# The TOP25 Supercomputer Sites.

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**Abstract**

In this short note the TOP25 supercomputer sites worldwide are introduced. This list of the TOP25 sites has been compiled based on the information given in the TOP500 report. First we briefly explain how this list was established and comment on recent changes. For most of the top twentyfive supercomputer centers we provide a short description of facilities, equipment, and mission.

# 1 Introduction

The TOP500 [1] provides an opportunity to rank the top supercomputer sites worldwide. In the TOP500 report the 500 highest performing supercomputers are listed. The measurement of performance is based on the LINPACK benchmark as reported in [2]. All the information here is based on the TOP500 list of November 1995. We use results from this list because because it provides the most comprehensive list of supercomputer sites. Also real LINPACK figures are available for all the machines on the list. Some of the limitations of using LINPACK and relying on the TOP500 list are discussed elsewhere [3].

An alternative "List of the World's Most Powerful Computing Sites" is compiled by Ahrendt [4]. This list is based on the NAS Parallel Benchmarks code BT [5]. There is considerable overlap between these two lists. BT as benchmark generally does not perform as well on highly parallel machines as LINPACK, when compared to vector machines. Also BT results are not always immediately available on new machines, so [4] resorts sometimes to estimates and extrapolations. On the other hand the list [4] is updated more frequently. In general, however, the results and the ranking are fairly consistent. The main point here is that we will give some additional information about the supercomputer sites, beyond just a listing of machines. This provides a general overview and pointers to further reading, on what the most powerful supercomputers on earth are actually used for.

# 2 List of the TOP25 Sites

The TOP25 list of supercomputer sites is given in Table 1. This list has been established by simply adding the LINPACK $R_{max}$ performance in Gflop/s of all supercomputers installed at a given site. Generally under a "site" we have combined supercomputers, which are installed in the same geographical location, and belong to the same organizational unit. Thus all machines belonging to a university on the same campus were added, even though they might be in different departments.

The list does not contain any of the vendor machines. Most of the supercomputer vendors have substantial compute capabilities, which would make the TOP25 centers list. However, the intent of this list is to give an indication where most compute power in terms of scientific and research applications is concentrated. Therefore we decided to list the vendors separately in Table 2.

Finally we note that there a no European sites among the TOP25. Details on the European Centers can be found in a companion article. Most of the top European centers are occupying ranks between 25 and 50 worldwide, starting with the University of Edinburgh at rank 28.

In all tables the column "machines" lists the machines whose performance have been added to reach the total performance for a site. The integers refer

Table 1: **TOP25 Supercomputer Sites**

| | 1993 | Institution | Machines | Perf. |
|---|---|---|---|---|
| 1 | 1 | National Aerospace Lab. (NAL), Tokyo | 1, 116, 278 | 184.4 |
| 2 | 11 | Oak Ridge National Laboratory | 3, 54, 102, 405, 499 | 159.9 |
| 3 | 7 | National Security Agency | 4, 57, 74, 173, 193, 254, 334 | 156.5 |
| 4 | 2 | Los Alamos National Laboratory | 10, 16, 37, 119, 120 | 155.4 |
| 5 | 12 | Sandia National Labs, Albuquerque | 2 | 143.4 |
| 6 | 4 | University of Minnesota | 13, 17, 164, 227, 346, 347, 460 | 124.6 |
| 7 | | Natl. Lab. High Energy Physics, Japan | 5 | 98.9 |
| 8 | | Cornell Theory Center | 6, 285, 312 | 96.0 |
| 9 | | Tokyo University | 15, 29, 361 | 83.8 |
| 10 | | Maui HPCC | 8, 110, 402, 403 | 83.7 |
| 11 | 24 | Japan Atomic Energy Commission | 11, 142, 188, 274, 275 | 75.9 |
| 12 | | Tohuku University | 41, 43, 83, 98 | 71.3 |
| 13 | 22 | Pittsburgh Supercomputing Center | 18, 81 | 64.5 |
| 14 | 6 | NASA Ames Research Center | 26, 78, 145, 163, 496 | 59.4 |
| 15 | 13 | Atmospheric Env. Serv., Dorval, Canada | 39, 45, 52 | 58.7 |
| 16 | | Nagoya University | 12, 279 | 58.5 |
| 17 | 3 | US Government, Classified | 70, 71, 72, 73 | 54.8 |
| 18 | 18 | National Genetics Res. Japan | 14 | 52.1 |
| 19 | 10 | Lawrence Livermore National Laboratory | 36, 77, 221, 223, 446 | 51.9 |
| 20 | | US Government, Classified | 123, 124, 130, 131, 132, 133 | 50.1 |
| 21 | | Angstrom Partnership, Japan | 19, 135 | 50.1 |
| 22 | 5 | NCSA, Univ. of Illinois | 24, 146, 261, 262, 357 | 49.9 |
| 23 | | Jet Propulsion Laboratory | 31, 139, 240, 470 | 40.5 |
| 24 | | Tsukuba University | 20 | 39.8 |
| 25 | | RIKEN, Japan | 21 | 37.2 |
| Total | | | 89 Systems | 2098.7 |
| Percentage | | | 17.8% | 43.9% |

