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Welcome
cathrin stöver, chief collaboration officer, géant

with over 20 years of experience working in global telecommunication and the roll-out of network infrastructures across various continents, cathrin is a highly effective global team leader, successfully working across borders and cultures in complex multi-dimensional projects.

a member of the géant team since 1997, cathrin has held various positions as the organisation has grown and developed, always with a specific focus on growing the geographic reach of the géant network and the deepening of the global r&e collaboration for the benefit of the global research and education community. she holds a degree in european business from the fh osnabrück in germany.

a warm welcome to the géant compendium of national education networks in europe which highlights data collected during the 2016 nren compendium survey.

i invite you to read on for insight into the developments in research and education networks across europe. for the last 17 years, the compendium has delivered valued commentary on the evolution of these networks and the organisations driving them.

you will read many references to the collaborative effort from the national research and education network (nren) community – indeed, without this effort, the compendium would not exist. nren representatives input their information directly into the database that holds the source data of the compendium, and write this commentary. the compendium team relies solely on the content and accuracy of the survey entries.

this year we have added some critical background information to help the reader understand the context and subtleties of the r&e sector. we have also pulled out a few country-specific case studies on selected topics to delve behind the survey data, and added a feature on the géant network.

as noted in previous years, we encourage the reach of the compendium beyond europe and to that end, invite all nrens to complete the survey. through my work on projects like africaconnect2, i personally get to witness the diversity of the global community. to see this reflected in the compendium would offer great insight. the development of the resource into a global tool will take time, but you will find comments and information from those outside the géant sphere who share their valuable experiences with us.

we are proud to be able to collate and promote this material for the use and benefit of the nren community. by harnessing this understanding of the past and current nren landscape, the compendium offers an informed look at ways to further support the research and education sector.

all the data from the survey is available at https://compendium.geant.org so please do consult it at your leisure.

enjoy!

cathrin stöver
A Guide to the GÉANT Compendium of NRENs

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ABOUT THE COMPENDIUM

The GÉANT Compendium of National Research and Education Networks in Europe (The Compendium) is the result of a broad, collective effort to portray the networks of the research and education community in Europe and beyond.

National research and education network (NREN) organisations run special internet networks dedicated to supporting the needs of the scientific and academic community within a country. In Europe, NRENs are interconnected by the pan-European GÉANT network, the largest and most advanced R&E network in the world, connecting over 50 million users.

The Compendium is a living picture of what we, the NRENs, do every day to meet our users’ requirements and help them in their research, teaching and learning activities. The annual NREN Compendium survey invites the world’s NRENs to provide detailed information about their network, equipment and users. The results from this survey are highlighted here. This year, in addition to the Compendium survey, we have also spoken with a number of NRENs and people who define the community by their participation to provide some background information in order to better understand the market/context of the NRENs’ environments. Their comments are presented here as case studies and quotes.

The diversity and complexity of the NREN community can make comparison challenging, but it is the Compendium’s ambition to help provide an insight into this thriving community.

This Compendium is a community-led document, created by the NREN community, for the NREN community, as a means to understand the status of the collective as a whole, as well as of each NREN. It is a dataset that provides a base upon which NRENs can inform and build their strategy decisions.

The Compendium shows what NRENs are doing to meet users’ requirements and help them in their research, teaching and learning activities. Unlike many other studies, it is not just a collection of desk research put together by a small editorial team. It reflects the people who carry out this work, from the executive directors, to technical officers, to service portfolio strategists and many more professionals. Almost 500 people participated in the joint effort of this edition by providing facts and figures to populate the rich and colourful picture it presents. Subject matter experts reflected on all of the responses within a given area and summarised the main data points in this document.

Reports compiled from NREN data may also be generated from the online version of the Compendium (COMPENDIUM).

A massive thank you to the NRENs that took the time to complete the survey and provide their views.

NOTES FOR THE READER

When reading the data, keep in mind that NRENs are a large and diverse family. Each national organisation reflects the specific environment in which it grew, with country-specific peculiarities such as the political situation, the history of the organisation and its relations with user groups, funding agencies, and the status of research and education in that country all woven into its fabric. Another important aspect is the difference between the leading communities that formed the first NRENs – each NREN was set up in a form that suited a country’s needs and background. In articulating these peculiarities, we wish to show that although all of the survey respondents were NRENs, they are far from being a homogeneous community. It is important to recall this when comparing results.

It is also important to understand the variations in NREN infrastructure and the reasons why an NREN is or is not connecting a specific institution. Infrastructure choice has an impact on all aspects of NREN operations, including the reach of the network, connection possibilities, and selection of equipment/technology. The development and support of this infrastructure is often determined by the vision, resource and funding levels in a given country – and this differs between national authorities. As well as infrastructure limitations, why an NREN is or is not connecting a specific institution is also dependent upon an acceptable use policy, which varies by NREN; some can connect schools, while others’ mandates may extend to private R&D firms.

An example infrastructure difference is outlined here: some NRENs have a hierarchical architecture that includes a national backbone, which interconnects a number of separately managed regional networks, which, in turn, connect end users. Such an NREN will have an indirect view of the organisations connected to its network. By comparison, there are networks without regional branches, which connect institutions directly and have a more direct view of an NREN’s connected institutions.

Such diversity, although puzzling at times, is an inherent characteristic that we strive to preserve, because the current shape in which NRENs have grown comes from their unique environments, which have fostered their scientific, educational and cultural communities.
About GÉANT

In Europe, NRENs are interconnected in the pan-European GÉANT network, which, funded by the GN4-2 project with its 40 partners, is the largest and most advanced R&E network in the world, connecting over 50 million users.

