GÉANT PROJECT

Global Data Sharing for Earth Observation through R&E Networks

At a Glance – The Earth Observation Challenge

From scientists to policy makers, meteorologists, forecasters, transport planners and insurers, a diverse mix of Earth Observation users are increasingly collaborating on a global scale. As satellite imaging, radar and seismic probes offer more detailed ways of recording information, increasingly sophisticated instruments, tools and models are needed to cope with this growing volume and complexity of data.

Managing this data on a global scale represents a great challenge for the earth science community. The intergovernmental Group on Earth Observations (GEO) was established in response to this challenge and is leading a plan to globally interconnect the different user communities, facilitating collaboration and knowledge through the creation of the Global Earth Observation System of Systems (GEOSS).

Earth Observation is a key area for Research and Education Networks. Together with high-energy physics, life sciences and astronomy, it is one of the most data-intensive areas of science in terms of bandwidth required, computational demands and collaboration services.

Today many Earth Observation collaborations rely on the infrastructure and services offered by Research and Education (R&E) networks. R&E networks are high-speed, high-capacity data-communications networks designed to meet the specific demands of the academic and research communities. Organised at both national and international level, their mutual interconnections create a global infrastructure that enables scientists to collaborate in real time even when thousands of miles apart.

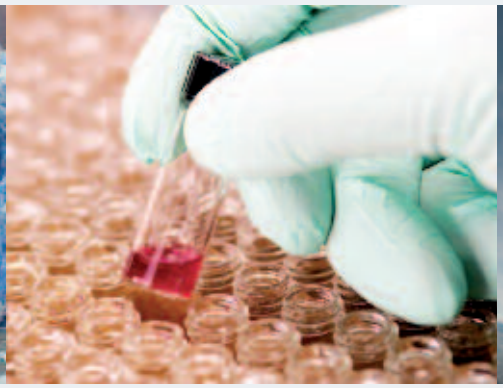
R&E networks can play a fundamental role in providing the Earth Observation community with the high-speed, high-capacity, secure data transmission capability it requires to collect, integrate, share and analyse environmental data.

In particular R&E networking can support Earth Scientists by facilitating:

- Transfer of extremely large files such as satellite images over large distances in real time.
- Real-time distribution of monitoring data to provide early warning of impending natural disasters, such as earthquakes or typhoons.
- Parallel dissemination of satellite data to weather agencies using multicast.
- Simulations via grid infrastructures requiring colossal amounts of computing power and bandwidth.
- Dedicated private connectivity between two or more institutions for research projects with specific security or computing needs.
- Seamless secure access to distributed data archives via single sign-on.

GÉANT is the largest and most advanced research and education network in the world. Operating at speeds of up to 500Gbps, GÉANT interconnects Europe's National Research and Education Networks (NRENs), together connecting over 50 million users at 10,000 institutions, and reaching over 100 national networks worldwide. GÉANT has extensive experience working with Earth Observation and supports a number of GEO activities including TIGGE, GEONETCAST and the Geohazard Supersites..

The information that follows gives an overview of R&E Networks and GÉANT and how these facilitate seamless data exchange on a global scale. Examples of use cases from GEO activities that already benefit from R&E network services are also shown to illustrate the support these networks can provide for Earth Observation collaborations.

The Power of R&E Networks

R&E networks are high-speed, high-capacity data-communication networks that are independent of (but connected to) the commercial internet and are designed to meet the specific demands of the academic and research communities. These range from enabling secure access to services worldwide via single sign-on to providing dedicated high-speed networks connecting research groups irrespective of their geographical location.

The specific needs of the R&E community cannot typically be met by the commercial internet, whereas building dedicated infrastructure would not be cost-effective for individual institutions. By consolidating national and global requirements in one network, connectivity costs for individual member institutions are significantly reduced, while at the same time their users receive the benefit of being able to access a wider range of services.

When very high data rates are required, dedicated connectivity can provide reliable and secure date exchange at predictable speeds and with an assured quality-of-service which is especially important for transferring huge amounts of time-critical data. Congestion, delays, interruptions and limitations caused by overbooking and competing traffic on public internet services are also avoided.

As well as physical connectivity, R&E networks provide services such as wireless roaming, videoconferencing, media streaming, federated access, troubleshooting, cloud-based computing and storage services and facilitate community activities promoting knowledge and best practice sharing.

Innovative services are essential to ensuring the Earth Observation community get the most out of this powerful, unrestricted bandwidth. R&E networks fuel the Internet's innovation engine and play an important role in its development by eliminating the boundaries of local and national collaboration and introducing new standards and services, such as the IPv6 protocol, multicast and providing single sign-on to services worldwide for students and researchers.

Thanks to R&E networks and the services that support them, the Earth Observation community has access to tailored services and consistently high performance – at its fingertips.

See the Case Studies and How to Connect to find out how you can benefit from international research networking, or request more info by contacting: partner-relations@geant.net.

Creating a global infrastructure

R&E networks are structured on both a national and international level. At a national level, these networks are organised as National Research and Education Networks (NRENs), which link together some or all of the universities, research institutions, schools, hospitals and museums within a country, allowing them to benefit from access to increased bandwidth and to share services and applications, working collaboratively on projects of national interest and concern.

The organisational models on which the various NRENs are based can be diverse, in that they may be either independent legal entities or part of the government or a specific university, but they are usually not-for-profit organisations supported by public funding.

NRENs fund their own in-country costs, and may contribute to the costs of the regional network they are part of and pay their share of global networking costs. Users who are part of a connected institution gain free access to the services offered nationally as well as to those offered at a regional level if their NREN is part of a regional network.

Today's NREN landscape is diverse, and includes networks ranging from long-established and advanced NRENs and regional R&E networks with over 20 years of experience, alongside newly emerging networks that build on that experience. The number and kind of services offered differ, due to differences between the user groups and availability in terms of resources and infrastructure in the various countries.

Some NRENs are invested in connecting schools and public institutions and focus on services that facilitate educational activities such as online learning. Others are concerned with providing services for highly demanding research collaborations, and offer supercomputing and grid computing facilities.

Most National Research and Education Networks (NRENs) are connected to international networks such as GÉANT, which in turn mutually interconnect to create a global infrastructure serving the R&E community.

GÉANT – the European Network at the Heart of Global Research and Education Networking

GÉANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs) to each other and to the rest of the world. Reaching over 100 national networks worldwide, GÉANT operates at the heart of international R&E networking, eliminating geographical boundaries and accelerating collaboration in scientific research.

GÉANT is the largest and most advanced research and education network in the world, connecting over 50 million users at 10,000 institutions across Europe and supporting research in areas such as energy, the environment, space and medicine. The network operates at speeds of up to 500Gbps and reaches over 100 national networks worldwide.

Co-funded by the European Commission, the network and associated services comprise the GÉANT project, a collaboration of 41 project partners including 38 European NRENs, DANTE, TERENA and NORDUnet (representing the 5 Nordic countries). GÉANT is operated by DANTE on behalf of Europe's NRENs. Responsibility for the network is allocated to the individual NREN organisations for supporting and maintaining their respective national networks, while DANTE maintains and operates the GÉANT network on a pan-European basis.

GÉANT has a long history in engaging with the Earth Observations sector both through its coordination of the International User Advisory Committee and with DANTE's participation in GEO. GÉANT is also strongly engaged in this area on an operational level, providing tailored services to Earth Observation collaborations, programmes and services.

The International User Advisory Committee

In 2013 The International User Advisory Committee (IUAC) was established as an international knowledge hub bringing together 11 members from large international research projects or organisations covering research sectors such as astronomy, high energy physics, life sciences and humanities. The members exchange best practices in R&E networking and discuss how to best serve a large international user base, keeping abreast with bandwidth-demanding and data-intensive scientific developments. Representatives from ESA, EUMETSAT and ENES (Climate) ensure that current and future requirements in the sector are channelled in the development of GÉANT's strategy and services.

LHC Radio Frequency Accelerators, CERN

Since its establishment over 20 years ago, GÉANT has developed progressively to ensure that European researchers are at the forefront of international and global collaboration. The high-speed, high-capacity connections that GÉANT provides, both within Europe and globally to other regions, allow researchers to seamlessly share information, access the largest databases of relevant information and work with their peers in real time, regardless of their location.

The GÉANT network is a world leader in many areas, and is helping to drive the development of new networking technologies and services. In 2012–2013, GÉANT rolled out a new 100 Gbps dark fibre backbone. Over 1000 terabytes of data is transferred via the GÉANT IP backbone every day. More than just an infrastructure for e-science, it stands as a positive example of European integration and collaboration.