to the ranking of these supercomputers on the Top500 list. The performance column lists the aggregate performance of all the machines at the site in Linpack $R_{max}$-Gflop/s. An overview of many of the supercomputers in use is [6].

There are several intriguing observations one can make from Table 1. In order to qualify as a top supercomputer site, and installation must have at least a machine with more than 35 Gflop/s performance. Two years ago the cutoff was only 13.7 Gflop/s, and 35 Gflop/s would have placed an institution on rank seven. There has been a tremendous acceleration of available cycles at the top supercomputer centers.

Another significant change is in the geographical distribution. Whereas two years ago there were only four Japanese sites on the Top25 list, there are now ten sites in 1995. This can be (in part) attributed to an agressive investment in supercomputing technology in Japanese research institutes and universities in early 1994, which led to a wave of supercomputer installations. On the other hand there are currently no European sites among the Top25.

The list also shows how much U.S. government spending dominates the supercomputing world. All 14 U.S. sites directly or indirectly are funded by the U.S. government. There are 10 U.S. government laboratories/centers (4 Department of Energy, 3 classified, 2 NASA, 1 Dept. of Defense), and the four U.S. universities receive their support for supercomputers from the NSF or DoD (Minnesota). However, also the foreign sites are also all falling into the same category, and are government institutions in their countries.

# 3 Vendor Sites

Most of the supercomputer vendors maintain substantial benchmarking capabilities. These are usually distributed worldwide. Since the vendor centers are geared towards benchmarking and internal software development, we decided this year not to list them in the same list as the Top25 supercomputer centers, which are geared towards research. In Table 2, we list the vendor sites, which would have made the Top25 list.

Table 2: **TOP Vendor Sites**

| | Institution | Machines | Perf. |
|---|---|---|---|
| 1 | IBM | 7, 154, 185, 235 | 106.2 |
| 2 | NEC | 9, 40, 426 | 86.4 |
| 3 | Cray Res. | 32, 62, 63, 94, 193 | 71.2 |
| 4 | SGI | 30, 51, 267, 311 | 50.1 |
| Total | | | 313.9 |

# 4 Background Information about some of the TOP25 sites

Wherever available some short summary of the mission and the environment of the TOP25 sites will be given below. If not noted otherwise, this information was gathered from home pages of these sites on the world wide web (WWW). Many of the supercomputer sites have created such home pages. In order to facilitate browsing the net, URLs for site home pages are given.

## 4.1 National Aerospace Laboratory Numerical Wind Tunnel, Tokyo, Japan - 184.409 Gflop/s

Source: http://www.jicst.go.jp/www/Institutes/nal/contents.html

The laboratory was founded as the National Aeronautical Laboratory in 1955, and the space division was incorporated into the newly-designated National Aerospace Laboratory (NAL) in 1963. Since then, NAL has conducted research and development related to aircraft, aeroengines and rockets. At the same time, NAL has directed its effort towards constructing large-scale test facilities for common use with other Government organizations. NAL's research activities have made many important achievements in the field of aerodynamics,material strength, structural mechanics, aeroengines and control systems.

Major Areas of Research Research activities in the Computational Sciences Division are focused on numerical simulation technology, ranging from basic to applied, which is now a key technology in research and development in the field of aeronautical and space technology. Research on applied artificial intelligence and image processing is also being conducted. Additionally, the Computational Sciences Division is responsible for the management and operation of the Numerical Simulator.