GÉANT is a fundamental element of Europe’s e-infrastructure provider landscape, delivering the pan-European GÉANT network for scientific excellence, research, education and innovation. Through its integrated catalogue of connectivity, collaboration and identity services, GÉANT, together with its national research and education network (NREN) partners, provides users with highly reliable, unconstrained access to communication, computing, analysis, storage, applications and other resources, whenever and wherever needed. Through the network’s connections to similar infrastructures, both in Europe and across all continents, the GÉANT partnership ensures that Europe remains at the forefront of research.

GÉANT’s world-class, high-speed backbone provides seamless and secure connectivity with 42 NRENs, reaching over 50 million users in 10,000 institutions across Europe, and more than 100 countries worldwide through links with other regions. The core backbone is capable of multiple 100 Gbps over each fibre link, and Terabit connectivity can be achieved by a single node.

Connecting Over 50 Million Users

Safe and rapid connection of users to each other, to the increasing amounts of data generated by science and to the high-performance computing capacity required by collaborative research forms the foundation of the GÉANT partnership.

The focus of the GN4 Phase 2 (GN4-2) project is to raise European research to the next level, promoting scientific excellence, access and re-use of research data. It also aims to drive European-wide cost efficiencies in scientific infrastructure through the promotion of interoperability on an unprecedented scale with other e-infrastructures.

It should also be emphasized that while the GÉANT network provides mainly pan-European coverage, the project and its members currently also fund GÉANT’s international connectivity to the R&E networking partners in North America (Internet2, ESnet and CANARIE) as well as in China and Latin America. Other world regions are also connected to GÉANT, thanks to support received over the past 15 years from DG DEVC0. Through these projects, and with the support of the GÉANT community, the GÉANT network today connects to 68 NRENs beyond its European footprint.

The projects include: AfricaConnect2, supporting pan-African connectivity and interconnections to Europe; TERN, which interconnects the Asia-Pacific region and South Asia; EAPConnet, for the Eastern Partnership countries; as well as CAREN, in Central Asia, and EUMIDCONNECT3, in the eastern Mediterranean region.

The overall objective for the GÉANT partnership is to contribute to the effective European Research Area by making Europe the best-connected region in the world. GÉANT must offer European researchers the network, communications facilities and application access that ensure the digital continuum around their peers around the world.

The GÉANT network interconnects 165 networks and has: 31 active routers; 19 Infinera nodes; 286 10 G and 50 100 G active interfaces; 2 SONET interfaces and 20 1 G interfaces facing other networks. This section presents a specific snapshot of the GÉANT network, including statistics such as IP/MPLS traffic growth. For further information about national networks and capacities, see Section 5.

The GÉANT network is divided into two parts: the Infinera dense wavelength division multiplexing (DWDM) network and the Juniper-based internet protocol/multiprotocol label switching (IP/MPLS) network. The Infinera DWDM runs on dark fibre, providing 10 G and 100 G lambdas either for use as links on the IP/MPLS network or to be sold as lambda services. The IP/MPLS network provides all other services of GÉANT. Of the two, there is more extensive traffic information for the IP/MPLS network.

The highest traffic peak ever recorded on the IP/MPLS network was on 24 November 2016, when 526 Gbps was received at around 10:00 GMT. The highest aggregate average inbound traffic on the IP/MPLS network, 359.38 Gbps for the entire day, was tracked on 26 October 2016. Such traffic was even greater than peak levels the previous year. The year-on-year (YoY) growth rates on the IP/MPLS network are significant, with an overall growth rate of 64%. Internet service has grown by 32% and science traffic growth by circa 74%. If this continues, 10 Tbps interfaces will be needed in ten years as there will be 6 Gbps peaks on main network trunks.

The most utilised link in the IP/MPLS network is Frankfurt–Geneva 100 Gbps, soon to be 200 Gbps, with a 2016 average of more than 17 Gbps in each direction and the highest peak on any backbone link at 74 Gbps.

Overall Growth Rate of 64% on IP/MPLS Network

In terms of daily averages for 2016, the IP/MPLS network received 2.35 PB of data to deliver, this is 2.35 million gigabytes, or an average daily rate of 217.6 Gbps. The total, including lambda services, is 3.9 PB, or an average daily rate of 361 Gbps.
Defining Topics

A number of common threads were identified from interviews conducted with European NRENs.

Above-the-net services, such as AAI and cloud, are increasingly important for most of the respondent NRENs, and the need for NRENs to move up the services stack to deliver value means connectivity has become commoditised. The profile and importance of non-network services continues to grow among the user communities. If the NRENs do not add to their service propositions, they will not be of interest to users. NRENs will have to adapt their services and portfolios if they want to remain relevant. There is funding uncertainty and resource limitations, and increasingly global competition for research funding and the most-talented students.

Economic competition and funding constraints result in governments’ demand for higher ROI and bigger impact on near-term economic growth. There is also scrutiny over the value added by an NREN. NRENs need to be self-funded, sustainable, and coordination/integration with other e-infrastructures is required. Additionally, NRENs are decreasing their costs by aggregating demand for common services and achieving economies of scale.

National organisations are coming under increased funding pressure and are at risk of having to change or outsource parts of their portfolio, which places service deployment at risk. This is especially dangerous when these are services where the market is not meeting the needs of research for security and privacy of data. A significant difference can be made to improve NREN security and AAI through GÉANT services and partnership activities.

In contrast, policy makers are looking to NRENs to help boost economic competitiveness through NREN participation in public-private partnerships (PPP), technology parks, start-up incubators, etc. Security and AAI are important, however, it seems that NRENs have a clear idea of ways in which they can improve security. There is demand for privacy/safety (content and personal data protection) and a secure user/network environment. There are many ideas and approaches for fighting cybercrime going forward, and it is abundantly clear that the fight can only be won if everyone involved works together across national boundaries. This is yet another area in which NRENs fully intend to build on their established strengths. Although NRENs are well-versed in technical know-how, now is the time to prove once and for all the business and user-demand aspects for delivering secure services.

