Filing Information
November 2001
IDC #
Volume: 2 High-Performance Systems
Tab: Vendors

Workstations and High-Performance Systems

Bulletin

First Release: IDC Balanced Rating HPC Benchmark Results

Analysts: Earl Joseph II, Ph.D., Christopher G. Willard, Ph.D., Mike Swenson, Nick Kaufmann, and Debra Goldfarb

IDC Opinion

This bulletin presents the first IDC HPC balanced benchmark data and ratings. Over the last few months many changes have been made to the benchmark approach based on feedback from the broader HPC community. This is the first set of IDC benchmark tables and we welcome comments from the broader HPC community (send comments to: hpc@idc.com) to help refine and fill in the tables.

IDC and HPC User Forum benchmark activities are focused on providing HPC users with better tools for understanding and comparing different HPC computers and architectures. In this bulletin, comparisons are first separated into the four primary IDC market segments of: Capability; Enterprise; Departmental; and Divisional computers in order to compare different categories of computers.

Background Note

The need for a new HPC ranking method was initially proposed by the HPC User Forum at its inception in the fall of 1999. Since that time the Forum has worked closely with many HPC users including San Diego Supercomputer Center (SDSC) and the University of Texas to develop new approaches to evaluating the capabilities of high-performance systems. This bulletin is a refinement of the initial IDC proposal based on suggestions and ideas from Forum members and the broader HPC community.

Introduction – The Computer Evaluation Problem

The same analysis holds true for evaluating automobiles, garden plants, or fishing lures, with the major difference of the dimensions for computer evaluation being more abstract, and the costs of a bad decision much higher in the case of high-performance computers.

Evaluation of computer performance can be viewed as a search of a multi-dimensional performance space where dimensions are defined by such architectural characteristics as: processor cycle time; memory bandwidth; memory latency; cache size; I/O speeds; etc. The evaluation process can be viewed as a search for specific machines that that come closest to some local optimal points as defined by specific user requirements. It should be noted that this same analysis holds true for evaluating automobiles, garden plants, or fishing lures, with the major difference of the dimensions for computer evaluation being more abstract, and the costs of a bad decision much higher in the case of high-performance computers.

The Computer Evaluation Process

Although the above description may provide an interesting statement of the computer evaluation problem, it does not go very far in actually addressing the problem. The actual evaluation process consists of several general steps:

1. Identify target system requirements – Defining how an ideal system would behave to meet the needs of the buyers specific environments. That is defining a local optimum in the search space.
2. Gather information about current systems – Identifying candidate systems in the market, and attempting to collect as much information about their operational characteristics as possible from both vendor and public sources. This is populating the evaluation space.
3. Initial selection or filtering – Attempting to identify those systems that appear to most closely match the target system requirements. In this case users often look to standard industry benchmarks in addition to "pen and paper" analysis to begin to narrow the field of possible systems choices. This is an initial search of the evaluation space.
4. Selection refinement – Repeating the second and third step on an ever shrinking list of possible systems and with ever more detailed evaluations tools such as organization specific benchmarks. This is a set of more specific searches of the evaluation space.

5. Final selection and justification – Choosing a system purchase and explaining the final choice to others in the organization.

6. Technology monitoring – For many organizations it is necessary to continually collect and evaluate information of computer system performance after the selection process in complete. It is important to track advances in technology to make sure the current systems are still cost effective relative to alternatives, identify technology that could lead to significant advantages to the organizations, and prepare for future system selections.

Evaluation Challenges

The process outline above can be, time consuming, expensive, and complex. Among the challenges to this process are assembling and maintaining accurate up-to-date information of system performance, and finding or developing appropriate measures for initial section of candidate systems.

Computer Performance Tracking

Developing and maintaining a database of high-performance computer architectural characteristics is relatively involved effort that includes a number of subtasks:

1. Identifying architectural characteristics and measures related to performance. As architectures become more complex the number of system features and the number of inter-relationships between the features increases. The competitive nature of the computer industry all but guarantees that each new generation of systems will have new features that impact performance.

2. Developing standard definitions. Variations in architectural approaches, differences in terminology between vendors, and vendors propensity towards "specmanship" combine to make the task of developing specific, consistent and clear definitions of system characteristics and making sure that actual data on systems properly reflects the definitions a complex and time consuming task.

3. On going data collection, checking, and entry. Even with assistance from computer vendors creating and filling in the cells can be a surprisingly daughting task as it involves both converting vendor measures to standard measures, filling in data points that are not available from all vendors, and assuring data is reported consistently and fairly.

4. Maintaining the data over time – To be effective such efforts must be maintained over time to account for the continual introduction of new systems and upgrades to existing systems.

Identifying and Applying Appropriate Selection Criteria

Even when an up to date, uniform, accurate database is available it is still necessary to evaluate its contents in such away as to provide meaningful ranking of the described computer systems. This problem is made more complex in that ranking criteria necessarily vary between organizations, and applications areas within organizations.

The Standard Benchmark Alternative

One alternative to a detailed cataloging and analysis of systems is to look to standard industry benchmarks to rank and compare systems.

Benchmark pros

- Avoids data definition and gathering phase
- Provides a standard or at least similar measure of all systems
- Provides a real data point for systems that incorporates several performance characteristics of several features of each systems, although it may be unclear which features have what effect on the benchmark
- Published data available at no cost

Benchmark cons

- Provides a single number to define an entire system – essentially defines a local optima
- Does not necessary reflect specific user requirements -- users can hope that their specific requirements fall close that optima – but there is no guarantee
- Over simplifies the problem and complicates decision justification process
- Difficult to keep current given the advancement in computer systems

IDC and HPC User Forum Approaches

Goals have evolved to:

- Provide a database that describes technical characteristics
- Provide tools to allow users to rank systems in the database based on their specific requirements
- Provide a variety of standard measures that reflect well defined views of balanced system performance

Strategy – Stepwise refinement

- Develop an initial database of system with a limited number of characteristics
- Provide a variety of standard systems metrics and rankings

- Develop tools to allow users to combine and weight features per their specific requirements.
- Increase fidelity of the data base in terms of listed systems characteristics
- Update database on a regular basis

Where We Are Today

HPC computer users have expressed a concern about using peak performance and peak-related benchmarks in comparing computers. We see peak performance as an ineffective and essentially outdated metric for comparing computers. It fails to account for overall system attributes that contribute to true delivered performance: memory bandwidth, latency, system balance, scalability, I/O, etc. This benchmark addresses many of the limitations with using only peak-related processor benchmarks for comparing HPC computers.

The excessive focus on peak performance has contributed to a tendency for HPC vendors to develop new generations of computers with impressive gains in peak performance while lagging behind in other critical system features.

The excessive public focus on peak performance has contributed to a tendency for HPC vendors to develop new generations of computers with impressive gains in peak performance while lagging behind in other critical system features. And has made it difficult for some HPC users to justify purchasing computers that don't maximize the price-to-peak-performance ratio.

We are looking for continued feedback from the broader HPC community to refine and improve this approach. Initially the new ratings will be dominated by currently available calculated metrics, but the underlying metrics will evolve over time to contain predominately actual measured capabilities instead of relying on calculated capabilities.

