**Supercomputer**

The fastest computer available. It is typically used for simulations in petroleum exploration and production, structural analysis, computational fluid dynamics, physics and chemistry, electronic design, nuclear energy research and meteorology. It is also used for Realtime animated graphics. See supercomputer sites.

Encyclopedia

supercomputer, a state-of-the-art, extremely powerful computer capable of manipulating massive amounts of data in a relatively short time. Supercomputers are very expensive and are employed for specialized scientific and engineering applications that must handle very large databases or do a great amount of computation, among them meteorology, animated graphics, fluid dynamic calculations, nuclear energy research and weapon simulation, and petroleum exploration. There are two approaches to the design of supercomputers. One, called massively parallel processing (MPP), is to chain together thousands of commercially available microprocessors utilizing parallel processing techniques. A variant of this, called a *Beowulf cluster,* or cluster computing, employs large numbers of personal computers interconnected by a local area network and running programs written for parallel processing. The other approach, called vector processing, is to develop specialized hardware to solve complex calculations. This technique was employed in the *Earth Simulator,* a Japanese supercomputer introduced in 2002 that utilizes 640 nodes composed of 5104 specialized processors to execute 35.6 trillion mathematical operations per second; it will be used to analyze earthquake and weather patterns and climate change, including global warming. Currently the fastest supercomputer is the unfinished *Blue Gene/L,* due to be completed in 2005, when it will utilize 130,000 processors to execute 360,000 trillion mathematical operations per second for environmental simulations. A prototype of Blue Gene/L demonstrated in 2003 was air-cooled, as opposed to many high-performance machines that use water and refrigeration, and used no more power than the average home. In 2003 scientists at Virginia Tech assembled a relatively low-cost supercomputer using 1,100 dual-processor Apple Macintoshes; it was ranked at the time as the third fastest machine in the world.

The Cray-2; world's fastest computer 1985–1989.



A supercomputer is a computer that leads the world in terms of processing capacity, particularly speed of calculation, at the time of its introduction. The term Super Computing was first used by New York World newspaper in 1920 to refer to the large custom built tabulators IBM had made for Columbia University. Supercomputers introduced in the 1960s were designed primarily by Seymour Cray at Control Data Corporation (CDC), and led the market into the 1970s until Cray left to form his own company, Cray Research. He then took over the supercomputer market with his new designs, holding the top spot in supercomputing for 5 years (1985–1990). In the 1980s a large number of smaller competitors entered the market, in a parallel to the creation of the minicomputer market a decade earlier, but many of these disappeared in the mid-1990s "supercomputer market crash". Today, supercomputers are typically one-off custom designs produced by "traditional" companies such as IBM and HP, who had purchased many of the 1980s companies to gain their experience, although Cray Inc. still specializes in building supercomputers.

The term *supercomputer* itself is rather fluid, and today's supercomputer tends to become tomorrow's also-ran, as can be seen from the world's first (nonsolid state) digital programmable electronic computer Colossus, used to break some German ciphers in World War II. CDC's early machines were simply very fast single processors, some ten times the speed of the fastest machines offered by other companies. In the 1970s most supercomputers were dedicated to running a vector processor, and many of the newer players developed their own such processors at lower price points to enter the market. In the later 1980s and 1990s, attention turned from vector processors to massive parallel processing systems with thousands of simple CPUs; some being off the shelf units and others being custom designs. Today, parallel designs are based on "off the shelf" RISC microprocessors, such as the PowerPC or PA-RISC, and most modern supercomputers are now highly-tuned computer clusters using commodity processors combined with custom interconnects.