In three years’ time, the future NREN service portfolios will be providing End-to-End resilient services, offering access to sovereign and/or public cloud and providing virtual network services across multiple networks.

Patrick Donath – RENATER

Campuses are now run as a business which means that University CIOs are much more likely than previously to have a market-oriented approach, creating services as a commodity. CIOs compare offerings in the market and expect NREN services and network to add value.

Lars Fischer – NORDUnet

I see the profile and importance of non-network services continuing to grow among the user communities, but at the same time national organisations are coming under increased funding pressure and are at risk of having to change or outsource parts of their portfolio, which places these growing services at risk. This is especially dangerous as these are services where the market is not meeting the needs of research for secure and private trust and are therefore where we can make a real difference. I think we will have to collaborate and share information more to support each other, and perhaps even coordinate as GÉANT to support national gaps.

Ann Harding – SWITCH

The focus is moving away from the provision of capacity and towards the defining services, such as multimedia which can make us attractive for the R&E community. If we do not add to our service proposition, we will not be of interest to our users.

Artur Binczewski – PSNC

Most user organisations are continuously looking for better value for money for access bandwidth. Above the net, there is interest in improving seamless federated identity access to diverse service providers, as well as phasing out legacy web technologies for video/web conferencing (no-Flash solutions). There is growing interest in more integrated collaboration platforms beyond sync&share.

In the next three years, we expect a growing demand for lower location dependence on performance availability of user-facing services, allowing more mobile and distributed collaboration workflows. This implies growing demand for more mobile and cloud-based services catering to R&E needs.

Increased network performance and flexibility across domains will also be required to deliver the next generation of more-mobile services to research and education. Wireless mobile communications services will likely play a greater role in the service portfolio also. Increasing availability of custom R&E applications built on top of commodity commercial cloud services, resold or brokered by NRENs, are also expected.

Jakob Tendel – DFN
In recent years, the role of NRENs has become more than just a connectivity and commodity provider. Constant changes in national networks and take-up of new technologies are needed to support dynamic and growing user needs. The essential development factor for NRENs is therefore, not only the ability to satisfy the current requirements of their user communities, but also to expand their service portfolios beyond traditional data communications to offer services above the net, if necessary.

NRENs have been adding new services to their service portfolios. These new fields of activity need dedicated effort and expanded skill sets, for example: legal expertise, standards development compliance, regulatory requirements, and new forms of procurement, such as those for cloud service provision, as well as tracking and integrating the network and its everyday operation with new technologies.

Outreach to end users is essential for NRENs, not only to connect research communities and offer network support, but also to provide a feedback mechanism that can inform future service development in a way that accurately reflects the end users’ needs.

The annual NREN Compendium survey looks at the NRENs as organisations by observing annual budget and funding; staffing; participation in projects and e-infrastructures; connected institutions; and user interaction. It also looks at what has changed in NRENs’ organisational form, service policies and portfolios.

Within this section, a distinction has been made between the NRENs as entities and the users they serve.

A number of key points can be derived from the survey responses:

- Although the total budgets of the majority of NRENs are increasing, overall, a small decrease is noticeable compared to 2015 data.
- With changing technologies, networks and services, there has been an expansion of staff functions from “hands-on” network engineers to software developers, information security officers, product managers, marketing and business development, as well as legal and procurement specialists.
- Half of the respondents have changed their NREN’s service portfolio: either adding or planning to add new services for cloud, authentication and authorisation infrastructure (AAI), multimedia and network.
- National conferences are organised by 70% of all the respondents and all the NRENs’ networks organise face-to-face user training.

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NRENs have a number of different funding models. Many obtain funding directly from national government and public sources, whereas others rely on their user institutions. The Compendium survey reports on income from the following areas: commercial services (such as domain registration fees, security), GÉANT subsidy, connected client institutions, government and public bodies, other European Union funding, or other sources, as shown in Table 4.1.

The data presented in this Compendium reflects the staff engaged in the NREN activities in full-time equivalents (FTE), both for permanent and subcontracted staff, and the staff engaged in the functional areas. The majority of NRENs work with directly employed staff members.

The 2016 NREN Compendium survey data on the functional areas of personnel has shown greater variance than the previous surveys. As shown in Figure 4.2, in addition to the traditional profiles, such as network operations centre (NOC), financial and administration, user support and training, the

### Table 4.1: Income sources per NREN

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### Figure 4.2: Weighting of staff FTE by function

The 2016 data also includes staff from general management, information security, communications, marketing and business development, product and project management, procurement and brokerage, IT and software development, legal and policy, as well as research staff. In previous Compendium results, these profiles were included in a general category of “other staff” or added as specialists for new areas.

### CHANGES IN ORGANISATIONS’ FORM, POLICY OR SERVICE PORTFOLIOS

The 2016 NREN Compendium survey maps new strategies and environmental policies, but also looks into the changes of legal status, network access and services portfolio:

- Out of 35 respondent NRENs, 4 reported changes in their legal status.
- Corporate strategy was updated by 9 out of 29 respondent NRENs.

According to the data from the survey, 10 NRENs now have an environmental policy in place.

Almost half the respondents reported that they have already made, or are planning to make changes to their service portfolio. The majority have added new services. Only one NREN has decommissioned a service (its national learning object repository) and another is planning to drop its commodity services, platform as a service (PaaS) and mailboxes.

