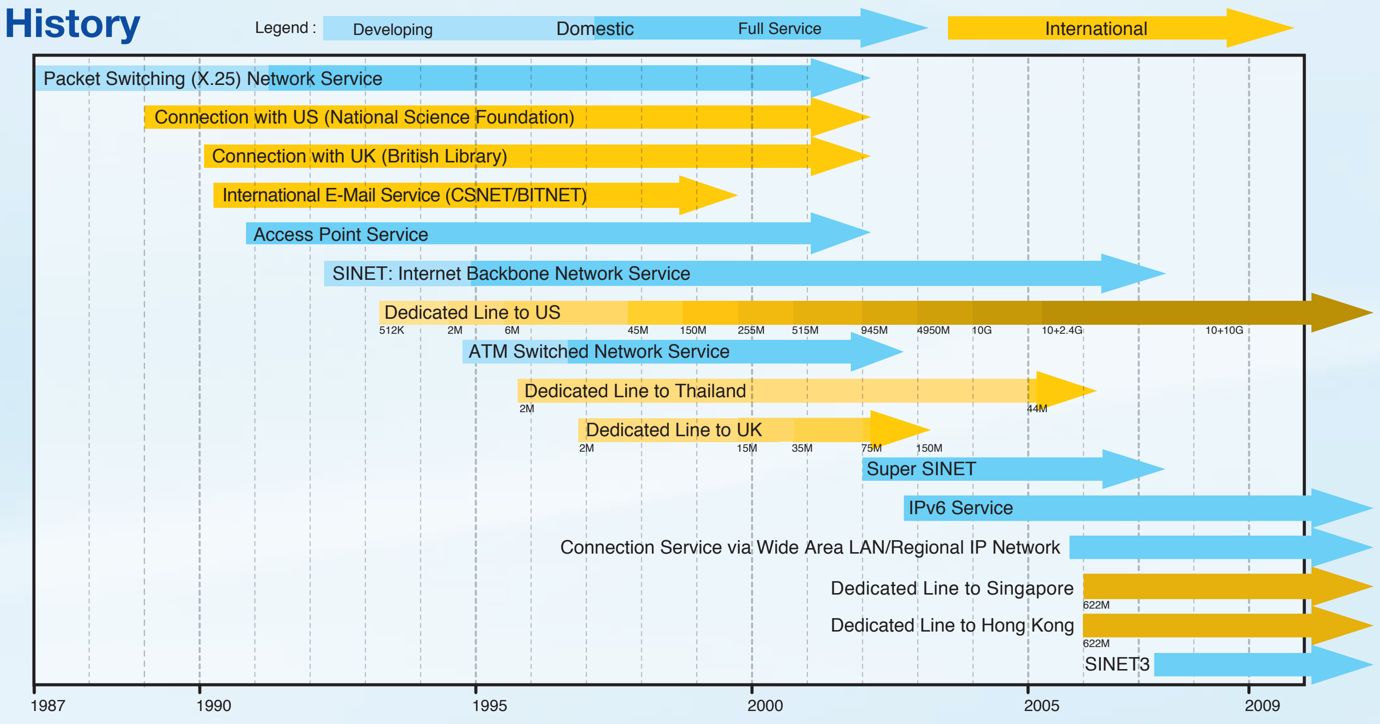
History



SINET Promotion Office

The SINET Promotion Office was established in October 2007 in order to promote the use of SINET. It provides consulting on the advanced use of the network, user support, and training and promotion regarding network services, and also carries out an educational campaign. If you experience any trouble or find something you do not understand, please contact us for assistance.

【Main activities in fiscal 2008】

- Held presentations on using SINET3 in Nagoya, Fukuoka, Sapporo, Tokyo, Osaka, Toyama, and Okinawa
- Conducted survey of performance-related problems and provided advice on usage (E-mail responses: 98; Phone responses: 81; Visitors received: 8; Visits made: 31)

【Please direct queries to】

SINET Promotion Office
Research and Development Center for Academic Networks
Tel: +81-3-4212-2269 Fax: +81-3-4212-2270
E-mail: support@sinet.ad.jp

Services

User consultation/response
Consulting on the use of network services

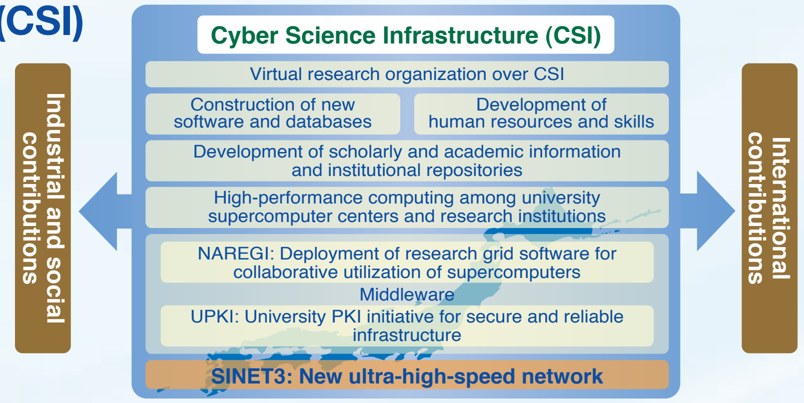
Interviews/surveys on user requests
Solicitation of comments and requests for SINET3

Troubleshooting of performance-related problems
Support for network service usage problems and performance improvements

Technology promotion and educational campaign (lectures and technological exchanges)
Presentations on using SINET3, educational campaign, case examples of SINET3 promotion, creation of documentation, and publication of information on the Web

Cyber Science Infrastructure (CSI)

The National Institute of Informatics (NII) is promoting the development of the Cyber Science Infrastructure (CSI) through cooperation with universities and other organizations. CSI supports Japan's academic research and educational activities and strengthen international competitiveness.
SINET3 plays an important role as the core component of CSI.



Inter-University Research Institute Corporation
Research Organization of Information and Systems
National Institute of Informatics
NII

2-1-2 Hitotsubashi, Chiyoda-ku, Tokyo 101-8430 URL http://www.nii.ac.jp/

Contact SINET Planning Team, Academic Network Division
Cyber Science Infrastructure Development Department
TEL: +81-3-4212-2255, FAX: +81-3-4212-2270
E-mail: support@sinet.ad.jp URL http://www.sinet.ad.jp/