GÉANT is able to offer more flexible and bespoke options than commercial operators. Organisations such as ESA, EUMETSAT or CERN use GÉANT to disseminate their data worldwide. CERN became the first user of a dedicated 100 Gbps wavelength across the GÉANT network in December 2012.

GÉANT additionally connects to 65 countries outside of Europe, bringing the total number of users it reaches to 100 million, placing it at the heart of a truly global network connecting to regional networks all over the world.

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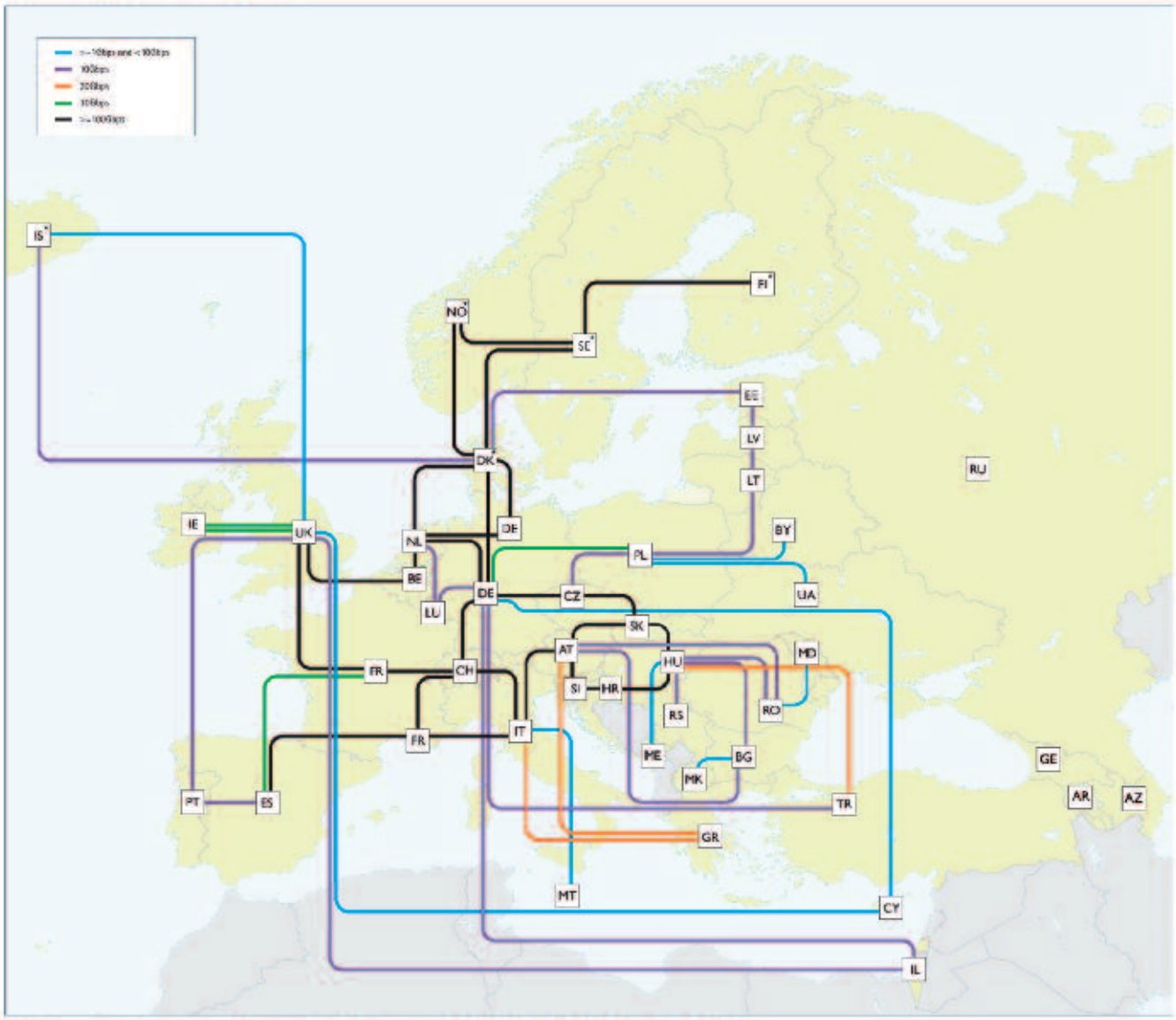
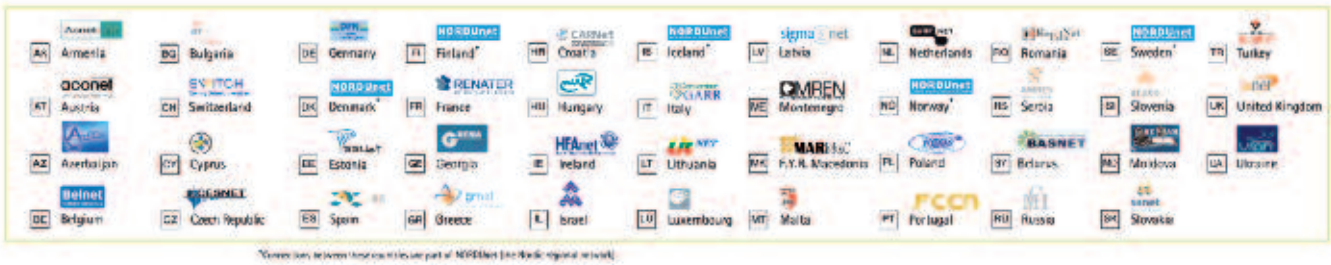
The Pan-European Research and Education Network

GÉANT interconnects Europe's National Research and Education Networks (NRENs). Together we connect over 50 million users at 10,000 institutions across Europe.



GÉANT connectivity as at September 2014. GÉANT is operated by DANTE on behalf of Europe's NRENs.



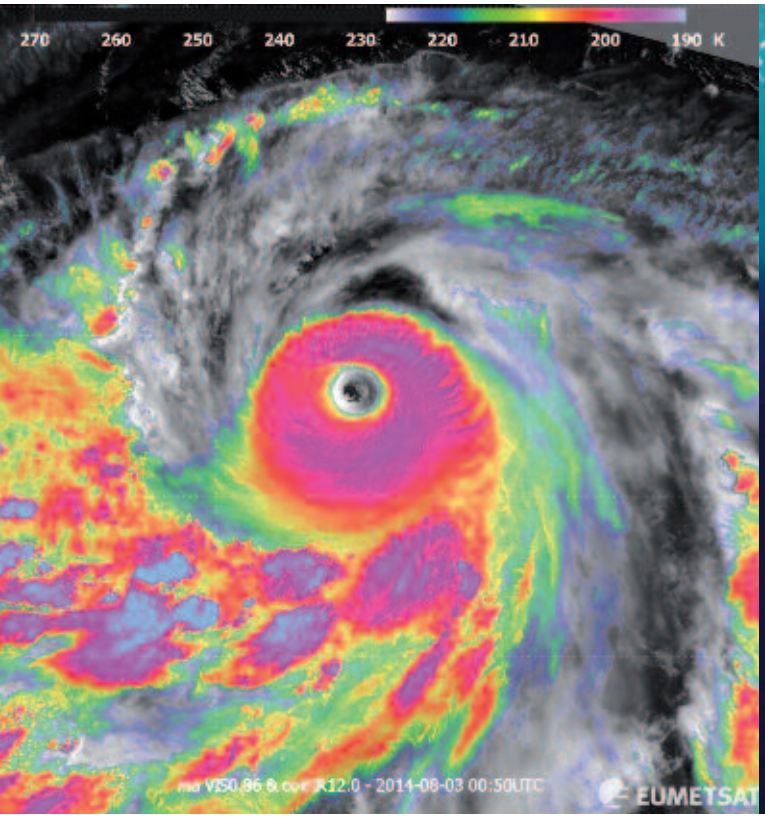
GEO activities benefitting from GÉANT

GÉANT's services allow the Earth Observation community to get the most out of its powerful, unrestricted bandwidth. Many GEO participants are already GÉANT users, either by using the network of a university or research facility or by participating in a project or collaboration which uses GÉANT services within the GEOSS framework. See the Case Studies for more information on these initiatives.