Services have also altered, including:

- Cloud services were added by 7 of the respondent NRENs. Services included ownCloud, FileSender, storage, compute, e-administration services.
- AAI services were added by three NRENs.
- Network services including eduGAIN, Firewall on Demand, DDoS protection were added by 7.
- Multimedia services were added by only one respondent (video management system for education).
- Changes in network access have occurred in 10 of the respondent NREN countries.
**GÉANT's Work with Other e-Infrastructures**

Annabel Grant, Senior Business Development Officer (GÉANT) co-ordinated GÉANT’s first Open Call Programme supporting innovative Research and Development into ground-breaking new networking technologies and applications for the R&I networking community – bringing a number of SMEs into the GÉANT project as partners. Annabel joined GÉANT in 2012, and leads Partner, User and Stakeholder Relations as well as e-infrastructure engagement for the GN4-2 project. Annabel has worked on European projects since 2005. Prior to GÉANT she managed a portfolio of government and EC-funded R&D programmes, business support/finance programmes and innovation initiatives focused on early stage technology start-ups, SMEs, and commercialisation of University research.

E-infrastructure empowers scientific communities with ubiquitous, trusted and seamless access to facilities, resources and collaboration tools, delivering the power of technology for communication, computation, storage, access and instrumentation. In recent years, Europe has invested significantly in the development of these e-infrastructures that support scientific research and the commercialisation of resulting services. In parallel to the thematic investments under the European Strategic Framework for Research Infrastructure (ESFRI), e-infrastructures such as GÉANT, PRACE, EGI, EUDAT and OpenAIRE have gained the trust of the wider research community.

The main e-infrastructure providers, including those mentioned above, are working together on a number of initiatives to support wider take-up of e-infrastructures by a broader set of stakeholders, focusing on improving service accessibility, interoperability, and clarity with a view to establishing an “e-infrastructure commons”. This requires closer interaction among the existing major e-infrastructures, as well as special-purpose e-infrastructures and VREs. From the 2010 “Riding the Wave” report [RIDING], reflecting the EC’s Digital Agenda strategy, up to the emerging European Open Science Cloud (EOSC) stated in the INFRADEV-04-2016 initiative [INFRADEV-04-2016] there has been a pivotal point change in the EC’s Digital Single Market strategy for research. The vision is seamless access, use, re-use, and trust of all scientific resources (network, computing, and data).

Current initiatives in which GÉANT is involved, working, in partnership with other e-infrastructures, towards the e-infrastructure commons include:

- **Service-focused collaboration:**
  - AAI INFRADEV-04-2016 – European Open Science Cloud for Research: This initiative will have a strong collaborative approach, with opportunities for interaction between the e-infrastructures, including best practice development regarding the generation, handling and sharing of significant amounts of data using cloud services [INFRADEV-04-2016].
  - e-InfraCentral: The aim of this European e-infrastructure services gateway is to present a harmonised set of services towards new and future users and enables e-infrastructures to become more accessible to a wider group of potential users including industry, government, educators and citizens [e-InfraCentral].
  - AAI-focused collaboration: AARC aims to develop and pilot an integrated cross-discipline authentication and authorisation framework enabling different e-infrastructures and research collaborations to implement interoperable authentication and authorisation infrastructures (AAs) [AARC].

- **Security-focused collaboration:**
  - WISE is a global trust community where security experts share information and work together, creating collaboration among different e-infrastructures. WISE provides a framework of standards, guidelines, and practices to promote the protection of critical infrastructure [WISE].

The drive towards a more interoperable set of e-infrastructures has started, and GÉANT is playing a central role in implementing the vision of an e-infrastructure commons to ensure all users can seamlessly access, use, re-use and trust e-infrastructure resources and services across network, computing and data.
END USERS

The NREN user landscape (the "end users" of the GEANT network, such as universities, research institutes, etc.) has broadened considerably in recent years. Many NRENs now go beyond their traditional remit of providing connectivity to researchers and university students by also offering networking, trust and identity (T&I), mobility, security and cloud services to schools, public institutions and commercial organisations. The reasons for this development are many, and can include: better utilisation of the bought infrastructure, increased return on investment of developed services, expansion of value-added services and facilitation of public–private partnerships between publicly funded and commercial research facilities.

To assess this trend and add actual numbers to the discussion, the questions in this section of the NREN Compendium survey were extensively revised and updated in 2016.

As in previous years, in order to allow a consistent categorisation across different national education systems, the classification in this section follows the ISCED 2011 classification system (the UNESCO scheme for International Standard Classification of Education) [ISCED 2011].

This section provides an overview of the NRENs’ formal remit, including: which users and organisations are able to connect, current market shares of the institutions connected to each NREN, the bandwidth provided to connected institutions on a national level and the approved purposes for which commercial organisations can connect to each NREN.

Responses from 39 of 41 GEANT Association Member NRENs have been collected in this section of the Compendium.

WHO IS CONNECTED? APPROXIMATE MARKET SHARES, CONNECTED INSTITUTIONS AND USERS

For-profit organisations with R&E project links have also been included in this year’s Compendium. Note that Compendium respondents submitted only indicative percentages, as shown in Table 4.2.

It should also be noted that research institutions and national nodes of international research organisations are often located on a university campus or are part of a university department and are therefore, indirectly connected through the university. This may have an impact on the market shares, as some institutions may not have been individually accounted for.

Table 4.2 shows the estimated market shares per institution type, per NREN. The overall market share distribution in 2016 is comparable to the 2015 Compendium results. In comparison to the overview presented in NREN Organisations, in most cases, the market shares reflect the formal remit of the NRENs.

