GÉANT

Networks • Services • People

Annual Review 2015

GÉANT

The leading collaboration on e-infrastructure and services for research and education

A membership organisation that acts with and for its members to further research and education networking in Europe and globally

Owned by our core membership

- *36 National Members - European national research and education network (NREN) organisations*

- *One Representative Member – NORDUnet, which participates on behalf of five Nordic NRENs*

- *Eleven Associates - commercial organisations, multi-national research infrastructures and projects*

GÉANT

Contents

Foreword

The GÉANT General Assembly elected a new Board of Directors and a new Chair of the Board on 25-26 November 2015. From left to right and front to back: Alberto Pérez, Dorte Olesen, Marko Bonač, Valter Nordh; Ivan Marić, Erik Huizer, Sabine Jaume-Rajaonia, Christian Grimm (Chair), Raimundas Tuminauskas.

I am honoured to have been entrusted as chair of the GÉANT board, when elected in November 2015.

GÉANT and European NRENs have long been a trusted partner of the European Commission, building and operating networks in Europe and around the world, leading collaborative innovation, federated service-delivery and support for knowledge-sharing. The European Commission's new ambition for the next years is that all research in Europe has access to world-class supercomputing, data storage and analysis to support research-driven innovation ecosystems.

With the annual report 2015, we illustrate the pivotal role the GÉANT community already has in realising this, not only through our support of many work programmes and initiatives, but also through the services we jointly develop, build and operate to the benefit of the European and global research and education environment. These achievements position GÉANT well towards the European Cloud Initiative, in which GÉANT is considered a founding element of the so called European Data Infrastructure.

In 2015, we have also invested renewed vigour into our relationships with the different EC directorates, with staff and community members by identifying and pursuing opportunities for our collaboration, using our community's expertise, channels and resources.

These achievements help to further our collaborative efforts and in doing so, to help secure the role of each NREN within its own national interests and stakeholder base.

Christian Grimm
Chairman

Membership map

as per 31 December 2015

NATIONAL MEMBERS
1 per country

REPRESENTATIVE MEMBER
NORDUnet*

ASSOCIATES

ADVA Optical Networking

Alcatel-Lucent

Ciena Corporation

CERN

Cisco Systems

Coriant GmbH

*CSC (Finland)

*DeIC (Denmark)

ECI Telecom GmbH

EMBL

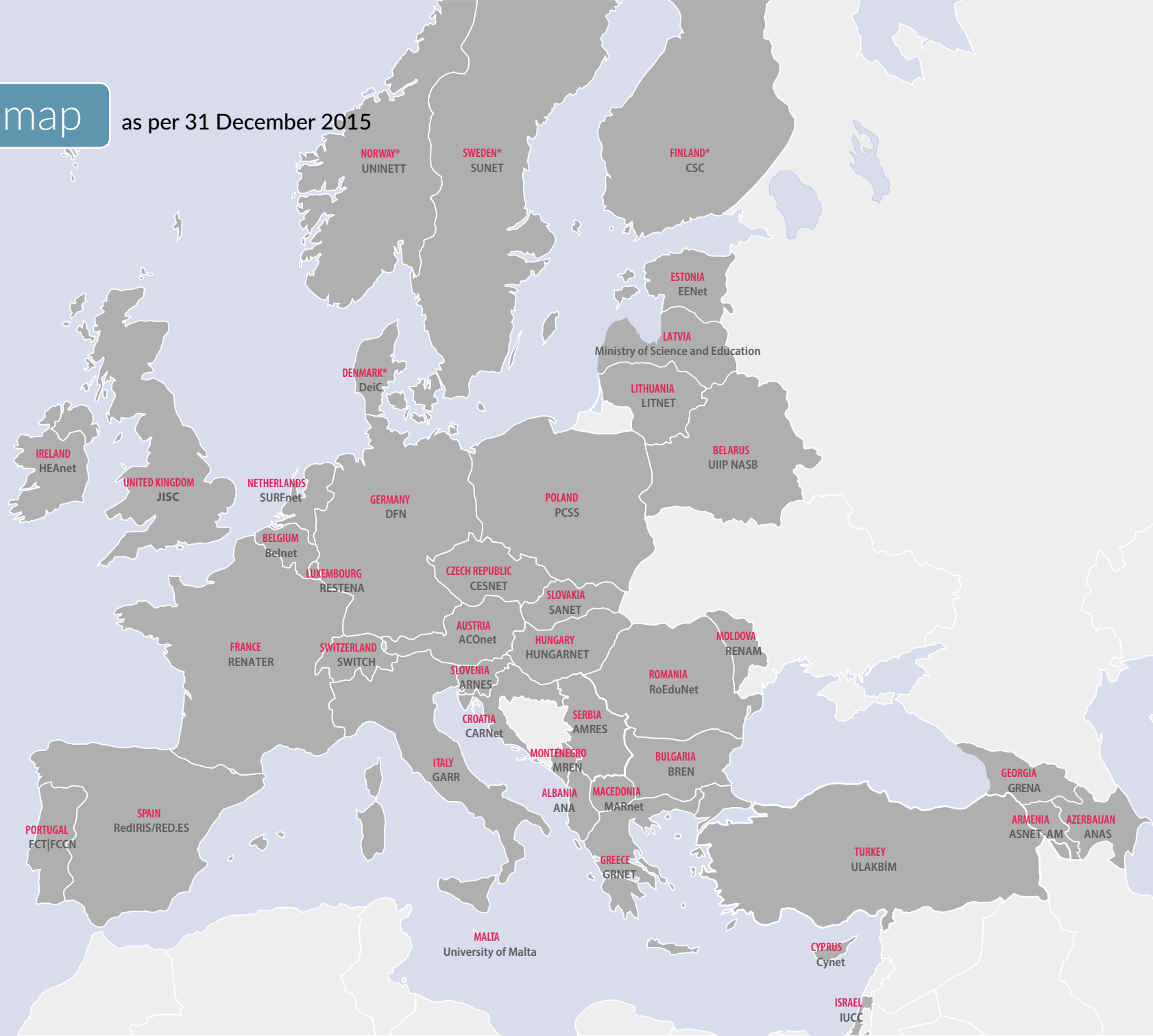European Space Agency

Google UK Ltd

Level 3 Communications

ownCloud

*RHnet (Iceland)

*SUNET (Sweden)

Tata Communications

*UNINETT (Norway)

ICELAND*
RHnet

NORWAY*
UNINETT

SWEDEN*
SUNET

FINLAND*
CSC

ESTONIA
EENet

LATVIA
Ministry of Science and Education

DENMARK*
DeIC

LITHUANIA
LITNET

BELARUS
UIIP NASB

IRELAND
HEAnet

UNITED KINGDOM
JISC

NETHERLANDS
SURFnet

GERMANY
DFN

POLAND
PCSS

BELGIUM
Belnet

LUXEMBOURG
RESTENA

CZECH REPUBLIC
CESNET

SLOVAKIA
SANET

AUSTRIA
ACOnet

MOLDOVA
RENAM

FRANCE
RENATER

SWITZERLAND
SWITCH

HUNGARY
HUNGARNET

SLOVENIA
ARNES

ROMANIA
RoEduNet

CROATIA
CARNet

SERBIA
AMRES

MONTENEGRO
MREN

BULGARIA
BREN

ITALY
GARR

ALBANIA
ANA

MACEDONIA
MARnet

GEORGIA
GRENA

SPAIN
RedIRIS/RED.ES

ARMENIA
ASNET-AM

AZERBAIJAN
ANAS

PORTUGAL
FCT|FCCN

GREECE
GRNET

TURKEY
ULAKBİM

MALTA
University of Malta

CYPRUS
Cynet

ISRAEL
IUCC

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1 • Strategy and vision

Supporting our membership,

serving the community

Purpose and Passion

Purpose and passion are two things that make the research and education networking community unique.

Along with many in our community, we at GÉANT believe our purpose is to make a difference. Unlike many professions, ours isn't obsessed with profits. Our work is so much more fulfilling than that; we make a deep and lasting impact. By bringing distance learning to remote corners of Europe, children have the opportunity to learn a profession that will allow them to one day provide for their families. By making computing resources available to climate scientists, we can help mitigate the effects of global warming. By connecting entrepreneurs to researchers and NRENs, we will help drive the European economy forward in a sustainable way.

And like our community, we are an organisation full of passionate people – passionate about what we do, serving our community, achieving our purpose. We realise that we must all do our jobs, not just well, but extremely well. Anything less, and our children don't reach their potential, scientists don't make breakthroughs, and millions remain jobless.

As the inaugural CEO of the new GÉANT Association, it is my responsibility to put all the pieces in place to maximise our impact – to make European research and education networking the best in the world.

To get there, we'll be focusing on four high-level objectives in 2016:
* delivering a world-class, end-to-end user experience;
* providing exceptional 'Value for Money';
* building and strengthening the community;
* running an efficient, highly effective organisation.

Steve Cotter, CEO GÉANT

This will require creativity, dedication, and hard work, but together with the community, we can achieve our purpose.

Getting there will require goal-setting. There are two types of goals: 'Organisational Goals' and 'Community Goals'. Think of them as 'Me Goals' and 'We Goals'. At GÉANT, we will focus on We Goals.

Me Goals are about accomplishing something by ourselves, for ourselves. However, our purpose is to lift the community and without the NRENs, we don't exist. Therefore, GÉANT must continue to provide services which support European NRENs to be/become better NRENs. That's why We Goals will take priority.

The payoff? Real impact. And resilience. It is like in the old fable 'The Father, His Sons, and The Bundle of Sticks' that teaches us that sticks in a bundle can't be broken, but sticks taken singly can be easily broken. The same applies to our community – strength is in the union.

When we set We Goals, and give context, meaning and purpose to them, we inspire others to join us. We Goals prompt people to jump in and even sacrifice for a shared vision. Why? The reward is much more than the achievement of the goal itself. It's the bond, the relationship and the stronger foundation we can rely on for the next challenge.

How cool will it be to say 'We've built this together." I expect to say that often in 2016.

Steve Cotter
CEO GÉANT

The GÉANT Project

Accelerating research, driving innovation and enriching education

Co-funded by the EC and Europe's NRENs, the flagship GÉANT Project represents a substantial proportion of the organisation's work. Together, we build and operate the 500Gbps pan-European research and education network, undertake collaborative research programmes, and develop and deliver a portfolio of innovative, federated services, including connectivity, trust and identity, cloud, real-time communications and media services. The current phase of the GÉANT project, GN4-1, marks the start of funding from the European Union's Horizon2020 research and innovation programme.

- The successful two-year GN3plus project ended 30 April 2015, having been extended by one month. It consolidated GÉANT's position as the best-connected R&E network in the world, which, together with its associated services, made a difference to innumerable research communities and, ultimately, to the European citizen. The first Open Calls programme was a new initiative for the GÉANT Project, which brought fresh ideas from thirty new partners and twenty-one new research projects to the Joint Research Activities.

- The twelve-month GN4-1 phase of the GEANT project started on 1 May 2015, marking the first step in implementing the actions defined in the 68-month Framework Partnership Agreement (FPA). The FPA is the instrument to deliver world-leading networking and emphasises the vital role of NRENs. The Project's objective is to provide a stable, though innovative environment for the growth of GÉANT as the European Communications Commons for the European Research Area (ERA) and providing the best possible digital infrastructure to ensure that Europe remains at the forefront of research.