Numerical simulation technology is a key research and development technology in the field of aeronautics and astronautics, which has been advancing rapidly together with the evolution of ultra-high speed computers. NAL's efforts are devoted to the research and development of numerical simulation technologies for results of studies on mathematical and numerical analysis, parallel computers, and image processings. The developed software packages are effective design tools for aircraft and spacecraft in Japan.

The main computational resource at NWT is is a unique parallel computer system of distributed memory architecture composed of vector processors. NWT consists of 140 Processing Elements (PE), two Control Processors(CP) and Crossbar Network. That is, each PE itself is a vector supercomputer similar to VP400. Each PE has 256 MBytes of memory and peak performance of 1.7 GFLOPS. PE has Vector Unit, Scalar Unit and Data Mover which communicates with other PE's. PE is 50% faster than the standard VP400 and same size of memory. CP has 128 MB of memory. CP manages NWT and communicates with VP2600 through SSU. CP's do not execute real computation of CFD code. The cross-bar network has 421 MByte/s x 2 x 142 performance between each processors. The total performance of NWT is 236 GFLOPS and 35 GB main memory.

## 4.2 Oak Ridge National Laboratory, Oak Ridge, Tennessee - 159.900 Gflop/s

Source: http://www.ccs.ornl.gov/

The Center for Computational Sciences (CCS) at Oak Ridge National Laboratory (ORNL) provides state-of-the-art resources for Grand Challenge computing and serves as a centerpiece for computational science at ORNL. The CCS is the ORNL focal point for the U.S. High Performance Computing and Communications (HPCC) Program, with responsibilities also extending to educational initiatives. The CCS is home to one of the two High Performance Computing Research Centers established by the United States Department of Energy (DOE). The CCS is a focus for collaborations with academia, industry, and other federal laboratories. Through these efforts, the Center extends its impact far beyond the boundaries of the Oak Ridge campus. The most extensive of these cooperative ventures is the Partnership in Computational Science (PICS) Consortium supported by the DOE's Office of Scientific Computing (OSC). The three national laboratories and six universities of the PICS collaborate on a variety of Grand Challenges and other research projects. In addition to ORNL and PICS, the CCS provides computational resources to the DOE's Advanced Mathematics and Model Physics (CHAMMP) program, as an essential component of its global climate modeling program, and to a number of other Grand Challenge programs (Quantum Chromodynamics, Quantum Structure of Matter, Numerical Tokamak, Computational Biology, Computational Chemistry). Resources are also provided to a number of other organizations or programs involved in systems evaluation (e.g., NASA, ARPA, other universities and federal labs) to assist scientists and engineers in evaluating current architectures and systems with an eye to superior capabilities in the future.

The main computational resource at ORNL is an Intel Paragon with 3072 Intel i860XP processors. This is one of the more recent Intel installations, which features the MP node (with two floating point processors per node).

## 4.3 National Security Agency, Fort Meade, Maryland - 156.471 Gflop/s

Source: http://www.nsa.gov:8080

The National Security Agency/Central Security Service is responsible for the centralized coordination, direction, and performance of highly specialized technical functions in support of U.S. Government activities to protect U.S. communications and produce foreign intelligence information. The National

Security Agency (NSA) was established by Presidential directive in 1952 as a separately organized agency within the Department of Defense under the direction, authority, and control of the Secretary of Defense, who acts as Executive Agent of the U.S. government for the production of communications intelligence (COMINT) information.

Detailed information about the computational resources at NSA are not directly available. However, it is believed that the largest Cray T3D ever built, a 1024 processor machine, is installed there. Evidence for the existence of this machine are NAS Parallel Benchmarks results, which were run on a 1024 T3D before this machine was installed at a "classified" site. The count of actual machines at this site may be inaccurate, but NSA is definitely a TOP10 site as far as supercomputing is concerned.