**Software tools**

Software tools for distributed processing include standard APIs such as MPI and PVM and open source-based software solutions such as Beowulf and open Mosix which facilitate the creation of a sort of "virtual supercomputer" from a collection of ordinary workstations or servers. Technology like Rendezvous pave the way for the creation of ad hoc computer clusters. An example of this is the distributed rendering function in Apple's Shake compositing application. Computers running the Shake software merely need to be in proximity to each other, in networking terms, to automatically discover and use each other's resources. While no one has yet built an ad hoc computer cluster that rivals even yesteryear's supercomputers, the line between desktop, or even laptop, and supercomputer is beginning to blur, and is likely to continue to blur as built-in support for parallelism and distributed processing increases in mainstream desktop operating systems. An easy programming language for supercomputers remains an open research topic in Computer Science.

**Uses**

Supercomputers are used for highly calculation-intensive tasks such as weather forecasting, climate research (including research into global warming), molecular modeling (computing the structures and properties of chemical compounds, biological macromolecules, polymers, and crystals), physical simulations (such as simulation of airplanes in wind tunnels, simulation of the detonation of nuclear weapons, and research into nuclear fusion), cryptanalysis, and the like. Military and scientific agencies are heavy users.

**Design**

Supercomputers traditionally gained their speed over conventional computers through the use of innovative designs that allow them to perform many tasks in parallel, as well as complex detail engineering. They tend to be specialized for certain types of computation, usually numerical calculations, and perform poorly at more general computing tasks. Their memory hierarchy is very carefully designed to ensure the processor is kept fed with data and instructions at all times—in fact, much of the performance difference between slower computers and supercomputers is due to the memory hierarchy design and componentry. Their I/O systems tend to be designed to support high bandwidth, with latency less of an issue, because supercomputers are not used for transaction processing.

As with all highly parallel systems, Amdahl's law applies, and supercomputer designs devote great effort to eliminating software serialization, and using hardware to accelerate the remaining bottlenecks.

**Supercomputer challenges and technologies**

* A supercomputer generates large amounts of heat and must be cooled. Cooling most supercomputers is a major HVAC problem.
* Information cannot move faster than the speed of light between two parts of a supercomputer. For this reason, a supercomputer that is many meters across must have latencies between its components measured at least in the tens of nanoseconds. Seymour Cray's supercomputer designs attempted to keep cable runs as short as possible for this reason: hence the cylindrical shape of his famous Cray range of computers.
* Supercomputers consume and produce massive amounts of data in a very short period of time. According to Ken Batcher, "A supercomputer is a device for turning compute-bound problems into I/O-bound problems." Much work on external storage bandwidth is needed to ensure that this information can be transferred quickly and stored/retrieved correctly.

Technologies developed for supercomputers include:

* Vector processing
* Liquid cooling
* Non-Uniform Memory Access (NUMA)
* Striped disks (the first instance of what was later called RAID)
* Parallel filesystems

**Processing techniques**

Vector processing techniques were first developed for supercomputers and continue to be used in specialist high-performance applications. Vector processing techniques have trickled down to the mass market in DSP architectures and SIMD processing instructions for general-purpose computers. Modern video game consoles in particular use SIMD extensively and this is the basis for some manufacturers' claim that their game machines are themselves supercomputers.

**Operating systems**

Supercomputer operating systems, today most often variants of UNIX, are every bit if not more complex than those for smaller machines. Their user interfaces tend to be less developed however, as the OS developers have limited programming resources to spend on non-essential parts of the OS (i.e., parts not directly contributing to the optimal utilization of the machine's hardware). This stems from the fact that because these computers, often priced at millions of dollars, are sold to a very small market, their R&D budgets are often limited. Interestingly this has been a continuing trend throughout the supercomputer industry, with former technology leaders such as Silicon Graphics taking a backseat to such companies as NVIDIA, who have been able to produce cheap, feature rich, high-performance, and innovative products due to the vast number of consumers driving their R&D.

Historically, until the early-to-mid-1980s, supercomputers usually sacrificed instruction set compatibility and code portability for performance (processing and memory access speed). For the most part, supercomputers to this time (unlike high-end mainframes) had vastly different operating systems. The Cray-1 alone had at least six different proprietary OSs largely unknown to the general computing community. Similarly different and incompatible vectorizing and parallelizing compilers for Fortran existed. This trend would have continued with the ETA-10 were it not for the initial instruction set compatibility between the Cray-1 and the Cray X-MP, and the adoption of UNIX operating system variants (such as Cray's UniCOS).