"The collaborative efforts of the project were recognised by the EC, as it achieved a fourth consecutive "Excellent" rating in the GN3plus EC Review."
– Tryfon Chiotis, Head of the GÉANT Project Office

- In preparation for the next phase of the GÉANT Project (GN4-2), white papers were prepared by groups of Activity Leaders and members of the GÉANT Programme Planning Committee (GPPC) to inform about future work, and NREN partners fed back prioritisation of the services and initiatives that should be included. Activity Leaders were appointed, the work programme was drafted and invitations for participation were issued. Throughout the GN4-2 phase, GÉANT will maintain the operational excellence of the established GÉANT services, and continue to drive innovation, while still achieving economies in the costs of the backbone network.

GN4-1 and future projects within the frame of the FPA are part of the EC's Excellent Science e-infrastructures programme, with a vital role to ensure that Horizon 2020 project participants are fully able to collaborate, share and access data, discuss and learn together, and test their innovations across the network unimpeded. An initiative is underway for the e-infrastructures to work together on dissemination materials and on activities to promote an integrated services portfolio to the research community.

Stability for Users – The GÉANT Framework Partnership Agreement

On 23 April 2015, the GÉANT Consortium and the EC signed a 68-month Framework Partnership Agreement (FPA) to contribute to the effective European Research Area by making Europe the best-connected region in the world.
The Agreement aims to *"…make every European researcher digital, increasing creativity and efficiency of research and bridging the divide between developed and less-developed regions."*
Six "actions" underpin the FPA:
- drive the evolution of the network;
- support the knowledge community;
- provide security, trust and identity;
- deliver GÉANT's collaborative ecosystem;
- develop the human capital of the GÉANT partnership;
- ensure the long-term future of the GÉANT infrastructure.

GÉANT Project* funded activities

Network	Europe: terabit-ready network, interconnecting 41 countries via 37 NRENs and NORDUnet (representing five Nordic countries) Global: reaching a further 66 countries outside Europe through interconnections with regional networks
Services	GÉANT connectivity: IP, Plus, Lambda, Open, VPN, Testbeds, eduroam, eduPERT, perfSONAR Trust, Identity & Security: eduGAIN, eduPKI, FaaS Clouds Catalogue: guide to service providers and procurement assistance Real-time communications and multimedia: eduCONF, eduOER
Joint research programmes	Network architectures, network services, trust and identity, Open Call projects
Community development	Campus Best Practice, Green Team, training, Community Awards, support for task forces and special interest groups

*GN3plus and GN4-1

2 • Creating world-class user experiences

Whether we are serving a member, researcher, educator or innovator, GÉANT aims to always deliver a service and experience that does what it says on the tin (and more).

We strive for great interactions in our collaboration, support and development activities and work hard to really understand what our members, project partners, and their constituents need that we can provide. There is always more to learn and deliver.

Supporting science

GÉANT delivers real value and benefit to society by enabling research communities across Europe and the rest of the world to transform the way they collaborate on ground-breaking research.

A focus on earth observation

A priority for 2015 was to engage with the earth observation community. The atmosphere, oceans and landscapes require a new level of understanding to help make informed decisions about natural hazards, energy, climate, health and other environmental and societal challenges. Analysing information from thousands of air, water, seismic and meteorological sensors is data-intensive work. The GÉANT community provides the high bandwidth that network scientists and researchers need to collaborate and study the Earth's physical, chemical and biological systems.

On 22-23 January, GÉANT and EGI hosted an Earth Science Workshop in Amsterdam (The Netherlands) for the earth sciences research communities with the European e-infrastructure providers, EUDAT and PRACE.

Together with NREN partners, GÉANT assisted many research projects and organisations, including:
- Copernicus (earth observation and monitoring programme);
- EUMETSAT (monitoring weather and climate from space);
- GEO (Group on Earth Observations);

"We've been proactively engaging with our user communities and collaborators, and working closely with NRENs to develop and deliver a range of networking and value-added services."
– John Chevers, Chief Business Development Officer, GÉANT

- EIDA (the European Integrated Data Archive);
- ESA (European Space Agency).

SSO for EIDA: facilitating the archiving and accessing of seismic data

The European Integrated Data Archive (EIDA) is a distributed data centre, which securely archives seismic waveform data and metadata gathered by European research infrastructures. It provides the geosciences research communities with transparent access to those archives. GÉANT (under GN4-1) provided EIDA with a tailored AAI (Authentication and Authorisation Infrastructure) solution that included a Service Provider prototype and the set-up of an IdP (Identity Provider) for the main node, as well as integration of all nodes in the national IdP and eduGAIN.

The result? Seismologists are now able to access globally-gathered data via single sign on. EIDA is the biggest community within the European Plate Observing System (EPOS); the solution that works for them is scalable and could be adapted for the whole EPOS community.

Multicast for EUMETSAT: ensuring delivery of meteorological data

EUMETSAT is an intergovernmental not-for-profit organisation that supplies weather and climate-related satellite data, images and products. It operates a system of meteorological satellites gathering accurate and reliable satellite data on weather, climate and the environment twenty-four hours a day, 365 days a year.

EUMETCast is EUMETSAT's primary data dissemination service. It is the European component of GEONETCast, the global network of satellite-based data dissemination systems coordinated by GEO.

In spring 2015, the first phase of a EUMETCast Terrestrial Demonstration service using GÉANT was established. The data is disseminated via IP multicast from EUMETSAT HQ in Germany, simultaneously reaching client sites across Europe using the infrastructure and services provided by GÉANT and the NREN networks. It is envisaged to reach selected sites in 31 European countries by 2018.

Conceptually, Multicast allows the dissemination of the same data over the IP infrastructure of a network from a single data source to multiple end sites at the same time. Technically, end users can access the service via their respective NREN.

Throughout the entire implementation process, GÉANT acted as single point of contact and coordinator between EUMETSAT and the NREN partners. GÉANT supported the implementation of the EUMETCast Terrestrial Demonstration service further by provision of a centralised network and operations centre and network service management using a specifically developed monitoring and reporting platform and first level support including the coordination of anomalies between the involved NOCs.

This usage of existing network capacities by GÉANT and the involved NRENs was seen as a major strength. This included how GÉANT and the NRENs addressed the specific demands for monitoring and provided technical service support. These where implemented by deploying network-level monitoring functions and developing a related web-based, nearly real-time monitoring platform. Both allow an efficient escalation process in case of anomalies.

EUMETSAT supplies weather and climate-related satellite data, images and products – 24 hours a day, 365 days a year – to the National Meteorological Services of many European countries and other users worldwide.

Extending LHC's network

To improve the LHC (Large Hadron Collider) user experience, GÉANT helped to set up the LHC Open Network Environment (LHCONE) in Asia-Pacific and Brasil in 2015. Working closely with TEIN, ThaiREN, RedCLARA and RNP, GÉANT staff designed and configured the GÉANT network so that it opened up LHCONE to users in Latin America (RedCLARA) and Asia (TEIN). This was the single most successful attempt at providing a multi-domain network service for a science community.

Strenghtening ties with the European Space Agency

A series of strategic discussions to improve mutual understanding and strengthen the relationship between the European Space Agency and European NRENs (RedIRIS, SURFnet, GARR, and DFN) led to more opportunities to work with ESA, which, in turn, enables researchers to make use of ESA.

Some of the KAT7 dishes in the Karoo that, with MEERKAT, form part of the SKA precursor Photo credit: R. E. Hughes-Jones, GÉANT

Networking expertise for SKA: creating the largest radio telescope

The world's largest radio telescope – Square Kilometre Array (SKA) – is being built by an international research project. It will be many times more sensitive and hundreds of times faster at mapping the sky than today's best radio astronomy facilities. GÉANT's networking expertise is crucial to the SKA's design and planning phase. Two complementary telescopes covering different sections of the electromagnetic spectrum will be built, one at the Murchison Observatory in Western Australia and the other in the Karoo in South Africa.

In collaboration with SANReN (South Africa) and AARNet (Australia), GÉANT has been leading the design and specification of the multi-terabit networks required internally by the SKA radio telescopes. These will move the information digitised by the antennas to the computer systems that extract the signals from the noise, and then on to the High Performance Computers (HPCs) that convert the data into sky maps.

There are three very different networking requirements within the SKA project, each with its own specific challenges:
- transporting real-time data from individual antennae (up to 100Gbps each) to the central signal processors, which requires hundreds of links across a radius of over 100 km and extremely accurate timing for the operation of the antennae;
- transporting this data (nearly 5 Tbps) to the HPC centre 800-900 km away in Cape Town or Perth;
- providing access to this data for researchers across the globe.

Crossing boundaries between technology and culture

Supporting the Arts

Over the years, GÉANT has responded to the community's demands for exploring cultural and artistic challenges with networking technology.
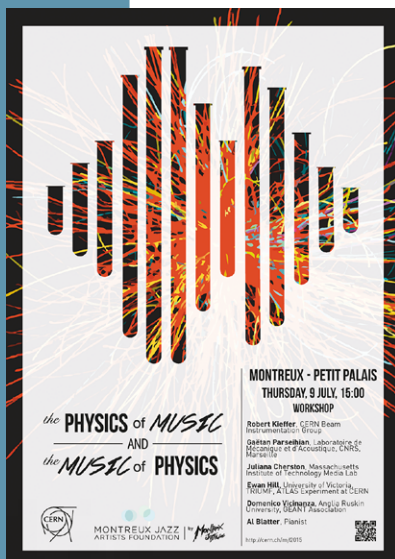
Network Performing Arts Production Workshop 2015

In May, GÉANT and Internet2 co-organised a Network Performing Arts Production Workshop, hosted by JISC and the Royal College of Music in London. It was the most successful workshop in the series to date, with the largest number of participants, several 'first time ever' demos, and a ground-breaking evening performance by RCM students to an audience of over 400 people. For the first time, the audience witnessed the use of Polycom and LOLA (low latency) technologies in a multimedia symphony.

CERN and GÉANT unveil 'Music of Physics' at Montreux Jazz Festival

Another exciting 'art meets science meets technology' event took place at the world-famous Montreux Jazz Festival. Using live data, the sound of the proton colliders from CERN's Large Hadron Collider (LHC) was brought to life, with improvised accompaniment from famous jazz pianist, Al Blatter.

The Montreux Jazz Festival poster announcing the 'Music of Physics' performance

Supporting education and learning

Online communications are crucial to research and education. Students, researchers and institute staff rely on e-learning services and audio and video conferencing to learn and share. This is a rapidly developing area and GÉANT is working to support and foster innovation for the national research and education networking (NREN) organisations and their communities.

Developing real-time communications

Enabling communication and collaboration across the community

A new service activity in the GÉANT Project looks after all service developments, pilots and production roll-outs in the areas of real-time communications and multimedia management, in order to streamline efforts in the community and safeguard a structured way forward.

eduOER - a search hub for Open Education Resources

eduOER supports access by users to multimedia content (e.g., lecture recordings, webinars, audio-visual learning objects, animations) that is published across multiple repositories, promising a wider pool of students and researchers for content providers, who are keen to open up access to their repositories. Having grown from the seed of an idea in the Task Force on Media in 2014, the initiative to develop an Open Educational multimedia Resource (eduOER) was picked up by the GÉANT Project.