R100 Printed on 100% Recycled Paper
PRINTED WITH SOY INK
2009.04

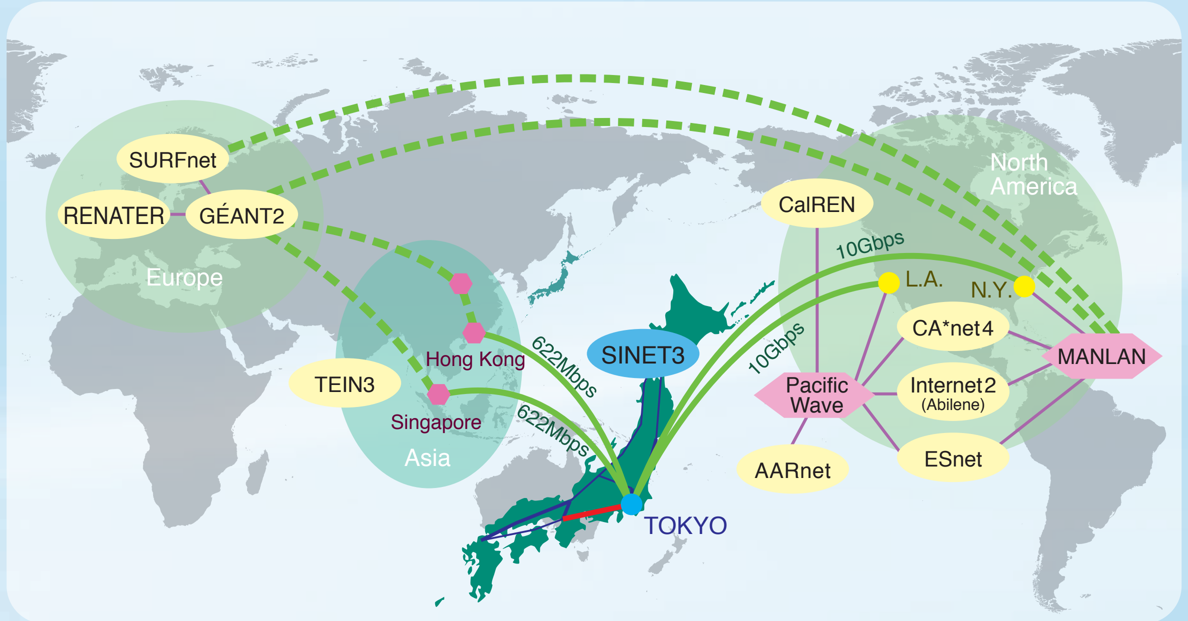
SINET3

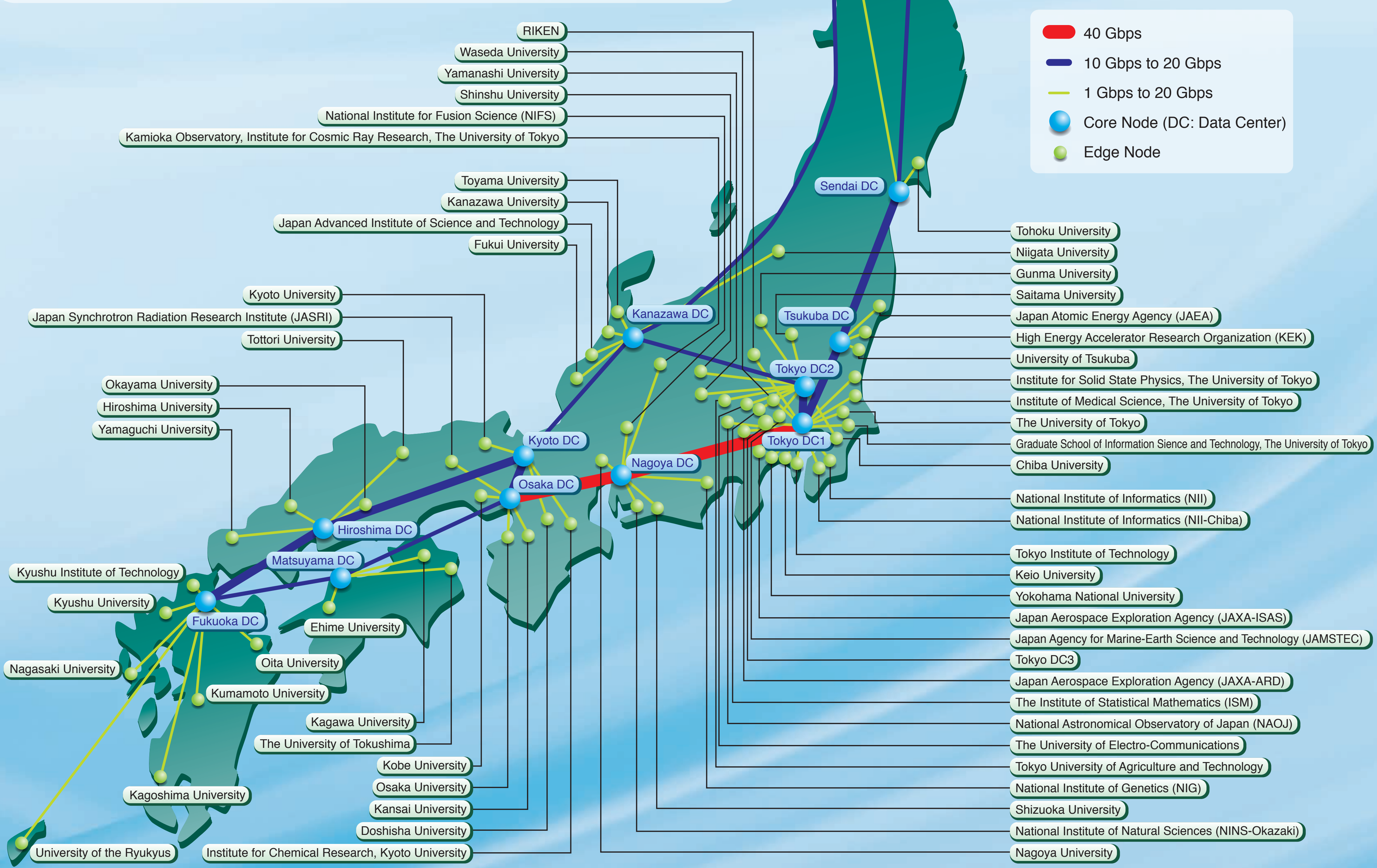
Science Information NETwork 3

The Science Information Network (SINET) is an information and communication network connecting universities and research institutions throughout Japan via nationwide connection points (nodes). It is designed to promote research and education as well as the circulation of scientific information among universities, research institutions, and similar entities. SINET is also connected to research networks such as Internet2 in the U.S. and GÉANT2 in Europe to facilitate dissemination of research information and collaborations over networks.

SINET3 began operations in April 2007, and it replaces the previous SINET and Super SINET. SINET3 plays an important role as the core component of the Cyber Science Infrastructure (CSI).

Network Architecture of SINET3





Before April 2007, the National Institute of Informatics (NII) had operated two academic infrastructures, the Science Information Network (SINET) and Super-SINET. SINET was a nationwide academic internet backbone, and it promoted research and education at more than 700 universities, research institutions, and related entities. The network provided pure IP-based services, and the line speed was up to 1 Gbps. Super-SINET provided a high-speed network environment, with line speeds up to 10 Gbps, to academic institutions concentrating on such research areas as high-energy physics, nuclear fusion science, space and astronomical science, genome analysis, nanotechnology research, simulation sciences, and grid computing.

After taking into consideration the increasingly diversified requirements and functional limitations of current equipment, i.e. IP routers, NII decided to construct SINET3, a next-generation academic infrastructure that integrates SINET and Super SINET.

SINET3 is a hybrid network composed of layer-1 switches and IP/MPLS routers. It provides layer-1 end-to-end circuit services as well as IP and Ethernet services in a cost-effective manner, and it enables flexible resource allocation in response to service demands.

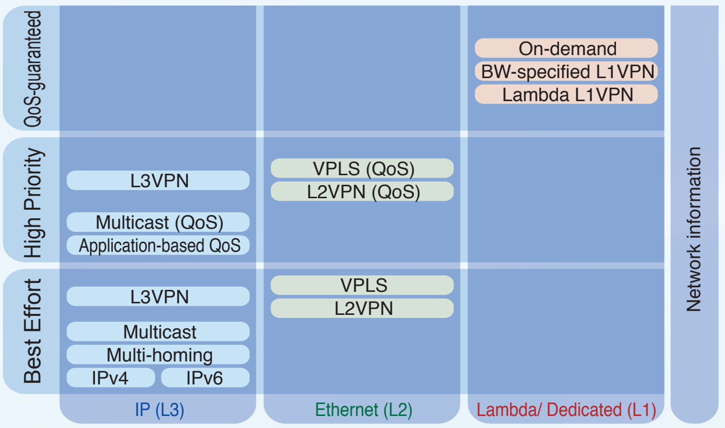
The network has a two-layer transport structure with edge and core nodes. To reduce the number of expensive IP routers and provide multi-layer services, the network does not have IP routers in the edge layer. The edge node is an edge layer-1 switch with layer-2 multiplexing. It is located at a university or research institution and accommodates user equipment. The core node is composed of a high-end IP/MPLS router and a core layer-1 switch located at a public data center.

As of April 2009, the network has 63 edge nodes and 12 core nodes, i.e., 75 layer-1 switches and 12 IP/MPLS routers. The line speed between the edge and core nodes is 1 to 20 Gbps, and the backbone line speed between the core nodes is a maximum of 40 Gbps. The network deploys Japan's first STM256 (40 Gbps) lines between Tokyo, Nagoya, and Osaka. The backbone links form three loops to enhance network resiliency nationwide and to enable quick service recovery after network failures. The topology also enables efficient use of network bandwidth by sharing backbone links among users for all services.

SINET3 Services

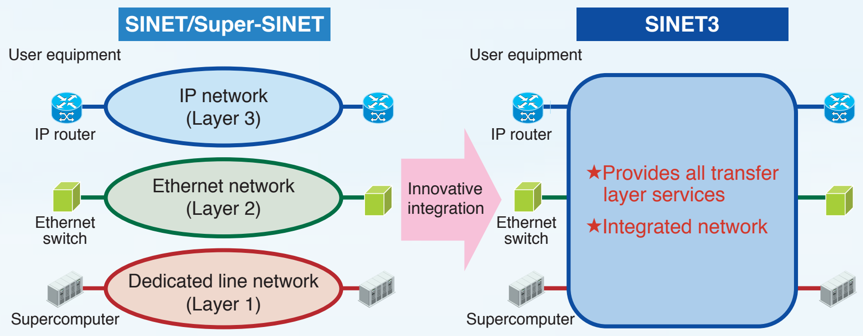
Service Categories in SINET3

SINET3 has five service categories: transfer layer, secure (VPN), quality-of-service (QoS), bandwidth-on-demand(BoD), and network information.



