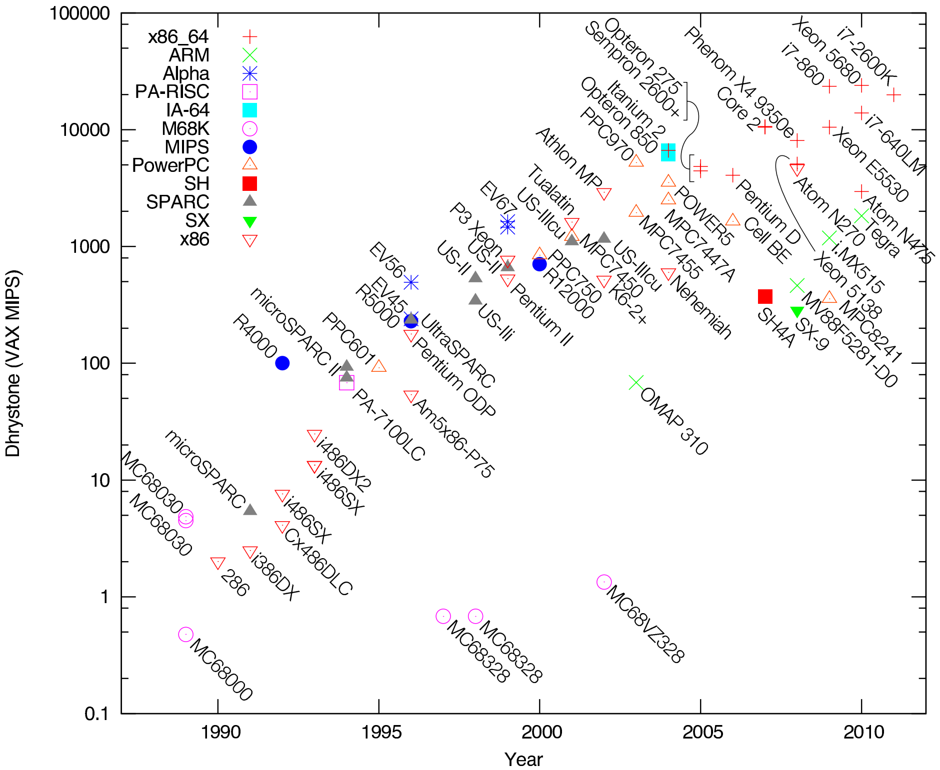

Fig. 1 Dhrystone benchmark.

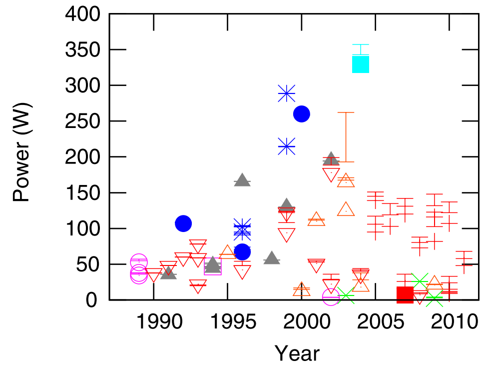

Fig. 2 Power consumption; the error bar represents idle state and running state.

running state changed little on most of the older systems, whereas on the newer systems it changed by dozens of watts. This reflects the power-saving features available on these new designs. As our electrical tester was attached to the AC input of the computer systems, the power consumption includes that of hard drives, graphic controllers, chipsets and other peripheral devices. For example, the SPARCstation 5 with a 85 MHz microSPARC II consumed 5 watts more power than its 110 MHz counterpart. This is attributed to the power consumed by different hard drive models. Even though this makes comparing the result harder, it is useful because it represents the power that a computer system consumes when it is configured as a cluster node or accelerator host. In some older systems, the power consumption in the running state was lower than that in the idle state by one to four watts. We are investigating this issue.