Conference materials archive: all session recordings for The Networking Conference (TNC) back to 2001 are indexed in eduOER and can be accessed by a much wider audience. Soon, eduOER will also index recordings from the NORDUnet conferences and the Research Data Alliance (RDA) events.

Training resources: more than 160 multimedia training materials from PRACE (Partnership for Advanced Computing in Europe) have been indexed on eduOER. Other e-infrastructures are following suit.

NRENum.net growth

Interconnecting multiple dialling methods for real-time communications

Seven new members joined the NRENum.net service in 2015: Mexico, Ecuador, El Salvador, Uruguay, Czech Republic, Norway and Sri Lanka, bringing the total number of country code delegations to 43. The service now lists over 200,000 phone numbers under 43 country codes and is an essential support service for VoIP and video conferencing.

The NREN service matrix

The NREN service matrix provides a comprehensive overview of all the services that GÉANT NRENs offer nationally, fully-integrated with the Compendium of NRENs' data. It is a tool developed to help NRENs with service portfolio strategy, to identify gaps and synergies, and to help users identify services available to them at national level.

Driving trust and identity

GÉANT provides services that build trust, promote security, and support the use of online identities, through a range of activities and international collaborations.

Identity is an increasingly critical component of research (data) infrastructures. With a decade of experience in authentication and authorisation (AAI), the reputation of the GÉANT community goes from strength to strength. Together we are driving AAI projects and solutions on a global scale: AARC project, eduroam, eduGAIN and REFEDS.

The AARC project brings together a consortium of twenty organisations to further a common goal of federated access and inter-operable AAIs. AARC follows two main paths to achieve its vision:

- improving the adoption of federated access among different communities;
- designing an AAI framework built on existing production infrastructures to enable single-sign-on among e-infrastructures.

"The service matrix is an invaluable tool and its very existence, setting out all this data in such a simple way, impressed many of the ministry and university people on our Board."
– Martin Bech, DeiC

AARC project

Project title	Authentication and Authorisation for Research and Collaboration
Topic	Adressing challenges of interoperability and functional gaps in authentication and authorisation structures
Start	1 July 2015
End	30 June 2017
Programme	H2020

"The composition of the consortium, with so many parties represented - NRENs, e-infrastructure providers and libraries - will enable us to progress on some very critical technical and policy areas." – Licia Florio, AARC activity leader

AARC offers training, best practices and validations of technical work for researchers, institutions, service providers and infrastructures. In 2015, AARC delivered an initial training package, recommendations on the Minimal Assurance Level Profile to support low-risk research use-cases, and kicked off a number of pilots for libraries so that they can provide federated access to resources.

eduGAIN

Unlocking global research and education collaboration

The uptake of the eduGAIN service interconnects identity federations around the world, simplifying access to content, services and resources for the global research and education community. eduGAIN support, development and promotion in Europe is provided through the GÉANT Project. GÉANT participates in the MAGIC and TANDEM projects, which are helping to promote eduGAIN uptake in other world regions.

- Federations: 37
- New members in 2015: GIF from Georgia, LEAF from Moldova; KID from Oman and FEBAS from Belarus (both voting-only members).
- Identity Providers and Service Providers: 2,600 (10 percent increase in 2015, now covering 50 percent of all IdPs)
- Federation as a Service (FaaS): pilot stage with seven NRENs
- Support: provides support for NRENS in building their identity federations

REFEDS – happy 10th birthday

The voice of research and education identity federations worldwide

GÉANT provides secretariat support for REFEDS, the neutral forum where all identity federation operators meet and agree on best practices in the area of federated access.

REFEDS launched two campaigns in 2015:

- to help promote entity categories to IdPs and SPs;
- to provide guidance on how to justify the use of entity categories according to the EU regulations on data protection.

Europe leads eduroam onwards and outwards

Seamless Wi-Fi access for research and education around the world

eduroam has seen huge growth over the last five years, and in 2015 the GÉANT community continued to grow, sometimes by inviting public, commercial and city Wi-Fi initiatives to offer the service. eduroam can be found in airports, city centres and other public spaces throughout Europe, notably Luxembourg, Norway, Sweden, Switzerland, and The Netherlands.
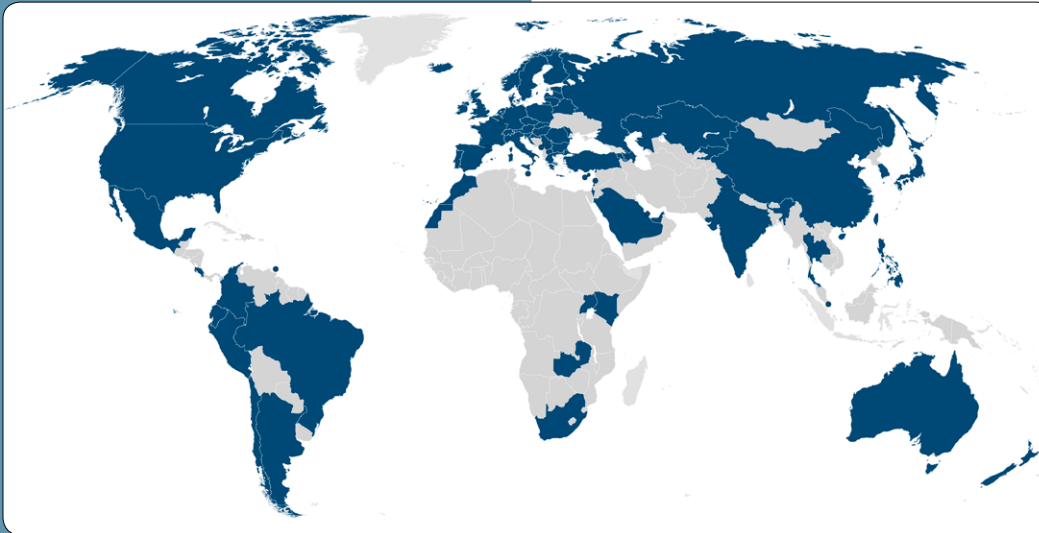
eduroam territories at the end of 2015

- Territories: 76 (up from 69 in 2014) with an additional twenty-one pilot roam operator initiatives underway
- New roaming operators: Trinidad & Tobago, China, Qatar, United Arab Emirates, Uganda and Lebanon
- Authentications: doubled to 180 million per month
- A new NREN: eduroam provided the tipping point for the decision to establish an NREN in Lebanon. Lebanese eduroam members agreed to join forces and develop an NREN to further expand eduroam and other services.

Sweden takes eduroam off campus

The implementation and use of eduroam in Sweden has been a great success. eduroam operates in most Swedish universities and colleges, has more than 100,000 unique devices authenticated per month, and a potential user base of 500,000 individuals in higher education. Now Sweden is moving to new markets.

SUNET (The Swedish research and education network organisation) partnered up with The Cloud to provide eduroam off-campus in places where students hang out through existing access points.

- SUNET first targeted travel hubs, such as airports and railway stations, and today provides eduroam in 934 locations through 16,146 access points all over Sweden: from universities to municipalities and commercial venues, covering city centres, railway stations, airports, ferry terminals, municipal buses and libraries, hotels, fast food restaurants, cafés, gas stations and malls.

- Pär Weilow, Product Owner for mobile solutions at Swedavia Airport Telecom AB, the Swedish airport operator: *"We offered free Wi-Fi connections to all airport visitors from May 2012 and although we gave quite generous amounts of data, customers complained about the data limitations. As soon as we launched eduroam in March 2015 the complaints almost disappeared. Overall, airport visitors are a crowd that expect excellence, and Wi-Fi is an extremely important part of the experience. So, today we are very happy to be able to offer eduroam together with SUNET and The Cloud."*

The Netherlands: eduroam for school visitors

Institutions can offer eduroam to visitors by using the eduroam Visitor Access feature. In the Netherlands, for example, the ROC MN school group started offering eduroam to visitors from February 2015, through reception desks in all school buildings across six towns. Guest accounts are given to individuals, and during events, group accounts are made available.

Frank Pinxt, ICT Manager at ROC MN: "Visitors are very happy with this service, and it works great!"

Links: to check eduroam coverage in specific countries, go to http://eduroam.xx, whereby you replace the xx with the applicable country code, for example http://eduroam.nl and http://eduroam.no.

NREN activity highlight

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

www.geant.org
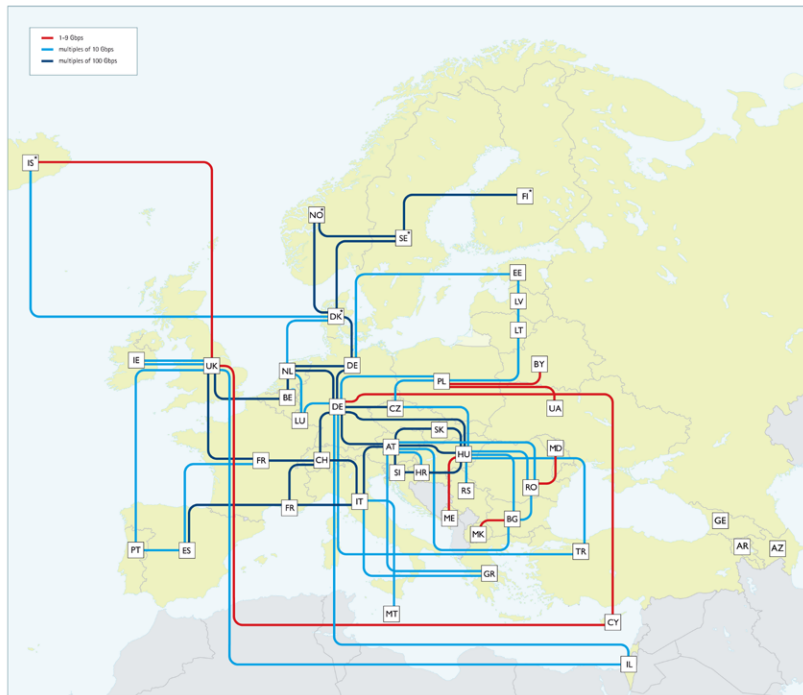
GÉANT's pan-European network is funded by the GÉANT Project (GN4-1). This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 691567. The map shows topology as at October 2015. The GN4-1 partners are listed below.

*Connections between these countries are part of NORDUnet (the Nordic regional network)

This document has been produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of GÉANT and can under no circumstances be regarded as reflecting the position of the European Union.

Europe's essential terabit-ready network

Developing the GÉANT network – the best it can be

The GÉANT network continues to set the standards for speed, service availability, security and reach: 500Gbps super-channels are now on offer to users, with rapid scalability to 2 Tbps and far beyond, but we do not rest on our laurels. Instead, we continuously strive to improve our level of service, implement upgrades to the network and engage in two-way communication with our community experts to obtain feedback and ideas for further improvement.

The GÉANT network, the backbone of the European research and education community, reaches more than 100 countries – an average transfer rate of 180 Gigabits of data per second or 1.9 PB (1,900 Terabytes) per day with a peak activity of 300 Gbps. If we look at a comparison of all routed IP traffic across our network, this is estimated by our traffic statistic experts to have grown from over nearly 117 Petabytes of data in Q1 of 2015 to nearly 156 Petabytes of data in Q4 of 2015, an increase of over 33 percent.