For this reason, in the future, the highest performance systems are likely to have a UNIX flavor but with incompatible system unique features (especially for the highest end systems at secure facilities).

**Programming**

The parallel architectures of supercomputers often dictate the use of special programming techniques to exploit their speed. Special-purpose Fortran compilers can often generate faster code than the C or C++ compilers, so Fortran remains the language of choice for scientific programming, and hence for most programs run on supercomputers. To exploit the parallelism of supercomputers, programming environments such as PVM and MPI for loosely connected clusters and OpenMP for tightly coordinated shared memory machines are being used.

**Types of general-purpose supercomputers**

There are three main classes of general-purpose supercomputers:

* Vector processing machines allow the same (arithmetical) operation to be carried out on a large amount of data simultaneously.
* Tightly connected cluster computers use specially developed interconnects to have many processors and their memory communicate with each other, typically in a NUMA architecture. Processors and networking components are engineered from the ground up for the supercomputer. The fastest general-purpose supercomputers in the world today use this technology.
* **Commodity clusters** use a large number of commodity PCs, interconnected by high-bandwidth low-latency local area networks.

As of 2002, Moore's Law and economies of scale are the dominant factors in supercomputer design: a single modern desktop PC is now more powerful than a 15-year old supercomputer, and at least some of the design tricks that allowed past supercomputers to out-perform contemporary desktop machines have now been incorporated into commodity PCs. Furthermore, the costs of chip development and production make it uneconomical to design custom chips for a small run and favor mass-produced chips that have enough demand to recoup the cost of production.

Additionally, many problems carried out by supercomputers are particularly suitable for parallelization (in essence, splitting up into smaller parts to be worked on simultaneously) and, particularly, fairly coarse-grained parallelization that limits the amount of information that needs to be transferred between independent processing units. For this reason, traditional supercomputers can be replaced, for many applications, by "clusters" of computers of standard design which can be programmed to act as one large computer.

**Special-purpose supercomputers**

**Special-purpose supercomputers** are high-performance computing devices with a hardware architecture dedicated to a single problem. This allows the use of specially programmed FPGA chips or even custom VLSI chips, allowing higher price/performance ratios by sacrificing generality. They are used for applications such as astrophysics computation and brute-force codebreaking.

Examples of special-purpose supercomputers:

* Deep Blue, for playing chess
* Reconfigurable computing machines or parts of machines
* GRAPE, for astrophysics
* Deep Crack, for breaking the DES cipher

**The fastest supercomputers today**



Blue Gene/L

The speed of a supercomputer is generally measured in "FLOPS" (Floating Point Operations Per Second); this measurement is based on a particular benchmark, which mimics a class of real-world problems, but is significantly easier to compute than a majority of real-world problems.

**Current fastest**

As of March 25, 2005, the fastest supercomputer in a single installation is IBM's Blue Gene/L prototype, with 32,768 processors. It is capable of 135.5 TFLOPS. The Blue Gene/L prototype is a customized version of IBM's PowerPC architecture. The prototype currently sits at IBM's Rochester, Minnesota facility, but production versions will be at various sites, including Lawrence Livermore National Laboratory (LLNL). The LLNL system is expected to achieve at least 360 TFLOPS, and a future update will take it to 1.5 PFLOPS.

**Past record holders**

Prior to Blue Gene/L, the fastest supercomputer was the NEC Earth Simulator at the Yokohama Institute for Earth Sciences, Japan. It is a cluster of 640 custom-designed 8-way vector processor computers based on the NEC SX-6 architecture (a total of 5,120 processors). It uses a customized version of the UNIX operating system.