GÉANT already provides solutions for data distribution and access for:

- **CleanSeaNet:** Supporting the EMSA CleanSeaNet Service, a near real time satellite-based monitoring system for marine oil spill surveillance and detection in European waters. The service is part of Copernicus, the European Earth Observation Programme.
- **THORPEX:** Supporting THORPEX, the world weather research programme by the World Meteorological organisation, ensuring the timely and reliable transfer of weather data for disaster mitigation from Europe to Asia and other world regions.
- **EUMETCAST:** Providing the networking infrastructure and operational management for the EUMETCAST service, facilitating the parallel and constant distribution of weather data from single source to sites in over 31 countries.
- **GEOHAZARD SUPERSITES:** Provide a federated cloud infrastructure for the development of the Geohazard Supersites, an earth observation platform focusing on earthquake and volcano research operated by ESA.

In early August Typhoon Halong became the third super typhoon of 2014 in the Western Pacific basin. Image: EUMETSAT



Indian city of Mumbai, image from Japan's ALOS satellite. Copyright JAXA/ESA

International R&E Networks connected to GÉANT

Regional R&E Networks link the NRENs of each world region to each other via international fibre infrastructure, facilitating collaborative work on multi-domain service offerings. These regional R&E networks are in turn connected to each other, creating opportunities for large-scale and collaborative research in areas of concern to more than just one country, such as health, climate or environmental issues. There are R&E networks covering most world regions, such as GÉANT in Europe, RedCLARA in Latin America, and TEIN in the Asian Pacific regions, among others.

Access to the global R&E network enables students or researchers to potentially connect to and work with any other fellow students or researchers anywhere in the world. These interconnections are crucial to enable research groups in different world regions to benefit from each other's experience and make possible applications such as tele-medicine, climate modelling or disaster mitigation.

GÉANT – At the Heart of Global Research and Education N

Asia Pacific and South Asia

NRENs of the Asia Pacific and South Asia are connected by TEIN, the Trans-Eurasia Information Network which provides dedicated high-capacity Internet connectivity for research and education across the Asia-Pacific region. Starting with a single circuit between France and Korea in 2001, the TEIN regional network has been managed since 2006 by DANTE. In September 2012 the network responsibility was transferred to the TEIN* Cooperation Center (TEIN*CC), which was established by the Korean government.

With over 50 million users and representing over 60% of the world's population, TEIN currently interconnects universities and research centres in 16 countries: China, India, Indonesia, Japan, Korea, Malaysia, Nepal, Pakistan, the Philippines, Singapore, Sri Lanka, Thailand, Vietnam, Australia, Bangladesh and most recently Cambodia.

TEIN provides the IP capacity for India's participation in high energy physics projects and supports other Asia/Europe collaborative programmes in areas such as disaster mitigation, climate research or food security. The connection between GÉANT and TEIN allows the near real-time transfer of satellite data collected by the Thaichote satellite from the ground receiving station in Sweden to the Space agency in Thailand.

Additional connectivity to Europe is provided via the ORIENTplus link: a joint project between Europe and China to provide high-capacity, direct connectivity between both regions. ORIENTplus connects CERNET and CSTNET (the Chinese NRENs) to GÉANT via a 10Gbps trans-Siberian link between Beijing and London. The link is able to establish private connections between two sites (so called point-to-point services) supporting large research collaborations between Europe and Asia.

The ORIENTplus Link plays a pivotal role in earth observations such as the THORPEX Interactive Grand Global Ensemble (TIGGE), which use it to transfer data between the UK and China.

Caribbean

C@ribNET is the Caribbean regional R&E Network providing connectivity across the Caribbean region, to Europe, and to Latin and North America. Officially launched in February 2013, C@ribNET interconnects universities and colleges and also aims to connect hospitals, libraries, schools and governmental agencies. At present C@ribNET interconnects 15 Caribbean countries: Anguilla, Antigua, Bahamas. Barbados, British Virgin Islands, Dominica, Dominican Republic, Grenada, Jamaica, Montserrat, St. Kitts and Nevis, St. Lucia, St. Vincent, Suriname, and Trinidad and Tobago.

A well-established R&E networking infrastructure and its global interconnection are especially important for seismic research. Due to its close location to plate boundaries, the Eastern Caribbean region is a seismically active area with a history of large earthquakes, and also potentially affected by tsunamis and volcanic eruptions. Therefore the measurement of earthquake activity in the region for early warning systems and disaster mitigation can greatly benefit from collaboration with other seismic researchers worldwide.

Central Asia

The Central Asia Research and Education Network (CAREN) interconnects research centres and educational institutions throughout Central Asia. Operational since July 2010, CAREN currently interconnects half a million scientists and students in more than 500 universities and research centres in Kazakhstan, Kyrgyzstan, Tajikistan and Turkmenistan, with Uzbekistan also as candidate country.

The connection between CAREN and GÉANT plays a pivotal role in glacier monitoring and provides early warning of potential flooding by sharing monitoring data of melting glaciers from Kyrgyzstan with sites in Austria and Germany where the data is processed and analysed.

Southern Caucasus

The Southern Caucasus region is organised in NRENs for Azerbaijan, Georgia and Armenia. The region currently has no dedicated regional R&E network. However, as affiliated partners of GÉANT, they benefit from the international connectivity it provides.

Latin America

RedCLARA is the regional network for Latin America. It interconnects more than 750 institutions in 13 Latin American countries: Argentina, Brazil, Chile, Colombia, Costa Rica, Ecuador, El Salvador, Guatemala, Mexico, Peru, Panama, Uruguay and Venezuela. Following EC-funded projects from 2003–2013, RedClara is now self-sustaining. RedCLARA connects to GÉANT via 5 Gbps and also directly to Internet2, C@ribNET and TEIN.

RedClara and GÉANT collaborate on the extension of GÉANT Identity and Trust services to Latin America and the creation of tools for web-conferencing and large file transfer to develop an e-infrastructure supporting academic collaborations between Latin America and Europe.

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North Africa and Middle East

Since 2010, ASREN is the regional R&E network for the southern and eastern Mediterranean region connecting the following countries: Jordan, Algeria, Morocco, Egypt, United Arab Emirates, Somalia, Tunisia, Lebanon, Palestine, Syria, Oman, Saudi Arabia, Sudan and Qatar. Currently the NRENs in the remaining Arab countries – Bahrain, Comoros, Djibouti, Iraq, Kuwait, Libya, Mauritania and Yemen – are in various different stages of development.

International connectivity is provided via the EUMEDCONNECT3 project. Initially connecting Algeria, Egypt, Jordan, Morocco, Palestine, Syria and Tunisia since 2004, the network has been affected by the Arab Spring with currently only Algeria remaining connected to Europe.

Some of the NRENs in the region (ANKABUT in the United Arab Emirates, the Qatar foundation in Qatar and SARInet in Saudi Arabia) are not organised in a regional R&E network but are internationally connected via direct links to Europe or the United States.

North America

The North American research networking environment is more diverse than in Europe, with research connectivity provided by CANARIE in Canada, and three main research and education networks in the USA: ESnet, Internet2 and the NASA Integrated Services Network (NISN).

There is a long-standing relationship between pan-European research networking and North American research networks. The connections to North America are key in enabling research collaboration on intercontinental projects, and are particularly significant for the Large Hadron Collider (LHC) at CERN with a number of their data-processing centres located in North America.

Dedicated connectivity can be provided between GÉANT and CANARIE, Internet2 and ESNET.

CANARIE is Canada's Advanced Research and Innovation Network since 1993 and connects one million end users at over 1,100 institutions (including universities, colleges, research institutes, hospitals and government laboratories) across 12 networks in Canada.

Launched in 1996, Internet2 is a not-for-profit advanced networking consortium comprising more than 250 U.S. universities in cooperation with 82 leading corporations and over 100 government agencies, laboratories and other institutions of higher learning. User groups who benefit from the connectivity provided by Internet2 include science and engineering, health, education and the arts and humanities.

ESnet is the Energy Sciences Network in the United States which serves Department of Energy scientists at over 40 institutions, enabling researchers to collaborate on projects including energy, climate science, and the origins of the universe. Established 1986, ESnet is funded by the US Department of Energy Office of Science, and managed and operated by the ESnet team at Lawrence Berkeley National Laboratory.

Sub-Saharan Africa

Sub-Saharan Africa is organised in two regional R&E networks together covering the whole region. The single countries are in different stages of NREN development and connectivity and huge efforts are underway on the further development of the region.

The UbuntuNet Alliance is a regional association of National Research and Education Networks (NRENs) in Africa. It was established in 2005 by five NRENs in Eastern and Southern Africa and comprises to date the NRENs of 14 countries: Democratic Republic of Congo, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Namibia, Rwanda, Somalia, South Africa, Sudan, Tanzania, Uganda and Zambia.

WACREN is the West and Central African Research and Education Network. Initiated in 2006 it has member NRENs in Côte d'Ivoire, Ghana, Gabon, Mali, Niger; Nigeria, Senegal and Togo.