Over the year, the team focused on finding cost efficiencies, staying ahead of user needs, increasing network performance and operational effectiveness, and supporting network innovation for the development of future network enhancements.

- 100 percent availability was delivered for IP, Plus, Lambda, L3 VPN and GÉANT Open services.
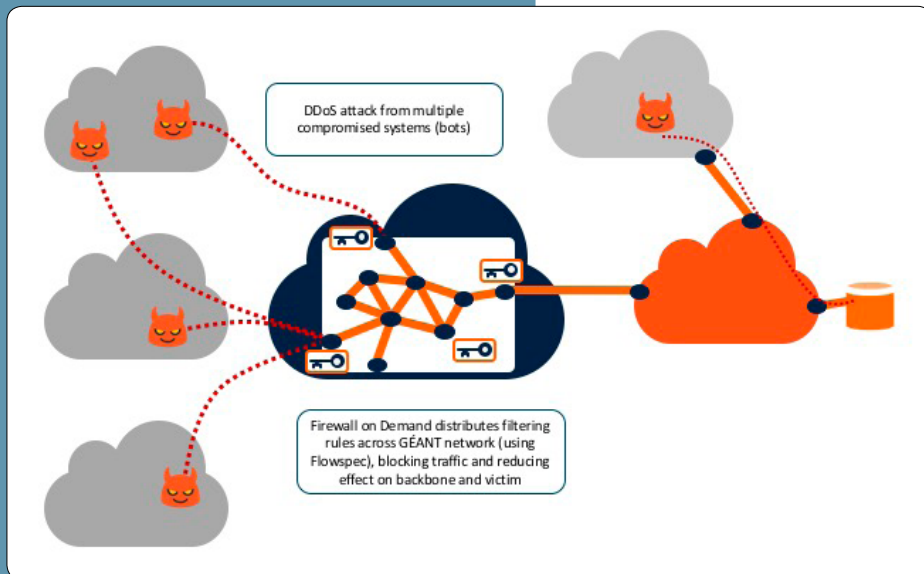- More than 200 engineering changes were made to optimise the network.

- A test and research facility was set up, for evaluating and certifying software and hardware before it gets deployed.
- IP access bandwidth increased by 19 percent: four NRENs upgraded their access connection to 100 Gbps, five NRENs upgraded to 10 Gbps; and five new 100G connections were added to GÉANT Open.
- GÉANT staff coordinated the delivery of 59 network services for NRENs in 2015, establishing services across multiple domains, ensuring services were delivered more efficiently and accurately.
- Terabit line card and alien wave trials supported network innovation for the development of future network enhancements.
- 100 percent uptime was achieved for software development support systems.
- GÉANT Testbeds Service (GTS) completed the first phase in its development, and rolled out to four cities with three more planned and demos were performed at key industry events.

Network service operations

Supporting the GÉANT networks - ensuring reliability, security and integrity

In 2015, the GÉANT Network Operations team consolidated the GÉANT network infrastructure to match the capacity requirements of partner NRENs with provisioning.
- Resilient nodes in London and Marseille were expanded, and connectivity to the Poznań PoP at the Supercomputing and Networking Center was enhanced, using CBF (charge-based flooding).
- We delivered strongly on the ESNet Extention to Europe (EEX) service to ESNet and services delivered to EUMETSAT.
- State-of-the-art network monitoring systems: two reporting portals were created for ESNET and the ANA projects to display availability and traffic utilisation data for their services. These tools keep the community updated on the status of these services.
- Security mitigation through NSHaRP: the NSHaRP process provides a mechanism to quickly and effectively inform affected users and to manage mitigation. During 2015, the NSHaRP security service management was enhanced with the deployment of NetFlowAlerts, plus a new service desk and an OTRS (Open Technology Real Service) ticketing system.

DDoS attack from multiple compromised systems (bots)

Firewall on Demand distributes filtering rules across GÉANT network (using Flowspec), blocking traffic and reducing effect on backbone and victim
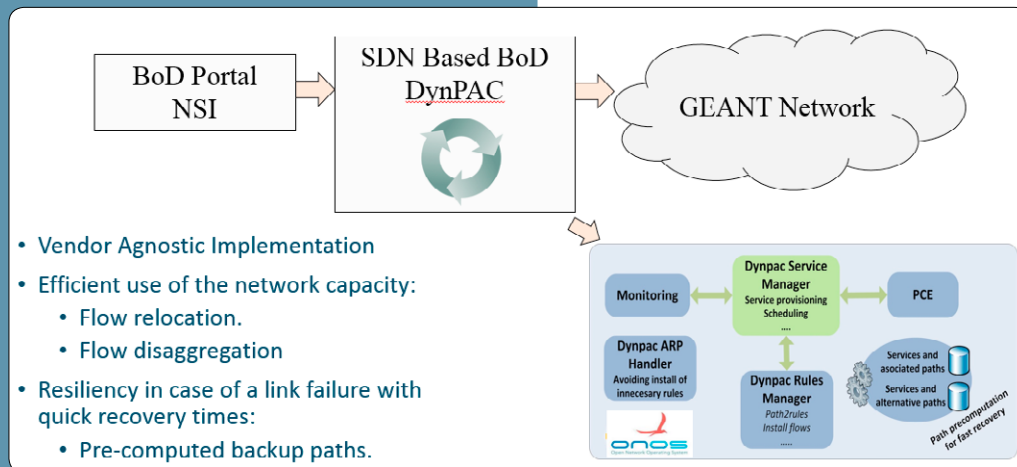
- Firewall on Demand enhanced: threats to the GÉANT network are mitigated in various ways. In 2015, the Firewall on Demand tool was added to the toolkit and was deployed on the GÉANT network. Training was provided on secure coding and security audits were undertaken. Nine NRENs currently use Firewall on Demand as part of their DDoS mitigation strategy.

Staying ahead in technological leadership

The GÉANT network has moved towards separation of the control/management planes and the data plane. This separation is made possible with the use of discrete management systems to manage the Juniper MX IP/MPLS routers and the Infinera DTN-X optical transmission equipment. While this is an important step forward in evolving the GÉANT network architecture, this solution is based inherently on management systems that affect vendor lock-in. To be able to continuously introduce the new features most needed by the research and education community, GÉANT is developing its own Software Defined Networking (SDN) operating environment. This will involve both in-house development and working with existing open-source SDN initiatives to further evolve SDN controllers and develop new services, implemented as applications running on top of these controllers.

To stay on top of the game in the networking area, GÉANT has prepared the network evolution plan for the next three years and initiated two major studies that are currently ongoing: the Layer 1 Infrastructure Study and the Multi-Domain NREN Transit Network Study.

- Vendor Agnostic Implementation
- Efficient use of the network capacity:
  - Flow relocation.
  - Flow disaggregation
- Resiliency in case of a link failure with quick recovery times:
  - Pre-computed backup paths.

The CTO team has been working very closely with different vendors to work on SDN use cases and has built on the work carried out in the GN3plus Open Call DyNPaC (Dynamic Path Computation Framework) to evolve the GÉANT Bandwith on Demand service to a vendor-independent implementation.

Software Defined Network

GÉANT staff led the work on GÉANT backbone-related use cases.

- SDN-IP
- SDN BoD
- Transport SDN

GÉANT has been leading the development of an SDN strategy. Together with Corsa, Infinera and On.Lab, the CTO team have designed a transport SDN approach that will allow GÉANT to manage both layer 2/3 and optical layer equipment using the same controller.

GÉANT - helping develop standards across research and education networking

GÉANT is heavily involved in creating standards and policies that support research and education networking and services. Two good examples of this are the Cloud Service Provider connection policy and the NSI Connection Service standards.

A trial connectivity policy was formulated to facilitate connection of cloud providers to NREN or GÉANT network nodes. The policy defines how Cloud Service Providers can be connected to GÉANT or NRENs. This means that, for the first time, GÉANT has a policy enabling us to connect Service Providers directly, if necessary. The policy directly benefits the Helix Nebula Initiative and its members ESA, EMBL, CERN, by providing them with access to Cloud SPs via GÉANT and NREN networks. This also means that scientists and educators will have easier access to commercial providers' research and education services. The policy ensures that NRENs are not obliged to connect SPs where they are unable to recover costs.

GÉANT continues to work on helping to define NSI Connection Service standards to support the growing need for multi-domain point-to-point services. These services go far beyond the capabilities of commercial service providers and demonstrate how research and education networking organisations can work together to deliver uniquely powerful services to the community.

Cloud Service Strategies

Research and education, in general, is set to benefit substantially from the growth in cloud services. These services offer improved flexibility and cost savings across the community. In order to maximise the benefits of cloud services, GÉANT is leading a range of activities.

- A collective NREN cloud strategy guide was completed with NRENs as trusted advisors, brokers and providers.
- The GÉANT cloud catalogue became available with fourteen services listed.
- Collaboration on clouds with other e-infrastructure projects across Europe is set to expand.
- Progress has been made on developing relationships with major cloud service providers to reduce data ingress and egress charges.
- The Infrastructure as a Service framework tender will offer NRENs and institutions access to cost-effective IaaS services. This major piece of work has seen GÉANT working with NRENs and Service Providers to develop a strong understanding of the needs of all stakeholders.

Open Cloud Mesh project

GÉANT is a strong advocate of federating on-premise sync-and-share solutions in an open, standardised way. In this way, files and folders can be synced and shared between different administrative cloud domains, in the same way that emails can be sent and read with different email systems.

In order to progress in this area, GÉANT launched the Open Cloud Mesh project, in collaboration with ownCloud and CERN, which shared draft specifications. During the Open Cloud Mesh demonstration on 18 November, users were able to sync and share files and folders between independent service domains operated by the University of Münster in Germany, University Vienna in Austria, SWITCH (Switzerland) and AARNet (Australia).

3 • Providing exceptional value for money

By continuously listening to our community and seeking out ways in which we can add value – be it the provision of additional support, refinement of services and their delivery, or gaining savings by harnessing combined demands – GÉANT is in a permanent cycle of improvement to assist our members in adding value for their constituents.

Access to expertise

Across the GÉANT organisation and community, there is proven expertise in winning, running and administering EC projects: procurement, dissemination and user engagement, network engineering, research, and secretariat services for collaborations. Members are able to gain the benefit of this expertise through informal knowledge-sharing or by a more formal arrangement if specific assistance is required.

NREN interests and EC Influence

GÉANT has stayed abreast of EC developments and opportunities, and has coordinated the effort of the NREN community to position our collaboration as nearly as possible at the centre of the deliberations in order to influence developments, with the following results.

- Horizon 2020 2016-17 Work Programme: developing our combined position towards the proposed Research Infrastructures and coordination of NREN intervention at national level across the EU and beyond resulted in amendments being made to the EC Work Programme.
- Horizon 2020 2016-19 Work Programme: EC funding for GÉANT operations and development work continues to be combined in a single project and its flexibility retained, in order to incorporate technology developments in the operational platform.
- e-Infrastructures Concertation initiative: Coordinating GÉANT's involvement in the EC has assured us a place in the editorial group working with the EC to develop service descriptions of consolidated e-infrastructures.