Benchmark Goal

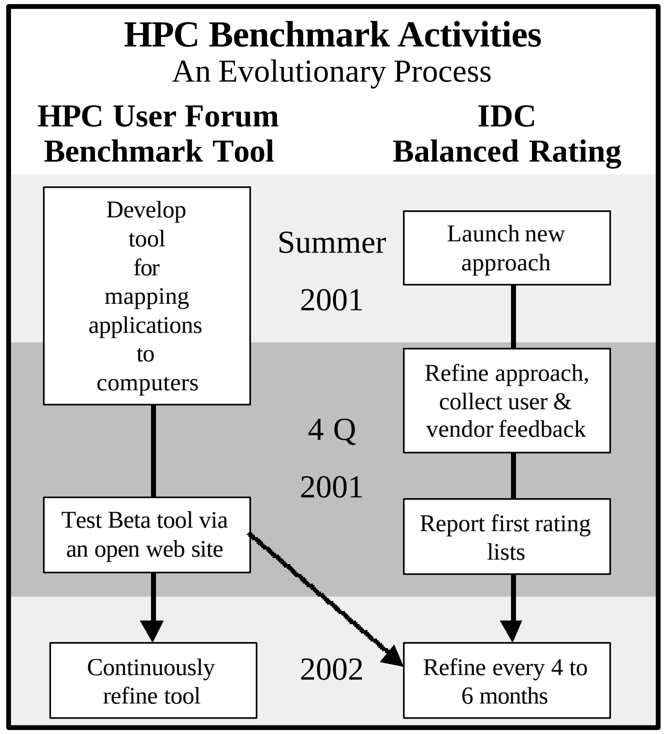
The goal of this benchmark is to create a more meaningful comparison of technical computers as compared to peak performance metrics.

To create a more meaningful high-level comparison of technical computers as compared to peak performance metrics, in order to show a general rating of how powerful different HPC computers are on a general purpose workload.

Two Separate Benchmark Activities

1. The HPC User Forum is developing a "User Tool" benchmark as a separate HPC User Forum activity to address the evaluation of computers based on actual workloads of individual HPC users. The HPC User Forum, IDC, SDSC and University of Texas are working closely with users and vendors to develop this acquisition-oriented benchmark tool that will allow HPC users to create a custom rating of HPC computers based on the specific application profile of their site.
2. The IDC Balanced Rating benchmark (this bulletin) aims to be useful for comparing a broad set of computers and architectures against a general purpose workload, but it isn't meant to replace benchmarking of computers for a specific purchase acquisition.

Two Separate Benchmark Activities



Computer Performance Attributes

The IDC Balanced Rating benchmark focuses on three broad performance areas:

1) Processor performance

2) Memory system capability

3) Scaling capability

There are many attributes that contribute to the performance of a computer. For different HPC users the importance of these attributes vary based on the algorithmic structure of the problems being solved, the size and mix of the workloads generated by multiple users, and the urgency of solving key problems. The IDC Balanced Rating benchmark focuses on three broad performance areas:

- Processor performance
- Memory system capability
- Scaling capability

Processor Performance

The desired measurement is the speed at which the processors could generate results if they were kept fully occupied with work. Peak processor performance measurements only take into consideration the processor's clock rate, the number of instructions or other work that theoretically could be accomplished in each clock cycle, and the number of processors in the system. For the initial IDC Balanced Rating single processor SPECfp_rate2000 and single processor Linpack Rmax results times the number of processors in the computer are used in the rating. In the future additional processor metrics will be incorporated.

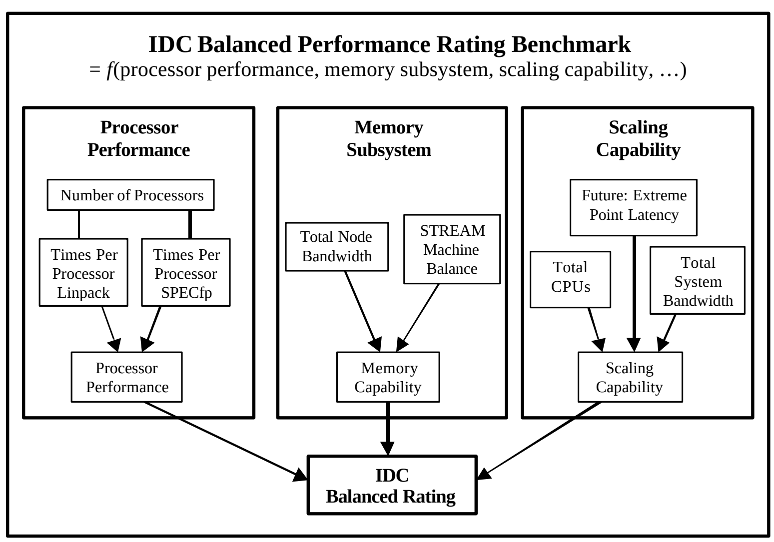
Memory System Capability

Actual performance is also dependent on how much data can be moved into and out of the processors in a given time period. Key attributes include: cache size, cache speed, bandwidth and latency; local memory size, bandwidth and latency; and main memory size, bandwidth and latency. For the initial IDC Balanced Rating total single node bandwidth and the STREAM Machine Balance benchmarks are used. In the future latency and other metrics will be integrated into the benchmark based on the availability of consistent data on HPC computers.

Scaling Capability

Different HPC computers are designed for different uses and different markets. Systems that scale to larger sizes often require additional hardware and software to provide useful performance. These extra components increase both delivered or available performance and price but do not affect peak performance rating. Factors affecting performance include: number of nodes that can be configured; node size (processors and memory per node); total number of processors; total memory size; bandwidth between nodes (and access rates to remote memory); and latency over the interconnect fabric. Larger nodes are more expensive to build, but are generally easier to use, place less stress on the interconnect, and often provide higher performance on a broader set of problems. For the initial IDC Balanced rating total processor count and total system memory bandwidth is used in the rating. For larger computer configurations only the actual installed configurations are used in the benchmark tables.

IDC Balanced Performance Rating Metrics



IDC Balanced Rating Benchmark

Computers Listed In The Tables

The benchmark tables list the different types of HPC computers currently available in the market and computers that are still in active use by customers. For each computer configuration only one table row entry is included. Only configurations that are actually manufactured are included in the tables, e.g. for highly scalable systems only the configurations that are installed at a customer site or permanently installed at the vendor's site are included.

IDC plans to publish analysis of the tables based on four competitive market segments:

1. Technical Capability Computers (TCAB): This segment is comprised of systems configured and purchased to solve the largest most demanding problems.
2. Technical Enterprise Computers (TENT): Capacity systems sold for $1 million or more.
3. Technical Divisional Computers (TDIV): Capacity systems sold from $250,000 to $999,000.
4. Technical Departmental Computers (TDEP): Capacity systems sold for less than $250,000.

How Ratings Are Calculated

First a complete "system descriptor data base" table is created that shows each computer configuration along with its performance attributes and characteristics.

Computers are then separated into the four IDC competitive segments (Capability, Enterprise, Divisional and Departmental).

Then each column is normalized on a scale of 0 to 100, with 100 equaling the best in each category. Missing data points receive a value of 0.

Then each of the three sub-ranking metrics are calculated based on:

1. Processor = (Linpack + SPECfp)/2
2. Memory = (node peak bandwidth + STREAM TRIAD)/2
3. Scalablility = (total system bandwidth + number of processors)/2

Note that in the future these metrics will evolve as better metrics are added to the data set.

Then the three separate ratings are consolidated into one overall rating, giving each combined metric equal weighting (1/3 for processors, 1/3 for memory and 1/3 for scaling).

For a spreadsheet with the complete list of the data and ranking tables send a request to: hpc@idc.com. In the near future the list will be available at: www.idc.com/hpc.