At the time of introduction, the Earth Simulator's performance was over five times that of the previous fastest supercomputer, the cluster computer ASCI White at Lawrence Livermore National Laboratory. The Earth Simulator held the #1 position for 2½ years. Because it was largely unanticipated by the top performers at the time, its introduction spawned the term "computnik," in a reference to the Soviet Union's upstaging of the Western space program with the 1957 launch of Sputnik.

A list of the 500 fastest supercomputers, the TOP500, is maintained at http://www.top500.org/ .

**Quasi-supercomputing**

Some types of large-scale distributed computing for embarrassingly parallel problems take the clustered supercomputing concept to an extreme. One such example, the SETI@home distributed computing project has an average processing power of 72.53 TFLOPS (*http://setiathome.berkeley.edu/totals.html*).

On May 16 2005, the distributed computing project Folding@home reported a processing power of 195 TFLOPS on their CPU statistics page. (*http://vspx27.stanford.edu/cgi-bin/main.py?qtype=cpustats*). Still higher powers have occasionally been recorded: on February 2 2005, 207 TFLOPS were noted as coming from Windows, Mac, and Linux clients (*http://castlecops.com/t103306-Folding\_Home\_News.html*).

Google's search engine system may be faster with estimated total processing power of between 126 and 316 TFLOPS. Tristan Louis estimates the systems to be composed of between 32,000 and 79,000 dual 2 GHz Xeon machines. (*http://www.tnl.net/blog/entry/How\_many\_Google\_machines*) Since it would be logically difficult to cool so many servers at one site, Google's system would presumably be another form of distributed computing project: grid computing.

**Timeline of supercomputers**

Historical and present:

|  |  |  |  |
| --- | --- | --- | --- |
| **Period** | **Supercomputer** | **Peak speed** | **Location** |
| 1906–1938 | Babbage Analytical Engine Mill | .3 FLOPS | RW Munro, Woodford Green, Essex, England |
| 1938–1939 | Zuse Z1 | 1 FLOPS | Konrad Zuse's parents' apartment, Methfeßelstraße, Berlin, Germany |
| 1939–1941 | Zuse Z2 | 5 FLOPS | Konrad Zuse's parents' apartment |
| 1941–1942 | Zuse Z3 | 20 FLOPS | German Aerodynamics Research Institute (*Deutsche Versuchsanstalt für Luftfahrt*) (DVL), Berlin, Germany |
| 1942–1943 | TRE Heath Robinson | 200 FLOPS | Bletchley Park, England |
| 1943–1944 | TRE Colossus Mk I | 5 kFLOPS | Bletchley Park, England |
| 1944–1946 | TRE Colossus Mk II | 5 kFLOPS | Bletchley Park, England |
| 1946–1956 | U. of Pennsylvania ENIAC | 50 kFLOPS | Aberdeen Proving Ground, Maryland, USA |
| 1956–1958 | MIT TX-0 | 83 kFLOPS | MIT, Lexington, Massachusetts, USA |
| 1958–1960 | IBM SAGE | 400 kFLOPS | U.S. Air Force, USA |
| 1960–1961 | UNIVAC LARC | 500 kFLOPS | Lawrence Livermore National Laboratory (LLNL), California, USA |
| 1961–1964 | IBM 7030 "Stretch" | 1.2 MFLOPS | Los Alamos National Laboratory (LANL), New Mexico, USA |
| 1964–1969 | CDC 6600 | 3 MFLOPS | Lawrence Livermore National Laboratory, California, USA |
| 1969–1974 | CDC 7600 | 36 MFLOPS | Lawrence Livermore National Laboratory, California, USA |
| 1974–1975 | CDC Star-100 | 100 MFLOPS | Lawrence Livermore National Laboratory, California, USA |
| 1975–1981 | Burroughs ILLIAC IV | 150 MFLOPS | NASA Ames Research Center, California, USA |
| 1981–1983 | CDC Cyber-205 | 400 MFLOPS | numerous sites worldwide; |
| 1983–1984 | Cray X-MP4 | 941 MFLOPS | Battelle, Boeing, LANL, LLNL |
| 1984–1985 | M-13 | 2.4 GFLOPS | Scientific Research Institute of Computer Complexes (SRICC), Moscow, USSR |
| 1985–1989 | Cray-2/8 | 3.9 GFLOPS | Lawrence Livermore National Laboratory (LLNL), California, USA |
| 1989–1993 | ETA10-G/8 | 10.3 GFLOPS | Florida State University, Florida, USA |
| 1993–1994 | Thinking Machines CM-5 | 37.5 GFLOPS | Los Alamos National Laboratory (LANL), California, USA |
| 1994–1995 | Fujitsu Numerical Wind Tunnel II | 236 GFLOPS | National Aerospace Lab, Japan |
| 1995–2000 | Intel ASCI Red | 2.15 TFLOPS | Sandia National Laboratories, New Mexico, USA |
| 2000–2002 | IBM ASCI White | 9.216 TFLOPS | Lawrence Livermore National Laboratory, California, USA |
| 2002–2004 | NEC Earth Simulator | 35.86 TFLOPS | Yokohama Institute for Earth Sciences, Japan |
| 2004–2005 | IBM Blue Gene/L prototype | 74 TFLOPS | IBM, Rochester, Minnesota, USA |
| 2005–present | IBM Blue Gene/L prototype | 135.5 TFLOPS | IBM, Rochester, Minnesota, USA |