- Intelligence gathering has raised GÉANT's profile within the EC on the European Open Science Cloud and other aspects of the Digital Single Market policies, such as Open Education, Security and Trust & Identity.
- GÉANT continuously monitors developments in EU policy areas, such as data protection and the Connecting Europe Facility.

Collaboration opportunities

GÉANT's NREN members have the opportunity to benefit from and engage with a range of projects according to their resources and interests. Below is a list of GEANT's portfolio of projects in 2015.

Networking projects	Trust & Identity
GÉANT Project - Europe	AARC
EaPConnect - Eastern Partnership countries	REFEDS
EUMEDCONNECT3 – the Mediterranean	**Collaboration**
CAREN2 – Central Asia	MAGIC
AfricaConnect2 - Africa	TANDEM

GÉANT Open Call results exceeded expectations in all areas

The first GÉANT Open Call (2014-15) was a resounding success. It funded twenty-one new project ideas at the cutting edge of innovation, and brought thirty new project partners from industry and academia. Fresh ideas, new expertise and new uses of the network came with them, feeding into the research programmes as an innovation pipeline.

External evaluations confirmed the high quality of innovative research work undertaken, with 70 percent of projects scoring very highly (thirteen or more out of fifteen) and four projects receiving maximum scores.

40→70 30 new partners from Open Call

Open Call Spotlight on: Secure Enterprise Networks Simple and Easy (SENSE)

The SENSE Open Call project sought to improve the usability of eduroam whilst maintaining security through addressing IEEE 802.1X supplicants. The SENSE project provides a benefit for developers and administrators in the network access niche of the IT industry by:

- having created tools to verify operations and performance of EAP supplicants;
- providing metrics to assess security and usability;
- providing guidance and standardisation for the industry regarding network authentication configuration metadata.

Many of its ideas and results are genuinely new and push the envelope in this area of the IT industry. The full work area descriptions and links to the results can be found on the SENSE homepage.
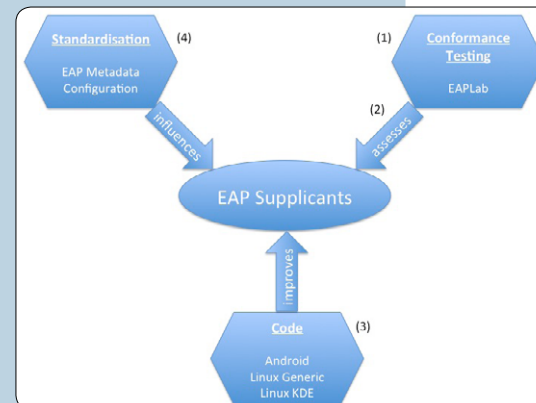
Value-added Services

Trusted Certificate Service

An important, established value-added service offered by GÉANT is TCS, the Trusted Certificate Service. Over the year, twenty-eight NRENs made use of TCS, issuing 31,626 certificates, across a range of eighteen types. The service was re-tendered, taking NREN feedback into account and an enhanced version launched in July 2015, with a new supplier, DigiCert. This simpler, more attractive service offers bundles with certain types of certificate.

ownCloud agreement

Back in 2014, GÉANT secured a good deal for members and their users with the open source-based, on-premises file sync-and-share provider, ownCloud. The total number of licenses purchased grew from 80,000 in 2014 to 100,000 in the six months to June 2015. This brought the unit price down to 1.90 euro per license per year for 2016. The more licenses are purchased under the agreement, the

cheaper the unit price will be according to the scale agreed. In total, over 2014 and 2015, more than 400,000 licenses (250,000 by GWGD) were purchased by sixteen organisations through the GÉANT agreement.

The ownCloud framework is widely used within the community, such as in CERNbox, SURFdrive, CloudStor, GARRbox, SWITCHdrive, AustriaCloud, and many others. At the end of 2015, GÉANT and ownCloud agreed another special discount for new participants joining in December.

Community communications channels

GEANT provides members and the wider community with a number of communications tools through which they can share their news and events.

- **PeaR newsletter:** the community newsletter for and about the community was published weekly. 236 stories were issued, contributed by eighteen European NRENs, one non-European NREN and nine e-infrastructure and research projects.
- **CONNECT:** three issues of the GÉANT community magazine were published. Copies were handed out at key events, sent to members and global partners on request and available online. 90 feature articles were written: twenty-two services-related; three opinion pieces; six user stories; fourteen global-related; twenty-three community-submitted; twenty-two open call/technically related. Online readership added to 2,613 reads and 14,051 impressions for the three issues. Additionally, over 3,000 copies were shipped to NRENs and global partners and distributed at events, such as TNC15, SC15 and ICT2015.
- **EventR:** the GÉANT events planning system, EventR, is for use by the community and a resource for GÉANT staff. Through increased use, we are a step closer to a unified research and education community events calendar. With federated login, EventR is also used as an event management/registration interface.

The CONNECT innovation issue

In 2015, an innovation issue of the GÉANT CONNECT magazine was issued, to share the Open Call research results with the community. Fifteen of the GÉANT Open Calls contributed papers of an academic standard to this issue.

In 2015, 185 events, such as training courses, task force meetings, conferences and seminars were organised by the community. In total, these events hosted 4431 participants of 455 different organisations.

GÉANT Learning

The mission of GÉANT Learning is to support GÉANT excellence through personal growth, discovery and the sharing of knowledge. To realise this objective, courses continue to be developed that range from online to coaching and face-to-face training. These solutions are available for GÉANT employees, various project participants, such as GÉANT Project, AARC and to the wider community.

GÉANT Learning solutions offer a range of knowledge and expertise and can be broadly structured around three key areas:
- leadership and personal effectiveness;
- technical management expertise;
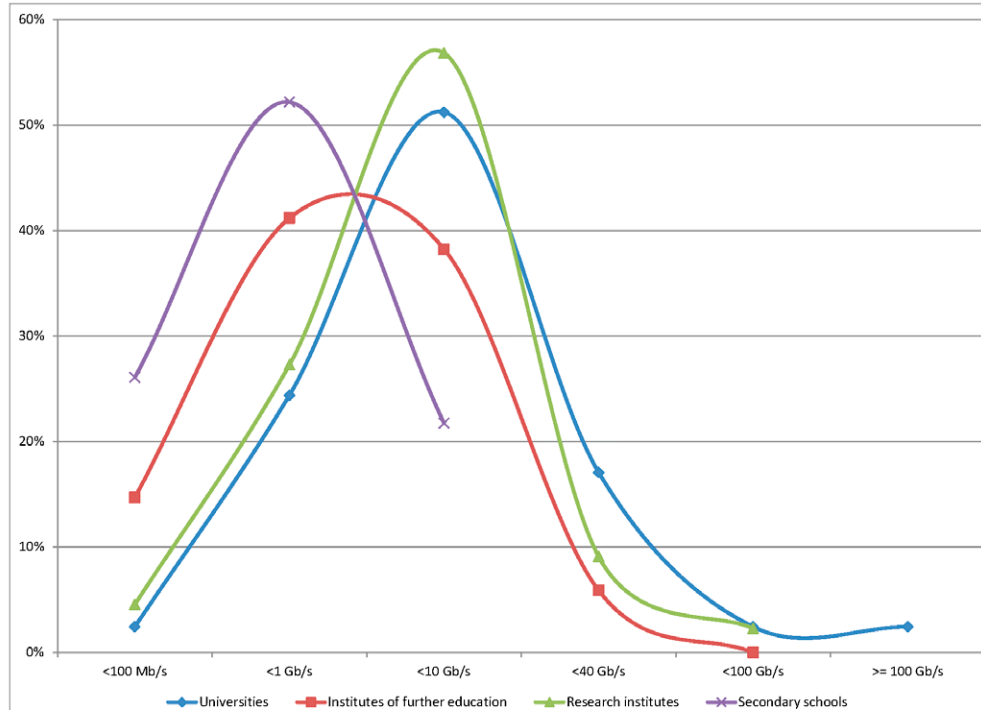- technical training.

For instance, in the course of 2015, the Managing Performance in Virtual Teams course was developed to focus on managing teams that are geographically distributed. MPiViT delivered knowledge, skills and tools for managing performance, meeting facilitation and coaching. It also delivered Adobe Connect through an experience of a virtual learning environment. There were twenty-four participants on the course from ten NRENs.

Equally, GÉANT's flagship cyber security course, called TRANSITS, was held three times during 2015 and trained over 70 participants from various countries and security teams. The course offers basic (TRANSITS I) and advanced tracks (TRANSITS II). A noteworthy feature is that the course has been created through a collaborative effort, which is one of the priorities of GÉANT Learning.

NREN Compendium

The annual NREN Compendium is one of the resources by which GÉANT NRENs share information and benchmark each other. The online Compendium tool documents the work that is being done by NRENs, examining the different contexts in which they operate and explaining important trends in research and education networking that concern them. GÉANT has unique data for Europe and beyond going back to 2001, and thus, it serves as an authoritative reference for policy makers, funders, NRENs and their users.

Jim Buddin

It was with great sadness that we had to say a final goodbye to our friend and colleague, Jim Buddin, who suddenly passed away on 12 September 2015. Jim started at TERENA in 2003 and his work took him from supporting the Enabling Grids For E-SciencE (EGEE) Project to coordinating project conferences and organising workshops, to becoming training coordinator April 2013. Jim played guitar, rode a motorbike, spoke Spanish, and was a stalwart member of Amsterdam's English-language improvisational comedy community. His dedication, humour and personality continue to be missed by us all.

Jump in connectivity

**Modest increase in cloud services**

Top three in-service types are:
- Infrastructure as a Service;
- file storage and backup;
- Software as a Service, collaboration services, video conferencing.

Some NRENs are building their own cloud services, while others offer cloud solutions from commercial vendors and some use both models.

Increased attention to security

Also worth noting
- Growth in services. The top three in the growth of service types are Infrastructure as a Service (IaaS), file storage and backup, and Software as a Service, collaboration services and video conferencing.
- There was almost universal adoption of eduGAIN across GÉANT NREN members.
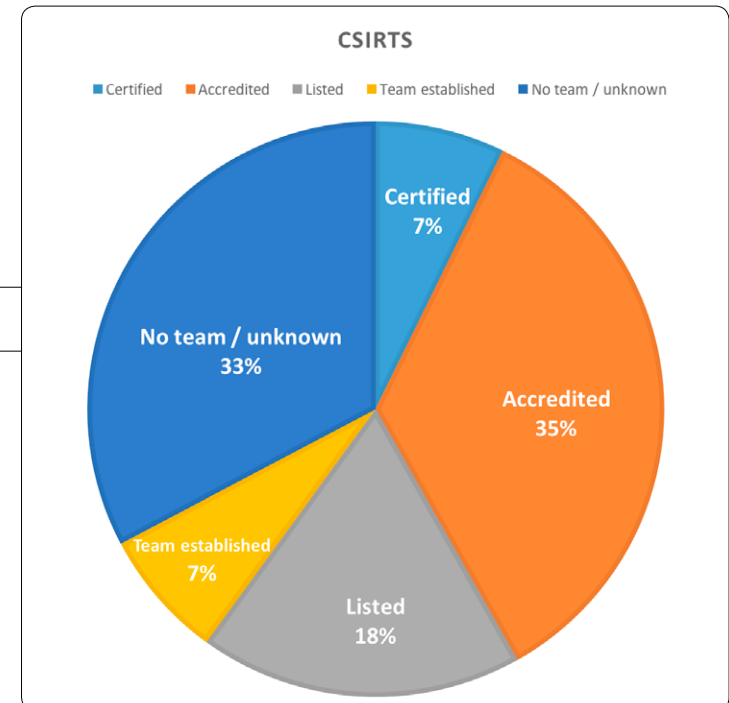
- eduroam continued to grow.
- 56% of the GÉANT partner NRENs are currently active in delivering cloud services and a further 22% are planning to be involved.
- There is growing interest in providing and developing WebRTC solutions.
- Many NRENs provide more than just the underpinning network services.
- There is a move towards hybrid models of provision – from solely internal to mixed internal and external services.
- e-infrastructure developments cause new and different demands on NRENs and their service portfolios.