The Africa Connect Project is a collaboration between DANTE, Ubuntunet Alliance, WACREN and European NRENs. It supports the establishment of the African regional networks, connecting NRENs and providing a gateway to global research collaboration, e.g. remote access to powerful ICT resources in Europe, enabling African researchers to perform complex data analysis which would not be possible on slow or unreliable connections.

At present, the development of the NREN networks in the majority of the Western and Central African countries is limited. While NRENs are established as organisations in the aforementioned countries, the implementation of network infrastructure is not as advanced. Nevertheless, it is expected that the NRENs in Ghana (GARNET), Nigeria (NgREN) and Senegal (snRER) will have fully operational networks in the near future.

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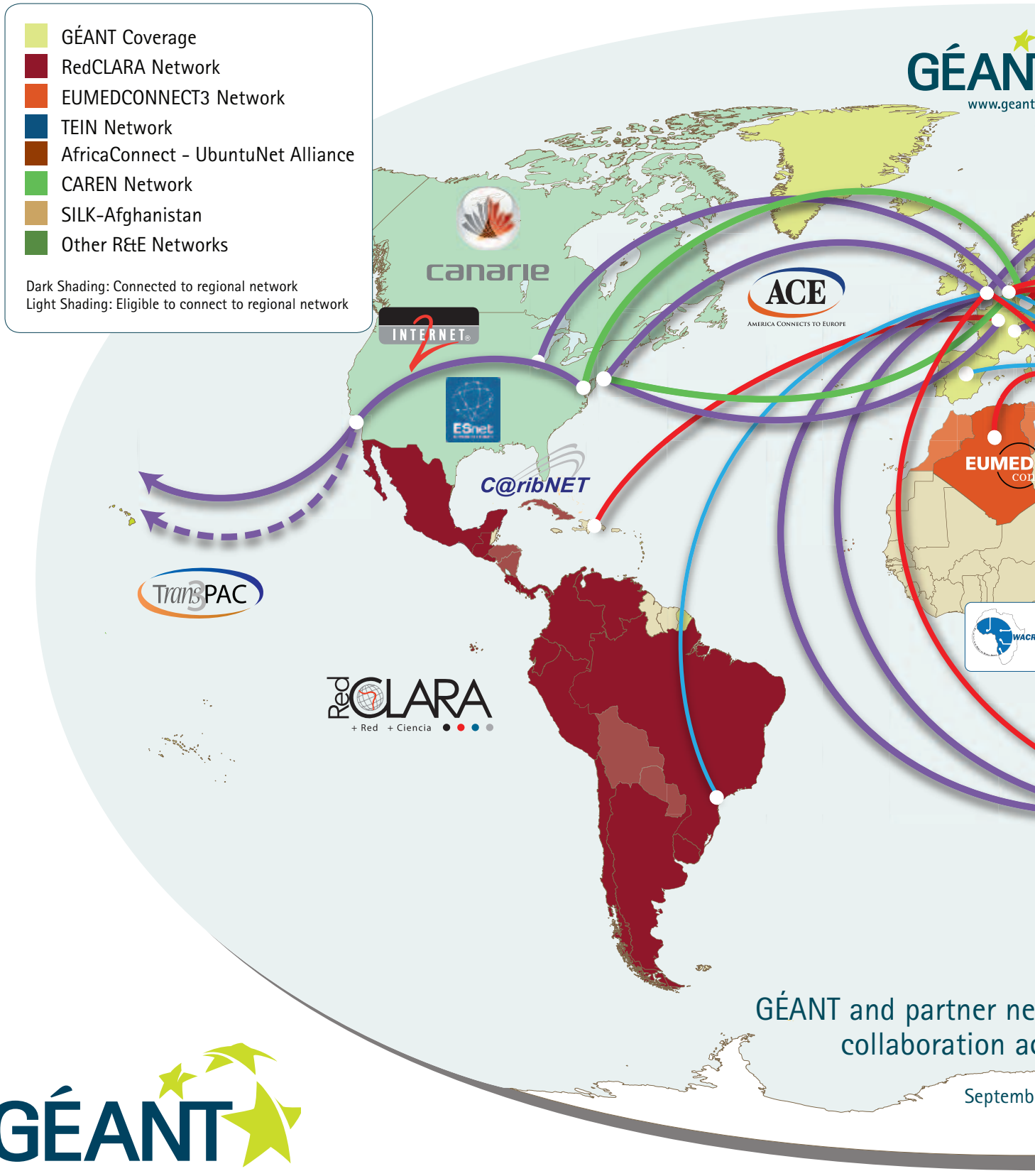

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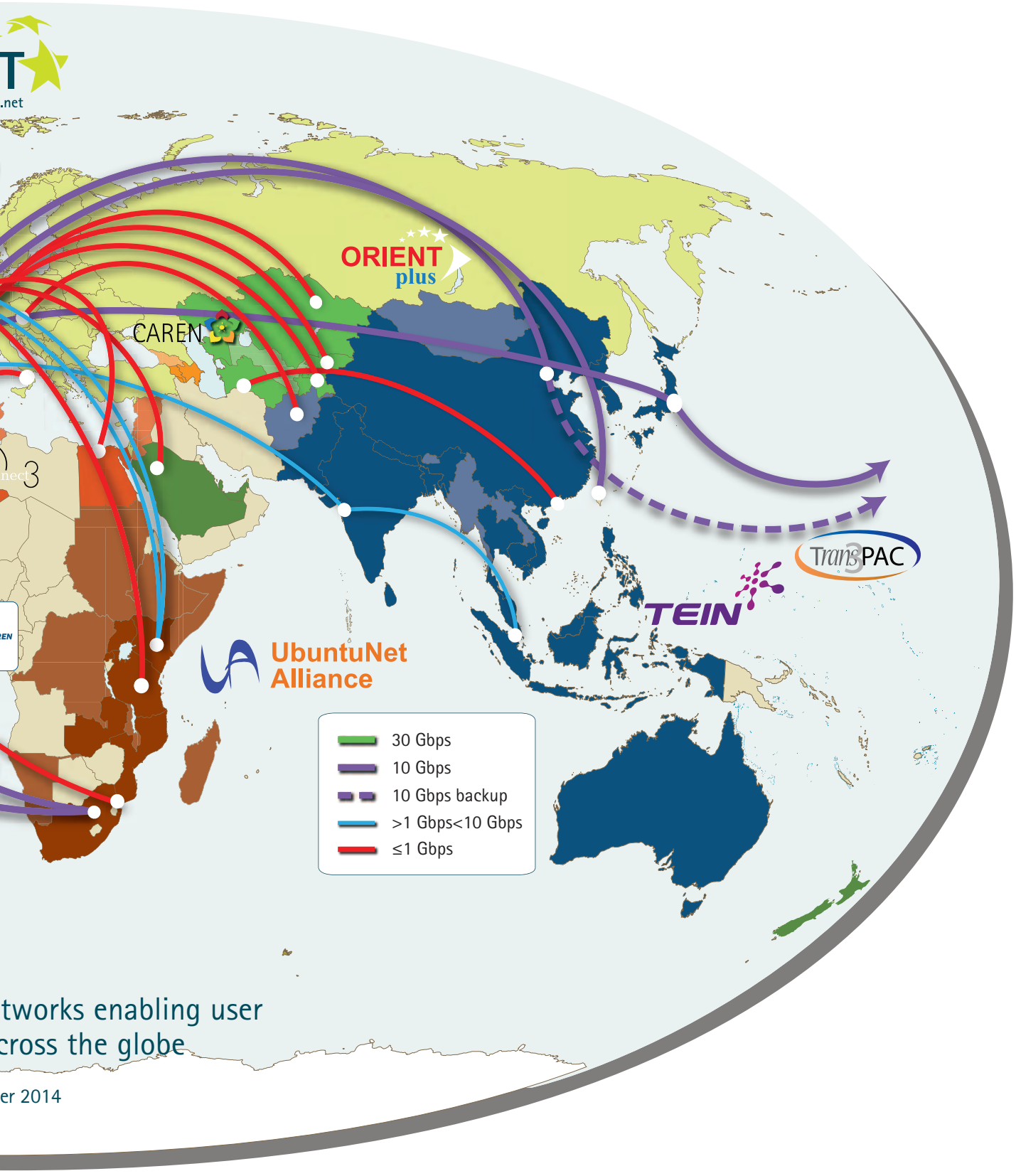