Performance per power consumption is also increasing (**Fig. 3**), but this is driven mainly by performance improvements. Even though the distribution is similar to that of Fig. 1, the high-performance system tends to score low in the performance/power metric. As Dhrystone is a single-threaded benchmark, large SMP systems like Sun Fire 3800 with four threads and IBM p5 570 with 32 threads perform badly in this metric. Multi-core systems would have scored better if we used multithreaded benchmark programs, but newer designs that feature multicore usually also support power-saving features, so the resulting performance/power ratio will not grow as high as the number of processor cores. The highest performance/power ratio is achieved by an Atom N270 (1,600 MHz) netbook with the Intel Compiler Suite 11.1, at 468.36 VAX MIPS/W followed by other portable machines. However, it is important to note that the Atom netbook performed at less than half the performance with GCC 4.5.1 compiler (4,683 VAX MIPS vs. 2,152 VAX MIPS). We will discuss the compiler issues later. Other portables also scored better in this metric.

The trend line on Fig. 3 is calculated using the least square method. As the trend is changed in year 1995, the fitting is based on data in years 1995 to 2011. In year y, the approximate VAX MIPS/Watt is calculated as:

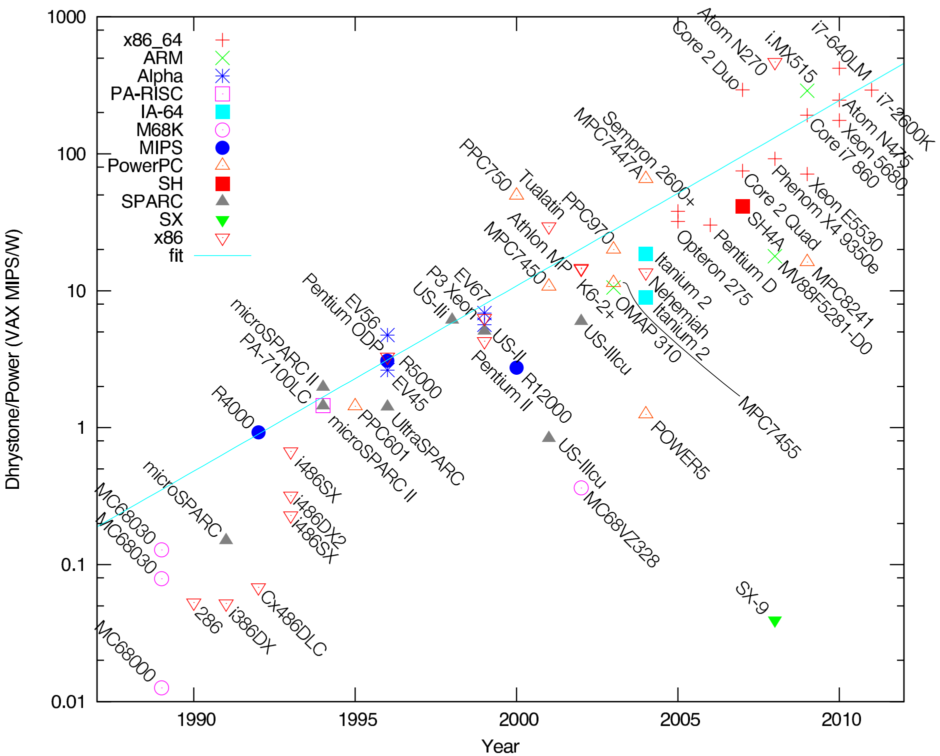

Fig. 3 Dhrystone/power; Dhrystone performance divided by the power consumption in running state. Not all systems shown in Fig. 1 appear in this figure.