A National Education Network for

Shared ICT Services

Established in 1983 by Ireland's Universities, with the support of the Higher Education Authority, GÉANT member, HEAnet, provides essential connectivity and ICT services across all levels of the Irish education system. Their 100 Gbit-capable, resilient network connects all Irish Universities, Institutes of Technology, publicly funded third-level colleges and research organisations, in addition to approximately 4,000 schools.

VLE Hosting

HEAnet provides a managed Moodle VLE (an open-source Virtual Learning Environment) service to help clients deal with the increasing cost and complexity of providing a continuously available, highly interactive VLE experience. VLEs are pivotal to the delivery of classes, tutorials and educational content for both teachers and learners, leading to increasing demand for fast content delivery and low latency interaction.

HEAnet deploys distributed storage and server resources to provide a scalable, fault-tolerant and fast platform for this Moodle service, delivered over a very low latency network. The principal benefits for clients are the ability to scale their service without worrying about infrastructure, and the capability to take advantage of optimisations and economies pertaining to a multi-client operating environment.

The managed service allows clients to dedicate more time to the development of online teaching and learning tools, and less time on managing the technical aspects of it. This enables clients to better concentrate on the development of educational content and the core business of delivering education. HEAnet manages the technical components, thus ensuring that the service is optimised to meet the needs of the client.

NREN activity
highlight

HEAnet connectivity and shared services
Graphic: HEAnet

Media Hosting

HEAnet has been hosting videos for lecturers and students for many years. The service delivers simplicity for users, with all popular media formats (and live streaming) supported. The service provides a simple (federated) user interface to all, and allows users to upload unlimited-length content, which they can share within their institution, or the wider world. The service leverages the functionality of FileSender to make sure very large files can be accommodated.

In 2015, HEAnet integrated the service with the VLE Moodle to make it even easier for lecturers to use, and staff are currently working to add support for a Blackboard plugin. The service has quickly become the go-to place to keep all video content for educators, with self-developed multimedia content, such as video lectures and tutorials becoming quite popular.

Similarly, students find the service an excellent repository for all their video content, and quickly learn to use it as a multimedia portfolio manager, and to make podcasts for projects. Video production experts have also adopted the service for its straight forward adaptive transcoding capabilities, and the bridge it provides from video files to a fully featured online streaming service, while retaining all licencing rights for the content owners.

Schools

HEAnet first extended its network connectivity services to Ireland's schools in 2005. Under this programme, HEAnet provided all of Ireland's primary and post-primary schools (approx. 4,000 schools) with high-availability Internet and network security services. Schools are provided with a portfolio of services, including network monitoring, IP management, a managed router, security and filtered Internet access, in addition to web hosting and blog services.

In 2009, HEAnet was appointed to manage a new high-speed network, providing 100 Mbit/s to Ireland's 750 post-primary schools. Following a successful pilot, this programme was extended to all post-primary schools nationwide by the end of 2014.

Connecting schools to the HEAnet network builds on the investment made in higher education and up to 59,000 teachers and 884,000 students use the schools network on a daily basis, enabling students to learn and collaborate online.

The provision of high-speed broadband to Ireland's post-primary schools affords a greater opportunity for schools to embed technology in the teaching and learning process. This opens the door to a faster, richer, more interactive and more informative Internet experience than was possible before, and the streaming of videos, plays, movies, animation, documentaries, concerts can now be seamlessly incorporated into the teaching day.

The services featured above illustrate that HEAnet has extended its role beyond that of a network provider, to that of an NREN that provides a diverse portfolio of shared services to its client base.

Today, HEAnet is a valued provider of ICT shared services, offering a wide range of services across all levels of the Irish education system, and serving client needs in a trusted, collaborative and cost-effective manner.

4 • Building the community

GÉANT's raison d'être is to act for and with our members to further research and education through our networking and services. A fundamental goal is to provide collaboration and (human) networking opportunities, which support and develop European NRENs in their quest to be the ICT cornerstone of their national communities.

Fostering community collaboration

Supporting collaboration across the research and education networking community and working with the community is a core attribute of GÉANT's mission.

Task forces

Getting the community together and fostering collaboration happens in many ways. GÉANT facilitates task forces and special interest groups in the areas of web real-time communications (TF-WebRTC), data storage infrastructures, applications and services (TF-Storage), information security management (SIG-ISM), computer incident response (TF-CSIRT), mobility and network middleware (TF-MNM), marketing communications (TF-CPR), management of service portfolios (TF-MSP), and network operations centres (SIG-NOC). The groups are open to anyone who can contribute with appropriate expertise and manpower. In 2015, more than 600 participants joined these task force and special interest group meetings.

International initiatives

Global CEO Forum

GÉANT has played a role in the Global CEO Forum, contributing in areas, such as security, knowledge sharing,

At the end of November, a new 'greenhouse' Special Interest Group (SIG) was launched to support open-source software development and to keep it sustainable within the NREN community. SIG-Greenhouse can offer advice and guidance on licensing, legal agreements and good practice for code management. The group also helps to provide a framework for managing donations to open-source software projects. The group attracted initial funding from NLnet and will continue to grow within the community.

global network architecture and mobility. The group consists of executive leaders from a range of leading national and regional research and education networks from around the world. The CEO Forum's objective is to stimulate and accelerate global implementation and adoption of new network solutions and services to create additional value for the global research and education community. In 2015, the Global CEO Forum was instrumental in expanding eduGAIN into a global service.

The Case for NRENs web portal

During 2015, in response to demand from regional networks, GÉANT coordinated the development of a web portal with resources to help NRENs and RRENs argue the case for research and education networking with key stakeholders. Global experiences, best practices and a toolkit with guidance material are shared from the site. This initiative complements an activity of TF-MSP, focusing on arguments in support of NRENs in Europe.

In The Field Stories blog

An inspiring and exciting collaborative effort that came to fruition in 2015 is the In The Field Stories blog. Kick-started by AARNet with support from TF-CPR and the Global PR Network, the blog was jointly developed and edited by GÉANT and NORDUnet team members. This community blog published more than fifty stories by the end of the year.

Forty organisations (NRENs and RRENs) across six continents provided articles covering a diverse range of topics: supporting India's Department of Atomic Energy, genomics research paving the way for personalised cancer treatment, how weather and climate research affects our daily life and more. It is a great blog for all who want to see how research and education networking has a real, positive impact around the world.

Workshops

DDoS workshop

In response to community requests, GÉANT offered a workshop on DDoS (Distributed Denial of Service) mitigation, hosted by ACOnet in Vienna. More than 50 representatives of twenty-four organisations from around the world discussed a wide range of issues concerning DDoS and how to manage security. Follow-up meetings with providers were undertaken immediately following the workshop.
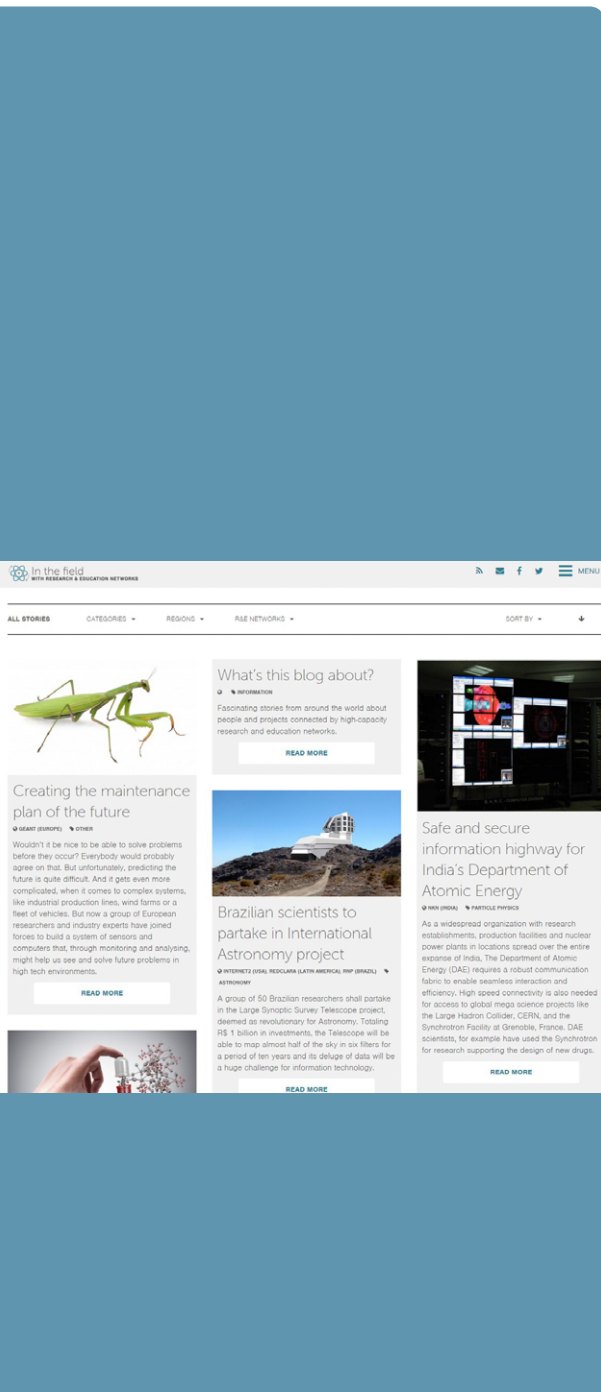
WISE: Joining organisations in information security

GÉANT is pivotal in bringing together other e-infrastructure organisations on topics of high relevance to the research and education community. In October 2015, WISE (Wise Information Security for collaborating e-Infrastructures) was born. The goal is to build a global trust community in which security experts share information and work together, creating collaboration among different e-infrastructures.

The first three-day 'WISE' event was held in Barcelona on 20-22 October 2015, hosted by the Barcelona Supercomputing Centre. It was organised through the joint effort of the GÉANT group SIG-ISM (Special Interest Group on Information Security Management) and of SCI, the 'Security for Collaboration among Infrastructures' group of staff from several large-scale distributed computing infrastructures.

Attendants of the 'WISE' event, held in Barcelona on 20-22 October 2015

The workshop brought together four big e-infrastructures - EGI, EUDAT, GÉANT and PRACE - as well as national research and education network (NREN) organisations, user communities such as HEP/CERN and the Human Brain Project, and other initiatives such as XSEDE, NCSA, and CTSC, in order to facilitate the exchange of experience and knowledge on information security management and other topics of relevance.