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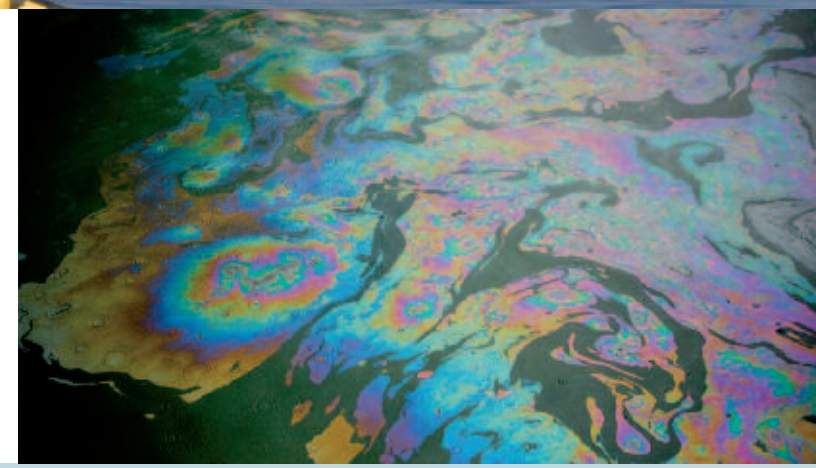
Case Study:

CleanSeaNet

Overview

The CleanSeaNet service is a near real-time satellite-based oil spill monitoring and vessel detection service in European waters operated by EMSA, the European Maritime Safety Agency, as being tasked by the European Directive 2005/35/EC on ship-source pollution and on the introduction of penalties, including criminal penalties, for pollution offences.



Challenge

The CleanSeaNet service aims to reduce maritime pollution by providing fast detection of oil spills through real-time analysis of satellite images.

Identification of potential spills in near real-time is essential as oil spills change very rapidly depending on wind and tidal conditions, and on chemical processes. CleanSeaNet aims to provide alerts to relevant member states within 30 minutes, enabling them to react quickly.

Solution

CleanSeaNet uses the research networks of GÉANT and its NREN partners to deliver high-resolution satellite images from downlink stations across Europe.

Low orbit polar orbiting synthetic aperture radar satellites downlink over 2,000 images per year to stations in Norway, Italy, Portugal and France. The data is then processed and sent via local NRENs e.g. UNINETT in Norway and GARR in Italy, across GÉANT via FCCN in Portugal to EMSA HQ in Lisbon – within a 10-minute time frame. This satellite data is then combined with CleanSeaNet's web-based GIS system and alert reports are generated, which are delivered to relevant European member state authorities.

The pan-European footprint of GÉANT and its NREN partners play an important role in transmitting satellite data, wherever the downlink station is, across Europe to EMSA HQ in Lisbon.

Maritime authorities can then access information immediately through the CleanSeaNet website and take action accordingly. This includes launching clean-up initiatives and using the evidence in the prosecution process. In order to maximise effectiveness, CleanSeaNet works with multiple satellites, each of which uses different downlink stations located across Europe dependent on their orbit.

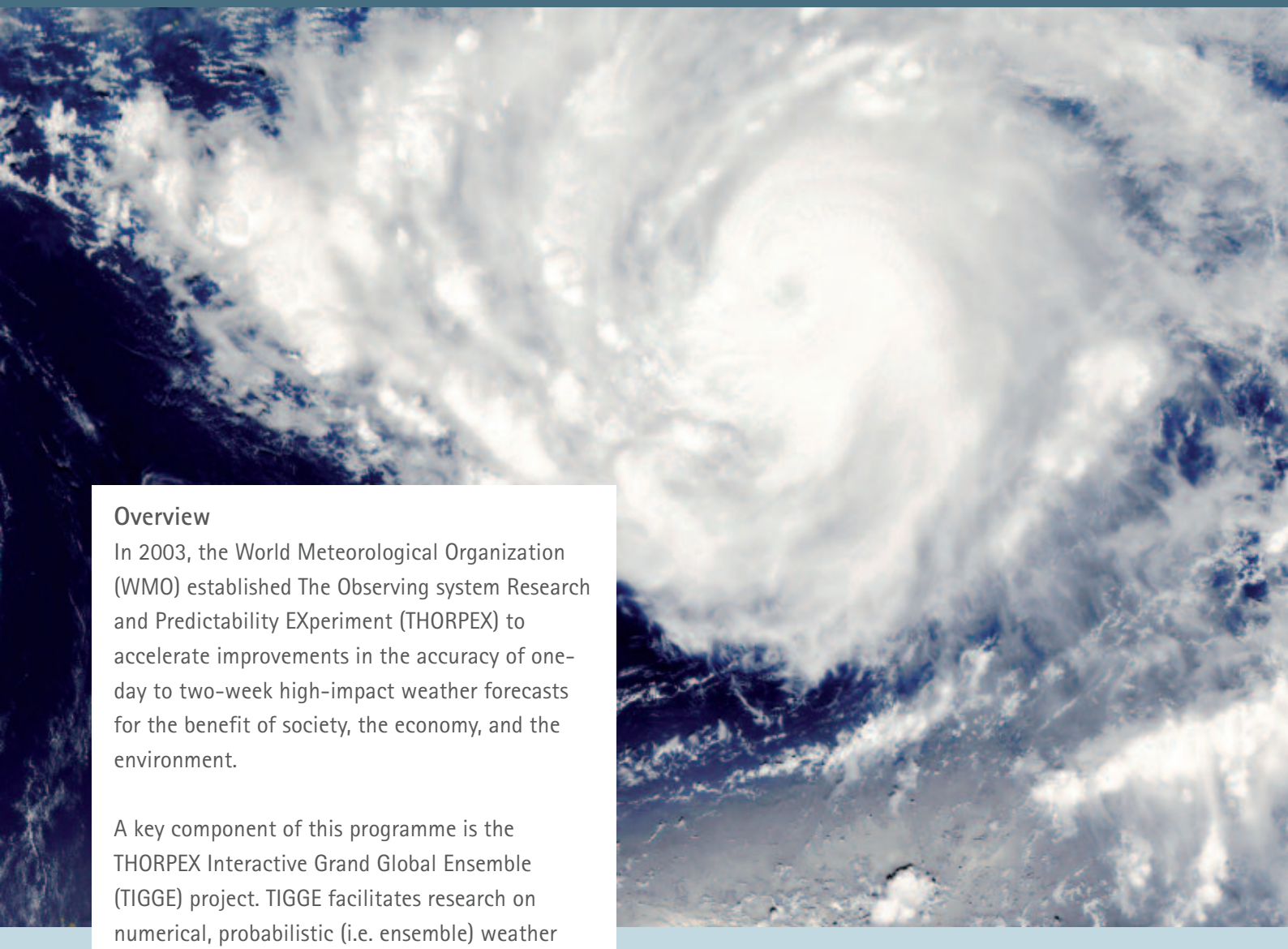
Benefits

Since CleanSeaNet went live in 2007, the number of potential oil spills detected on the images taken in European waters has decreased by half. While this is due to a range of factors including better ship design and greater environmental awareness, CleanSeaNet has proved to be a strong deterrent tool in safeguarding the European maritime environment.

Today CleanSeaNet is able to identify potential pollution and provide alerts to maritime authorities in near real-time, allowing them to act efficiently with the necessary response actions.

Case Study:

TIGGE – Helping to win the race against severe weather



Overview

In 2003, the World Meteorological Organization (WMO) established The Observing system Research and Predictability EXperiment (THORPEX) to accelerate improvements in the accuracy of one-day to two-week high-impact weather forecasts for the benefit of society, the economy, and the environment.

A key component of this programme is the THORPEX Interactive Grand Global Ensemble (TIGGE) project. TIGGE facilitates research on numerical, probabilistic (i.e. ensemble) weather prediction by providing researchers access to ensemble forecast data collected daily in near real-time from 10 leading operational forecasting centres across the world.

Challenge

With extreme weather events increasingly hitting news headlines around the world, accurate and timely forecasts are essential for effective disaster warning and mitigation systems. This, in turn, calls for joint research efforts within the global meteorological community to improve models and tools for predicting severe weather, such as hurricanes, tornadoes, cyclones, floods, heat waves, etc.