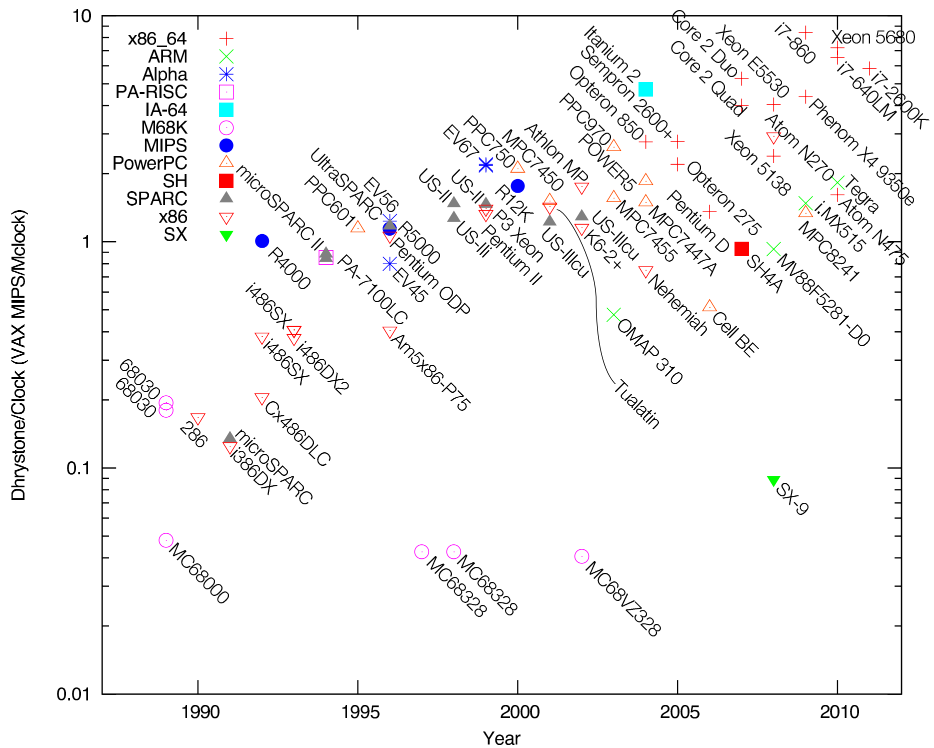

Fig. 4 Dhrystone/clock.

$$dw = \exp(0.31(y - 1988) - 1.35) \quad (1)$$

Using TOP500 projection, it is estimated we will get exaflops systems in about 2018. Using this equation, we can estimate that in the year 2018, the Dhrystone/power ratio of desktop processors will be approximately 2,963 VAX MIPS/Watt if this trend continues. For example, a system with an Intel Atom N475 at 1,833 MHz performs at 2,960 VAX MIPS and its whole system consumes twelve watts of power, so we are going to increase the performance/power to twelve times its current level.

Dividing Dhrystone by the processor frequency yields a performance/cycle ratio (**Fig. 4**). The performance/cycle ratio is largely dependent on the microarchitecture of each processor. The performance/cycle ratio of embedded processors is also improving at a similar rate to those of contemporary desktop and server processors. The high-performance systems are often high performance/cycle systems. However, high-performance/power systems have lower performance/cycle than high-performance systems do. It remains to be seen whether the performance/cycle of high-performance/power systems will also stall for eight years as happened with desktop systems.

The performance of the NEC SX-9 supercomputer was lower than expected on the Dhrystone benchmark, because Dhrystone is hard to vectorize. Numerical

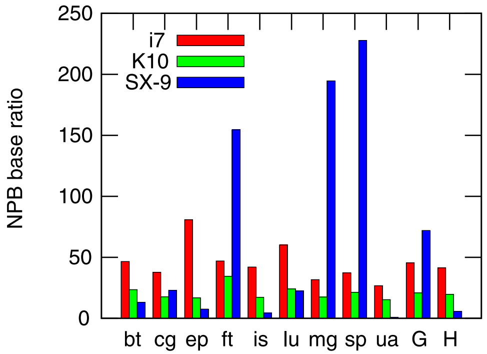

Fig. 5 NPB OpenMP results on Intel Core i7-860@2800 MHz (4 cores/8 threads)/ICC, AMD Phenom 9350e@2000 MHz (4C/4T)/GCC and NEC SX-9 (4C/4T)/SXCC; G: Geometric mean, H: Harmonic mean.