System Descriptor Table Example Source: IDC, 2001:

IDC Balanced Rating Benchmark: Sample Data Table
Computers Sorted By Number Of CPUs --> Those With More Than 250 CPUs

Basic System Data										Processor		Memory		Scaling		
Vendor	Model	Number of CPUs	Total/ Max. Memory	CPU Clock	System Peak Gflop/s	# Of Nodes	FCS	IDC Segment	One Computer or Cluster	Total Ststem Linpack	Total SPECfp	In Node Total Bandwidth	STREAM TRIAD	Number of CPUs	Total System Memory Bandwidth	*1 = Missing Data*
		#	*GBs*	*Mhz*	*Gflop/s*	*#*	*Year*		*See List*	*Rmax*	*Gflop/s*	*GB/s*	*GB/s*		*GB/s*	
Intel	ASCI Red	9632			3207		1999	Cap	C	2379				9,632		1
IBM	ASCI White, SP Power3 375 MHz Nighthawk2	8192	6000	375	12288	512	2000	Cap	C	7226		2		8,192		1
SGI	ASCI Blue Mountain	6144			3072		1998	Cap	C	1608				6,144		1
IBM	ASCI Blue-Pacific SST, IBM SP 604e	5856	2600	332	3868	1464	1999	Cap	C	2144		3		5,856	2,100	1
Compaq	PSC AlphaServer SC45/1000	3024		1000	6048	756	2001	Cap	C	4059	2546208	8	3.62	3,024	6,048	
IBM	NERSC Seaborg SP Power3 375 Nighthask 2	2528	5000	375	3792	158	2001	Cap	C	2526		2		2,528		1
SGI	ORIGIN 2000 250 MHz	2048		250	1024		1999	Cap	C	691	*409600*			2,048		1
Hitachi	CP-PACS/2048	2048			614		1996	Cap	C	368				2,048		1
Cray	T3E	1904	512	600	2285	1904	1998	Cap	1	1333	238000	1	1,055.00	1,904	1,828	
Compaq	LANL AlphaServer ES45/1000	1536		1000	3072	384	2001	Cap	C	2096	1293312		3.62	1,536	3,072	1
IBM	SP PC604e 332 MHz	1504		332	998		1999	Cap	C	490				1,504		1
Cray	T3E	1356	173.568	300	813	1356	2000	Cap	1	542	85428	1	560.90	1,356	1,302	
IBM	ASCI Blue-Pacific CTR, IBM SP 604e	1344			892		1998	Cap	C	468				1,344		1
IBM	SP Power3 375 MHz (Winterhawk2) NAVO	1336	1336	375	2004	334	2000	Cap	C	1417		2		1,336		1
Cray	T3E900	1324	338.944	450	1192	1324	1997	Cap	1	728	124456	1	653.75	1,324	1,271	
IBM	SP Power3 375 MHz 8 way (SDSC) Blue Horizon (winterhawk2)	1152	576	375	1728	156	2000	Cap	C	929		2		1,152		1
IBM	SP Power3 375 MHz (National Centers for Environmental Prediction)	1104		375	1656		2000	Cap	C	1179				1,104		1
IBM	SP Power3 375 MHz (National Centers for Environmental Prediction)	1104		375	1656		2001	Cap	C	1179						1
Cray	T3E1200	1084	555.008	600	1301	1084	1998	Cap	1	759	135500	1	603.68	1,084	1,041	
Cray	T3E900	1084	277.504	450	976	1084	1999	Cap	1	596	101896	1	535.24	1,084	1,041	
IBM	PIII - 933MHz	1024	1568	933	1024	784	2001	Cap	C	594				1,024		1
SGI	ORIGIN 2000 195/250 MHz	1024		250	328		1998	Cap	C	265	*204800*			1,024		1
Hitachi	SR2201/1024	1024			307		1996	Cap	C	232				1,024		1
Compaq	Sandia CPLANT 1024 AS DS10L Myrinet/LINUX	1024		600	1228	1024	2000	Cap	C					1,024		1
Compaq	JAERI AlphaServer SC40 6/833 (*2)	908		833	1513	227	2001	Cap	C		513020			908	1,180	1
Sun	HPC 4500 400 MHz Cluster	896		400	717		1999	Ent	C	420				896		1
Cray	T3E900	876	112.128	450	788	876	1997	Cap	1	482	82344	1	432.54	876	841	

System Descriptor Table Example Source: IDC, 2001 (cont.):

IDC Balanced Rating Benchmark: Sample Data Table
Computers Sorted By Number Of CPUs --> Those With More Than 250 CPUs

Basic System Data										Processor		Memory		Scaling		
Vendor	Model	Number of CPUs	Total/ Max. Memory	CPU Clock	System Peak Gflop/s	# Of Nodes	FCS	IDC Segment	One Computer or Cluster	Total Ststem Linpack	Total SPECfp	In Node Total Bandwidth	STREAM TRIAD	Number of CPUs	Total System Memory Bandwidth	*1 = Missing Data*
		#	*GBs*	*Mhz*	*Gflop/s*	*#*	*Year*		*See List*	*Rmax*	*Gflop/s*	*GB/s*	*GB/s*		*GB/s*	
Compaq	LLNL AlphaServer SC40 6/667	512		667	683	128	2000	Cap	C		221696			512		1
Compaq	Blue Sky Studios 512 DS10/DS10L	512				512	2001	Cap	C					512		1
IBM	SP S80s 450 MHz	510		450	459		2000	Cap	C	168				510		1
Compaq	APAC AlphaServer SC45/1000	480		1000	960	120	2001	Cap	C	706	404160	8		480	960	1
IBM	SP PC604e 332 MHz	452		332	300		2000	Cap	C	138				452		1
IBM	SP PC604e 332 MHz	440		332	292		1999	Cap	C	181				440		1
IBM	SP Power3 375 MHz	424		375	636		2000	Cap	C	441				424		1
Cray	T3E1200	404	103.424	600	485	404	1999	Cap	1	283	50500	1	224.99	404	388	
Cray	T3E900	404	103.424	450	364	404	1999	Cap	1	222	37976	1	199.48	404	388	
IBM	SP Power3 375 MHz	404		375	606		2000	Cap	C	420				404		1
IBM	SP2/402	402			107		1997	Cap	C	69				402		1
Cray	T3E1200	396	101.376	600	475	396	2000	Cap	1	277	49500	1	220.53	396	380	
IBM	SP PC604e 332 MHz	396		332	262		2000	Cap	C	163				396		1
IBM	SP PC604e 332 MHz	392		332	260		2000	Cap	C	162				392		1
IBM	SP PC604e 332 MHz	364		332	241		2000	Cap	C	151				364		1
Cray	T3E900	348	44.544	450	313	348	1997	Cap	1	191	32712	1	171.83	348	334	
IBM	SP Power3 375 MHz	322		375	483		2000	Cap	C	330				322		1
IBM	SP Power3 375 MHz	320		375	480		2000	Cap	C	327				320		1
IBM	SP PC604e 332 MHz	320		332	212		2000	Cap	C	133				320		1
IBM	SP Power3 375 MHz	318		375	477		2000	Cap	C	325				318		1
IBM	SP PC604e 332 MHz	302		332	200		1999	Cap	C	126				302		1
IBM	SP PC604e 332 MHz	298		332	197		2000	Cap	C	124				298		1
IBM	SP S80s 450 MHz	294		450	264		2000	Cap	C	139				294		1
IBM	SP PC604e 332 MHz	292		332	193		2000	Cap	C	122				292		1
IBM	SP PC604e 332 MHz	288		332	191		2000	Cap	C	120				288		1
Cray	T3E1200	284	145.408	600	341	284	1999	Cap	1	199	35500	1	158.16	284	273	
IBM	SP Power3 375 MHz	284		375	426		2000	Cap	C	288				284		1
Cray	T3E1200	268	68.608	600	322	268	1999	Cap	1	188	33500	1	149.25	268	257	
Cray	T3E900	268	34.304	450	241	268	1997	Cap	1	147	25192	1	132.33	268	257	
Cray	T3E	268	34.304	300	161	268	1996	Cap	1	107	16884	1	110.90	268	257	
IBM	SP PC604e 332 MHz	268		332	177		1999	Cap	C	112				268		1
Compaq	ARL MSRC ES40 6/667 Myrinet/LINUX	268		667	358	67	2001	Cap	C		116044			268	348	1
IBM	SP Power3 200 MHz	260		200	208		1999	Cap	C	152				260		1
IBM	SP PC604e 332 MHz	260		332	172		2000	Cap	C	109				260		1