## 4.4 Los Alamos National Laboratory, Los Alamos, New Mexico - 155.400 Gflop/s

Source: http://www.acl.lanl.gov/Home.html and http://www.lanl.gov:/welcome.html

In December, 1991 Los Alamos National Laboratory was named as one of two national high performance computing research center (HPCRC) sites by the Department of Energy's (DOE) HPCC Program. The Advanced Computing Laboratory (ACL) at LANL is the foundation upon which this center is being built. The goal of the ACL as an HPCRC is to promote technology transfer in advanced computing to industry, academia, and other national laboratories through the operation of an experimental computational laboratory. The ACL will support an advanced environment for computational scientists working together in interdisciplinary teams to solve today's Grand Challenges, forming the building blocks of tomorrow's computing environment and educating others in the tools of the trade. Together, the Grand Challenge problems, the GRAnd Challenge Computing Environment (GRACCE), and the ACL form the nucleus of the HPCRC.

The main computational resources at LANL are a 1056 node CM-5, the largest CM-5 ever built, as well as a large 512 processor Cray T3D.

## 4.5 Sandia National Laboratory, Albuquerque, New Mexico - 143.400 Gflop/s

Source: http://www.cs.sandia.gov/

The Department of Energy's Sandia National Laboratories is one of the nation's largest and most diverse research and development facilities. It employs more than 8,000 people at two locations in New Mexico and California. One of Sandia's strengths is in computational and experimental mechanics where several advanced code development efforts are in progress. These codes are run on state-of-the-art vector and massively parallel computer systems at Sandia. They support internal customers with analysis capabilities and the codes are also distributed to external customers. In addition, Sandia makes use of commercial and externally developed codes when applicable.

The highly parallel supercomputers are located at Sandia's Massively Parallel Computing Research Laboratory (MPCRL) in Albuquerque, NM. The main computational resource at Sandia is the largest Intel Paragon, a 3680 processor machine. Several applications which run in excess of 100 Gflop/s have been developed at Sandia. Sandia recently announced that it will acquire a Teraflops computer in 1996, under a joint research contract with Intel in the framework of the new DoE ASCI program.

## 4.6 University of Minnesota, Minneapolis, - 124.620 Gflop/s

Source: http://www.msc.edu/ and http://www.arc.umn.edu/html/ahpcrc.html and http://www.lcse.umn.edu/

Resources at the University of Minnesota include supercomputers at several University associated or managed centers such as the Minnesota Supercomputer Center, the Army High Performance Computing Research Center (AHPCRC), and the "Laboratory for Computational Science and Engineering".

AHPCRC is a university led research and educational consortium. Consortium members include the University of Minnesota as prime contractor and Howard, Jackson State, and Purdue Universities. The AHPCRC is funded by the Army Research Office's Division of Mathematical and Computer Sciences. The AHPCRC mission is to advance the state of the art in heterogeneous and networked high performance computing, to educate Army researchers and the next generation of engineers and scientists in new techniques in high performance computing, and to promote technology transfer and encourage joint research and development projects which include both university and Army researchers.

## 4.7 National Laboratory for High Energy Physics (KEK), Japan - 98.900 Gflop/s

Source: http://www.kek.jp/kek/shomu/hajimeni-e.html

The National Laboratory for High Energy Physics (KEK) was established on April 1, 1971, as a national center of high energy physics open to users from universities and other institutions. KEK is the first of thirteen so called "Inter-University Research Institutes", which are a new type of institutes operated under MONBUSHO (Ministry of Education, Science and Culture).

KEK is located at the northern boundary of Tsukuba Science City, in which about 40 research laboratories and two universities have been established, and occupies the site approximately 1 km x 2 km. KEK was originally established for the purpose of promoting experimental studies on elementary particles, and a 12 GeV proton synchrotron was constructed as the first major facility. Since its commissioning in 1976, the proton synchrotron played an important role to boost experimental activities in Japan and thus laid the foundation of the next big step in high energy physics program of KEK, i.e., a 30 GeV electron-positron colliding-beam accelerator called TRISTAN. The TRISTAN project was approved by the Government in 1981 and the accelerator complex was completed in 1986. The TRISTAN electron-positron collider is open to the international community of high energy physicists, for instance, the AMY collaboration has international participation by US, China, Korea and Philippine physicists.

KEK is also a key laboratory for many cooperative programs between university groups in Japan and foreign institutions. Most of them are being executed under formal arrangements or memorandum between Governments or institutions. Two major ones are the Japan-US Cooperation Program in high-energy physics and the Japan-UK Collaboration Program in neutron diffraction experiments. KEK is responsible for funding and coordination of these programs. The total number of the KEK staff members is now 627, consisting of 324 scientific researchers, 149 technical engineers and 154 administrative staff. In addition, there are 106 foreign long-term visiting scientists.