WHO CAN CONNECT? NRENS’ ACCEPTABLE USE POLICY

NRENs have different funding structures, organisational set-up and business models that define their scope and service offerings. The formal remit of NRENS (in terms of which institutions they are eligible to connect) is defined in their acceptable user policy (AUP) and is a key element in assessing an NREN’s user base, and identifying possible areas for development.

An overview of acceptable use for each country, including a link to the AUP, can be found online [AUP].

All NRENs connect universities and research institutions. Nearly all are permitted to connect institutes of further education, libraries and museums.

Providing connectivity to government institutions is also in the remit of a large majority of the NRENS (although a significantly smaller number actually do so at present – as discussed later in Connectivity to and for Commercial Organisations). More than half of the NRENS allow connectivity to other, not-for-profit institutions, highlighting their role as connectivity provider covering the entire R&E and public administration spectrum. Connectivity to for-profit companies, is, for most NRENS, not part of their remit and if it does occur, often entails restrictions, such as being limited to a specific research project or only with the endorsement of an already connected research institute.

WHO CAN CONNECT? NRENS’ ACCEPTABLE USE POLICY

The organisations with the largest market share, with full or nearly full coverage across most NRENS, are universities and research institutes. A market share of less than 100% in this area may result from private universities, which, as commercial organisations, fall outside of some NRENS’ remit.

The 2016 NREN Compendium survey data shows an upward trend of connected schools, with a number of countries connecting more than 80% of primary schools in their country – nearly double that reported last year. NRENs are not yet the standard connectivity provider for cultural institutions, hospitals and government institutions. This is reflected in the partial coverage in those countries where data has been provided.

Table 4.2: Approximate market shares (%)

This section details the market share for each institution type per country.
Overall, the typical connectivity to universities is widespread, ranging from 1 Mbps up to 100 G. Half of all responding GÉANT Association countries indicate 1 G as typical capacity for connected universities and research institutions. Both of these institution types are the best connected, with the largest share of typical connectivity of 10 G.

Figure 4.5 and Figure 4.6 show the typical and the highest capacity of connected institutions to GÉANT Association countries.

So far, a standard offering of 100 G only applies to single institutions in Sweden (universities and further education) and Hungary (international research organisation). This is followed by Denmark, with a standard bandwidth connectivity of 20 G for Danish universities.

The direct comparison between the typical and the highest capacity also indicates that the highest capacity in most cases, is the logical next-capacity step from the standard bandwidth (1 G – 10 G; 10 G – 20 G).

TYPICAL AND HIGHEST CAPACITY OF CONNECTED INSTITUTIONS

It is not common for NRENs to connect commercial organisations to their networks. However, there has been increased interest from NRENs to connect to other organisations, such as the R&D division of a commercial entity. As mentioned in Who Can Connect, most AUPs do not allow such connections.

Over the last year, this increased interest of commercials to connect to GÉANT has already been observed for the purposes of joint research projects or as service providers of online applications and cloud services. Such requests to connect typically range in the area of 1 to 10 G.

On a national level, commercial organisations are becoming more relevant to NRENs. Some NRENs actively seek to expand their user base, and view the services and collaboration potential of these other organisations as a means to do so. Such public–private partnerships may also create favourable conditions for the increased take-up of cloud services.

“IT will be important for NRENs to diversify our income streams to provide for our longer-term sustainability. If we have a relationship with the commercial world, which has its own income, we have a new opportunity, and one which does not come with the same political restrictions.” PSNC

Some NRENs see this expansion as a clear opportunity to secure long-term sustainability, others stress the need for a clear positioning of the NREN.

“An NREN is unlikely to prosper if it attempts to become just another supplier or system integrator in the marketplace”. Jisc

CONNECTIVITY TO AND FOR COMMERCIAL ORGANISATIONS

AMRES expanding the scope and range of services

AMRES has signed a contract to expand internet services to schools. This will change the number of connected organisations from currently only 300 institutes to over 2000. This will significantly raise the profile of AMRES. The new service is primarily Internet but also content filtering, including virus scanning.

Those “Above the net” services take AMRES beyond pure IP. In this project, AMRES is project manager for a VPN service rather than building out its existing network.

Pavle Vuletic – AMRES

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Pavle Vuletic – AMRES
Exploring new sectors in the UK

Bob Day, Executive Director (Janet), CTO (Jisc) has oversight of the Janet network, ensuring that it remains fit for purpose and relevant to those that use it to conduct their business and to provide services over it. This includes meeting the very diverse present and future needs of the education, research and other communities who rely upon Janet every day of the year. One important aspect of Bob’s work is maintaining and developing the relationships with government and other bodies so that the role of Janet in serving the UK’s economic interests is properly understood; and so that Janet can provide the most effective set of services to all Janet’s customers. As chief technology officer for Jisc technologies, Bob maintains oversight of the wider range of technologies and infrastructure deployed to provide infrastructure services.

1. Please briefly outline Jisc’s approach to diversifying its user base?

Jisc is broadly involved in three types of diversification. The first supports collaboration between the R&E community in the UK and those sectors with which this community collaborates, for example by providing interconnectivity between Janet and health networks.

The second is the export of technologies and services developed here is partly to maximise return on the investment made in these services, but we also look for some financial return on that future running costs. An example is the creation of a government roaming service, based on eduroam.

The third is relatively new, and involves packaging and reselling services on the open market (with the appropriate measures to avoid unlawful state aid). The intention here is to derive additional revenue that can be used to reduce the future cost of services to Jisc’s core R&E community.

2. What do you consider to be the top three challenges for NRENs when looking at a non-traditional customer base?

We see the main challenges as financial. These customers (public or private sector) are often adverse to longer-term financial budgets decline?

in this way. Service wrap is another consideration. An NREN’s existingservice portfolio is tuned for delivery to universities and colleges, and its staff have a good understanding of how they will deploy services. This understanding needs to be built up for these newer customers as well.