applications such as in NPB, that are not optimized for vector supercomputers, can often be vectorized and run faster than conventional processors like Intel Core i7 (**Fig. 5**). We used OpenMP implementation of the NPB [19]. This characteristic is true for both NPB and CFP2006. The SX-9 performed the best among the systems we tested, in geometric mean metric for all of these floating-point benchmarks. It is expected that for specially-optimized programs the SX-9 will perform even better.

3.2 Relations between Benchmarks

We ran three benchmarks on many computer configurations and the characteristics of these benchmarks are now compared. Not all systems that we tested have a sufficiently large memory space to run CPU2006 or NPB. We ran benchmarks on all machines that satisfied minimum memory requirement for each benchmark. The Dhrystone and the CINT2006 results correlates well (**Fig. 6**). The correlation coefficient is 0.986. Even though it is often considered obsolete, Dhrystone still reflects system performance as well as CINT2006. There were two cases where a machines deviate from the main trend. One case is where Dhrystone performs better than expected from CINT2006 scores, and the other case is where Dhrystone performs worse than CINT2006. Both cases are caused by the dependency of Dhrystone performance on the string functions in the standard C library. Intel compiler links objects against highly optimized string functions

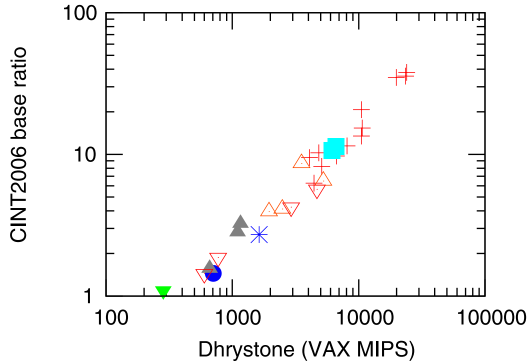

Fig. 6 CINT2006 and Dhrystone.

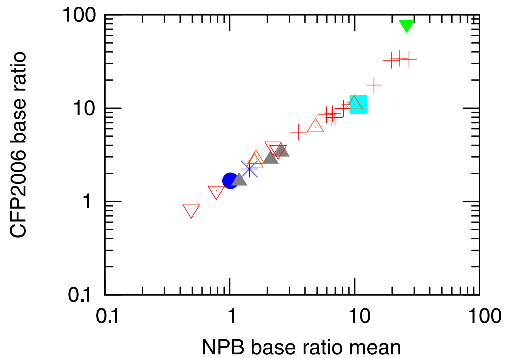

Fig. 7 CFP2006 and NPB base ratio geometric mean.

shipped with the compiler. The performance of string functions in GNU C library differs from version to version, but generally the newer the better. Using the same string manipulation functions will increase the precision of Dhrystone benchmark. The inter-procedure optimization (IPO) in the Intel Compiler Suite also does an excellent job of optimizing Dhrystone whereas IPO is not available in GCC.

NPB and CFP2006 also correlate well (**Fig. 7**). These NPB figures are based on the serial implementation of the benchmark. The correlation coefficient of the geometric mean of the NPB ratio and CFP2006 is 0.878. In the case of SX-9, the performance of a particular program depends almost solely on how much part of the program can be vectorized. Excluding NEC SX-9 raises the figure to 0.979.

4. Conclusion

We measured the power consumption of old and new systems. First, we found that improvement in the performance/power ratio was driven mainly by performance improvements. The embedded processors like the Intel Atom and the ARM have a better performance/power ratio, but still lack the performance to use them in high-performance computers. Secondly, performance/power evaluations revealed that performance/power ratio will improve to only 10 times that of current processors in 2018, when we are scheduled to deliver exaflops systems. Finally, we showed that there are strong correlations between the SPEC CPU2006 benchmarks, the NPB and the Dhrystone. Even though the SPEC CPU2006 is popular as the standard for evaluating system performance, it is large and hard to run in experimental or prototype setups. We showed that the SPEC CPU2006 can be substituted by Dhrystone and NPB in cases where total system performance is to be measured.

