

Research networks: global connectivity

As science becomes increasingly global and collaborative, researchers' dependence on fast and reliable data and communication links continues to grow. Research and Education (R&E) networks are designed to meet these demands providing high-speed and reliable internet links to support applications and experiments crucial to research.

In the next decade, it is predicted that computationally driven data collection and information-sharing requirements will escalate. GÉANT and other R&E networks will inevitably play a central role in enabling interconnectivity and collaboration across Europe and the world. This briefing document summarises the benefits of R&E networking, and addresses the pertinent challenges faced.

Enabling research and innovation

Networking is an essential part of the e-infrastructure connecting people around the world to global ICT services. Without reliable access to scientific instruments, data, collaborators, and other resources many international research experiments would not be possible.

Within Europe, the dedicated pan-European R&E network, GÉANT, transmits huge quantities of data (over 1,000 terabytes per day) for fields as diverse as radio-astronomy and drug research. In the past moving such large data-set may have taken days (equivalent of 250,000 DVDs) or would not have been possible, but now with high-bandwidth technology, transmission can take seconds.



Neelie Kroes, Vice-President of the European Commission responsible for the Digital Agenda – “Bringing together the brightest minds in the world, GÉANT not only benefits Europe’s competitiveness, but is also boosting collaboration between researchers on a global scale. Rich with these successes, GÉANT must now position itself to face the challenges of the next decade such as the upcoming «data deluge», connectivity at world scale, and providing a seamless service to all EU scientists to build an online European Research Area.”

Knowledge without Borders

The GÉANT network is aiding the European Commission’s vision of providing equal opportunities and access for European researchers irrespective of their location within Europe.

In October 2011, a report entitled ‘Knowledge without Borders: GÉANT 2020’ provided an action plan to serve the

needs of the community and help maintain and strengthen Europe’s research agenda. Among its recommendations were the provision of a more user-based service culture, and a continued commitment to increasing collaborations with other continents as well as testing emerging Internet technologies.

Helping radio-astronomers see further back in time

Helping radio-astronomers see further back in time. Reliable and robust links also allow researchers to share data in real-time. Astronomers are using networks to connect multiple radio telescopes all over Europe. Using a technique called e-VLBI, or real-time, electronic very long baseline interferometry, astronomers can inspect their results almost immediately. This technique relies on the GÉANT network that connects telescopes to a central data processor (a supercomputer), which correlates the data from the telescopes synchronously.

In 2010, the Joint Institute for VLBI in Europe (JIVE) in the Netherlands detected a possible black hole. Exploiting e-infrastructures such as the GEANT network, data can be streamed from each telescope and correlated in real-time. This updated technique yielded results for the researchers in a matter of hours rather than the weeks it took with the traditional technique of recording data to disk and physically shipping them for processing.





Brian Nisbet, Network Operations Manager, HEAnet - *NRENs although primarily dedicated to research communities, can extend their connectivity to benefit other users such as libraries and hospitals. The life-blood of NRENs is development of new services for the learning and research communities. They can use the trust relationships within these communities to combine subsidiarity and centralisation in innovative ways.*

A global campus

The ability to access a pool of resources (e.g. scientific instruments, data and collaborators) from anywhere ensures equal opportunities for all researchers wherever they are located. It helps to bridge the 'Digital divide' and ensures inclusivity. Seamless global connectivity allows virtual communities of researchers to co-operate and collaborate across continents as if they were on the same campus. As part of a larger consortium, individual NRENs can also benefit from long-term economy of scale.

Worldwide networking

Coordinating the day-to-day running of the pan-European network (GÉANT) is the organisation DANTE (Delivery of Advanced Network Technology to Europe). Co-funded by European NRENs, DANTE is extending the pan-European link to 59 worldwide NRENs and a number regional R&E networks including North America (Internet2, CANARIE, ESnet, NLR, NISN), Asia-Pacific (TEIN3), EUMEDCONNECT2 (North Africa and the Middle East), Sub-Saharan Africa (The UbuntuNet Alliance), Central Asia (CAREN) and Latin America (RedClara).



DANTE works closely with TERENA (The Trans-European Research and Education Networking Association), a collaborative forum that has supported and shaped the development of the Internet for the last 25 years for R&E communities.

Supporting 'Big Science' and everyday research

Research increasingly depends on large-scale databanks and massive processing power to help solve complex scientific or engineering problems. Any network performance issues can significantly impact scientists' ability to perform their research.

Users from a diverse number of academic disciplines rely on R&E Networks including scholars in the arts and humanities. Biologists at the European Bioinformatics Institute (EBI) have utilised networks to share, store, manage and interpret bioinformatics data.