The highest Ranked Capability Computers

(IDC, November 2001, note that there are missing data points):

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating	Overall Rating	1 = Missing Data
				LP+SPEC	*bw+STREAM*	*CPUs+B/W*	*1/3,1/3,1/3*	
1	Compaq	PSC AlphaServer SC45/1000	3024	0.781	0.005	0.657	0.481	
2	IBM	ASCI White, SP Power3 375 MHz Nighthawk2	8192	0.500	0.001	0.425	0.309	1
3	NEC	SX-5/128M8	128	0.082	0.386	0.430	0.300	1
4	NEC	SX-5/32M2	32	0.017	0.629	0.171	0.272	1
5	Cray	T3E	1904	0.139	0.415	0.250	0.268	
6	NEC	SX-5/40M3	40		0.563	0.214	0.259	1
7	Compaq	LANL AlphaServer ES45/1000	1536	0.399	0.001	0.334	0.245	1
8	Intel	ASCI Red	9632	0.165		0.500	0.222	1
9	IBM	ASCI Blue-Pacific SST, IBM SP 604e	5856	0.148	0.001	0.478	0.209	1
10	NEC	NEC_SX_5-16A	16	0.011	0.500	0.107	0.206	1
11	Cray	T932/321024-2	32	0.005	0.493	0.076	0.191	
12	Cray	T932/321024-3	32	0.005	0.493	0.076	0.191	
13	Cray	T932/322048-4	32	0.005	0.493	0.076	0.191	
14	Cray	T932/321024	32	0.005	0.493	0.076	0.191	
15	Cray	T932/321024	32	0.005	0.493	0.076	0.191	
16	Cray	T932/321024	32	0.005	0.493	0.076	0.191	
17	Intel/SGI	SGI Itanium Cluster	146	0.038	0.502	0.033	0.191	
18	Cray	T932/191024	25	0.004	0.462	0.076	0.180	
19	Cray	T932/221024	22	0.003	0.449	0.076	0.176	
20	Cray	T932/18	18	0.003	0.431	0.075	0.170	
21	Cray	T3E900	1324	0.075	0.258	0.174	0.169	
22	Cray	T932/32512	32	0.005	0.422	0.076	0.168	
23	Cray	T932/161024	16	0.002	0.422	0.075	0.167	
24	Cray	T932/24512	24	0.003	0.405	0.076	0.161	
25	Cray	T3E1200	1084	0.079	0.238	0.142	0.153	
26	NEC	NEC_SX_5-8B	8	0.005	0.400	0.053	0.153	1
27	Cray	T3E	1356	0.054	0.221	0.178	0.151	
28	SGI	ASCI Blue Mountain	6144	0.111		0.319	0.143	1
29	NEC	NEC_SX_4	32	0.004	0.372	0.044	0.140	1
30	Cray	T3E900	1084	0.061	0.211	0.142	0.138	
31	NEC	SX-5/32Me2	32		0.313	0.086	0.133	1
32	SGI	SGI_Origin3800-500	512	0.079	0.237	0.060	0.126	
33	SGI	SGI_Origin3800-400	512	0.068	0.237	0.060	0.122	
34	NEC	SX-5/16Be	16	0.004	0.313	0.043	0.120	1
35	Cray	T3E1200	812	0.059	0.178	0.107	0.115	
36	Cray	T3E900	876	0.050	0.171	0.115	0.112	
37	IBM	NERSC Seaborg SP Power3 375 Nighthask 2	2528	0.175	0.001	0.131	0.102	1
38	Fujitsu	VPP5001	8		0.255	0.051	0.102	1
39	NEC	SX-5/10A	10		0.250	0.053	0.101	1
40	Fujitsu	VPP700	32		0.245	0.054	0.100	1
41	Cray	T916/16512-2	16	0.002	0.252	0.038	0.098	
42	Cray	T916/161024	16	0.002	0.247	0.038	0.096	
43	Cray	T3E	812	0.033	0.133	0.107	0.091	
44	Cray	T3E1200	636	0.046	0.140	0.083	0.090	
45	NEC	SX-5/6	6		0.236	0.032	0.089	1
46	Cray	T3E900	692	0.039	0.135	0.091	0.088	
47	Cray	T916/51024	10	0.001	0.220	0.038	0.086	
48	Cray	T916/8512	16	0.002	0.211	0.038	0.084	
49	Cray	T916/14512	14	0.002	0.207	0.038	0.082	
50	Cray	T916/14512	14	0.002	0.207	0.038	0.082	