Even though further analysis of performance on more specific features of processors requires more benchmarks using computers with similar configurations, running the same benchmark on many different configurations was useful in obtaining an overview of the improvement in system performance. We want to include POWER7 and SPARC64-VIIIfx systems to our list as soon as they became available for our benchmarking. Newer systems should be benchmarked as they emerge to understand where we are and to improve system performance.

Acknowledgments Benchmarks were in part carried out on the NEC SX-9 at Center for Computational Astrophysics, CfCA, of the National Astronomical Observatory of Japan. We thank them for letting us use their system for benchmarking. We are also grateful to Takeshi Watanabe for contributing three computers for this experiment, and Kazuei Hironaka for driving his car to help us transport the computers.

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Appendix

Hardware configurations and power consumption are shown in **Table 1**. 'C' represents the number of processor cores in the system. Versions of the operating system, compilers, and performance results are on **Table 2**.

Table 1 Hardware configurations and power consumption.

Machine	CPU	MHz	C	Mem[MB]	Year	P_{idle}[W]	P_{run}[W]
SHARP X68000 PRO HD	MC68000	10	1	2	1989	38	38
SONY NWS-1460	MC68030, 68882	25	1	16	1989	53	57
Apple Macintosh IIci	MC68030, 68882	25	1	32	1989	34	38
EPSON PC-286UX	286, 287XL	12	1	3	1990	38	38
Sun SparcStation IPX	microSPARC	40	1	64	1991	35	36
NEC PC-9801DA	i386DX, i387DX	20	1	5	1991	48	48
NEC PC-9801RA	Cx486DLC, FasMath	20	1	12	1992	60	60
Fujitsu FM TOWNS II HR	i486SX	20	1	10	1992	48	48
SGI IRIS Indigo R4000	R4000	100	1	320	1992	107	109
EPSON PRO-486	i486DX2	66	1	13	1993	78	78
NEC PC-9821As2	i486SX	33	1	36	1993	59	59
NEC PC-9801BS2	i486SX	33	1	4	1993	22	20
HP 9000 712/80	PA-7100LC	80	1	32	1994	47	47
Sun SPARCstation 5/85	microSPARC II	85	1	96	1994	49	52
Sun SPARCstation 5/110	microSPARC II	110	1	32	1994	44	47
Apple PowerMac 7100/80	PPC601	80	1	136	1995	64	64
Advantech PCA-6144V	Am5x86-P75	133	1	16	1996	—	—
NEC PC-9821V13	Pentium ODP	167	1	64	1996	42	54
SGI O2	R5000	200	1	256	1996	67	74
Sun Ultra2 2200	UltraSPARC	200	2	512	1996	165	166
DEC AlphaStation 255/300	EV45	300	1	256	1996	95	91
DEC AlphaStation 500/400	EV56	400	1	256	1996	102	104
PalmPilot Professional	MC68328	16	1	1	1997	—	—
Sun Ultra5	US-IIi	270	1	512	1998	56	56
Sun Ultra60 2360	US-II	360	2	1,152	1998	—	—
Symbol SPT 1500	MC68328	16	1	2	1998	—	—
SGI VWS 320	Pentium II	400	2	256	1999	123	124
Intergraph TDZ 2000 GX1	P3 Xeon	550	2	1,024	1999	94	122
Sun Ultra60 1450	US-II	450	1	1,280	1999	130	130
Compaq XP1000	EV67	667	1	1,536	1999	215	214
API UP2000	EV67	750	2	2,048	1999	289	289
Apple PowerBook G3(Pismo)	PPC750	400	1	512	2000	12	17
SGI Octane2	R12000	400	2	1,024	2000	260	258
Shuttle FV25	Tualatin	1,133	1	768	2001	51	55
Apple PowerMac G4 (DA)	MPC7450	800	1	768	2001	110	113
Sun Fire 3800	US-IIIcu	900	4	23,552	2001	1,318	1,318
Cobalt Qube 3 Plus	K6-2+	450	1	512	2002	22	36
Sun Blade 2000	US-IIIcu	900	1	8,192	2002	195	194
Tyan Tiger MPX	Athlon MP	1,666	2	2,048	2002	178	199
Palm m130	MC68VZ328	33	1	8	2002	3.7	3.7
Apple PowerMac G4 (FW800)	MPC7455	1,250	2	2,048	2003	164	171
Apple PowerMac G5 (7,2)	PPC970	2,000	2	3,072	2003	124	262
Palm Zire 71	OMAP 310	144	1	16	2003	6.3	6.5
VIA EPIA-ML	Nehemiah	800	1	512	2004	36	44
IBM p5 570	POWER5	1,900	16	32,768	2004	2,772	2,814