Dr Torsten Reimer, Programme Manager (Digital Infrastructure), Joint Information Systems Committee (JISC) - *Today research is increasingly collaborative – across institutions but also countries and even continents – and it relies on ever growing amounts of data. In some research areas we are only beginning to understand the potential of this change, but collaborative access to data and digital infrastructure are now at the heart of research. Building and connecting research networks across and beyond Europe is critical to enable the potential of the digital transformation of research.*

R&E networks have provided the foundation transport 'layer' for Grid infrastructures such as the Worldwide Large Haldron Collider Grid (WLCG). The 15 million gigabytes of data generated from collisions at CERN is transferred and shared for analysis to 11 separate major computing centres dispersed around the world by high-speed optical fibre networking links.

Networks have also made an important contribution to speeding up of the reconstruction of physical infrastructure after natural disasters. High-resolution satellite images sent for analysis for rescue teams via GEANT and TEIN3 networks have helped plan rescues in the aftermath of earthquakes in China.

Sharing experiences

Experience and knowledge gained from R&E networking in Europe can help to advance e-infrastructure and innovation across other global regions. Advice, case studies as well as best practices in areas such as technical support, are assisting networking partners in other regions.

For developing countries, establishing an R&E network provides a framework for delivering on the United Nations anti-poverty Millennium Development Goals (health, climate, agriculture, education and the environment). It can also be one of the building blocks for building an effective education system.

Researchers in Sub-Saharan Africa will soon be connected to international networks from early 2012 via the AfricaConnect project. It is expected that many research areas will advance through the high-speed connectivity and supplementary services provided by networking.

In the remote parts of Africa, researchers can benefit from distance learning and live videoconferencing enhancing skills and knowledge for the local research community unlocking Africa's intellectual potential. In South Africa, e-Health and telemedicine, astronomy and physics are already actively exploiting the high-performance network infrastructure.



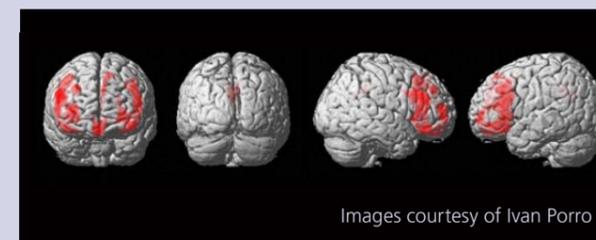
Professor Peter Clarke, Professor of Physics at the University of Edinburgh. - *R&E networking is vital to the Large Hadron Collider (LHC) operations. We transmit many Petabytes of data each year to be reconstructed and analysed in computing centres around the world. Without our NRENs and GÉANT we wouldn't be able to produce the results you see from the LHC.*



Richard Hughes-Jones, Technical Customer Support Manager, DANTE - *"To improve the way we deal with disease, disasters and other natural challenges, we need to understand more about our world - how it works and how it's changing. If we're going to make life better for people, we have to learn to share our knowledge and our skills. The answer lies in working together effectively. R&E networking is important because it provides a platform that enables better cooperation, collaboration and integration within and between geographically dispersed research and education communities."*

Assisting early diagnosis of Alzheimer's

Rapid, easy and secure access to networks is also important in healthcare. Clinicians often require access to large medical reference databases in order to compare patient imaging data for making and informed diagnosis, especially important for an early diagnosis of Alzheimer's.



Images courtesy of Ivan Porro

The DECIDE (Diagnostic Enhancement of Confidence by an International Distributed Environment) project uses high-speed research links to provide doctors with an easy-to-use online application for the analysis of neurological data (i.e. brain scans). The network and processing power to carry out such analysis is effectively beyond the budgets and computing power of most hospitals. R&E networks provide connectivity to hospitals and national research networks allowing doctors to access and upload biomedical images irrespective of location in order to collaborate and better understand the disease process.



Fulvio Galeazzi, Project Manager, DECIDE - *The high speed European network GÉANT and the other national research networks are focused on supplying connectivity and a growing portfolio of advanced services, allowing researchers to derive maximum benefit from a simple and secure access to a high capacity network. Dedicated network services for specific applications or projects, network performance monitoring tools, secure roaming services and authentication and authorization services for accessing shared resources (data and image archives, libraries, e-learning systems, etc.) are some of the innovative services available to the researchers.*

Guiding technological innovation

R&E networks offer opportunities for experimentation and are established pioneers in the use of advanced network applications and emerging Internet technologies. By facilitating the development—from idea, to archetype, to the commercial Internet many technologies and applications find their way from research networks to the commercial world.

For example, the 10 Gb/s technology provided by GÉANT and other international R&E networks was previously not available on the market.