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating	Overall Rating	1 = Missing Data
				LP+SPEC	*bw+STREAM*	*CPUs+B/W*	*1/3,1/3,1/3*	
51	Compaq	JAERI AlphaServer SC40 6/833	908	0.101		0.145	0.082	1
52	Compaq	APAC AlphaServer SC45/1000	480	0.128	0.003	0.104	0.079	1
53	SGI	ORIGIN 2000 250 MHz	2048	0.128		0.106	0.078	1
54	Cray	T916/8256	14	0.002	0.191	0.038	0.077	
55	Cray	T3E1200	540	0.039	0.119	0.071	0.076	
56	Cray	T3E-1350	512	0.040	0.119	0.067	0.076	
57	Cray	T916/4256	8	0.001	0.185	0.038	0.074	
58	Cray	T916/8256	8	0.001	0.185	0.038	0.074	
59	NEC	NEC_SX_4	16	0.002	0.198	0.022	0.074	1
60	Cray	T3E-1200	512	0.037	0.112	0.067	0.072	
61	Cray	T3E900	540	0.031	0.105	0.071	0.069	
62	SGI	SGI_Origin2000-300	512	0.039	0.121	0.044	0.068	
63	SGI	SGI 2800-400	512	0.060	0.099	0.044	0.068	
64	Compaq	AlphaServer SC45 6/1000	512	0.085	0.005	0.111	0.067	1
65	Cray	T3E750	540	0.026	0.099	0.071	0.065	
66	SGI	SGI_Origin3800-500	256	0.040	0.119	0.030	0.063	
67	SGI	SGI_Origin3800-400	256	0.034	0.119	0.030	0.061	
68	NEC	SX-5/12Be	12		0.150	0.032	0.061	1
69	Cray	T3E	540	0.022	0.088	0.071	0.060	
70	Cray	T3E1200	404	0.029	0.089	0.053	0.057	
71	Cray	T3E1200	396	0.029	0.087	0.052	0.056	
72	IBM	SP Power3 375 MHz (Winterhawk2) NAVO	1336	0.098	0.001	0.069	0.056	1
73	Cray	T3E900	404	0.023	0.079	0.053	0.052	
74	Fujitsu	VPP300	16		0.123	0.027	0.050	1
75	Fujitsu	VPP700	16		0.123	0.027	0.050	1
76	Compaq	AlphaServer SC40 6/833	512	0.057	0.003	0.082	0.047	1
77	IBM	SP Power3 375 MHz (National Centers for Environmental	1104	0.082		0.057	0.046	1
78	Cray	T3E900	348	0.020	0.068	0.046	0.044	
79	Hitachi	CP-PACS/2048	2048	0.025		0.106	0.044	1
80	IBM	SP Power3 375 MHz 8 way (SDSC) Blue Horizon (winterhawk2)	1152	0.064	0.001	0.060	0.042	1
81	Cray	T3E1200	284	0.021	0.063	0.037	0.040	
82	Compaq	AlphaServer SC40 6/667	512	0.035	0.003	0.082	0.040	1
83	Cray	T3E1200	268	0.020	0.059	0.035	0.038	
84	Cray	T3E-1350	256	0.020	0.060	0.034	0.038	
85	IBM	SP PC604e 332 MHz	1504	0.034		0.078	0.037	1
86	SGI	ORIGIN 2000 195/250 MHz	1024	0.059		0.053	0.037	1
87	SGI	SGI 2800-400	256	0.030	0.059	0.022	0.037	
88	Cray	T3E-1200	256	0.019	0.056	0.034	0.036	
89	Cray	T3E900	268	0.015	0.052	0.035	0.034	
90	Compaq	AlphaServer SC45 6/1000	256	0.042	0.005	0.056	0.034	1
91	IBM	ASCI Blue-Pacific CTR, IBM SP 604e	1344	0.032		0.070	0.034	1
92	SGI	SGI_Origin2000-300	256	0.019	0.061	0.022	0.034	
93	IBM	SP Power3 375 MHz (Schwab)	768	0.055		0.040	0.032	1
94	SGI	SGI_Origin 3800-500	128	0.020	0.060	0.015	0.032	
95	IBM	PIII - 933MHz	1024	0.041		0.053	0.031	1
96	SGI	SGI_Origin3800-400	128	0.017	0.060	0.015	0.031	
97	Cray	T3E	268	0.011	0.044	0.035	0.030	
98	IBM	SP Power3 375 MHz (North Carolina Supercomputer Center)	720	0.051	0.001	0.037	0.030	1
99	IBM	SP Power3 375 MHz (ORNL) Winterhawk2	704	0.050	0.001	0.037	0.029	1
100	IBM	SP Power3 375 MHz (NCAR)	668	0.048	0.001	0.035	0.028	1

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating		Overall Rating	1 = Missing Data
				LP+SPEC	*bw+STREAM*	*CPUs+B/W*		*1/3,1/3,1/3*	
101	IBM	SP Power3 375 MHz (National Centers for Environmental Prediction)	1104	0.082				0.027	1
102	Fujitsu	VPP5000/100	100	0.061	0.015	0.005		0.027	1
103	Hitachi	SR8000-F1/112	112	0.072		0.006		0.026	1
104	Fujitsu	VPP700	8		0.061	0.013		0.025	1
105	Compaq	AlphaServer SC40 6/833	256	0.028	0.003	0.041		0.024	1
106	SGI	SGI_Origin 3800-500	96	0.015	0.045	0.011		0.024	
107	Compaq	LLNL AlphaServer SC40 6/667	512	0.044		0.027		0.023	1
108	Hitachi	SR2201/1024	1024	0.016		0.053		0.023	1
109	SGI	SGI_Origin3800-400	96	0.013	0.045	0.011		0.023	
110	Hitachi	SR8000-F1/100	100	0.063		0.005		0.023	1
111	Hitachi	SR8000/128	128	0.060		0.007		0.022	1
112	IBM	SP Power3 375 MHz (ASC MSRC) Winterhawk2	528	0.038	0.001	0.027		0.022	1
113	Compaq	ARL MSRC ES40 6/667 Myrinet/LINUX	268	0.023		0.043		0.022	1
114	IBM	SP Power3 375 MHz 16 way Nighthawk2	512	0.038	0.001	0.027		0.022	1
115	Cray	T3E	188	0.008	0.031	0.025		0.021	
116	Cray	T3E750	172	0.008	0.032	0.023		0.021	
117	SGI	SGI_Origin 300-500	128	0.017	0.029	0.015		0.020	
118	Cray	T3E1350	132	0.010	0.031	0.017		0.020	
119	Cray	T3E	172	0.007	0.029	0.023		0.020	
120	IBM	SP Power3 375 (MHPCC)	812	0.058				0.019	1
121	Cray	T3E-1350	128	0.010	0.030	0.017		0.019	
122	Compaq	CEA CIVIL AlphaServer SC40 6/667	232	0.020		0.037		0.019	1
123	SGI	SGI 2800-400	128	0.015	0.031	0.011		0.019	
124	Cray	T3E	164	0.007	0.027	0.022		0.018	
125	Cray	T3E-1200	128	0.009	0.028	0.017		0.018	
126	IBM	SP PC604e 332 MHz	716	0.017		0.037		0.018	1
127	Compaq	AlphaServer SC45 6/1000	128	0.021	0.005	0.028		0.018	1
128	SGI	ORIGIN 2000	512	0.027		0.027		0.018	1
129	Compaq	Sandia CPLANT 1024 AS DS10L Myrinet/LINUX	1024			0.053		0.018	1
130	SGI	ORIGIN 2000 250 MHz - Eth-Cluster	512	0.026		0.027		0.018	1
131	IBM	SP Power3 200 MHz	604	0.021		0.031		0.018	1
132	IBM	SP Power3 375 MHz	424	0.031		0.022		0.018	1
133	IBM	SP Power3 222 MHz	562	0.023		0.029		0.017	1
134	Hitachi	SR8000-E1/80	80	0.048		0.004		0.017	1
135	Fujitsu	VPP5000/56	56	0.034	0.015	0.003		0.017	1
136	SGI	SGI_Origin2000-300	128	0.010	0.031	0.011		0.017	
137	Fujitsu	VPP5000	1		0.045	0.006		0.017	1
138	Cray	T3E900	132	0.007	0.026	0.017		0.017	
139	IBM	SP Power3 375 MHz	404	0.029		0.021		0.017	1
140	SGI	SGI 2800-400	112	0.013	0.027	0.010		0.016	
141	IBM	SP Power3 222 MHz	512	0.021		0.027		0.016	1
142	SGI	SGI_Origin2000-300	116	0.009	0.028	0.010		0.016	
143	SGI	SGI 2800-400	104	0.012	0.025	0.009		0.015	
144	Cray	T3E	134	0.005	0.022	0.018		0.015	
145	Cray	T3E	132	0.005	0.022	0.017		0.015	
146	Compaq	AlphaServer SC40 6/667	256		0.003	0.041		0.015	1
147	Hitachi	SR8000-F1/60	60	0.040		0.003		0.014	1
148	IBM	LosLobos	512	0.016		0.027		0.014	1
149	Cray	T3E900	108	0.006	0.021	0.014		0.014	

The Highest Ranked Enterprise Computers Include

(IDC, November 2001, note that there are missing data points):