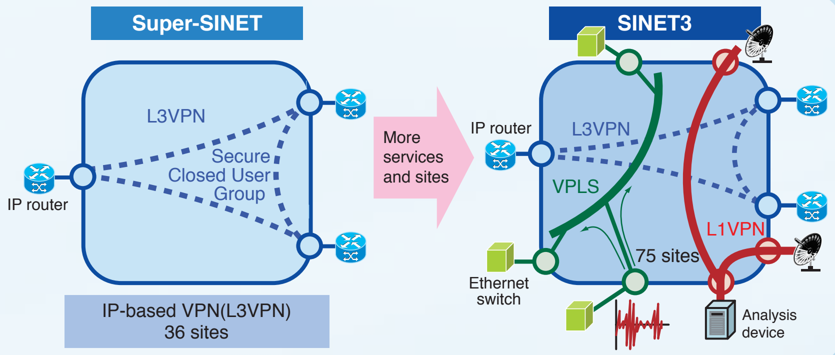
Multiple Layer Services

SINET3 is an integrated network providing all transfer layer services. Users can freely choose the best transfer layer for their applications. SINET3 enables economical service provision and flexible network resource assignment for ever-changing and unpredictable service demands.



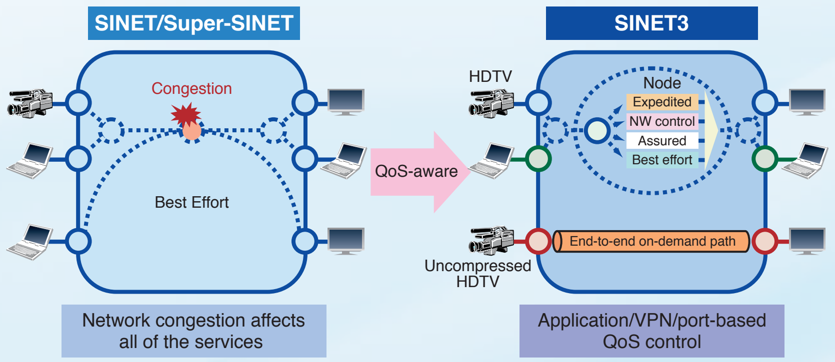
Multiple VPN Services

A closed user group environment (virtual private network: VPN) is essential for ensuring the security of collaborative research. Users can choose from L3VPN (IP), L2VPN/VPLS (Ethernet), and L1VPN.



Multiple QoS Services

SINET3 provides QoS by identifying applications, VPNs, and physical/logical ports. Layer-2/3-based QoS has four priority classes: expedited forwarding (EF), network control (NC), assured forwarding (AF), and best effort (BE). Layer-1-based QoS has the smallest packet delay, no delay variance, and no packet loss.

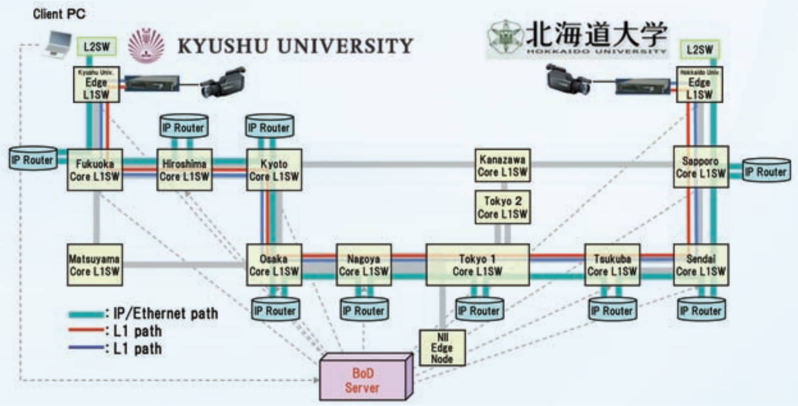


Network Information Service

SINET3 gives users performance measurements (throughputs and round trip times) and security information, which will help to improve usability and facilitate network research. (For traffic information, please contact SINET Promotion Office.)

Bandwidth-on-Demand Service

SINET3 provides Bandwidth-on-Demand (BoD) service on layer-1 (a dedicated line with quality assurance). Users can specify destination, duration, bandwidth with granularity of 150 Mbps, and route option. The BoD server receives reservation requests, schedules accepted reservations, and triggers layer-1 path setup. The service enables users to transmit extremely large volumes of data using high-quality communications instantly, whenever necessary. It offers an environment for the acceleration of innovative scholarly research and the development of academic applications.



Demonstration of L1 BoD between Kyushu University and Hokkaido University (Dec. 2, 2008)(Note: Connected with L1 paths totaling 2 Gbps)

Confirmation of bandwidth reservation

Comparison of SINET/Super SINET and SINET3 services

Service Menu			SINET	Super SINET	SINET3	Notes
User Interface	Serial	1.5Mbps or less	✓			Service terminated at end of August 2008
	Ether family	10Mbps (Ethernet)	✓		✓	
		100Mbps (FE)	✓	✓	✓	
		1Gbps (GE)	✓	✓	✓	
		10Gbps (10GE)			✓	Limited node availability at present. Individual requests to be studied for implementation.
	SDH/SONET family	2.4Gbps (STM-16)		✓	✓	Only for large data transfers.
Network Service	L3 service	IPv4	✓	✓	✓	
		IPv6	✓		✓	SINET3 uses native IPv6.
		Multi-homing	✓		✓	
		Full routes			✓	
		Multicast			✓	
		L3VPN		✓	✓	
		Application-based QoS			✓	
		Multicast (QoS)			✓	
		L3VPN (QoS)			✓	
	L2 service	L2VPN			✓	
		VPLS			✓	
		L2VPN (QoS)			✓	
		VPLS (QoS)			✓	
	L1 service	On-demand*			✓	IF: GE, 2.4G (STM-16), 10GE. Granularity: 150Mbps.
		Dedicated line		✓		SINET3 provides on-demand services instead.
	Network information service	Security information	✓	✓	✓	
		Performance measurements			✓	Throughput measurements, round trip time measurements
		Traffic information			✓	Please contact SINET Promotion Office for details.

* The lambda and BW-specified L1VPN services were integrated into the on-demand service upon its full implementation.

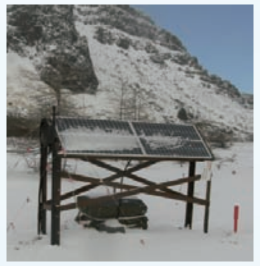
Case examples using SINET3

Research

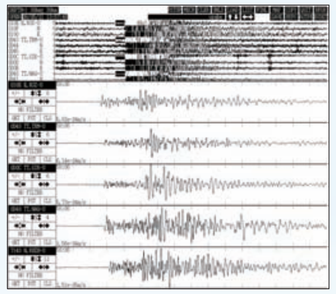
Internet connection VPN QoS L1

— A next-generation national earthquake data exchange and distribution system —

The Earthquake Research Institute at the University of Tokyo (ERI) is building a system, in cooperation with other institutes, that uses the SINET3 high-quality nationwide L2 network (VPLS [QoS]) to enable the exchange of seismic waveform data collected at universities and research institutes. The system provides the nations's universities and other institutions with real-time waveform data from highly sensitive seismic observation networks throughout Japan.

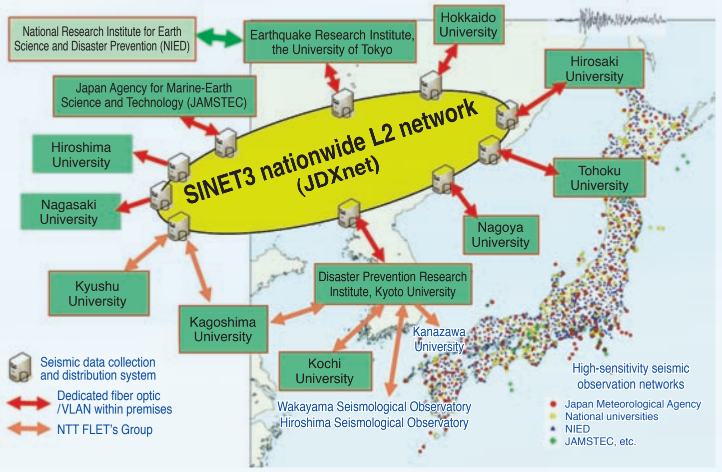


Seismic station
(Picture shows the Mt. Asama/ Yunotaira seismic station in Nagano Prefecture)



Waveform data
from seismic observation networks

Construction of a next-generation national earthquake data exchange and distribution system using the SINET3 nationwide L2 network



(Source : ERI)