User-focused and flexible service

In addition to high-speed Internet access, users benefit from a number of services provided by international R&E networks from large file transfers, computer modelling and stimulations, application sharing and a whole-host of visualisation tools.

However, research communities differ in their requirements so flexibility and scalability are increasingly being built into services. For example, LHC physicists may need increased access to large volumes of data for relatively short times.

GÉANT's perfSONAR is a monitoring tool that makes it easier to simplify troubleshooting and access performance problems occurring between sites connected through several networks.

Bandwidth-on-demand is expected to be valuable to users who may need to transport high volumes of data over the network in relatively short time periods. The autobahn service allows you to request dedicated bandwidth.



Domenico Vicinanza, Project Support Officer, DANTE - *From a network management perspective, R&E networks provide new standards of clarity and control. You can monitor use of resources in real time and rely on network repair, maintenance and development activities being managed centrally, with 24-hour central support. R&E networks offer tomorrow's network today."*

Future challenges

Big challenges lie ahead for R&E networking; not only will the networking consortiums have to meet the needs of supporting large scale computing but there are a number of organisational and technical hurdles to overcome.

- **Increasing capacity** by moving from 10-Gb/s to 40-Gb/s and 100-Gb/s line speeds.
- **Providing 'Greener' networks** by investigating ways to operate more environmentally friendly networks. This entails carrying out environmental impact studies to formulate best practices across the infrastructure.
- **Safeguarding and addressing security (privacy and anonymity) issues.** As capacities increase and global connectivity advances, it will be increasingly important to develop an integrated security framework in order to safeguard against cyber-attacks. GÉANT employs an automated system - the National Security Handling and Response Process (NSHaRP). The system not only informs affected users of threats but also provides support for dealing with security incidents.
- **Moving towards interoperability** - The Open Grid Forum (OGF) is leading the global standardisation effort and interoperability between the different technologies used in distributed computing systems in the world. Their Network Services Interface (NSI) protocol will provide an interface between network domains in order to provide interoperability in a heterogeneous multi-domain environment.
- **Ensuring governance is transparent and inclusive** - Streamlining the governance arrangements to reflect the European and international dimensions, and allowing users more of a role in the development of governance activities.
- **Cutting the costs of data roaming.** Expensive data roaming within the commercial mobile networks is a big obstacle to the mobility of scientists.

Switching over: IPv4 to IPv6

The phenomenal global growth of the Internet has led to a shortage of internet addresses which is the numerical label assigned to each device. IPv6 is the new version of the Internet address protocol that has been developed to supplement (and eventually replace) IPv4 the version that underpins the Internet today. The switch to IPv6 has been validated and certified prior to wider release by GÉANT and many European NRENs.



Scan this QR code into your smart phone for more on this e-ScienceBriefing

Bringing to life ancient instruments

Reconstructing the sounds of ancient musical instruments has become a reality for archaeologists through the ASTRA (Ancient instruments Sound/Timbre Reconstruction Application) project which has been facilitated by high-speed transatlantic Internet links. A technique termed, physical modelling synthesis, was used to reconstruct two South American instruments – a Chilean drum and a Peruvian flute – that had not been played for more than two thousand-years.



Video - excerpt of a concert - www.astraproject.org/download.html

Archaeological data (i.e. fragments from excavations, written descriptions, pictures of the two instruments) were sent through the ALICE2 transatlantic link between Europe and Latin America. Several gigabytes of data were exchanged in almost real-time by two teams of researchers in the two continents. To speed up the procedure and achieve the necessary processing power, the reconstruction processes were run simultaneously on hundreds of computers throughout Europe and the lower Mediterranean (using the European Grid Infrastructure). The sounds were transferred back to Santiago in Chile, to be played for the first time for a public performance of an opera.

For more information:

TERENA: www.terena.org
 DANTE: www.dante.net
 GEANT: www.geant.net
 TEIN3: www.tein3.net
 RedCLARA: www.redclara.net
 SURFNet www.surfnet.nl/en/
 CAREN: <http://caren.dante.net>
 AfricaConnect: www.africaconnect.org
 Internet2: www.internet2.edu
 DECIDE, <http://www.eu-decide.eu>
 ASTRA, www.astraproject.org
 Knowledge without Borders: <http://cordis.europa.eu/fp7/ict/e-infrastructure/docs/geg-report.pdf>
 GEANT Real time Monitor (RTM) http://rtm.hep.ph.ic.ac.uk/net_webstart.php
 EGI: www.egi.eu
 iSGTW: www.isgtw.org
 e-ScienceTalk: www.e-sciencetalk.org