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating	Overall Rating	1 = Missing Data
				LP+f p	*bw+STREAM*	*CPUs+B/W*	*Normalized*	
1	HP	SuperDome (PA-8700)	256	1.000	0.325	0.543	0.623	
2	HP	SuperDome (PA-8600)	256	0.737	0.327	0.543	0.536	
3	NEC	NEC_SX_5-4C	4	0.043	1.000	0.502	0.515	1
4	NEC	NEC_SX_5-4C	4	0.043	1.000	0.502	0.515	1
5	NEC	SX-5/4B	4	0.033	0.803	0.402	0.413	1
6	NEC	SX-5/4C	4	0.033	0.803	0.402	0.413	1
7	Cray	SV1ex-4	128	0.339	0.487	0.390	0.406	
8	HP	SuperDome (PA-8700)	128	0.528	0.213	0.271	0.337	
9	Sun	HPC 4500 400 MHz Cluster	896	0.458		0.500	0.319	1
10	Cray	SV1-4	128	0.202	0.292	0.390	0.295	
11	HP	SuperDome (PA-8600)	128	0.390	0.214	0.271	0.292	
12	NEC	NEC_SX_5-2D	2	0.021	0.503	0.251	0.258	1
13	Cray	SV1-4/64-128	64	0.101	0.286	0.354	0.247	
14	Cray	SV1-4/64-128	64	0.101	0.286	0.354	0.247	
15	Cray	SV1ex-2	64	0.170	0.284	0.195	0.216	
16	NEC	SX-5S/4	4	0.017	0.402	0.202	0.207	1
17	NEC	SX-5/2D	2	0.016	0.403	0.201	0.207	1
18	HP	SuperDome (PA-8700)	64	0.269	0.156	0.136	0.187	
19	HP	SuperDome (PA-8600)	64	0.195	0.157	0.136	0.163	
20	SGI	SGI_Origin 3800-500	64	0.180	0.134	0.116	0.143	
21	HP	N4000 /HyperPlex	96	0.196	0.013	0.213	0.141	1
22	HP	SuperDome (PA-8700)	48	0.202	0.118	0.102	0.140	
23	SGI	SGI_Origin3800-400	64	0.154	0.134	0.116	0.135	
24	NEC	NEC_SX_5-1D	1	0.011	0.252	0.126	0.129	1
25	Compaq	AlphaServer GS320 6/1000	32	0.129	0.139	0.107	0.125	
26	HP	SuperDome (PA-8600)	48	0.148	0.119	0.102	0.123	
27	Cray	SV1ex	32	0.085	0.182	0.098	0.121	
28	HP	V2600/HyperPlex	256	0.214		0.143	0.119	1
29	NEC	SX-5S/2	2	0.009	0.202	0.101	0.104	1
30	Cray	SV1ex	16	0.042	0.169	0.089	0.100	
31	Sun	HPC 10000 400 MHz Cluster	256	0.149		0.143	0.097	1
32	Compaq	AlphaServer GS320 6/731	32	0.050	0.133	0.107	0.096	1
33	HP	SuperDome (PA-8700)	32	0.136	0.079	0.068	0.094	
34	Cray	SV1-1/32-8	32	0.051	0.133	0.098	0.094	
35	Cray	SV1-1/32-16	32	0.051	0.133	0.098	0.094	
36	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
37	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
38	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
39	Cray	SV1/321024	32	0.051	0.133	0.098	0.094	
40	Cray	SV1-124-8	32	0.051	0.133	0.098	0.094	
41	Cray	SV1-1/32-8	32	0.051	0.133	0.098	0.094	
42	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
43	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
44	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
45	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
46	Cray	SV1-1/32-32	32	0.051	0.133	0.098	0.094	
47	SGI	SGI 2800-400	64	0.136	0.069	0.076	0.094	
48	Cray	SV1-1/24-8	24	0.038	0.132	0.093	0.088	
49	Cray	SV1-1/24-16	24	0.038	0.132	0.093	0.088	
50	Cray	SV1-1/24-32	24	0.038	0.132	0.093	0.088	

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating		Overall Rating	1 = Missing Data
				LP+SPEC	*bw+STREAM*	*CPUs+B/W*		*1/3,1/3,1/3*	
51	Cray	SV1-1/24-32	24	0.038	0.132	0.093		0.088	
52	Cray	SV1-1/24-32	24	0.038	0.132	0.093		0.088	
53	Cray	SV1-1/24-32	24	0.038	0.132	0.093		0.088	
54	Cray	SV1-1/24-32	24	0.038	0.132	0.093		0.088	
55	Cray	SV1-1/20-8	20	0.032	0.132	0.091		0.085	
56	Cray	SV1-1/20-16	20	0.032	0.132	0.091		0.085	
57	Cray	SV1-1/20-32	20	0.032	0.132	0.091		0.085	
58	Compaq	AlphaServer GS320 6/1000	16	0.039	0.115	0.098		0.084	1
59	HP	SuperDome (PA-8600)	64	0.094	0.057	0.098		0.083	1
60	HP	SuperDome (PA-8600)	32	0.099	0.079	0.068		0.082	
61	Cray	SV1-1/16-4	16	0.025	0.132	0.089		0.082	
62	Cray	SV1-1/16-8	16	0.025	0.132	0.089		0.082	
63	Cray	SV1-1/16-16	16	0.025	0.132	0.089		0.082	
64	Cray	SV1-1/16-32	16	0.025	0.132	0.089		0.082	
65	Cray	SV1-1/16-16	16	0.025	0.132	0.089		0.082	
66	Cray	SV1-1/16-32	16	0.025	0.132	0.089		0.082	
67	Cray	SV124/4096	16	0.025	0.132	0.089		0.082	
68	Cray	SV1-1A/16-2	16	0.025	0.132	0.089		0.082	
69	Cray	SV1-1/16-32	16	0.025	0.132	0.089		0.082	
70	Cray	SV1ex	8	0.021	0.138	0.084		0.081	
71	SGI	SGI_Origin2000-300	64	0.098	0.069	0.076		0.081	
72	Sun	HPC 10000 400 MHz Cluster	192	0.129		0.107		0.079	1
73	Sun	HPC 420 400 MHz Cluster	180	0.133		0.100		0.078	1
74	Cray	SV1-1A/8-4	8	0.013	0.120	0.084		0.072	
75	Cray	SV1-1A/8-8	8	0.013	0.120	0.084		0.072	
76	Cray	SV1-1A/8-16	8	0.013	0.120	0.084		0.072	
77	SGI	SGI_Origin 3400-500	32	0.090	0.067	0.058		0.072	
78	SGI	SGI_Origin 3800-500	32	0.090	0.067	0.058		0.072	
79	Compaq	AlphaServer GS320 6/1000	8	0.019	0.101	0.094		0.071	1
80	Compaq	AlphaServer GS320 6/731	16	0.025	0.089	0.098		0.071	1
81	Sun	HPC 420 450 MHz Cluster	160	0.120		0.089		0.070	1
82	Sun	HPC 10000 400 MHz Cluster	168	0.115		0.094		0.070	1
83	Compaq	AlphaServer GS320 6/1000	4	0.010	0.095	0.091		0.065	1
84	Compaq	AlphaServer GS320 6/731	8	0.012	0.089	0.094		0.065	1
85	Compaq	AlphaServer GS320 6/731	4	0.006	0.089	0.091		0.062	1
86	Compaq	AlphaServer GS320 6/1000	2	0.005	0.089	0.090		0.061	1
87	Compaq	AlphaServer GS320 6/1000	1	0.002	0.092	0.090		0.061	1
88	Compaq	AlphaServer GS320 6/731	2	0.003	0.089	0.090		0.061	1
89	Compaq	AlphaServer GS320 6/731	1	0.002	0.089	0.090		0.060	1
90	Sun	HPC 10000 400 MHz Cluster	144	0.098		0.080		0.059	1
91	Compaq	AlphaServer HPC320 6/833	32	0.071	0.014	0.083		0.056	1
92	Sun	HPC 10000 400 MHz Cluster	128	0.087		0.071		0.053	1
93	Compaq	AlphaServer HPC320 6/667	32	0.054	0.013	0.083		0.050	1
94	Sun	HPC 10000 400 MHz Cluster	120	0.083		0.067		0.050	1
95	Sun	HPC 10000 400 MHz Cluster	120	0.082		0.067		0.050	1