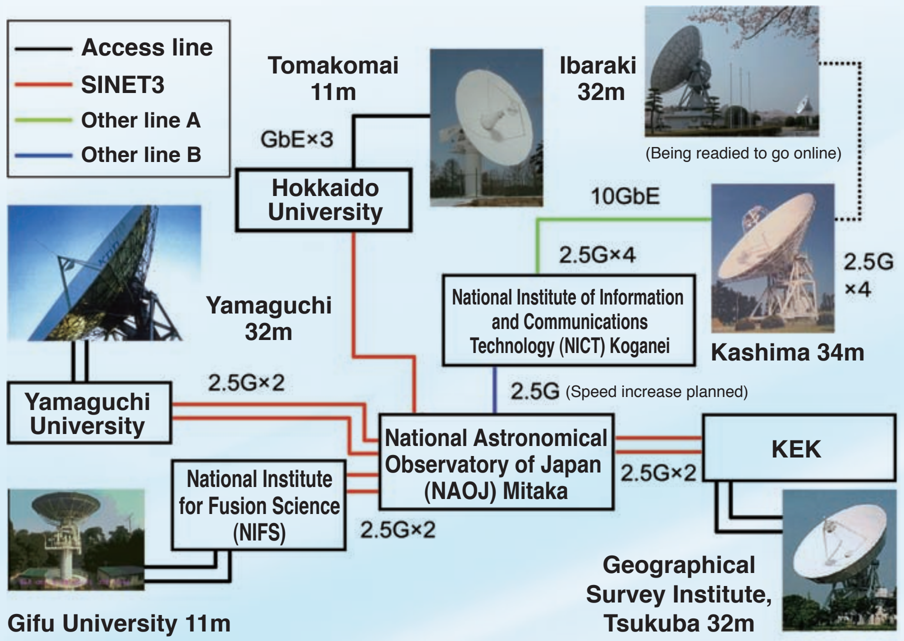
Research

Internet connection VPN QoS L1

— Construction of an Optically Connected Array for VLBI observatories —

The National Astronomical Observatory of Japan uses SINET3's Layer-1 (quality assured) path to connect radio telescopes located throughout Japan —with antenna diameters of 11 m in Gifu, 32m in Yamaguchi, 34m in Kashima, 32m in Tsukuba, and 11 m in Tomakomai—and conduct high-sensitivity radio interferometer observations (optically connected VLBI observations) in real time. (It uses a Layer-1 bandwidth-on-demand (BoD) service starting June 2008.)

With VLBI observations able to perform correlation processing in real time, astronomical objects that were difficult to detect before—such as fixed stars, gamma-ray bursters, and flare stars—can be observed in real time, opening up a new type of astronomy previously impossible to do, in addition to making a major contribution to astronomical research.



(Source : National Astronomical Observatory of Japan)

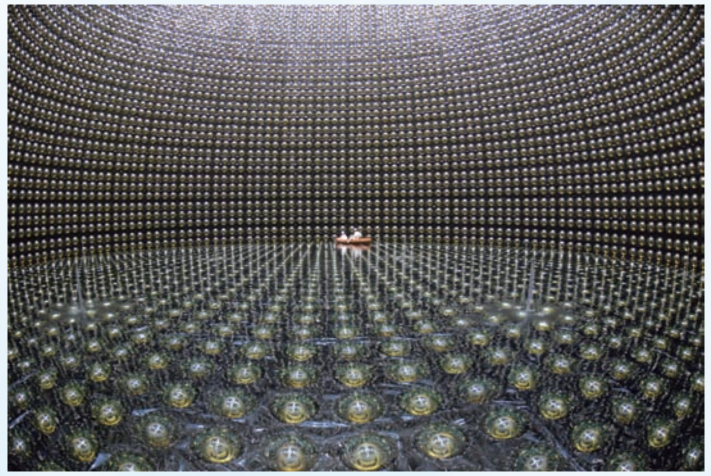
Research

Internet connection VPN QoS L1

— Super-Kamiokande experiments, next-generation long-baseline neutrino oscillation experiment (T2K experiment) —

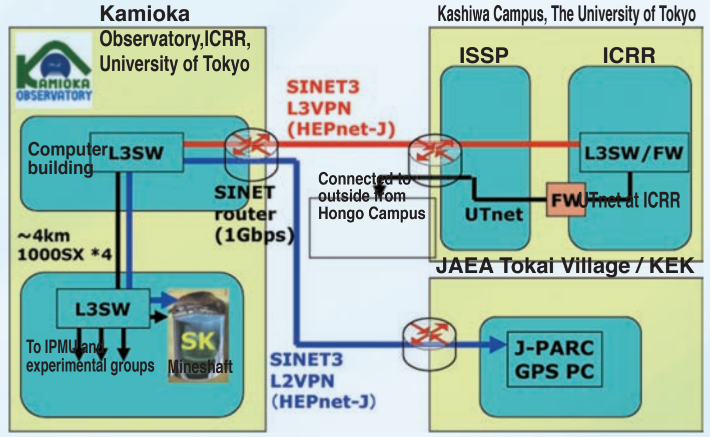
In a mineshaft 1,000 meters underground can be found Japan's largest subterranean physics experiment site, run by the University of Tokyo's Institute for Cosmic Ray Research (ICRR) Kamioka Observatory, located in Hida City, Gifu Prefecture. In this mineshaft, the Kamioka Observatory is conducting the world's most cutting-edge, precision physics experiments and research and development, including the Super-Kamiokande (SK) experiments.

SINET3's L3 VPN is currently being used as the LAN connecting the Kamioka Observatory and the ICRR located on the University of Tokyo's Kashiwa Campus. The Kamioka Observatory is connected to the Internet through the ICRR with the use of an L3 VPN. This is essential in order to allow collaborative researchers in Japan and abroad to access the data retrieved by the experimental equipment installed at the observatory. The L3 VPN also allows the on-site researchers to communicate with researchers in Japan and overseas through e-mail, the Web, IP video conferencing, and by other means.



View inside Super-Kamiokande
(© Kamioka Observatory, ICRR<Institute for Cosmic Ray Research>, The University of Tokyo)

An L2 VPN is in use between the Kamioka Observatory and Japan Atomic Energy Agency's Tokai Research and Development Center (Tokai-mura, Naka-gun, Ibaraki Prefecture), the location of a high-intensity proton accelerator (Japan Proton Accelerator Research Complex [J-PARC]). Preparations are ongoing for the successor to the K2K experiment, a next-generation long-baseline neutrino oscillation experiment (T2K). In the experiment, SINET3 will be used to transmit the GPS timing of a neutrino beam shot from J-PARC to SK in real time. Tests for the long-term stability confirmation and development of the data-transfer program are currently underway. This is one way in which SINET3 is actively making major contributions to advances in particle physics.



Network connection to Kamioka (ICRR-related facilities)

Note 1. K2K: KEK to(2) Kamioka
Note 2. T2K: Tokai to(2) Kamioka

(Source : Kamioka Observatory, ICRR, University of Tokyo)

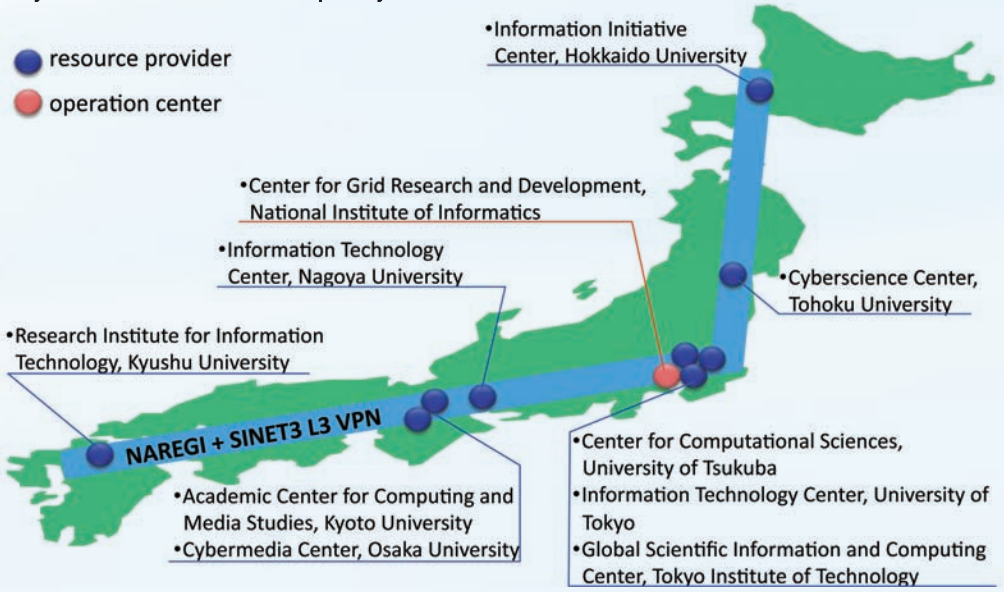
Case examples using SINET3

Research

Internet connection VPN QoS L1

— grid operation using the NAREGI middleware —

Computer centers in nine universities (listed in the figure below) and Center for Grid Research and Development in NII (CGRD) started pilot grid operation using the NAREGI middleware in Spring 2009. The computer centers play as resource providers offering their high-performance computer systems, and CGRD plays as an operation center to coordinate grid operation collaborating with the computer centers. SINET3's L3 VPN (CSI-GRID) is used to link the high-performance computer systems in the computer centers. Researchers can run their scientific applications on the grid computing environment utilizing computing power on the computer systems and network capacity in CSI-GRID.