Finally, and perhaps most challenging, is the cost of sales. This has been relatively low for sales into universities and colleges, where an NREN is often seen as an in-house supplier (although this is changing). The cost of sales can be much larger outside this community. There are also compliance requirements for services to be provided that do not exist for supply to universities and colleges (this too is beginning to change). Additionally, in the public sector, the need for the customer to use public procurement regulations significantly adds to the cost and timescale of any sale.

3. What employee skill sets become important within the R&E community when non-traditional markets are explored? Do these reside within the community at present?

Needed skills include marketing and sales, bid management (and pricing), pre- and post-sales technical support, compliance to regulatory and other requirements, and a product development capability that is agile enough to be aligned to new customer needs. The technical, compliance and product development aspects can probably be found within the NREN with appropriate training and development. The other skills will probably need to be brought into the NREN, as they often do not exist.

4. Where do you see NRENs needing to invest as budgets decline?

In their people (see above). And in the services and supporting infrastructure that provide what their core research and education communities need but cannot find elsewhere. Although diversification is important, it is this core community that will ensure the medium to long-term sustainability of the NREN. An NREN is unlikely to prosper if it attempts to become just another supplier or system integrator in the marketplace. It needs to invest in further strengthening the strong trust relationship it has within its core community, supplementing this with operational services of a quality, capacity and reliability that universities and colleges will pay for as they are critical to the fulfilment of their missions.

5. What value-add does the NREN community have to offer commercial organisations?

The main value added by the NREN community is twofold. First, access to innovative services (such as eduroam and trust and identity services) that can be translated into new domains where no solution exists at present. Commercial organisations may benefit as customers of these services, but are possibly more likely to find a role as suppliers, perhaps in partnership with the NREN.

Second, access to expertise and knowledge, either within the NREN or the R&E community it supports. There is a chronic and probably widening digital and data skills gap in most, if not all, countries, and the NREN can be part of reducing this. The NREN’s infrastructure, such as its high-speed network is unlikely to be of more than niche interest until such time as that upskilling takes place.

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Vincenzo Capone, Senior Technical Business Development Officer (GÉANT), is in charge of the user support for network solutions of pan-European and international scientific groups and collaborations and in the Science and Research engagement activities, with a background in computer science and networking. Previous positions included the Department of Physics of the University of Naples, where Vincenzo was the Network Architect and manager in charge of the computing resources for physics experiments, and Technical Associate to the ATLAS experiment collaboration at CERN.

From the long-standing relationships with the more engaged user communities (e.g. high energy and particle physics, radioastronomy, etc.), to the initial needs-gathering encounters with the newcomers (those that are just entering the world of high-speed networks and distributed computing), GÉANT’s support provides a single point of contact for all international user communities to give seamless access to the global R&E network infrastructure.

In addition to the dedicated account management for the most demanding users such as CERN, the Square Kilometre Array (SKA), BELLE II and the ITER, GÉANT fosters a novel approach to involve the “long tail” of science into the world of e-infrastructures. This includes promoting a strategy for science and research engagement in collaboration with partner NRENs and user communities.

GÉANT will always strive for the “voice of users” to be heard. We rely on feedback, such as that collected when compiling the Compendium, to inform the plans and developments of the next-generation network infrastructure, as we build a network environment that is even more able to respond to our current and future users’ needs.
Guy Roberts, Senior Network Architect, (GÉANT), is responsible for the introduction of new technology into the transport layers of the GÉANT network. Guy is Co-Chair of the Network Service Interface working group in the Open Grid Forum. Guy received his BEng degree from RMIT University in Australia and his PhD in photonics from the University of Cambridge.

Network

Network is a vast, generic term that could cover many aspects of infrastructure and communications technology in varying levels of detail. Within this section, network is defined as a snapshot of the services, infrastructure and monitoring tools that NRENs use to connect their users.

NREN networks, like the countries they reside in, are unique and tailored to fit the community they serve, within the limits of the resources at their disposal. This section presents an overview of NREN network traffic, infrastructure and services. It also looks at respondents’ views of the future, including the move towards a software-led approach offered by software defined networking (SDN).

Network Traffic

Much of the data on national networks collected via the annual NREN Compendium survey does not lend itself to being shown clearly in this static format of a printed publication, as it covers so many countries. However, the complete dataset is available on the Compendium website (COMPRENDIUM), and includes information about external IP capacity links and traffic flows. The following graphs give an indication of the levels and types of traffic that European NRENs deal with, including traffic on the GÉANT network, which transits traffic from one national network to another.

In this section, the data for the Compendium is augmented with data from GÉANT’s Deepfield application. This software platform is used to collect data about traffic on the GÉANT network via various live feeds from the GÉANT network equipment. The main sources of data include: domain name system (DNS), border gateway protocol (BGP) and, most importantly, NetFlow data from GÉANT routers. GÉANT has been using Deepfield for several years as a network planning tool. It provides a better understanding of traffic patterns, traffic growth and sources, and types of data on the network.

This graph highlights the wide variation in traffic from GÉANT partner NRENs. The gap between the smallest and the largest research network in Europe is vast, with the largest NREN having 2000 times as much traffic as the smallest. Some traffic emanating from these NRENs will also include the direct peerings between them, so Figure 5.1 does not represent the full picture of NREN traffic.

Figure 5.1 shows the average traffic into the GÉANT network from the NRENs. This is captured in Gbps, and includes data from both R&E and commodity IP. As expected, the five largest Western European countries (UK, Germany, France, Italy and Spain) are the largest sources of GÉANT traffic. CERN is also notable as one of GÉANT’s largest sources of data.