Apple PowerBook G4	MPC7447A	1,666	1	2,048	2004	18	38
Intel SR870BH2	Itanium2	1,400	2	4,096	2004	329	357
HP Integrity rx5670	Itanium2	1,300	4	24,576	2004	663	688
Sun Fire V40z	Opteron 850	2,400	4	7,680	2004	—	—
HP ProLiant DL145 G2	Opteron 275	2,200	2	2,048	2005	139	151
Leadtek Winfast K8N	Sempron 2600+	1,600	1	2,048	2005	95	117
Sony Playstation 3	Cell BE	3,200	1	256	2006	—	—
ASUS P5LD2 SE	Pentium D	3,000	2	3,072	2006	103	135
Toshiba Dynabook CX/47E	Core 2 Duo	2,000	2	2,048	2007	16	36
XFX nForce 780i	Core 2 Quad	2,666	4	8,192	2007	120	142
SH-2007	SH4A	400	1	128	2007	7	9
QNAP TS-409	MV88F5281-D0	500	1	256	2008	26	26
DELL Inspiron 910	Atom N270	1,600	1	1,024	2008	7	10
NEC SX-9	SX-9	3,200	4	131,072	2008	—	7,240
J&W MINIX-780G-SP128M	Phenom X4 9350e	2,000	4	3,072	2008	73	88
Convey HC-1	Xeon 5138	2,133	2	24,576	2008	—	—
Buffalo Kuro-box/T4	MPC8241	266	1	128	2009	21	22
SHARP PC-Z1	i.MX515	800	1	512	2009	2.2	4.1
DELL PowerEdge R410	Xeon E5530	2,400	8	12,288	2009	116	148
ASUS P7P55D LE	Core i7 860	2,800	4	2,048	2009	82	123
Intel S5520HCR	Xeon 5680	3,333	6	6,144	2010	107	137
Fujitsu Lifebook MH380/1A	Atom N475	1,833	1	1,024	2010	9	12
Toshiba Dynabook AZ	Tegra 2	1,000	2	512	2010	—	—
Lenovo ThinkPad X201s	Core i7 640LM	2,133	2	8,192	2010	15	33
ASRock P67 Extreme6	Core i7 2600K	3,400	4	4,096	2011	48	68

Table 2 Software configurations and performance results.