To meet TIGGE's mission to foster research on ensemble forecasting and the development of tools to improve the prediction of severe weather, based on the near real-time exchange of high volumes of ensemble data between multiple forecasting centres, including The European Centre for Medium-Range Weather Forecasts (ECMWF) in the UK and the China Meteorological Administration (CMA) in China

Solution

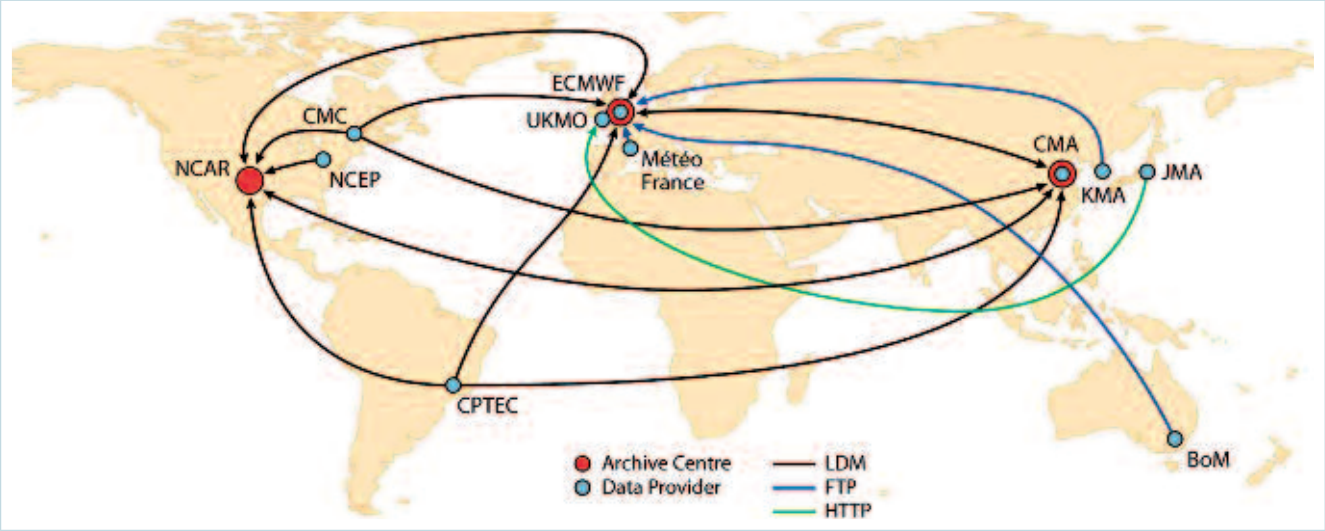
By offering the highest capacity connection and the shortest network path between Europe and China, ORIENTplus and the pan-European GÉANT network enable daily, direct, seamless data exchange between TIGGE database archive centres ECMWF and CMA, connected to the UK's research network Janet and the China Science and Technology Network (CSTNET) respectively.

Benefits

High-speed R&E network connections, such as ORIENTplus, are vital for supporting data-intensive, meteorological research tools, such as the TIGGE ensemble archive, aimed at improving severe weather forecasting and providing early warnings to civil protection agencies and the public. The UK Met Office, also supported by Janet, directly benefits from the collaboration between ECMWF and CMA, enabled by ORIENTplus.

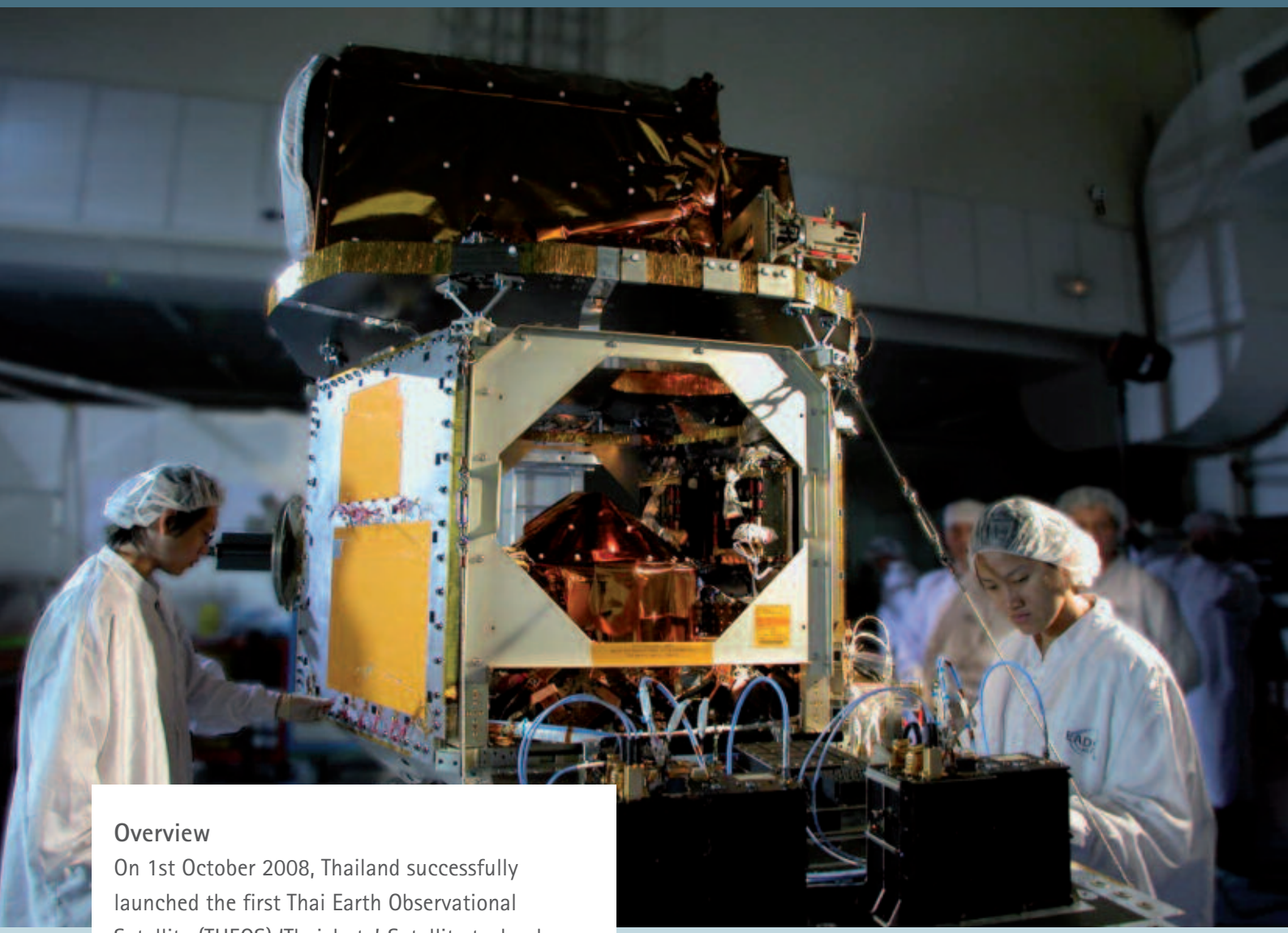
"TIGGE is a good example of international cooperation that provides a Petabyte-sized resource to the benefit of the research community as well as to providers and users of meteorological services. ECMWF alone has 2500 registered users worldwide. Without high-speed networks the daily database input and synchronisation between the archive centres would simply not be possible".

Manuel Fuentes, TIGGE Project Manager, ECMWF



Case Study:

Thai Earth Observational Satellite (THEOS)



Copyright : Astrium / C. Mériaux / 2006

Overview

On 1st October 2008, Thailand successfully launched the first Thai Earth Observational Satellite (THEOS) 'Thaichote'. Satellite technology enables scientists to monitor and mitigate the effects of natural disasters.

THEOS is operated by Thailand's Geo Informatics and Space Development Agency (GISTDA), and collects high-resolution images for analysis and deployment in areas such as Cartography, Land use, Crop yield forecast, Coastal zone monitoring, Flood risk management, and Disaster response.

'Without TEIN and GÉANT we would have to resort to transferring the imagery data over the commercial internet which will be less secure and definitely more time consuming. Prior to the connection we had to copy the data to backup tapes and send it by airmail.'

The GISTDA team

Challenge

Thailand is subject to a disaster cycle that needs monitoring – from forest fires and drought in the dry season to landslides and flooding in the rainy season.

In 2011, the system was put to the test when serious flood risks hit Bangkok. GISTDA needed guaranteed frequent, fast and reliable data transmission of large satellite images between Sweden and Thailand - particularly important in time-critical disaster mitigation and response applications.