Figure 5.1: NREN traffic greater than 1 G into GÉANT (one-week average, February 2017) (Source: GÉANT Deepfield)
NETWORK INFRASTRUCTURE: DARK FIBRE

NREN networks are all built differently, as each has its own unique design based on local requirements and funding models. Some NRENS have a large install base of dark fibre with long-term indefeasible rights of use (IRUs), while others have no dark fibre. “Dark fibre” originally referred to any infrastructure that was not in use or the potential capacity of a network. Now the term usually means any optical fibre network built using fibre leased or purchased from another supplier (as opposed to bandwidth or leased line capacity purchased from a third-party provider).

There are compelling reasons for an NREN to acquire dark fibre, including: rapid roll-out of new services by holding spares and installing transponders based on demand projections, the ability to automate service restoration, integration into the NREN’s own network operations systems, and potential new functionality developed for community requirements.

Figure 5.2 shows the number of kilometres of fibre each NREN has reported in its own network.

As shown in Figure 5.3, a notable example of the acquisition of international fibre is PIONIER, which now reports 2450km of such fibre. The other notable fibre owner is EENet, with around 1500km of international dark fibre. This is a relatively new trend in the NREN community, and can be seen to demonstrate NRENS’ need for integrated, European-wide services.

This trend can be leveraged in conjunction with the rise of cross-border fibre (CBF) and alien wave (AW) technology to make possible a new way of sharing fibre infrastructure in Europe. These advances are currently being investigated as part of the GN4-2 project [GN4-2].

IRU or a permanent lease of dark fibre within a network was reported by 36 out of 42 NRENS. Twenty-six NRENS now own and operate the transmission equipment to light their dark fibre. An additional eight NRENS own the transmission equipment and outsource the operations. Two NRENS run a full outsource model, which includes equipment and operations.

Such responses show continuation of a significant trend for NRENS’ increased use of dark fibre during the past 12 months. Four NRENS have over 10,000km of dark fibre in their networks. Another 10 NRENS have over 1,000km of dark fibre.

The typical duration of an NREN’s dark fibre indefeasible right of use is 10 years or 15 years (10 NRENS for each duration) (Figure 5.4). RedIRIS stands out from the other survey respondents, with a fibre IRU of 30 years. Longer-duration IRUs provide an NREN with considerable certainty of fibre supply. Longer IRUs also typically have a lower annuited cost of ownership than short IRUs.
NETWORK SERVICES

NRENs deliver a broad portfolio of services to meet user needs. This section explores the current status of network services in this portfolio.

In addition to these network services, NRENs offer above-the-net services that are delivered on top of the network infrastructure. These form an extremely varied and rich set of services, such as conferencing, virtual dedicated networks, remotely triggered black hole (RTBH) filtering, IPTV, cloud services, education, CloudStor, hosted IP telephony, software distribution, cloud data storage, purchasing and administration, and digital exams, which are explored in other sections.

As ever, IP remains at the core of the NREN service offering, with all respondent NRENs offering IPv4, and all but three supporting IPv6 (those three are working towards an IPv6 offer). The next most common network services are: layer 2 virtual private network (L2 VPN), lambda, distributed denial of service (DDoS) mitigation and wifi. These are offered by 40% to 50% of European NRENs.

ALIEN WAVES

In the optical transport world, the term “alien wavelength” or “alien wave” (AW) is used to describe wavelengths in a dense wavelength division multiplexing (DWDM) line system that traverse the network but are not sourced/terminated by the line system vendor’s equipment. This setup is in contrast to traditional DWDM systems, where the DWDM light source (transponders) is in the same management domain as the amplifiers.

The benefit of alien waves is that the transponder is removed or moved to the customer domain. Transponders are the most complicated, expensive and profitable piece of equipment in an optical vendor’s portfolio. When implementing packet-optical-based equipment, they can be eliminated, which lowers the cost of the end-to-end service. As a result, recently introduced DWDM pluggables, such as Acacia’s CFP2 ACOs, are being integrated into packet optical transport equipment.

There has been a substantial take-up of alien waves by content providers in the past few years. These network operators see AWs as providing the benefits of owning a transmission system without having to pay the full cost of ownership. They also allow multiple providers to share a common fibre infrastructure, which also increases the number of services on the fibre and divides the costs.

In 2016, GÉANT turned up its first alien wave on SURFnet’s fibre from Amsterdam to Hamburg. This service has now been running successfully for over a year. The aim is to replicate this service model on other stretches of NREN CBFn in Europe.

NRENs increasingly offer alien waves as part of their service portfolios to carry DWDM light from a third-party source. That source can either be located in a customer’s network or be sourced from coloured optics on a switch/router in the NREN’s own network. At the time of writing, 31% of NRENs offer AW services, which reflects the increasing strategic importance of this service to the community.

While the total number of AW services currently provided is 89, this is still much smaller than the 512 lambda services provided by the NRENs. Multidomain virtual private network (MVVPN) L2 and 4G services are the most recent technologies, which consequently, have the lowest adoption rate among NRENs.

IPv6

IPv6 is the most recent version of the internet protocol (IP). Its continued take-up is important to network evolution as IPv6 simplifies routing and supports the further growth of the number of connected hosts, as well as transmitted data traffic. In February 2017, IPv6 made up 2.8% of the total GÉANT traffic.

With an average of 610 Mbps during the week the snapshot shown in Figure 5.6 was taken, ARNES was the largest source of IPv6 traffic in the GÉANT network. It should be noted that the top users vary from time-to-time, as this traffic tends to be bursty. The largest consistent source of IPv6 data in the GÉANT network is CERN, with an average of 356 Mbps. The next-largest consistent source of IPv6 traffic in GÉANT is Isc, followed by DFN.