Forthcoming machines:

* [IBM](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=IBM&gwp=8&curtab=2222_1&sbid=lc04b) [Blue Gene/L](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Blue+Gene&gwp=8&curtab=2222_1&sbid=lc04b), 280–360 TFLOPS (est.), [Lawrence Livermore National Laboratory](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Lawrence+Livermore+National+Laboratory&gwp=8&curtab=2222_1&sbid=lc04b), [California](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=California&gwp=8&curtab=2222_1&sbid=lc04b), [USA](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=United+States&gwp=8&curtab=2222_1&sbid=lc04b)
* [Blue Gene](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Blue+Gene&gwp=8&curtab=2222_1&sbid=lc04b)
* [ASCI Purple](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=ASCI+Purple&gwp=8&curtab=2222_1&sbid=lc04b)
* [ASCI Thor's Hammer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=ASCI+Thor%27s+Hammer&gwp=8&curtab=2222_1&sbid=lc04b)

**See also**

General concepts, history:

* [Beowulf cluster](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Beowulf+%28computing%29&gwp=8&curtab=2222_1&sbid=lc04b)
* [Distributed computing](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Distributed+computing&gwp=8&curtab=2222_1&sbid=lc04b)
* [Flash mob computer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Flash+mob+computing&gwp=8&curtab=2222_1&sbid=lc04b)
* [Grid computing](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Grid+computing&gwp=8&curtab=2222_1&sbid=lc04b)
* [History of computing](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=History+of+computing&gwp=8&curtab=2222_1&sbid=lc04b)
* [MOSIX](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=MOSIX&gwp=8&curtab=2222_1&sbid=lc04b)
* [Parallel computing](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Parallel+computing&gwp=8&curtab=2222_1&sbid=lc04b)

Companies, computers:

* [Bull](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Groupe+Bull&gwp=8&curtab=2222_1&sbid=lc04b) claims to be building a supercomputer that will be the most powerful computer in Europe.
* [Convex Computer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Convex+Computer&gwp=8&curtab=2222_1&sbid=lc04b)
* [Cray Research](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Cray+Inc.&gwp=8&curtab=2222_1&sbid=lc04b)
* [Elbrus](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Elbrus+%28computer%29&gwp=8&curtab=2222_1&sbid=lc04b)
* [Kendall Square Research](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Kendall+Square+Research&gwp=8&curtab=2222_1&sbid=lc04b)
* MasPar
* [Meiko](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Meiko+Scientific&gwp=8&curtab=2222_1&sbid=lc04b)
* [nCUBE](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=NCUBE&gwp=8&curtab=2222_1&sbid=lc04b)
* [PARAM](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=PARAM&gwp=8&curtab=2222_1&sbid=lc04b)
* [Sequent Computer Systems](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Sequent+Computer+Systems&gwp=8&curtab=2222_1&sbid=lc04b)
* [Supercomputer Systems](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Supercomputer+Systems&gwp=8&curtab=2222_1&sbid=lc04b)
* [Tera](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Tera&gwp=8&curtab=2222_1&sbid=lc04b)
* [Thinking Machines](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Thinking+Machines&gwp=8&curtab=2222_1&sbid=lc04b)