Machine	OS	Compiler	Dhrystone	NPB	CINT	CFP
SHARP X68000 PRO HD	Human68K 3.02	X68k XC v2.11	0.48	—	—	—
SONY NWS-1460	NetBSD 5.0.1	GCC 4.1.3	4.50	—	—	—
Apple Macintosh IIci	NetBSD 5.0.2	GCC 4.1.3	4.87	—	—	—
EPSON PC-286UX	MS-DOS 3.30	LSI C-86 3.30c	2.01	—	—	—
Sun SparcStation IPX	OpenBSD 4.6	GCC 2.95.3	5.39	—	—	—
NEC PC-9801DA	MS-DOS 6.2	GCC 4.4.4	2.50	—	—	—
NEC PC-9801RA	MS-DOS 6.2	GCC 4.4.4	4.11	—	—	—
Fujitsu FM TOWNS II HR	MS-DOS V6.2L10	GCC 4.4.4	7.62	—	—	—
SGI IRIS Indigo R4000	IRIX 6.5	GCC 4.5.1	100.66	0.09	—	—
EPSON PRO-486	MS-DOS 5.0	GCC 4.4.4	24.84	—	—	—
NEC PC-9821As2	MS-DOS 6.2	GCC 4.4.4	13.49	—	—	—
NEC PC-9801BS2	MS-DOS 6.2	GCC 4.4.4	13.42	—	—	—
HP 9000 712/80	Linux 2.6.37	GCC 4.3.2	68.17	—	—	—
Sun SPARCstation 5/85	Solaris 8	GCC 3.4.6	75.11	—	—	—
Sun SPARCstation 5/110	NEXTSTEP 3.3risc	NeXT cc-437.2.6	92.79	—	—	—
Apple PowerMac 7100/80	MacOS J1-9.1	MPW 3.5	91.69	—	—	—
Advantech PCA-6144V	MS-DOS 6.22	GCC 4.4.4	53.86	—	—	—