## 4.8 Cornell University, Ithaca, NY – 96.024 Gflop/s

Source: http://www.tc.cornell.edu/Highlights/resources.html

The computational resources at Cornell University are located at the Cornell Theory Center (CTC), one of four supercomputing centers funded by the National Science Foundation. CTC also receives funding from the Advanced Research Projects Agency, the National Center for Research Resources at the National Institutes of Health, New York State, IBM Corporation, and other members of the center's Corporate Partnership Program.

The CTC's resources have been used by more than 5,000 researchers in fields as diverse as aerospace engineering, economics, and epidemiology. Its staff offers technical expertise in software, visualization, and parallel processing to its users, and investigates new, highly parallel processing resources for the scientific community in order to increase the usability of these computers through systems development and through examination of techniques to improve performance. A variety of education and training programs are also offered to high school, undergraduate, and graduate students, and their professors. The Theory Center's reputation as a world-class high-performance computing resource is based on its research collaborations among academia, industry, and government researchers, integrated and highly parallel high-performance computing environment, world-class education and training programs, and powerful local, national, and international technology exchange networks.

The CTC's main resource is a 512 node IBM SP-2.

## 4.9 University of Tokyo, Japan - 83.776 Gflop/s

Source: http://www.race.u-tokyo.ac.jp/RACE/db/ut-server/infoServers.html

The Computer Centre was established in 1965 as a national shared facility to offer computing, data processing and information retrieval to researchers in universities, junior colleges and specialized high schools and graduate students. Currently, the Centre is one of 7 such shared computer centers and is making close contact, information interchange and coordination with other centers and also with NACSIS (National Center for Science Information System) through various committees, coordinating meetings and research groups.

The main system is a loosely-coupled multiprocessing system consisting of a super- computer HITAC S-3800/480 (4 processors, 2GB of main storage, 16GB of extended storage), general-purpose computers HITAC M-880/310 (3 processors, 1GB of main storage, 4GB of extended storage) and HITAC M-682H(2 processors, 256MB of main storage). Users can access the same program and data files and execute programs in any of the computers of choice, because large- capacity discs and a magnetic-tape library (an automatic handling system of 3000 tapes) are shared by all the above computers. Besides HITAC VOS3, UNIX (OSF/1) is available as one of the OSs. HITAC M-880/310 Of the above systems, the S-3800/480 system is one of the fastest supercomputers in the world. The peak performance of each processor is 8 GFLOPS making the total 32 GFLOPS.

## 4.10 Maui High Performance Computing Center, Kihei, Hawaii - 83.700 Gflop/s

Source: http://www.mhpcc.edu/general/about.mhpcc.html

The Maui High Performance Computing Center (MHPCC) was developed and is managed by a consortium led by the University of New Mexico under a cooperative agreement administered by Phillips Laboratory, United States Air Force.

This center of the University of New Mexico is designated as a Support Center for the Department of Defense High Performance Computing Modernization Program. The funding source for the cooperative agreement, awarded in September 1993, is the Air Force Phillips Laboratory, Advanced Research Projects Agency, U.S. Dept. of Defense High Performance Computing Modernization Program. Of the $21 million initial funding, approximately 70% will be spent on equipment and communications.

Established only in 1994 the MHPCC is the newest TOP25 supercomputer center. Its main resource is a 384 processor IBM SP-2.

## 4.11 Japan Atomic Energy Institute, Japan - 75.918 Gflop/s

Source: http://www.jicst.go.jp/www/Institutes/jaeri-n/contents.html

As the central area of its research and development, the Japan Atomic Energy Research Institute(JAERI) has continued to search for future opportunities since Japan started development and utilization of atomic energy. At present, JAERI aims at developing innovative technologies such as new atomic energy, maintenance and security of higher safety in nuclear facilities, and expanded utilization of radiation, and it is coping with challenges which are yet known. As an organization researching atomic energy in general, JAERI has a variety of R&D themes, most prominently from the stance of a builder of the future, "to build tomorrow with atomic energy".

This cannot be achieved without integrating a variety of excellent technologies. In JAERI, five Research Establishments and two Research Facilities are engaging in their respective research activities and to integrate these activities enables the unique research and development at JAERI. JAERI's comprehensive research activities, not only serve as scientific and technological basis for nuclear development in Japan, but also contribute to the nuclear development of all over the world through international cooperation.

