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, the demand for computationally driven data collection and information-sharing will escalate dramatically. GÉANT and other R&E networks will inevitably play a central role in enabling interconnectivity and collaboration across Europe and the world.

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, transfers 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 datasets may have taken days 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 – “The power and scope of GÉANT ensure Europe remains a central hub for research and education, offering the best infrastructure to the brightest minds in the world. 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 fundamental to 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

Reliable and robust links also allow researchers to share data in real-time. Astronomers are using networks to connect multiple radio telescopes across Europe and beyond. 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 GÉANT and other networks to connect telescopes to a central data processor (a supercomputer), which correlates the data from the telescopes synchronously.

Exploiting e-infrastructures such as the GÉANT network, data can be streamed from each telescope and correlated in real-time. This updated technique yields results in a matter of hours, rather than the weeks it takes with the traditional technique of recording data to disk and physically shipping them for processing. The fast turnaround provides astronomers with a better tool for studying supernovae, gamma-ray bursts and other so-called transient activity that might otherwise be missed.
Ultra-fast networks help to minimise the delays that build up as data is transmitted over the internet. The actual physical infrastructure (the network cables) no longer relies on copper cables but state-of-the-art optical fibres, which provide much more bandwidth and a reliable ‘backbone’ linking the major ‘nodes’ allowing researchers to collect, distribute and analyse data securely.

R&E networking in Europe is organised in a hierarchical fashion, connecting research and education community users. The network connection between two end users will be provided by a chain of several networks, each connected to the next. This chain will typically start with a campus network then include a regional network before connecting to a national (NREN) network. Then to the pan-European backbone GÉANT, from there to another NREN and so on back down the chain to the user at the other end. Together, GÉANT and the National Research & Education Networks (NREN) partners interconnect more than 40 million researchers and students at more than 8,000 institutions across 40 countries. Key routes on GÉANT already run at 40 Gb/s (gigabits per second), with planned upgrades to 100 Gb/s scheduled for 2012 to ensure the network remains ahead of user demand for bandwidth.

In addition to its pan-European reach, the GÉANT network has extensive links to networks in other world regions including North America, Latin America, North Africa and the Middle East, South Africa and Kenya, the South Caucasus, Central Asia and the Asia-Pacific Region. Work is also on-going to connect to the Caribbean and to improve links to and within South America. Consequently GÉANT’s extensive geographical reach provides Europe’s NRENs with a gateway to NRENs worldwide, enabling European researchers to share huge quantities of data and collaborate effectively with their peers throughout the world.

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 creating an effective education system.

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

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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 carry out 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.

R&E networks have provided the foundation transport ‘layer’ for Grid infrastructures such as the Worldwide Large Hadron Collider Grid (WLCG). The 22 Petabytes 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 the reconstruction of physical infrastructure after natural disasters. High-resolution satellite images sent for analysis for rescue teams via GÉANT and the Asia-Pacific TEIN3 network have helped plan rescues in the aftermath of earthquakes in China.

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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 called physical modelling synthesis, was used to reconstruct two South American instruments – a Chilean drum and a Peruvian flute – which had not been played for over a thousand-years.

Archaeological data (e.g. 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, GILDA and EUMEDGRID). The sounds were transferred back to Santiago in Chile, to be played for the first time at a public performance of an opera.

For more information:
TERENA: www.terena.org
DANTE: www.dante.net
GÉANT: www.geant.net
TEIN3: www.tein3.net
RedCLARA: www.redclara.net
SURFNet www.surfnet.nl/en/
CAREN: http://caren.dante.net
Internet2: www.internet2.edu
AfricaConnect: www.africaconnect.eu
DECIDE: http://www.eu-decide.eu
ASTRA: www.astraproject.org
GÉANT 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

Switching over: IPv4 to IPv6

The phenomenal global growth of the internet has led to a shortage of internet addresses – 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.