NEC PC-9821V13	FreeBSD 8.0	GCC 4.2.1	178.04	—	—	—
SGI O2	Linux 2.6.32	GCC 4.4.5	228.37	0.16	—	—
Sun Ultra2 2200	Solaris 9	Sun C 5.9/F 8.3	235.19	0.58	—	—
DEC AlphaStation 255/300	VMS 8.3	HP C V7.3-009	239.84	—	—	—
DEC AlphaStation 500/400	VMS 8.3	HP C V7.3-009	493.91	—	—	—
PalmPilot Professional	PalmOS 2.0	GCC 3.3.1	0.68	—	—	—
Sun Ultra5	NetBSD 5.1	GCC 4.5.1	342.83	0.33	—	—
Sun Ultra60 2360	Solaris 10	Sun C 5.10/F95 8.4	531.04	1.00	—	—
Symbol SPT 1500	PalmOS 3.0.2	GCC 3.3.1	0.68	—	—	—
SGI VWS 320	Windows 2000	GCC 4.5.2	531.64	0.54	—	—
Intergraph TDZ 2000 GX1	Linux 2.6.33.3	GCC 4.4.4	770.92	0.78	1.87	1.31
Sun Ultra60 1450	Solaris 10	Sun C 5.11/F 8.5	659.29	1.19	1.56	1.64
Compaq XP1000	Linux 2.6.26	GCC 4.5.1	1,467.63	1.33	—	—
API UP2000	Linux 2.6.34	GCC 4.5.1	1,632.65	1.44	2.72	2.23
Apple PowerBook G3(Pismo)	Linux 2.6.26	GCC 4.5.1	841.61	0.46	—	—
SGI Octane2	IRIX 6.5	GCC 4.5.1	705.37	1.02	1.45	1.67
Shuttle FV25	Linux 2.6.32.16	GCC 4.5.1	1,622.48	1.04	—	—
Apple PowerMac G4 (DA)	MacOS 9.2.2	MPW 3.5	1,211.04	—	—	—
Sun Fire 3800	Solaris 9	Sun C 5.8/F 8.2	1,102.24	2.11	2.83	2.81
Cobalt Qube 3 Plus	Linux 2.4.27-pre5	GCC 4.5.1	519.44	0.39	—	—
Sun Blade 2000	Solaris 10	Sun C 5.9/F 8.3	1,160.10	2.60	3.25	3.35
Tyan Tiger MPX	Linux 2.6.30	GCC 4.3.2	2,921.36	2.23	4.24	3.91
Palm m130	PalmOS 4.1J	GCC 3.3.1	1.34	—	—	—
Apple PowerMac G4 (FW800)	MacOS X 10.5.8	GCC 4.4.4	1,952.00	1.58	3.95	2.58
Apple PowerMac G5 (7,2)	MacOS X 10.5.8	GCC 4.5.2	5,244.77	4.85	6.48	6.17
Palm Zire 71	PalmOS 5.2.1	GCC 3.3.1	68.57	—	—	—
VIA EPIA-ML	Linux 2.6.26	GCC 4.3.2	599.60	0.49	1.44	0.83
IBM p5 570	AIX 5.3	XLC 7.0, XLF 9.1	3,523.61	9.90	8.63	10.89
Apple PowerBook G4	Linux 2.6.31.6	GCC 4.3.2	2,490.65	1.62	4.11	2.83
Intel SR870BH2	Linux 2.6.30.2	Intel 11.1	6,622.86	10.73	11.37	11.07
HP Integrity rx5670	Linux 2.6.18	Intel 11.1	6,154.29	10.70	10.63	10.79
Sun Fire V40z	Linux 2.6.35	GCC 4.5.2	6,647.03	5.96	9.73	8.48
HP ProLiant DL145 G2	Linux 2.6.9	GCC 4.5.1	4,841.63	6.68	10.28	8.72
Leadtek Winfast K8N	Linux 2.6.34	GCC 4.4.5	4,440.47	3.57	6.28	5.54
Sony Playstation 3	Linux 2.6.31.5	GCC 4.4.4	1,641.72	2.17	—	—
ASUS P5LD2 SE	Linux 2.6.9	GCC 4.5.1	4,075.61	6.98	9.49	7.94
Toshiba Dynabook CX/47E	Linux 2.6.32	GCC 4.5.2	10,539.85	9.19	13.46	11.00
XFX nForce 780i	Linux 2.6.18	GCC 4.5.1	10,663.27	10.05	15.33	11.59
SH-2007	Linux 2.6.21	GCC 4.5.2	371.22	—	—	—
QNAP TS-409	Linux 2.6.26	GCC 4.3.2	464.02	0.17	—	—
DELL Inspiron 910	Linux 2.6.34.7	Intel 11.1	4,683.57	2.44	5.67	3.58
NEC SX-9	SUPER-UX 18.1	C++/SX V1.0	284.65	26.12	1.09	79.68
J&W MINIX-780G-SP128M	Linux 2.6.35	GCC 4.5.1	8,094.61	8.13	11.48	9.94
Convey HC-1	Linux 2.6.18	Convey64 2.0.0	5,101.20	6.48	8.22	7.86
Buffalo Kuro-box/T4	Linux 2.6.30.1	GCC 4.4.5	355.72	—	—	—
SHARP PC-Z1	Linux 2.6.28	GCC 4.3.3	1,184.58	0.36	—	—
DELL PowerEdge R410	Linux 2.6.18	GCC 4.5.1	10,524.82	14.25	20.71	17.63

ASUS P7P55D LE	Linux 2.6.18	Intel 11.1	23,547.94	19.71	35.73	32.44
Intel S5520HCR	Linux 2.6.35	Intel 11.1	24,033.47	22.94	37.95	34.27
Fujitsu Lifebook MH380/1A	Linux 2.6.35	GCC 4.5.1	2,960.31	2.56	—	—
Toshiba Dynabook AZ	Linux 2.6.29	GCC 4.4.5	1,828.43	—	—	—
Lenovo ThinkPad X201s	Linux 2.6.35.6	GCC 4.5.1	13,917.89	14.32	—	—
ASRock P67 Extreme6	Linux 2.6.32	GCC 4.5.2	19,883.04	27.28	34.99	33.34

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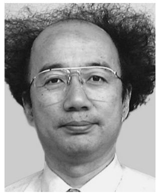

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