Education

Internet connection VPN QoS L1

— International remote lectures in coordination with universities abroad —

Since 2005, the University of the Ryukyus has used SINET3 to hold international remote lectures in coordination with the University of Hawai'i, the United Nations University in Tokyo, Keio University, the Asian Institute of Technology in Thailand, the National University of Samoa, and the University of the South Pacific. With students able to receive credits starting in the 2007 academic year, these lectures constitute an environment of high-level education that takes advantage of information technology.

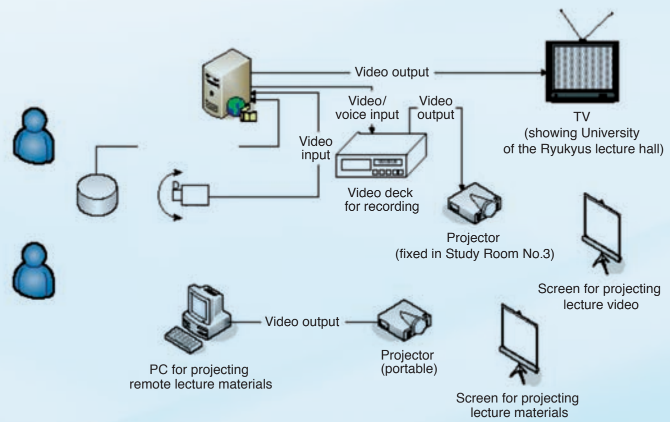


Diagram of the University of Hawai'i's remote lecture system (Attendance)

(Source : The University of the Ryukyus)

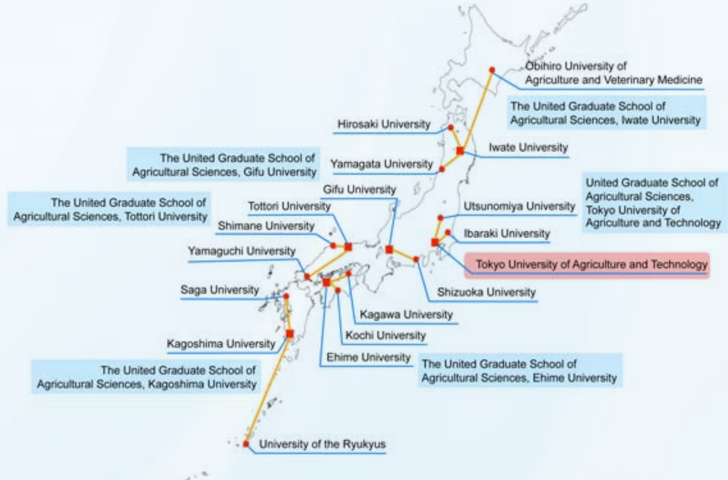
Education

Internet connection VPN QoS L1

— High-definition remote lecture system connecting 18 national universities across Japan —

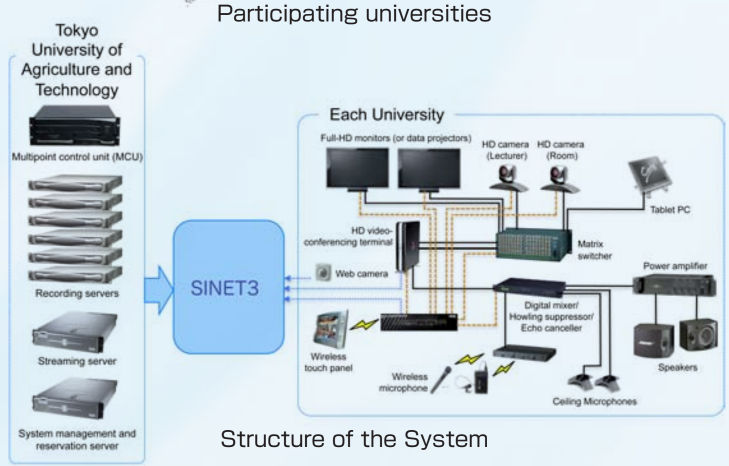
Since February 2009, Tokyo University of Agriculture and Technology has been running a remote lecture system connecting 18 national universities across Japan that participate in the United Graduate Schools of Agricultural Sciences.

The United Graduate Schools of Agricultural Sciences have been established at six universities (Tokyo University of Agriculture and Technology, Iwate University, Gifu University, Ehime University, Tottori University, and Kagoshima University) to carry out doctoral education and research in cooperation with the agricultural departments of other national universities. Two to four universities participate in each United Graduate School. Lectures at a United Graduate School are available to other universities associated with it. Remote lectures are also held for all the universities participating in the United Graduate Schools of Agricultural Sciences nationwide.



Participating universities

The United Graduate Schools were using a satellite communication system (SCS: Space Collaboration System) for connection between participating universities nationwide for remote lectures and the like. However, with the aging of the equipment, it became harder and harder to maintain the system. In view of demand for higher-quality video and audio for lectures, the current system was developed to replace the SCS.



Structure of the System

In the current system, two high-definition image streams can be sent and received simultaneously—one for an image of the lecturer (camera images) and one for materials (PC outputs), for example. The system can also be connected to general video conferencing systems installed at universities other than the 18 participating institutions. SINET3 is used as the backbone of the system, and it enables the universities to hold lectures and conferences with universities and research institutes overseas having Internet connections. In the field of agricultural sciences, cooperation with Southeast Asian, Latin American, and African countries will be particularly vital. The new system is expected to help boost communications with these areas.

Remote lecture connected 18 national universities

Case examples using SINET3

Education

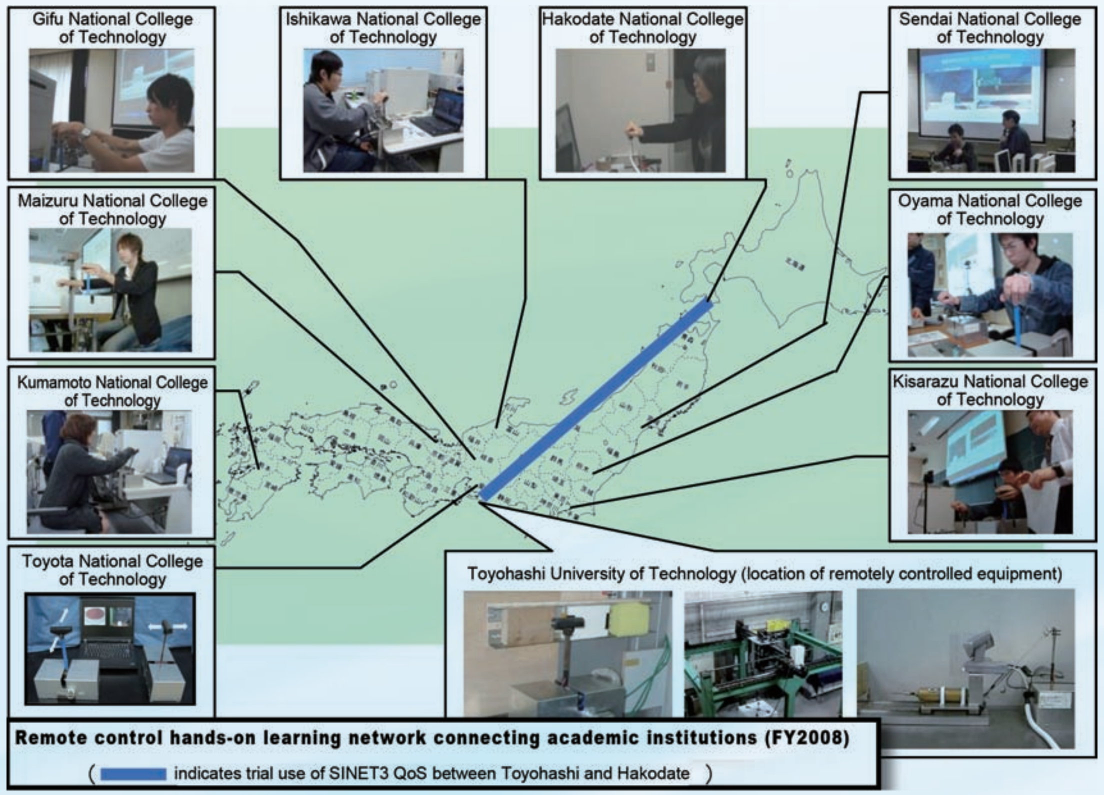
Internet connection VPN QoS L1

— Remote control system with haptic feedback —

Toyohashi University of Technology (TUT) and Hakodate National College of Technology are building a remote control system with haptic feedback using SINET3's QoS service. This is part of a project to establish infrastructure for joint education and research with colleges of technology. TUT and nine colleges including Hakodate National College of Technology are participating in the project, and they are now building the network and offering on-site training.