In the Research Support Computing and Information Systems Center a huge amount of scientific and engineering computation indispensable for key R&Ds is processed by main computer systems. To also meet the needs of advanced R&Ds, pioneering applications such as parallel computing are now under development.

## 4.12 Tohuku University, Japan - 71.300 Gflop/s

Sources: http://www.tohoku.ac.jp and http://www.imr.tohoku.ac.jp/index-e.html and http://hh.ifs.tohoku.ac.jp/IFS/INFORMATION

The Computer Center of Tohoku University (CCTU) was founded in June 1969 as an inter-university cooperative institution to meet the computation and information processing requirements' of students and research scholars. The SX-1 super computer was introduced in 1986 to meet the demand for large scale scientific computation. In February 1989, the SX-1 was replaced by the SX-2N super computer. And in January 1994, the SX-2N was replaced by a more powerful SX-3/44R. The current architecture is quite new and unique considering the quality as well as the magnitude of the features offered. The peak vectorial processing rate of SX-3/44R is 25.6 GFLOPS. It has 4GB main storage, 16GB extended memory units (XMU), 22. 9GB array disk units, 114 GB magnetic disk units, and 290GB cartridge tape library units.

The Institute of Fluid Science was originally founded on October 5, 1943 in Tohoku University as the "Institute of High Speed Mechanics (IHSM)" for promoting the researches on hydraulic machinery and cavitation on hydrofoils. The research field of the institute was extended to develop the Thermal Dynamics and the Gas Dynamics to cover the industrial fields of mechanical engineering and the aeronautical engineering. The research activity contributed to industrial technology, for example, the development of the jet engine "Ne20" in 1944, which was the first one in Japan. The researches on the flow phenomena in the various pipes had also made remarkable achievements. The institute consists of twelve research sections and one research center. The supercomputer CRAY Y-MP8 was installed at the institute on January 1, 1992 to promote the research on fluid science in the viewpoint of the computational fluid dynamics and the supercomputer CRAY C916 was reinstalled at the institute on November 1, 1994 to provide the computation with higher performance.

The Institute for Materials Research (IMR) was reorganized on May 21, 1987 as a collaborative research institute to meet the current rapid progress in materials science. IMR provides opportunities for the researchers both in academic institutes and industries to carry out cooperative work for mutual benefits. The chance for this collaboration is open not only to Japanese researchers but also to those overseas. Historically IMR was initiated in 1916 in Tohoku University as the Second Division of the Provisional Institute of Physical and Chemical Research for promoting physical, chemical and metallurgical research on alloys. It was inaugurated on May 21, 1919 under the name of the Iron and Steel Research Institute, as the first research institute affiliated with the national university in Japan. By 1922 the research activities of this institute were extended to cover light and nonferrous metals and alloys. The field of research of the Institute now covers the problems on ceramics and semiconductors.

## 4.13 Pittsburgh Supercomputer Center, Pittsburgh, Pennsylvania – 64.500 Gflop/s

Source: http://www.psc.edu/

Pittsburgh Supercomputing Center (PSC) is a joint project of Carnegie Mellon University and the University of Pittsburgh together with Westinghouse Electric Corporation. It is one of four national supercomputing centers funded by a grant from the National Science Foundation, and a member of the National MetaCenter for Computational Science and Engineering.

PSC's four-fold mission is to (1) enable solutions to important problems in Science and Engineering by providing leading-edge computational resources to the national community; (2) advance computational science, computational techniques and the National Information Infrastructure; (3) educate researchers in high performance techniques and their utility; and (4) assist the private sector in exploiting high performance computing for their competitive advantage.

## 4.14 Atmospheric Env. Serv., Dorval, Canada - 58.670 Gflop/s

Source: http://www.on.doe.ca/

The Atmospheric Environment Service is a national service of Environment Canada, a Canadian government department. Atmospheric Services Division promotes national quality service and delivery, sets data and environmental forecast product standards, manages warning delivery technologies, and publishes documentation. This is the only TOP25 site outside the US and Japan.

### 4.15 Nagoya University, Japan - 58.509 Gflop/s

Source: http://www.nagoya-u.ac.jp/index-e.html

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