Earth Sciences workshop and handbook

Creating an improved mutual understanding between GÉANT and the e-infrastructures on the one hand, and the earth science sector on the other hand was one of the spearheads for the GÉANT Business Development team in 2015. In January 2015, the team, together with other e-infrastructures, held its first user-focused workshop with European earth science community researchers. In total, eight user communities, research infrastructures and data providers attended, including EGI, EUDAT and PRACE. The earth sciences researchers were able to engage with all e-infrastructures and left

with a much better understanding of the services offered. Users were able to discuss their needs and problems with GÉANT and the e-infrastructures directly, leading to a better understanding of their requirements.

GÉANT also produced an updated version of a dedicated Earth science user handbook for GEO (Group on Earth Observations) and was appointed to lead a new Network Architecture Work Package in the GEO Work Programme. All this raises awareness and visibility of research and education networking and ensures that GÉANT and NREN architectures are central to the earth observation community. This work complements and builds on initiatives with Copernicus, ESA and EUMETSAT.

Event participation

Participation at events is an integral part of the communications and outreach programme. 60 staff represented GÉANT at more than 35 external events, with a large booth at ICT 2015 and SC15.

GÉANT at ICT 2015: featuring MD-Paedigree and CARDIOPROOF

ICT 2015 ran from 20-22 October in Lisbon, and showcased the best-in-class results of existing European ICT research and innovation - advanced products from individual companies that started, have grown and benefited from European funding. GÉANT exhibited in the EC Village under the title 'Open Science', featuring two health user projects as guests (MD-Paedigree and CARDIOPROOF), and received senior EC officials, Augusto Burgueño Arjona and Carlos Moedas, at the booth.

GÉANT at SC15: featuring InfiniCortex

GÉANT also participates in bringing together research communities by efficiently aggregating globally distributed HPC (High Performance Computing) resources:
InfiniCortex is a world-wide initiative that placed GÉANT in a central role in a cutting-edge network demonstration. This highlighted that GÉANT can provide much more than business-as-usual networking and cemented relationships with organisations in Asia and Europe. It provided an excellent showcase at the important SC15 exhibition in the US.

Together with RENATER, PSNC, TEIN and the GÉANT Network Operations team, the Business Development team carried out a successful test of deploying cutting-edge HPC fabric technology over the GÉANT backbone and the inter-continental links to Asia at various exhibitions during 2015. This culminated in a complete, around-the-world topology, showcased at SC15 in Austin, which was held between 16 and 19 November. The test demonstrated the ability of research and education networks to deploy the most advanced technology, and it nurtured collaboration with the TEIN community.

Pierre Bruyère, Chairman of GÉANT Board of Directors, and Gerhard Schumann-Hitzler, Director at the EC's Directorate-General for Neighbourhood and Enlargement Negotiations signing the EaPConnect contract on 11 June 2015

International relations

Looking beyond the GÉANT organisation, a wide variety of liaisons, relations and collaborations exist on a global scale. Successful examples of projects in the international arena are the Eastern Partnership Connect project, AfricaConnect, MAGIC, TANDEM, ORIENTplus. The United Nations Technology bank and Dengue fever workshops also contributed to our relationships with the global research and education community.

Eastern Partnership Connect

EaPConnect will enable GÉANT to reach out to a new region and pool of talents, integrating highly specialised countries in areas such as physics and earth sciences into the European research community. In doing so, EaPConnect also fulfils the EU wish to bring the Eastern Partnership closer to Europe by building a bridge of knowledge between the two regions.

Project title	Eastern Partnership Connect
Topic	Interconnecting the research and education communities across Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine and with their European counterparts
Start	1 July 2015
End	30 June 2020
Programme	Funded by DG NEAR and co-founded by the EaPConnect NREN partners

Project title	AfricaConnect2
Topic	Development of high-capacity Internet networks across the entire African continent and connecting them to the European GÉANT network.
Start	1 May 2015
End	31 December 2018
Programme	Co-funded by DG-CONNECT and the regional partners

AfricaConnect2

AfricaConnect2 was signed by the EC in December. It is a pan-African project, carried out through three regional clusters and in collaboration with ASREN (North Africa), the UbuntuNet Alliance (South and East Africa) and WACREN (West and Central Africa). The project will last three and a half years and has a total contract value of €26.6 million. It will allow GÉANT to build out its African reach, further increasing the opportunity for the European science community to engage and collaborate with their African counterparts.

MAGIC

GÉANT became a partner in the TANDEM and MAGIC projects, and the International Relations team was instrumental in the decision that MAGIC should extend to as many world regions as possible, and in supporting the discussions with prospective global partners.

MAGIC, led by RedCLARA, builds on the successes of the ELCIRA project and aims to improve the ability of researchers and academics around the world to collaborate. MAGIC will expand the global reach of eduroam and identity infrastructures through its partners, which include Latin America, the Caribbean, Europe (including GÉANT), West and Central Africa, Eastern and Southern Africa, North Africa and the Middle East, Central Asia and Asia-Pacific.

It will also establish middleware to enable NRENs to share services and real-time applications for international and inter-continental research groups via a common marketplace, and provide support to global user groups. MAGIC also continues to develop the Colaboratorio platform, which makes collaboration tools available to end users (e.g., web conferencing, file transfer, wiki, and community management).

MAGIC kick-off meeting at RENATER offices, Paris, France; 11-12 June 2015

| Project title	Middleware for collaborative Applications and Global vIrtual Communities
Topic	A cooperation project, which aims to significantly improve the ability of researchers and academics around the world to collaborate together
Start	1 May 2015
End	30 April 2017
Programme	H2020

TANDEM

The TANDEM project supports dialogue between the European and African research and education networks, with special attention to Western and Central Africa. The scope is to promote cooperation by exploiting the interconnection between GÉANT and the established African regional networks. This project aims to prepare WACREN in the deployment of e-infrastructures, answering end users' needs and taking into account policy, financial, regulatory and technical constraints. The project works in very close collaboration with AfricaConnect2.

Project title	TransAfrican Network Development
Topic	e-infrastructure policy development and international cooperation
Start	1 May 2015
End	30 April 2017
Programme	H2020
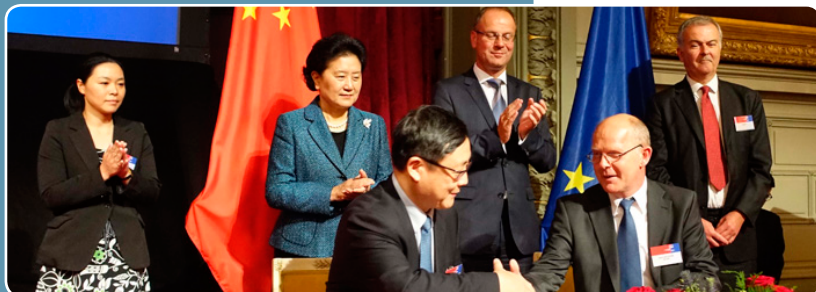
Signing of CERNET/GÉANT MoU on 15 September 2015 in Brussels. The MoU with CERNET shows the commitment to genome projects, LHC collaborations, and radio astronomy

ORIENTplus

A new 10Gbps link between Beijing and London provides direct, high capacity EU-China connectivity and is jointly funded and managed by GÉANT and CERNET for a ten year period. This follows on from the ORIENTplus project, which ended in December 2014.

United Nations Technology Bank

GÉANT's work in the development of NRENs through the EC's DEVCO projects has been recognised at top level of the UN. Cathrin Stöver and Dorte Olesen worked with the UN High Level Panel towards the creation of a Technology Bank for the 48 Least Developed Countries. The HLP submitted the study, proving the feasibility of the Technology Bank, to UN Secretary General Ban Ki Moon in October 2015. In this document, the UN promotes NRENs in emerging countries as vehicles to deliver science and innovation for development.

Handover of the Report of the High Level Panel of Experts on Technology Bank and Science to United Nations Secretary-General Ban Ki-Moon

Dengue fever workshops

GÉANT was instrumental in developing innovative workshops in Japan and Malaysia, bringing together clinical practitioners, medical researchers and NREN ICT experts to help understand and tackle Dengue Fever in the Asia-Pacific region. The adoption of this successful approach has been adopted in other world regions, notably the Caribbean and Africa, and the initiative has helped extend these workshops to addressing other infectious diseases.

Dengue Fever Workshop at APAN40 in Fukuoka, Japan in March 2015

TNC15 – bringing the community together

TNC is the annual GÉANT community event, to which all NRENs from worldwide partner organisations come together to share the latest results and developments, nurture relationships, and discuss opportunities to collaborate.

In 2015, TNC was hosted in Porto by FCT|FCCN, Portugal's unit for the operation of the National Research and Education Network within the funding agency for science and research. The event was attended by 667 participants from a record 59 countries. They were treated to six technology demonstrations, a choice of 137 presentations across 36 sessions, and seven BoFs.

- The TNC15 programme committee of fifteen people from across European and international NRENs and other organisations created a TNC Fellowship grant to support emerging NRENs' attendance at TNC (see photo).
- A panel session shone the spotlight on women in ICT to highlight the importance of gender equality, and an impromptu BoF was held, in which NREN-WiT (Women in Technology) was founded.

More than 70 percent of participants of the conference who responded to the evaluation questionnaire rated it very highly. The most popular sessions were those on AAI, storage and clouds, and strategy and regulations.

SURFnet, NORDUnet, SWITCH and FCT|FCCN kindly contributed funding to invite representatives from geographic regions across the world. Each region nominated attendees who could benefit from the GÉANT community support. From left to right: Carlos Guzman (CEDIA), Almaz Bakenov (National Information Technology Center Kyrgyzstan), Gyöngyi Horváth (GÉANT), Cathrin Stöver (GÉANT), Hean Samboeun (CamREN), Reiner Campillo (RADEI), Douglas Kunda (ZAMREN)

GÉANT activity highlight

5 • Running an efficient, cost-effective organisation

GÉANT

GEANT's aim is to get the most out of every contribution that our members, funders and partners put in. This attitude, to work in an as efficient manner as possible and to ensure that money is well spent, is reflected in many ways, not least in our continuous improvement programme.

Continuous improvement programme

Three major projects took place within the organisation to pursue efficiencies and cost savings, without compromising service quality:
- network-related systems and enhancements;
- corporate systems, process integration and streamlining;
- sharing with partners.

Network-related systems and enhancements

Over the year, network optimisation achieved per annum cost-efficiencies of 400,000 euros, with a further 580,000 saved through re-procurement of routes. Plans were already being actioned that are set to deliver network savings in GN4 of 2.1 million euros per year. Other cost-saving measures were the replacement of the Network Monitoring System (NMS) and the alien wave trial.

Replacement of the NMS

The purpose of the NMS is to identify, diagnose and fix any network-related issues. The new system that was introduced in 2015 is more accurate in identifying the root cause of an incident.
- The average repair time is improved since engineers can be more efficient in restoring the service.
- The community benefits from greater levels of service availability.
- The new data warehouse and reporting infrastructure allows automatic and ad hoc reports to be generated and published to the community.

- This keeps the community better informed and allows the organisation to review the business intelligence to assist in capacity planning and subscription upgrades.