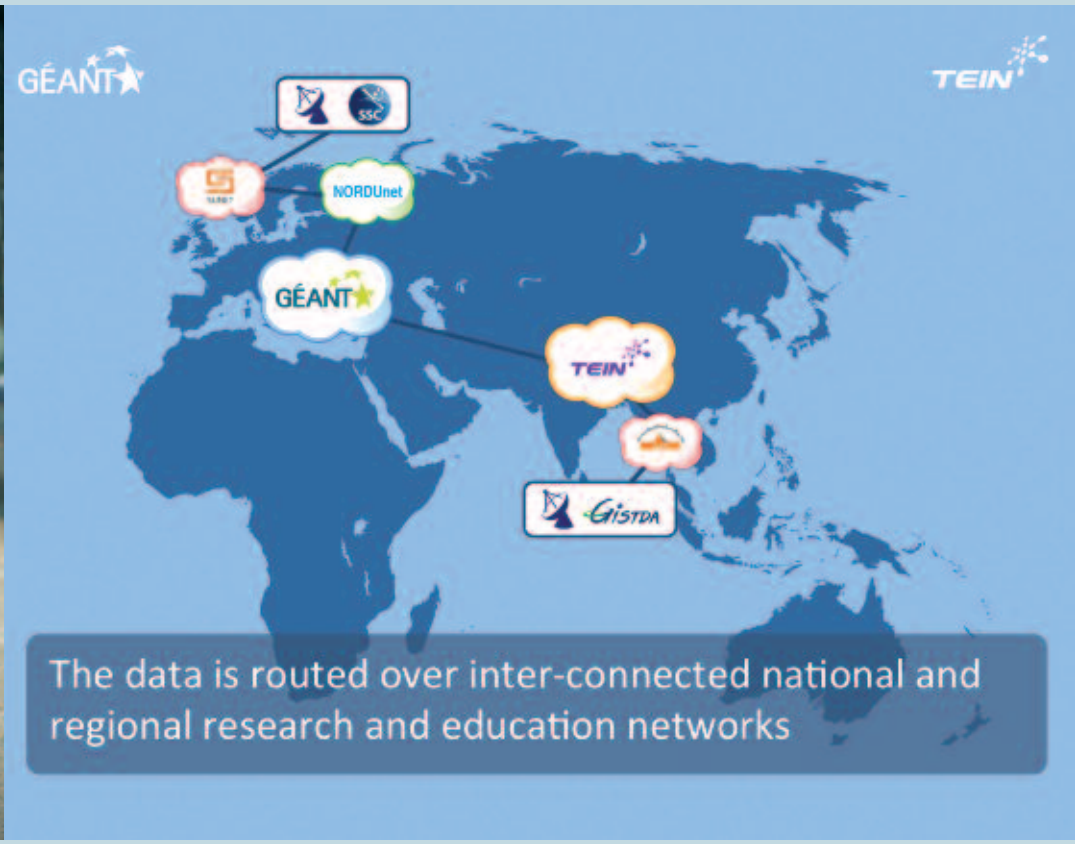
Solution

THEOS images were used to build flood maps to determine and predict the flow of water. The resulting water map was combined with a terrain model for more accurate prediction.
The only way to transfer these large images quickly and reliably is through high-speed dedicated research and education networks between Sweden and Thailand. The data is routed over inter-connected national and regional research and education networks.
The images were used to issue flood warnings to the public and guide the opening and closing of water gates to control the flow of water. This provided a visual display to describe the situation to senior government officials and the public.

Raw THEOS images are transmitted to the Swedish Space Corporation's Ground Receiving Station in Kiruna, Sweden and returned to Thailand for processing. Situated at a very high latitude of 68" N, the Swedish ground station can communicate with the satellite more frequently than GISTDA's own ground station.
GISTDA transfers an average of 5GB daily, and also using the TEIN and GÉANT links the transfer rate is almost 10Mbs end-to-end.

Benefits

Providing a high-quality connection with no data loss, research and education networks minimise the time needed to transfer data between the two sites in response to an emergency situation.



GÉANT Services – more than just a network

GÉANT offers a wide range of innovative services to enhance the experience of its network. Advanced connectivity, network support and access services make life easier for NRENs, institutions, projects, researchers and students alike – GÉANT's portfolio comprises a range of aligned services that allow it to cater for the most varied and demanding needs.

Connectivity services

Transporting data between collaborating institutions is an essential element in facilitating international projects. GÉANT has been providing these services for many years and is a persistent and reliable partner, chosen by many of the world's most data-intensive projects. GÉANT can provide a range of technical solutions (some of which are described below) and is happy to provide advice and consultancy to R&E initiatives.

The GÉANT IP Network

Access to the GÉANT network provides standard, high-bandwidth IP connectivity (GÉANT IP) of up to 500Gbps across Europe and connections with up to 100Gbps into other world regions. This service is available to all European research and education users who are connected to an NREN.

In addition, GÉANT offers various connectivity options reflecting the different flexibility and security needs of its users:

Specialist Connectivity Services

Certain performance-critical services require performance levels and additional security that cannot be easily met by shared IP services. In particular, applications such as data centre backup and replication, real-time mission-critical services and broadcast quality video need the guaranteed bandwidth and low latency that dedicated circuits isolated from general IP traffic offer.

By creating a **virtual private network (VPN)**, all sites on the VPN can communicate flexibly without the need to arrange separate networks, while benefiting from the privacy and security of a private infrastructure. GÉANT can provide virtual private networks between many sites (multi-point to multi-point connections) over great distances within Europe and reach Internet2 and ESnet in the US, Canarie in Canada, and Asia via the ORIENT+ link to Beijing.

Point-to-point services over GÉANT provide dedicated connectivity between two sites over the existing infrastructure without the cost and difficulty of building and managing a dedicated network. They can provide fixed latency between collaborating institutions, a high level of security and, if needed, guaranteed bandwidth of up to 100Gbps.

The **GÉANT Open** service is designed to offer NRENS, R&E organisations and commercial partners a flexible, high-performance, neutral interconnection point. Users can connect their own circuits at either 1Gbps, 10Gbps or 100Gbps, and can then request interconnections with any other participant.

GÉANT User support

End-to-end Monitoring and Performance services

perfSONAR MDM provides easy, transparent end-to-end data network monitoring allowing measurement over multiple network domains. It can operate at local level or around the globe and is scalable to provide at-a-glance information about multiple network paths simultaneously enabling network performance teams and operation centres to immediately address performance issues for end users and resolve them. GÉANT collaborates with ESNET, Internet 2 and Indiana University offering the same service and allowing end-to end monitoring between sites in Europe and the United States.

Leveraging on the GÉANT community, **eduPERT** provides multidisciplinary knowledge and support in solving end-to-end performance issues, shortening the time needed to troubleshoot and fix such issues. It provides a forum to share knowledge, skills, tools and best practice in this area.

Identity and Trust services (access to roaming and data services worldwide via single sign-on)

Eduroam is the roaming broadband service that enables students, researchers and staff from participating institutions to access the internet across their campus and at any other participating institutions using the same log-in details as they use at their home institution without any reconfiguration or new password credentials being needed. Leading in pioneering global roaming services, this secure and privacy-preserving technology is free-of-charge to its users. The service is already available in 36 European countries and in a total 69 territories spread over all world regions including North America, Latin America, Australia, Russia and Japan.

eduGAIN enables the trustworthy and secure exchange of authentication, authorisation and identity (AAI). It interconnects identity federations around the world, simplifying access to content, services and resources. eduGAIN provides one Pan-European Web Single Sign On (Web SSO) (one digital identity and password) to access all services provided by the participating federations and their affiliated service providers.

Although the service was initially developed for Europe, it is a huge success worldwide with federations across the globe from the US, Latin America, Australia, New Zealand, Japan and Israel joining. This service is especially of interest for distributed infrastructures or data archives, allowing data to be retained locally while researchers can access data sets from different locations via single sign on.

GÉANT serves the European R&E community. As such it works closely with NRENs and pan-European user groups to identify their requirements and channel this knowledge into strategy and service development, ensuring current and future developments reflect these needs.

Through a variety of different service options and international collaborations, GÉANT is able to cater to the specific needs of research collaborations. A dedicated User Support Team provides a central contact point and works closely together with R&E projects and the local NRENs to discuss and analyse their requirements and offer a tailored service solution.

One Stop Shop

While national R&E collaborations are well served by their respective NRENs, for those which are internationally distributed it can become quite complex to identify an ICT solution suiting their specific needs.

GÉANT provides a single point of contact to international collaborations and organisation for the analysis, implementation and management of their international networking needs, helping scientists all over the world realise their vision. From solving performance issues between two sites to the development of complete ICT solutions, GÉANT provides dedicated networks and bespoke services, including for performance monitoring, data access and security aspects.

The user support team covers communication with the NRENs and participating stakeholders to understand their specific requirements, collect all necessary technical, operational and financial information and present a consolidated and consistent solution for all involved sites. To ensure a seamless service implementation and smooth operation, project and operational service management are provided throughout the whole process.

You can contact the GÉANT User support by contacting partner-relations@geant.net.