As an example of remote control with haptic feedback, a hands-on training system for remote drill operation has been developed. With the system, a user can operate a drill located at a remote site to drill a hole in plywood. The system provides not only visual information (camera shots) and audio information (drilling sounds) but also haptic information (sensation of resistance at the start of drilling and at the time of pass-through). Operators can achieve a good sense of presence, as if they were at the drilling site. They can also learn about issues associated with the state-of-the-art technologies, such as communication delays and safety in remote control. There are other hands-on learning opportunities available, including operation of cranes and tactile examination of the hardness of objects. These forms of hands-on training will be provided to colleges of technology nationwide through SINET.
For details please refer to the following webpage (in Japanese):
http://www.syscon.pse.tut.ac.jp/nct_partnership/index.htm

Normally, similar systems are built using a network without quality assurance (on a best-effort basis). Such systems present difficulties such as interruption in video and audio streams due to network congestion. This could have impacts on safety management at the time of operations, and could also make it difficult to keep the students experiencing the operations interested. Use of the high-quality network service (QoS) provided by SINET3 resolves these issues, and a stable remote control environment can now be built using exiting networks.



Remote control hands-on learning network connecting academic institutions (FY2008)
(▬ indicates trial use of SINET3 QoS between Toyohashi and Hakodate)

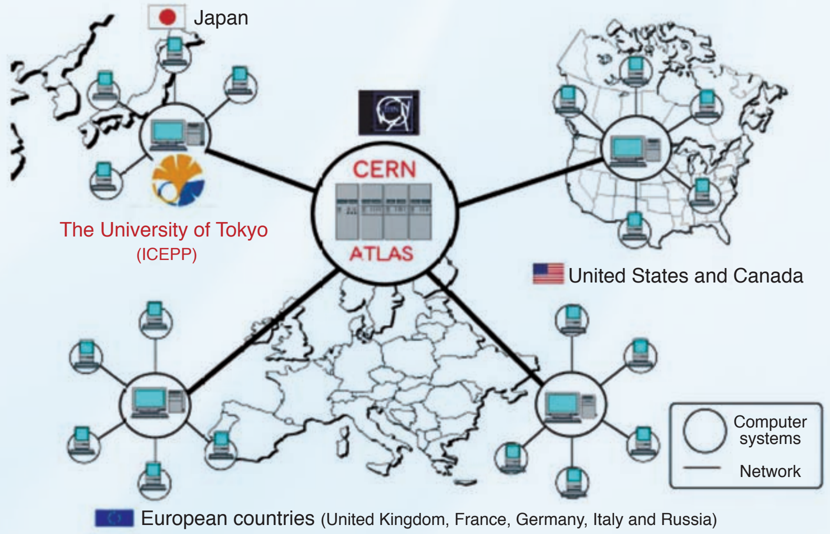
Use of international connection

Internet connection VPN QoS L1

— Distributed analysis of enormous amounts of data produced by the LHC accelerator —

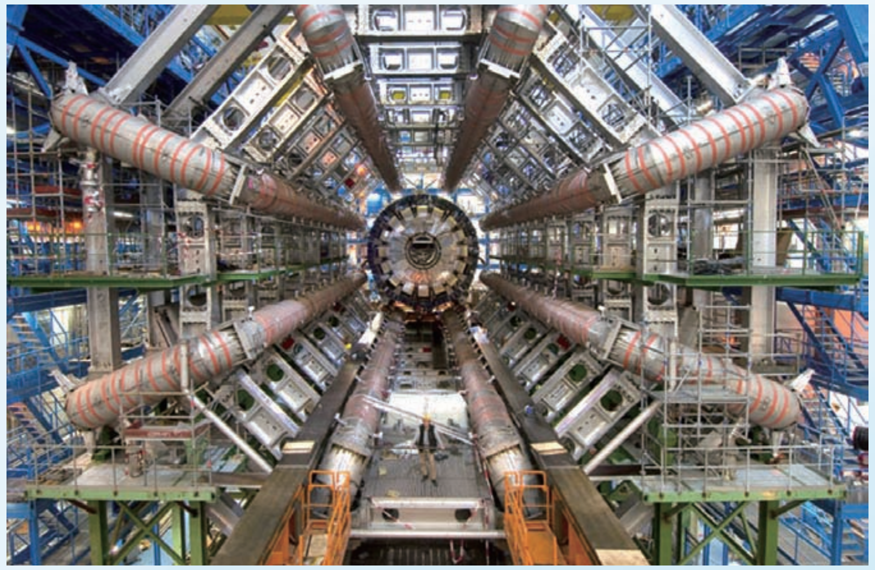
The International Center for Elementary Particle Physics (ICEPP) at the University of Tokyo, along with other Japanese research institutes, is participating in the ATLAS Experiment, a collaborative international experiment using the Large Hadron Collider (LHC) accelerator. Producing an enormous quantity of data far in excess of that associated with experiments of the past, the ATLAS Experiment will require incredible amounts of data storage equipment and computer processing facilities in order to process and analyze the data and produce physics results. The Worldwide LHC Computing Grid (WLCG), which provides this processing power through computer systems distributed across the globe, has been deployed, and ICEPP is responsible for serving as a regional center for data analyses in Japan.

ICEPP has a 10 Gigabit Ethernet connection to SINET3 through the university's LAN. SINET3 international lines are being used to transfer huge amounts of data among ICEPP and the computing center in Lyon, France, the European Organization for Nuclear Research (CERN), and other European centers. As of spring 2009, preparations are being carried out toward the start of the full-fledged data taking phase in the fall of 2009. Test and tuning of the grid system as well as preparations for physics analyses are being done using cosmic ray data and an enormous quantity of simulation data. In this way, SINET3 is providing a tremendous support for this kind of large-scale, collaborative international experiment.



Regional centers and world-wide network for ATLAS data analysis
(Source: ICEPP)

Note: The Large Hadron Collider of CERN is a giant particle accelerator of the world's highest energy in which two proton beams running in opposite directions collide head-on with each other. Its construction was completed in the summer of 2008.



The ATLAS detector during assembly (Copyright CERN)

Case examples using SINET3

Use of international connection

Internet connection | VPN | QoS | L1

— The “Belle experiment”: Major contribution to verification of the theory of Kobayashi and Maskawa, Nobel Laureates in Physics —

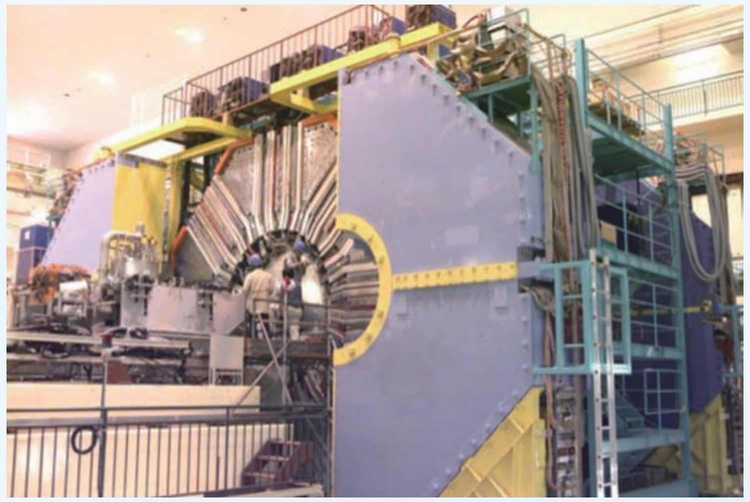
Makoto Kobayashi, Honorary Professor Emeritus at the High Energy Accelerator Research Organization (KEK), and Toshihide Maskawa, Professor at Faculty of Science, Kyoto Sangyo University and Professor Emeritus of Kyoto University, were awarded the Nobel Prize in Physics 2008 for the Kobayashi-Maskawa Theory. The Belle experiment, carried out at KEK, contributed greatly to verification of the theory. SINET3 plays an important role in the Belle experiment.