The Highest Ranked Divisional Computers Include

(IDC, November 2001, note that there are missing data points):

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating		Overall Rating		1 = Missing Data
			#	LP+f p	bw+STREAM	CPUs+B/W		Normalized		
1	SGI	SGI_Origin3400-400	32	0.839	0.949	0.949		0.912		
2	SGI	SGI_Origin3800-400	32	0.839	0.949	0.949		0.912		
3	SGI	SGI_Origin 300-500	32	0.864	0.928	0.949		0.914		
4	Compaq	AlphaServer GS160 6/1000	16	0.711	0.500	0.750		0.654		1
5	Compaq	AlphaServer GS160 6/731	16	0.244	0.907	0.750		0.634		1
6	SGI	SGI 2400-400	32	0.746	0.489	0.725		0.653		
7	HP	rp8400 (PA-8700)	16	0.811	0.543	0.531		0.628		
8	HP	SuperDome (PA-8700)	16	0.786	0.555	0.531		0.624		
9	HP	rp8400 (PA-8700)	16	0.699	0.540	0.531		0.590		
10	SGI	SGI_Origin2000-300	32	0.546	0.489	0.725		0.586		
11	Compaq	AlphaServer GS160 6/1000	8	0.191	0.500	0.625		0.439		1
12	HP	SuperDome (PA-8600)	16	0.580	0.554	0.531		0.555		
13	Compaq	AlphaServer GS160 6/731	8	0.122	0.500	0.625		0.416		1
14	Compaq	AlphaServer GS160 6/731	4	0.061	0.602	0.563		0.409		1
15	Compaq	AlphaServer GS160 6/1000	4	0.095	0.500	0.563		0.386		1
16	SGI	SGI_Origin 3400-500	16	0.493	0.480	0.475		0.482		
17	SGI	SGI_Origin 3800-500	16	0.493	0.480	0.475		0.482		
18	SGI	SGI_Origin3400-400	16	0.419	0.480	0.475		0.458		
19	SGI	SGI_Origin3800-400	16	0.419	0.480	0.475		0.458		
20	Compaq	AlphaServer GS160 6/1000	2	0.048	0.500	0.531		0.360		1
21	HP	rp8400 (PA-8700)	12	0.607	0.408	0.398		0.471		
22	Compaq	AlphaServer GS160 6/731	2	0.030	0.500	0.531		0.354		1
23	Compaq	AlphaServer GS160 6/731	1	0.015	0.540	0.516		0.357		1
24	Compaq	AlphaServer GS160 6/1000	1	0.024	0.500	0.516		0.346		1
25	HP	rp8400 (PA-8700)	12	0.521	0.406	0.398		0.442		
26	Compaq	AlphaServer GS80/1000	8	0.356	0.246	0.371		0.324		1
27	Compaq	AlphaServer GS80/731	8	0.122	0.450	0.371		0.314		1
28	SGI	SGI 2400-400	16	0.373	0.257	0.362		0.331		
29	HP	rp8400 (PA-8700)	8	0.405	0.273	0.265		0.315		
30	HP	rp7400 (PA-8700)	8	0.388	0.242	0.274		0.301		
31	SGI	SGI_Origin2000-300	16	0.273	0.257	0.362		0.298		
32	Compaq	AlphaServer GS80/1000	4	0.095	0.246	0.308		0.216		1
33	Compaq	AlphaServer GS80/731	4	0.061	0.246	0.308		0.205		1
34	Compaq	AlphaServer GS80/1000	2	0.048	0.246	0.277		0.190		1
35	Compaq	AlphaServer GS80/731	2	0.030	0.246	0.277		0.184		1
36	SGI	SGI_Origin 300-500	8	0.216	0.232	0.237		0.228		
37	Compaq	AlphaServer GS80/1000	1	0.024	0.246	0.261		0.177		1
38	Compaq	AlphaServer GS80/731	1	0.015	0.246	0.261		0.174		1
39	Sun	Sun Fire 6800	24	0.500		0.375		0.292		1
40	Sun	HPC 6500	30	0.303		0.469		0.257		1
41	Sun	HPC 6500	24	0.243		0.375		0.206		1
42	Sun	Sun Fire 6800	16	0.338		0.250		0.196		1
43	Sun	Enterprise Server Model 6002/30	30			0.469		0.156		1
44	Sun	Sun Enterprise 6000	30			0.469		0.156		1
45	IBM	375MHz Nighthawk 2node; 125MHz mem busX16	16		0.035	0.285		0.107		1
46	Sun	Enterprise Server Model 6002/18	18			0.281		0.094		1
47	HP	SPP1600 (PA-7200)	16			0.250		0.083		1
48	NEC	Express5800/1160Xa	16			0.250		0.083		1
49	HP	V2500 (PA-8500)	8		0.106	0.125		0.077		1
50	HP	V2600 (PA-8600)	8		0.106	0.125		0.077		1

The Highest Ranked Departmental Computers Include
(IDC, November 2001, note that there are missing data points):