Other classes of computer:

* [Mini-supercomputer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Minisupercomputer&gwp=8&curtab=2222_1&sbid=lc04b)
* [Mainframe computer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Mainframe+computer&gwp=8&curtab=2222_1&sbid=lc04b)
* [Supermini](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Supermini&gwp=8&curtab=2222_1&sbid=lc04b)
* [Minicomputer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Minicomputer&gwp=8&curtab=2222_1&sbid=lc04b)
* [Microcomputer](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Microcomputer&gwp=8&curtab=2222_1&sbid=lc04b)

**External links**

* See the [TOP500 Supercomputer list](http://www.top500.org/) (*http://www.top500.org/*) for more information.
* [HP announcement of contract to build Linux supercomputer](http://www.wswinteractive.com/hp/pnnl/default.htm) (*http://www.wswinteractive.com/hp/pnnl/default.htm*)
* [Linux NetworkX press release: Linux NetworX to build "largest" Linux supercomputer](http://lwn.net/Articles/4759/) (*http://lwn.net/Articles/4759/*)
* [ASCI White press release](http://www.llnl.gov/asci/news/white_news.html) (*http://www.llnl.gov/asci/news/white\_news.html*)
* [Article about Japanese "Earth Simulator" computer](http://www.hoise.com/primeur/02/articles/weekly/AE-PR-05-02-59.html) (*http://www.hoise.com/primeur/02/articles/weekly/AE-PR-05-02-59.html*)
* ["Earth Simulator" website (in English)](http://www.es.jamstec.go.jp/esc/eng/) (*http://www.es.jamstec.go.jp/esc/eng/*)
* [NEC high-performance computing information](http://www.nec.com.sg/necsin/hpcs.htm) (*http://www.nec.com.sg/necsin/hpcs.htm*)
* [Pittsburgh Supercomputing Center](http://www.psc.edu/) (*http://www.psc.edu/*) operated by [University of Pittsburgh](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=University+of+Pittsburgh&gwp=8&curtab=2222_1&sbid=lc04b) and [Carnegie Mellon University](http://www.answers.com/main/ntquery;jsessionid=43irngl6qbfrr?method=4&dsid=2222&dekey=Carnegie+Mellon+University&gwp=8&curtab=2222_1&sbid=lc04b).
* [Papers on the GRAPE special-purpose computer](http://grape.c.u-tokyo.ac.jp/gp/paper/hardpaper.html) (*http://grape.c.u-tokyo.ac.jp/gp/paper/hardpaper.html*)
* [More special-purpose supercomputer information](http://big.gsc.riken.go.jp/SPCtext.htm) (*http://big.gsc.riken.go.jp/SPCtext.htm*)
* [information about APEmille special-purpose computer](http://chimera.roma1.infn.it/apehdoc/apemille/INFN_APEmille.html) (*http://chimera.roma1.infn.it/apehdoc/apemille/INFN\_APEmille.html*)
* [information about QCDOC](http://phys.columbia.edu/~cqft/) (*http://phys.columbia.edu/~cqft/*)
* [Dead Supercomputer](http://www.paralogos.com/DeadSuper/Projects.html) (*http://www.paralogos.com/DeadSuper/Projects.html*)
* [Superconducting Supercomputer](http://www.hq.nasa.gov/hpcc/insights/vol6/supercom.htm) (*http://www.hq.nasa.gov/hpcc/insights/vol6/supercom.htm*)