-Hamburg alien wave trial – Sharing infrastructure costs

GEANT users' data is carried on the GÉANT backbone over 500Gbps super channels. These channels are made possible with the use of Infinera's integrated photonic circuit technology. In 2012, GÉANT rolled out our Europe-wide dark fibre footprint, lit using the Infinera DTN-X equipment. We are now focusing on achieving the best possible value from this investment. In 2015 GÉANT worked with SURFnet to carry out a field trial carrying an alien wave 500G super channel over SURFnet fibre. This trial was successful and showed that super channels can be carried over alien waves with no reduction in performance on the shared spectrum.
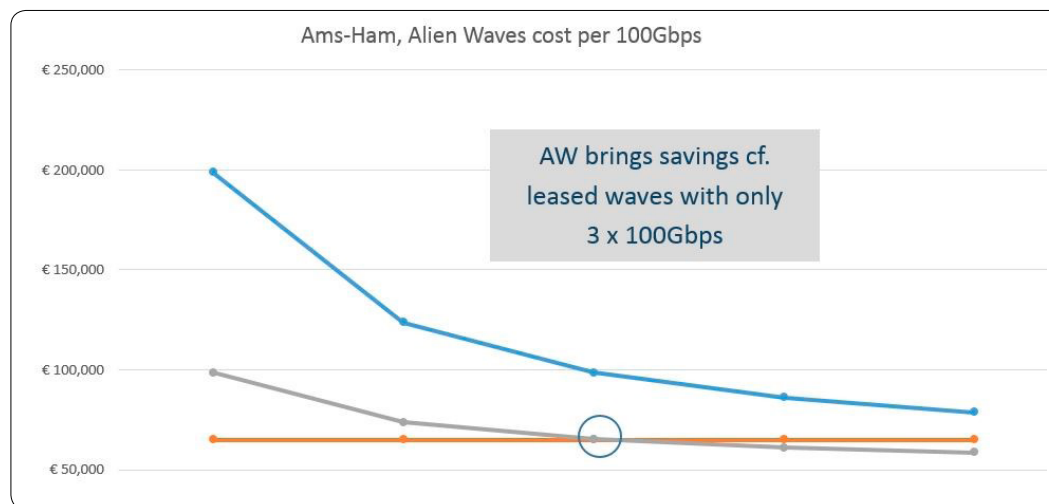

The figure at the right shows a break-even level of 3 x100G services. Once service exceed this point, the spectrum-sharing solution (grey line) is cheaper than even the most competitive commercial solution available on the market (brown line) and is much cheaper than the GÉANT-owned fibre (blue line).

Ams-Ham, Alien Waves cost per 100Gbps

AW brings savings cf. leased waves with only 3 x 100Gbps

Over-the-network for IP trunks

In the past, IP trunks in the east of Europe were built as shown in Figure 0.1, where the IP trunks follow the fibre and daisy chain the routers. This architecture was simple, but did not deliver the most efficient use of router interfaces. The availability of the PXM (a 200G Ethernet switch "on a blade" in the Infinera DTN-X) card means that it is now possible to rapidly right-size the IP trunks between 100G interfaces.

Figure 0.2 shows the planned IP trunks to be built on the eastern ring using the PXM card. By building the trunks to follow the traffic demand rather than the fibre, the cost of router interfaces is reduced. Because the solution uses a 100 Gbps interface between the local router and the DTN-X (Infinera DWDM equipment), the IP trunks can be rapidly re-configured to respond to changing demands.
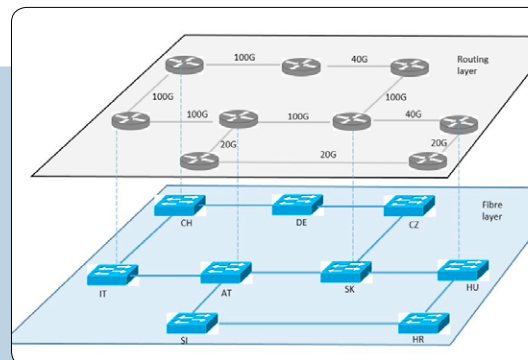

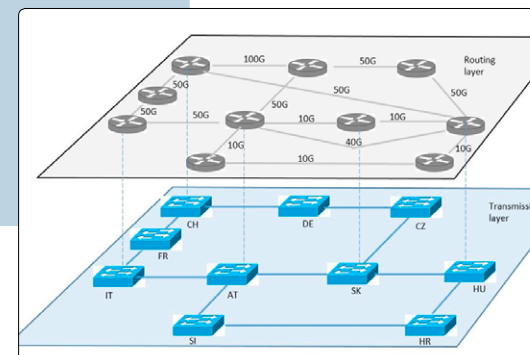*Figure 0.1: GÉANT IP trunks in the east of Europe*

Figure 0.2: Implementation of IP trunks using PXM

Corporate systems, process integration and streamlining

Efficient governance

The first efficiency brought in by the restructuring of TERENA and DANTE Ltd. is our consolidated and unified governance structure, which unifies what was formerly embraced by the NREN-PC, the TERENA General Assembly, the DANTE shareholders, and the GN3plus Assembly, each one with its respective Executive Board. At the same time, the GÉANT governance has streamlined its structure of committees and clarified the authority of the management. On a day-to-day basis in 2015, staff throughout the organisation conducted a number of integration projects to provide incremental savings across the board.

One GÉANT web presence

In November 2015 the new GÉANT website was rolled out, replacing the interim GÉANT Association

website and separate sites for DANTE, TERENA and the GÉANT Project. The new responsive website combines all the elements of the two companies into one site . As GÉANT develops its portfolio of services and activities, this site will be the core resource for all its activities, and act as a gateway to direct site visitors to other web-based and online resources.

Single point of contact

GÉANT streamlined the interaction with NRENs, providing them with a single point of contact for information and service requests, helping to maintain very high satisfaction levels with the Partner Relations Service.

GÉANT Central Authorisation Management System

The GÉANT Central Authorisation Management System (CAMS) provides an elegant solution to manage access rights for the 530 GÉANT Project participants. In the past, GÉANT Project participants had to remember different sets of credentials to access those services. Thanks to federated identity, participants can now login to most of these services using the credentials issued by their home organisation. This addresses the authentication issues very well but narrates only half of the story; the term, 'identity management', is incomplete without proper authorisation management.

The GÉANT CAMS addresses authorisation management by centralising authorisation data, but at the same time, decentralises the access management for these data. This approach not only allows GÉANT services to focus on the core functionality while leaving access rights management to the system, but at the same time reduces overhead on the central IT.
   Project participants and other community members benefit from the system; once registered with the system through invitation/self-enrolment, they can access GÉANT services, such as the Project Intranet, SYMPA, and the Wiki seamlessly.

To further enhance cost-effectiveness, GÉANT CAMS integrates nicely with SharePoint 2013. The system demonstrates one of very few implementations available worldwide for SharePoint 2013, Active Directory Federation Service and Grouper integration. Once all GÉANT services are integrated with GÉANT CAMS, we will be able to provide an excellent user login experience for all GÉANT services. The integration work is still in progress.

Other achievements in the area of raising efficiency included:

- the implementation of an Enterprise Service Bus (ESB) tools, which allow corporate systems to exchange information;
- the implementation of a data warehouse and report architecture to facilitate the acquisition of business intelligence;
- the initiating of storage and DNS replacement projects.

Sharing with partners

Advanced North Atlantic consortium

GÉANT engaged with the Advanced North Atlantic (ANA) consortium members in order to be able to participate and assist in establishing shared operational and financial processes. The resulting ANA partnership was established as one of the pathfinder exercises for the Global Network Architecture (GNA) initiated by the Global NREN CEO Forum. The ANA partnership models organisational, business and technological collaboration for a more integrated global network architecture for research and education.

Copernicus – achieving cost reductions and supporting NREN services

As part of the Copernicus project, the GÉANT Business Development team, together with DFN, achieved an agreement in June 2015 with ESA to connect their data centre in Germany, which hosts Sentinel data to GÉANT via DFN. Contracts were exchanged in October 2015 and the connection became operational in early 2016.

Prior to this, Copernicus traffic was being carried via commercial networks, making it more challenging for NRENs and users to access, and the agreement to distribute via GÉANT took significant lobbying effort.

Benefits
- For the first time, research and education users worldwide are able to access the Copernicus data via GÉANT and NRENs, resulting in high performance access at low cost.
- GÉANT NRENs no longer have to pay for commodity traffic in order to receive the Copernicus data that their users require.

- The agreement has brought new business to DFN, who received a financial contribution from ESA for connectivity.

Multi-domain monitoring

The converged perfSONAR multi-domain monitoring service has brought wider deployment (over 1400 end points by the end of the year) and has reduced operating costs for each partner, whilst CMon – the MultiDomain Circuit Monitoring System – has moved from design to pilot phase, with deployments in four NRENs.

Financial statements

	2015	2014 (restated)
	€000	€000
Fixed assets		
Tangible fixed assets	6,165	7,684
Current assets		
Cash at bank and in hand	42,949	33,843
Debtors	8,405	9,373
	51,354	43,216
Total assets	57,519	50,900
Group equity		
General reserve	7,338	7,047
Secretary General reserve	301	301
Future subscription reserve	13,750	10,900
	21,389	18,248
Provisions	1,004	1,105
Short-term liabilities	35,126	31,547
Total equity and liabilities	57,519	50,900

	2015	Budget 2015	2014 (restated)
	€000	€000	€000
Income			
GÉANT project	32,698	32,203	31,631
DevCo projects	4,312	4,920	6,323
Membership fees	1,141	1,148	1,121
Other income	1,565	1,453	1,221
GÉANT World Service	971	657	753
Interest received	35	50	40
	40,722	40,431	41,089
Project expenditure	25,154	30,767	28,172
Gross operating result	15,568	9,664	12,917
Other expenditure			
Personnel costs	9,043	8,481	7,905
Other administrative costs	2,762	2,583	2,690
Restructuring costs	387	572	439
Depreciation	187	208	243
Financial expenses	(112)	33	(192)
Total other expenditure	12,267	11,877	11,085
Non-operating income	-	-	301
Taxation	160	-	973
Result before appropriation	3,141	(2,213)	1,160
Transfer to specific reserve			
Secretary General reserve	-	-	(301)
Future subscription reserve	(2,850)	2,200	(2,450)
Result	291	(13)	(1,591)

The financial results of the GÉANT Association are prepared a consolidated basis and include the results of its subsidiary, GEANT Limited, a private limited company incorporated in the United Kingdom.

2015 was the first full year of operations under the Group's restructured governance that commenced in October 2014 after the Association acquired a majority shareholding in GEANT Limited. The Association currently owns 95.31% (2014: 93.43%) of the shares in GEANT Limited.

Total income in 2015 amounted to €40,722k (2014: €41,089k) and is in line with budget projections (€40,431k). Project expenditure amounted to €25,154k (2014: €28,172k) and is lower than budget projections (€30,767k) due to a compliance change in the depreciation policy adopted by the Association's UK subsidiary and other underlying network cost reductions.

Other expenditure amounted to €12,267k (2014: €11,085k) representing a 2% adverse variance against budget (€11,877k) primarily as a result of exchange rate factors caused by underlying GB pound payroll and rental costs as a result of the Group's operations in the United Kingdom.

Against a deficit budget of €2,213k, and as a result of decrease in project expenditures, the year 2015 ended with a net surplus before appropriation of €3,141k (2014: €1,160k), resulting in a transfer of €2,850k to the future subscription reserve to be used for investments in future years.