How to Connect

Research and Education Networks by country

Country	NREN	Contact	Region
Afghanistan	AfgREN	www.mohe.gov.af/?lang=en	Asia & Oceania
Algeria	ARN	http://www.arn.dz/	Middle East & Africa
Anguilla	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Antigua	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Argentina	INNOVA/RED	http://www.innova-red.net/	Americas & the Caribbean
Australia	AARNet	http://www.aarnet.edu.au/	Asia & Oceania
Austria	ACONET	http://www.aco.net/	Europe
Bahamas	BAHAREN	http://www.ckln.org/	Americas & the Caribbean
Bangladesh	BdREN	http://www.bdren.net.bd/	Asia & Oceania
Barbados	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Belgium	BELNET	http://www.belnet.be/	Europe
Brazil	RNP	http://www.rnp.br/	Americas & the Caribbean
Bulgaria	BREN	http://www.acad.bg/	Europe
BVI	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Cambodia	CamREN	www.itc.edu.kh/itc/en	Asia & Oceania
Canada	CANARIE	http://www.canarie.ca/	Americas & the Caribbean
Chile	REUNA	http://www.reuna.cl/	Americas & the Caribbean
China	CERNET	http://www.edu.cn/	Asia & Oceania
China	CSTNET	http://www.cstnet.net.cn/	Asia & Oceania
Colombia	RENATA	http://www.redclara.net/	Americas & the Caribbean
Costa Rica	Red CoNARE	http://www.conare.ac.cr/	Americas & the Caribbean
Croatia	CARNET	http://www.carnet.hr/	Europe
Cyprus	CYNET	http://www.cynet.ac.cy/	Europe
Czech	CESNET	http://www.cesnet.cz/	Europe
Denmark	DeiC	http://www.deic.dk/	Europe
Dominica	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Dominican Republic	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Ecuador	CEDIA	http://www.cedia.org.ec/	Americas & the Caribbean
Egypt	ENSTINET	http://www.sti.sci.eg/	Middle East & Africa
Egypt	EUN	http://wcm.portal.eun.eg:10040/wps/portal	Middle East & Africa
El Salvador	RAICES	http://www.raices.org.sv/	Americas & the Caribbean
Estonia	EENET	http://www.eenet.org.uk/	Europe
Finland	FUNET	http://www.csc.fi/hallinto/funet	Europe
France	RENATER	https://www.renater.fr/	Europe
Germany	DFN	https://www.dfn.de/	Europe
Greece	GRNET	https://www.grnet.gr/	Europe
Grenada	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Guatemala	RAGIE	http://www.ragie.org.gt/	Americas & the Caribbean
Hong Kong	HARNET	http://www.jucc.edu.hk/jucc/harnet.html	Asia & Oceania
Hungary	NIIF	http://www.niif.hu/	Europe
India	NKN	http://www.nkn.in/	Asia & Oceania
Indonesia	INHERENT/ITB	http://www.inherent-dikti.net/	Asia & Oceania
Ireland	HEANET	http://www.heanet.ie/	Europe
Island	Rhnet	http://www.rhnet.is/	Europe
Israel	IUCC	http://www.iucc.ac.il/	Europe
Italy	GARR	http://www.garr.it/	Europe
Jamaica	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Japan	JGN-X	http://www.jgn.nict.go.jp/	Asia & Oceania
Japan	MAFFIN	http://www.maffin.ad.jp/	Asia & Oceania
Japan	SINET4/NII	http://www.sinet.ad.jp/	Asia & Oceania
Kazakhstan	KazRENA	http://www.kazrena.kz/	Asia & Oceania
Kenya	KENET	https://www.kenet.or.ke/	Middle East & Africa
Korea	KOREN/NIA	http://www.koren.kr/koren/eng/index.html	Asia & Oceania

Generally speaking, most not-for-profit research and education activities, as well as some public institutions and offices, can use the network.

If you

... have any queries about using R&E networking, locally, regionally or globally, we recommend that you contact your local NREN or Regional Network, for which the contact details are given below.

If you

... are a prospective user wanting to benefit from the GÉANT infrastructure, you should contact your IT department or local NREN to establish whether your host institution is already connected and what services are available to it.

If you

... are a European or international research collaboration that:

- requires support relating to pan-European or international network issues.
- is interested in discussing how you can benefit from the GÉANT infrastructure and services.
- would like more information about specific areas or services GÉANT can offer.
- would like to discuss your future plans to identify how R&E networking can support you.

Please contact the GÉANT user support team at: partner-relations@geant.net.

For more information about R&E networking, global connectivity and GÉANT please visit: www.geant.net.

Country	NREN	Contact	Region
Kyrgyzstan	KRENA-AKNET	http://krena.kg/krena_en/cert.htm	Asia & Oceania
Laos	LERNET	www.nuol.edu.la	Asia & Oceania
Latvia	SigmaNet	http://www.sigmanet.lv/	Europe
Lithuania	LITNET	http://www.litnet.lt	Europe
Luxembourg	RESTENA	http://www.restena.lu/restena/fr/	Europe
Macedonia	MARNET	http://marnet.mk/	Europe
Malaysia	MYREN	http://www.myren.net.my/	Asia & Oceania
Malta	University of Malta	http://www.um.edu.mt/	Europe
Mexico	CUDI	http://www.cudi.mx/	Americas & the Caribbean
Montenegro	MREN	http://www.mren.ac.me/	Europe
Montserrat	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Mozambique	MoRENet	http://www.ubuntunet.net/morenet	Middle East & Africa
Nepal	NREN	http://www.nren.net.np/	Asia & Oceania
New Zealand	REANNZ	http://reannz.co.nz/	Asia & Oceania
Norge	UNI-NETT	https://www.uninett.no/	Europe
Pakistan	PERN2	http://www.pern.edu.pk/	Asia & Oceania
Panama	RedCyT	http://www.redclara.net/	Americas & the Caribbean
Peru	RAAP	http://www.raap.org.pe/	Americas & the Caribbean
Philippines	PREGINET	http://www.pregi.net/	Asia & Oceania
Poland	PSNC	http://www.man.poznan.pl/online/en/	Europe
Portugal	FCT	http://www.fccn.pt/pt/	Europe
Qatar	Qatar Foundation	http://www.qf.org.qa/	Middle East & Africa
Romania	RoEduNet	http://www.roedu.net/	Europe
Saudi Arabia	SARInet	http://asrenorg.net/	Middle East & Africa
Serbia	AMRES	https://www.amres.ac.rs/	Europe
Singapore	SingAREN	http://www.singaren.net.sg/	Asia & Oceania
Slovakia	SANET	http://www.sanet.sk/	Europe
Slovenia	ARNES	http://www.arnes.si/	Europe
South Africa	TENET	http://www.tenet.ac.za/	Middle East & Africa
Spain	RedIRIS	http://www.rediris.es/	Europe
Sri Lanka	LEARN	http://www.ac.lk/	Asia & Oceania
St.Kitts	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
St.Lucia	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
St.Vincent	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Sudan	SUIN	http://www.suin.edu.sd/	Middle East & Africa
Sweden	SUNET	http://www.sunet.se/	Europe
Taiwan	ASGC	http://ca.grid.sinica.edu.tw	Asia & Oceania
Taiwan	TWAREN	http://www.twaren.net/	Asia & Oceania
Tajikistan	TARENA	www.tarena.tj	Asia & Oceania
Tanzania	TERNET	www.ternet.or.tz	Middle East & Africa
Thailand	ThaiREN/ThaiSARN	http://www.thairen.net.th/ThaiREN/	Asia & Oceania
Thailand	ThaiREN/UniNet	http://www.uni.net.th/UniNet/index.php	Asia & Oceania
Trinidad	C@ribNET	http://www.ckln.org/	Americas & the Caribbean
Turkey	ULAKBIM	http://www.ulakbim.gov.tr/	Europe
Turkmenistan	TuRENA	http://science.gov.tm/	Asia & Oceania
United Arab Emirates	ANKABUT	http://www.ankabut.ae/	Middle East & Africa
United Kingdom	JANET	https://www.ja.net/	Europe
Uruguay	RAU2	http://www.rau.edu.uy/	Americas & the Caribbean
USA	Internet 2	http://www.internet2.edu/	Americas & the Caribbean
USA	ESNet	http://www.es.net/	Americas & the Caribbean
Venezuela	REACCIUN2	http://www3.reacciun.ve/	Americas & the Caribbean
Vietnam	VINAREN	http://en.vinaren.vn/	Asia & Oceania
Zambia	ZAMREN	https://www.zamren.zm/	Middle East & Africa

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