In the Belle experiment, the KEK-B accelerator is used to generate numerous pairs of B and anti-B mesons, and the discrepancies in the distances traveled by the mesons before their decays are measured precisely using the Belle detector. The circumference of the KEK-B detector is 3 kilometers, and light travels about 300,000 kilometers a second, which means that electrons and positrons cross each other 100,000 times a second. In the experiment, only intriguing events are extracted, but there still are some 200 events per second to be recorded. This means that the daily data volume amounts to about one terabyte. The accumulated experimental data accounts for one petabyte on hard disks and five petabytes on magnetic tapes.

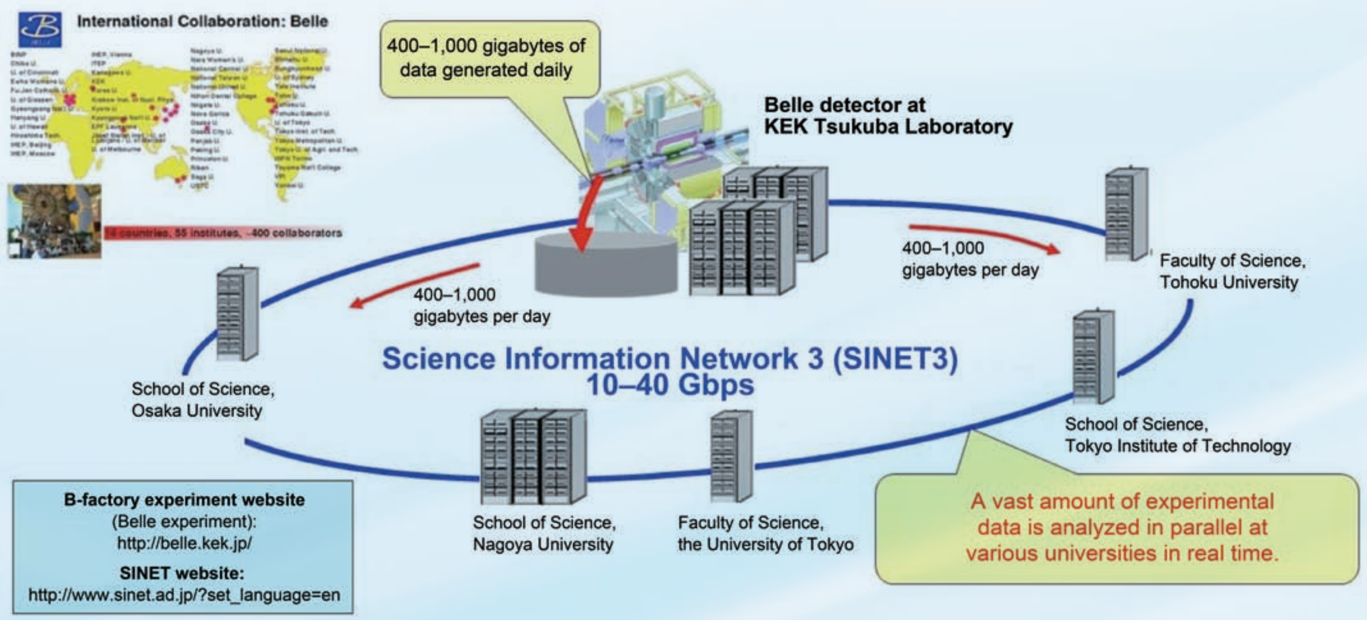
Networks play an important role along with the analysis system and storage devices. The data outputted from the Belle detector are analyzed not only at KEK but also at other universities. Similarly, simulation data prepared at other universities are sometimes brought to KEK. For this reason, a high-speed network is essential for exchange of large volumes of data in short periods of time.

In the Belle experiment, SINET and Super SINET have been put to use. SINET3 L3 VPN services are now used to connect KEK with Tohoku University, Tokyo Institute of Technology, the University of Tokyo, Nagoya University, and Osaka University. SINET3 networks are also used for exchange of data with universities across Japan and some 40 universities and research institutes abroad in 14 countries.

Mr. Nobuhiko Katayama of KEK, the key figure in the experiment, says that SINET is the aorta of the networks supporting the Belle experiment, highlighting its importance.



Belle detector



Use of international connection

Internet connection | VPN | QoS | L1

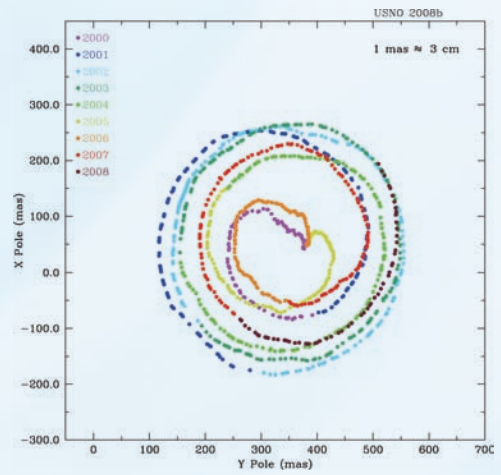
— International sharing of extra-large volumes of data from VLBI observations —

The Geographical Survey Institute uses SINET3 networks to transfer large volumes of data exceeding one terabyte obtained in Very Long Baseline Interferometry (VLBI) observations.

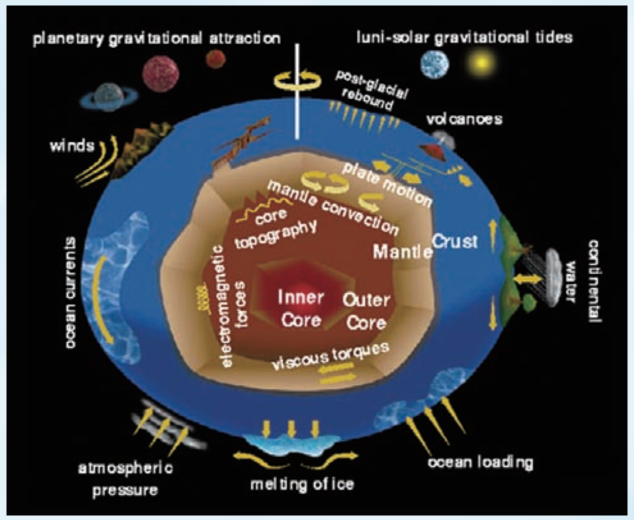
VLBI is a technology for precise measurements of differences in arrival times of radio waves from a radio star (a quasi-stellar object) located several billion light years away, received at a number of antennas simultaneously. By observing and analyzing time differences for many radio sources, the relative positions of antennas can be calculated. VLBI observations are used for: 1) maintenance of the International Terrestrial Reference Frame; 2) monitoring of plate motions that cause huge earthquakes; 3) study of the inner structure of the Earth based on information about the rotation and orientation of the planet; 4) attitude control of artificial satellites; and 5) determination of leap seconds.

In VLBI, radio waves are received simultaneously by a world wide network of antennas, which means that international cooperation is essential. Observations are made at observatories in many countries around the globe equipped with parabolic antennas, and the vast amount of observation data collected at each of the observatories is assembled at a station (called “correlator”) for processing. Usually, a 24-hour observation session is made about once per week, and about one terabyte of data is collected per session. There are also three one-hour sessions every week to collect data to accurately and promptly determine the speed of the Earth’s rotation, generating about 50 gigabytes of data per session. As the Earth’s rotation changes irregularly from moment to moment, the data must be processed and analyzed as soon as possible after each observation to calculate the results. The data therefore needs to be transmitted promptly and quickly from observatories to the VLBI correlator.

As a means for collecting data, airfreight was previously employed to carry magnetic tapes and other media. Today, however, with the widespread installation and use of ultrahigh-speed networks such as SINET3, it is possible to transmit data in a short period of time. Currently, data is mainly sent to the Bonn Correlator (MPIfR/IGGB/BKG) in Germany, the Wettzell Station (BKG) in Germany, and the Haystack Observatory (MIT) in the United States. For data transfer, the user datagram protocol-based “Tsunami” protocol offering high-speed file transfers is used. At present, the effective transfer rate between the Geographical Survey Institute (Tsukuba) and Bonn is 600 Mbps, allowing for a day’s data to be transferred in a few hours. In this way, SINET3 is contributing greatly to large-scale national projects and technology developments for space exploration such as VLBI observations that require sophisticated technologies and long-term international cooperation.



Polar motion from January 2000 to June 2008
(Copyright © The United States Naval Observatory)



Causes for Variations on the Earths Orientation
Source: Lambeck 1980, original drawing by Jos Verheijen.