	Vendor	Model	Number of CPUs	Processor Rating	Memory Rating	Scaling Rating		Overall Rating	1 = Missing Data
	Data Units		#	*LP+f p*	*bw+STREAM*	*CPUs+B/W*		*Normalized*	
1	HP	rp8400 (PA-8700)	8	0.964	0.562	0.450		0.659	
2	HP	rp7400 (PA-8700)	8	0.929	0.493	0.466		0.629	
3	HP	N4000 (PA-8600)	8	0.785	0.489	0.466		0.580	
4	IBM	RS/6000 SP-222 MHz High Node	8		1.000	0.700		0.567	1
5	SGI	SGI_Origin 3200-500	8	0.732	0.511	0.400		0.548	
6	SGI	SGI_Origin 3400-500	8	0.732	0.511	0.400		0.548	
7	SGI	SGI_Origin 3800-500	8	0.732	0.511	0.400		0.548	
8	Compaq	AlphaServer ES45/1000	4	0.656	0.590	0.350		0.532	
9	SGI	SGI_Origin3200-400	8	0.628	0.511	0.400		0.513	
10	SGI	SGI_Origin3400-400	8	0.628	0.511	0.400		0.513	
11	SGI	SGI_Origin3800-400	8	0.628	0.511	0.400		0.513	
12	HP	rp7400 (PA-8700)	4	0.550	0.476	0.366		0.464	
13	HP	rp7400 (PA-8700)	4	0.477	0.476	0.366		0.440	
14	HP	N4000 (PA-8600)	4	0.404	0.475	0.366		0.415	
15	Compaq	AlphaServer ES40/833	4	0.465	0.400	0.263		0.376	
16	SGI	SGI 2200-400	8	0.551	0.263	0.300		0.372	
17	HP	RX4610 (Itanium)	4	0.560	0.281	0.231		0.357	
18	HP	rp8400 (PA-8700)	4	0.556	0.281	0.225		0.354	
19	Compaq	AlphaServer ES45/1000	2	0.227	0.523	0.300		0.350	1
20	HP	rp7400 (PA-8700)	2	0.278	0.416	0.316		0.337	
21	Compaq	AlphaServer ES40/667	4	0.362	0.385	0.263		0.337	
22	HP	RX4610 (Itanium)	4	0.499	0.279	0.231		0.337	
23	HP	rp8400 (PA-8700)	4	0.482	0.277	0.225		0.328	
24	HP	rp7400 (PA-8700)	2	0.242	0.416	0.316		0.324	
25	HP	L3000 (PA-8600)	4	0.408	0.330	0.234		0.324	
26	SGI	SGI_Origin2000-300	8	0.393	0.264	0.300		0.319	
27	HP	N4000 (PA-8600)	2	0.206	0.415	0.316		0.312	
28	IBM	RS/6000 SP-222 MHz High Node	4		0.560	0.350		0.303	1
29	SGI	SGI_Origin 3200-500	4	0.366	0.247	0.200		0.271	
30	SGI	SGI_Origin 3800-500	4	0.366	0.247	0.200		0.271	
31	Compaq	AlphaServer ES45/1000	1	0.076	0.448	0.275		0.266	1
32	Sun	HPC 6500	16	0.363		0.400		0.254	1
33	SGI	SGI_Origin3200-400	4	0.314	0.246	0.200		0.253	
34	SGI	SGI_Origin3800-400	4	0.314	0.246	0.200		0.253	
35	HP	i2000 (Itanium)	2	0.300	0.267	0.181		0.249	
36	Compaq	AlphaServer ES40/833	2	0.153	0.347	0.213		0.237	1
37	HP	L3000 (PA-8600)	2	0.207	0.289	0.184		0.227	
38	Compaq	AlphaServer ES40/667	2	0.117	0.339	0.213		0.223	1
39	HP	RX4610 (Itanium)	2	0.311	0.146	0.181		0.213	1
40	HP	RX4610 (Itanium)	2	0.278	0.146	0.181		0.202	1
41	Sun	Sun Fire 6800	8	0.374		0.200		0.191	1
42	HP	i2000 (Itanium)	1	0.150	0.267	0.156		0.191	
43	Sun	HPC 6500	12	0.272		0.300		0.191	1
44	Compaq	AlphaServer ES40/833	1	0.076	0.304	0.188		0.189	1
45	SGI	SGI 2200-400	4	0.276	0.129	0.150		0.185	
46	Compaq	AlphaServer ES40/667	1	0.058	0.296	0.188		0.181	1
47	Sun	Sun_SC2000E	20		0.035	0.500		0.178	1
48	HP	J6000 (PA-8600)	2	0.214	0.195	0.109		0.173	
49	HP	J6700 (PA-8700)	2	0.195	0.195	0.109		0.167	
50	Sun	Sun_SC2000E	16		0.028	0.400		0.143	1

Best-In-Class as of November 2001

The table below shows the best-in-class levels for each metric for computers in the four IDC categories.

Capability class computers scale to an order of magnitude (10 times) higher than capacity computers on all metrics except STREAM TRIAD (only 3.2 times).

Enterprise class computers scale from 3.5 to 11 times Divisional systems, except on SPECfp which is only 2 times Divisional. Divisional system are generally two times Departmental except on number of CPUs (8 times).

IDC Category	Best-In-Class Metric (November 2001)					
	Linpack	SPECfp	Node Bandwidth	STREAM TRIAD	Number of CPUs	System Bandwidth
Capability Largest Problems	7,226	2,546,208	1,280	1,271	9,632	6,048
Enterprise Over $1 million	459	128,000	320	235	896	320
Divisional $250K to $1M	36	13,024	29	13	32	29
Departmental Under $250K	16	3,704	14	6	20	16

Source: IDC, 2001

Cautions

The approach used for the ratings is based on machine characteristics and simple performance benchmarks, and not on complete application benchmarks. Many factors affect the actual performance capability of the computer for an individual user. The IDC Balanced Rating benchmark aims to be useful for comparing a broad set of computers and architectures against a general purpose technical workload, but it isn't meant to replace benchmarking of computers for a specific purchase acquisition. This approach takes a broader view of the computer system as compared to peak and peak-related benchmarks, so it should provide a more comprehensive comparison of technical computers.

Also note that many computer models in the table have incomplete data and this impacts the ranking of those computer models. There are also a number of missing computer configurations. We are asking the broader HPC user and vendor community to help in locating installed configurations and their corresponding data points. IDC plans to update the tables on a regular basis to incorporate the improvement in the data set. We except that the order of the ratings will fluctuate as the data becomes more complete.

In Summary

IDC is working closely with HPC users and vendors in developing a new approach for evaluating HPC computers.

IDC is working closely with HPC users and vendors in developing new approaches for comparing HPC computers. The current standard way of calculating price/performance uses list price and theoretical peak performance. Unfortunately list price as a ratio of peak performance has become almost meaningless, as shown by a range of over 8 fold in the metric for technical computers. A metric that has a range of 8 fold, with highly competitive products spanning the entire range, provides almost no value in comparing computers.

In spite of this, peak performance is still very visible and is used in many situations including computer evaluations, budget allocations, site planning, etc. and can result in very sub-optimal solutions. Often users are forced to justify in detail their purchase decision because they didn't purchase the most peak Gflop/s for their budget.

Multiple ranking tables will be provided to allow HPC users to more closely match their unique computing needs.

Multiple ranking tables will be provided to allow HPC users to more closely match their unique computing needs. Some programs or problems are inherently very parallel and can take advantage of lower cost, highly parallel computers and clusters of low cost computers. At the other extreme are problems or programs that are very sequential or serial in nature. These problems have great difficulty running on more than a single processor and do best on large processors with expensive memory subsystems.

Future Plans

IDC plans to start publishing the new balanced ratings tables in future bulletins and at the IDC web site.

IDC plans to start publishing the new balanced ratings tables in future bulletins and at the web site: www.idc.com/hpc

Over time the separate rating methods will be enhanced and will evolve as new ways to make comparisons are incorporated. Additional performance rating tables may also be added to reflect other important attributes of high performance computers (I/O, software, etc.).

Appendix: Metric Definitions

- One computer (with a single system image), or multiple computers (multiple system images) = This column separates single individual computers from systems that consist of multiple separate computers and/or clusters.

- Linpack Rmax = The reported LINPACK Rmax benchmark results for one processor times the number of processors in the computer, e.g. as shown at: http://www.top500.org/lists/linpack.html The single processor Linpack is used in the calculation to ease the workload on vendors of running Linpack on all configurations. The intent of this metric is to provide an overall view of the peak processor power of the whole computer.

- Processor SPECfp = The reported SPECfp_rate2000 benchmark results for one processor times the number of processors in the computer, e.g. as shown at: http://www.specbench.org/osg/cpu2000/results/cpu2000.html http://www.specbench.org/osg/cpu2000/press/faq.html Again this is the single processor results times the number of processors. The intent of this metric is to provide a different overall view of the processor power of the whole computer.

- Total single node memory bandwidth = The calculated peak bandwidth between main memory and the processors for a single node in GB/s. The intent of this metric is to show how much data can be moved between memory and processors running a prefect problem.

- STREAM TRIAD = The reported or estimated STREAM TRIAD benchmark as shown at: http://www.cs.virginia.edu/stream/standard/Balance.html The intent of this metric is to provide an additional view of the capability of the memory system.

- Total peak system memory bandwidth = The calculated total amount of peak memory bandwidth available to move data between main memory and all of the processors (counting all nodes). This is often equal to the single node memory bandwidth times the number of nodes. This assumes that the computer is used for problems that fit the computer's architecture perfectly.

Note that over time all of the metrics will migrate to actual benchmark results as data becomes available in a consistent manor across all computers. This is where the HPC User Forum and SDSC are helping to improve the available metrics and data.