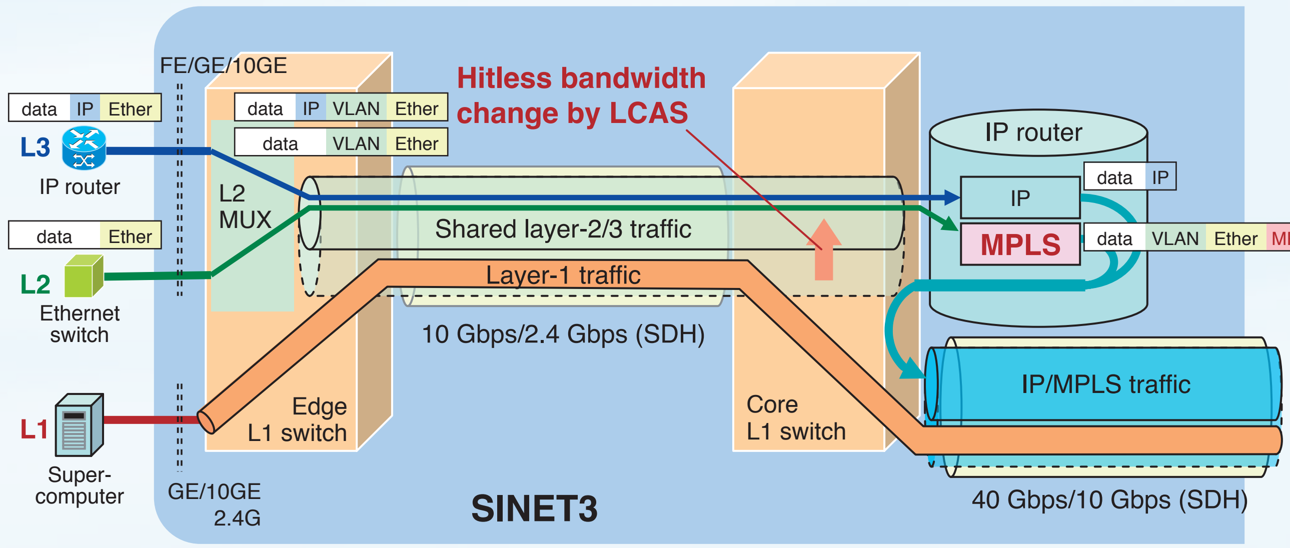
32 m parabolic antenna at Tsukuba VLBI Station

SINET3 Technologies

Accommodation of Multi-layer Services

L3 and L2 traffic are accommodated in the shared bandwidth by L2 multiplexing and are transferred to IP routers, where traffic is encapsulated with MPLS* labels as needed. L1 traffic is assigned a dedicated bandwidth and separated from L3/2 traffic. The bandwidth of L2/3 (or IP/MPLS) traffic can be hitlessly changed by LCAS*.

*MPLS: Multi-Protocol Label Switching, LCAS: Link Capacity Adjustment Scheme



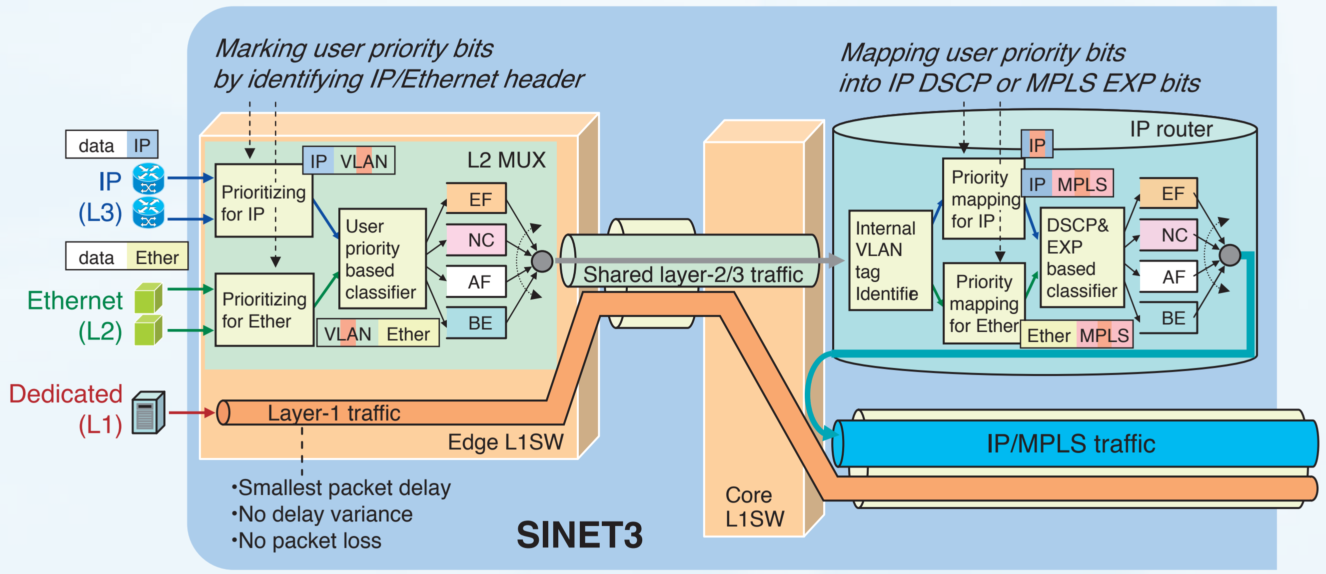
Accommodation of Multi-QoS Services

Layer-3/2 QoS:

- User priority bits of internal VLAN tags are marked at edge L2 MUX.
- User Priority bits are mapped into DSCP (IP) or EXP (MPLS) bits at IP router.
- There are four priority (forwarding) classes: EF, NC, AF, and BE.

Layer-1 QoS:

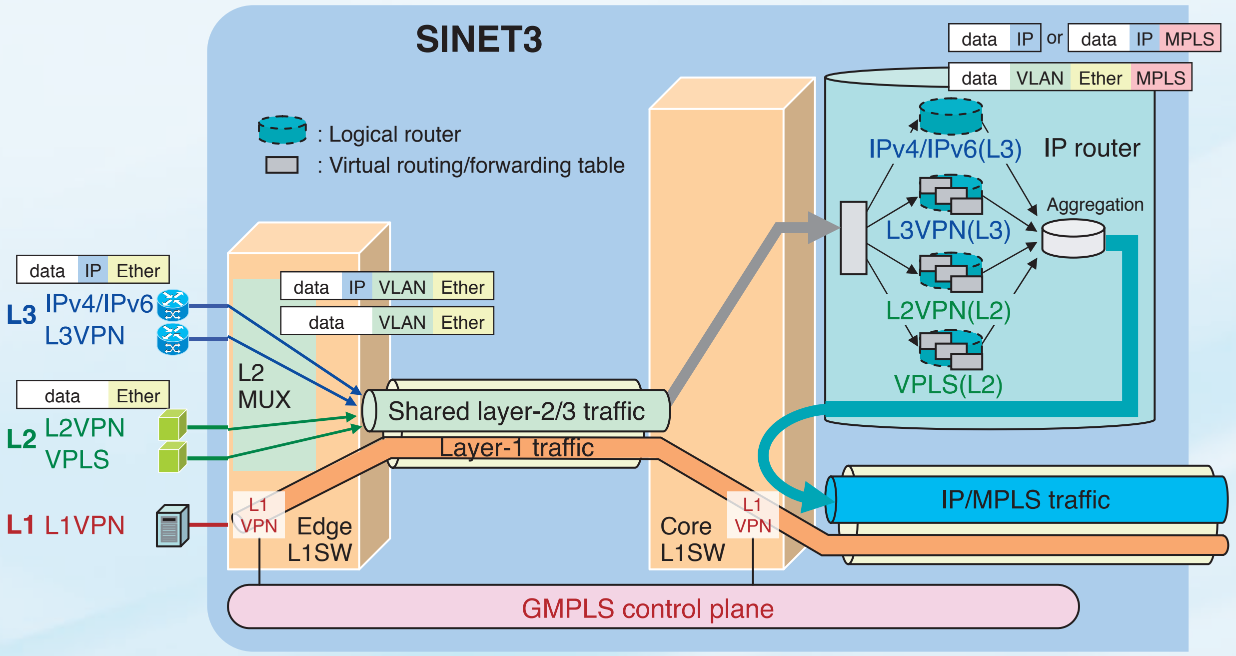
- Layer-1 switches assign the end-to-end bandwidth on demand.



Accommodation of Multi-VPN Services

L3VPN, L2VPN, and VPLS are logically separated by internal VLAN tags and logical routers. Each logical router exchanges different protocols for each VPN service. L1VPN and on-demand services need GMPLS* protocols to set up layer-1 paths and have a separate control plane from that of the IP routers.

*GMPLS: Generalized MPLS



Architecture of Bandwidth-on-Demand (BoD) Service

The BoD server receives reservation requests, schedules the accepted requests, and triggers layer-1 path setup of the source layer-1 switch via L1-OPS. The source layer-1 switch sets up the path to the destination by using GMPLS. The BoD server changes the bandwidth of L2/L3 traffic by LCAS via L1-OPS as needed.