IPv6 take-up is highly dependent on the take-up at end-user and client institutions, whose use of the protocol remained rather polarised in 2016. As shown in Figure 5.7, in the countries of many of the respondents, nearly half of the NREN’s client institutions are making use of IPv6. However, other NRENs do not yet have any institutions that have enabled IPv6. This variation can be partly explained by the nature of the institutions served by the NRENs. For example, smaller institutions, such as schools, are still choosing not to make use of IPv6, which means that the NRENs that service schools are more likely to have a lower rate of IPv6 take-up.

An exception to this point is KIFÜ (formerly NIF) in Hungary, which shows very high utilisation levels of IPv6 in its network and serves all primary and secondary schools with networking and above-the-network services (c.5500 service locations). KIFÜ enabled IPv6 by default for every school, making use of the preconfigured subnets it offers.
NETWORK PEERING

Network peering refers to the direct exchange of traffic between two networks. Most NRENs are now choosing to have at least some direct peering with commercial networks and content providers.

Settlement-free peering offers the possibility of saving fees for upstream traffic, but has the added cost of a presence in an internet exchange.

As shown in Figure 5.9, NRENs now peer with more than 100 non-NREN peers. An additional 16 NRENs peer with more than ten. With over 600 peerings, SWITCH has the most individual peerings of any respondent European NREN.

Figure 5.9: number of GÉANT’s non-NREN peers. Respondents stating 5 peers or below do not appear.

IP TRUNKS

The interface rates used in NREN networks to deliver their services continue the trend towards further take-up of 100 G trunks. IP trunks are the network circuits that connect the core routers in the NRENs’ networks.

Responses about the capacity of the largest link in the NRENs’ networks show that 13 European networks now have 100 G links, which means that nearly all of the large, Western European NRENs have moved to 100 G. N x 10 G links are still popular in smaller networks that do not need 100 G, and a few small NRENs still operate with sub-10 G links.

Figure 5.8: The largest link in NREN networks

NETWORK PERFORMANCE MONITORING

Monitoring the performance of the network is critical to ensuring services are being delivered. In support of this, 16 of 32 NRENs report that they run a performance enhancement response team (PERT) to help troubleshoot network performance issues.

Seventeen of the NRENs who responded provide a network/service status dashboard for their end users to monitor performance in real time. A larger group (22) have access to historical traffic volume information. This information is provided by a range of tools. The most common are Looking Glass and a NetFlow analysis tool. Cacti is also used by several NRENs.

perSONAR is a widely-deployed test and measurement infrastructure that is used by science networks and facilities around the world to monitor and ensure network performance (perSONAR). perSONAR measurement points have been installed by 22 out of 39 NRENs. FCCN reported 31, and PIONIER reported the next-highest number with 15. Otherwise, it is typical for NRENs to have one or two monitoring points.

NETWORK INNOVATION: SDN AND NFV

Networking technologies have been based on systems originally designed over 40 years ago, in a relatively static environment. Now programmable, scalable and secure network solutions are changing network development and service delivery. The move towards a software-led approach offered by software defined networking (SDN) allows greater network flexibility and deployment potential.

Open network function virtualisation (NFV) and orchestration helps to simplify network automation. This solution uses IT virtualisation technology to consolidate many different types of network equipment onto servers, switches and storage areas, controlled from a central point.

Together, the use of SDN and NFV can optimise the location of network functions and offer greater network control.

Sixteen of the survey respondents reported that they either have added or are working on adding SDN to their network. The controllers used are ONOS (used by 5 NRENs), OpenDaylight (6), Faucet (1) and other (7). The application programming interfaces (APIs) to SDN used are NETCONF (used by 2 NRENs), OpenFlow (6), PCEP (1) and other (1). SDN is being used for the following activities: testbed facility for researchers (7 NRENs), piloting new services (4), providing support for other services (4), production services (2) and other (5).

A total of 14 out of 21 NRENs report that they are either using NFV or plan to use it. Nine use this NFV for routing, six for firewalls, six for VPN concentrator services and four use it for load balancers.
1. What is the mission of the GÉANT network?

The aim of the GÉANT network is to provide unconstrained, high performance and trusted access to the scientific instruments and resources of the global R&E community, support for collaboration amongst researchers, knowledge sharing, and a portfolio of services and infrastructure community, support for collaboration amongst researchers, knowledge sharing, and a portfolio of services and infrastructure services and infrastructure resources alongside networking research and development. The ability to support large data flows across multiple domains differentiates GÉANT from the commercial networks.

The high-performance element of the network’s mission (i.e. high throughput, no congestion or contention, zero packet loss and low latency) is critical. The secondary element of the network’s mission is to ensure it provides leading-edge, customised solutions demanded by the community, such as: border gateway protocol (BGP) communities, multidomain virtual private networking (MVPN) and multicast.

2. What do you see as the top three trends across R&E networks in the next 12 months?

The top three network trends, which are already evident and which we see continuing over the next 12 months, are a focus on software, disaggregation of control and data planes, and network interoperation.

Software-focused networking covers topics as varied as the move to virtualised functions, the separation of services from hardware, and the introduction of network programmability that facilitates automation and orchestration capabilities. The hyperscale content providers, such as Google, have led and continue to lead the way in using software to change how content providers’ networks are managed and operated. The more traditional communications service providers are catching up slowly, and the R&E community needs to embrace this shift to remain relevant and valuable to its users. The realisation of this trend will require an overhaul of existing operations support system / business support system (OSS/BSS) stacks, an evolution of engineering and operational teams, and the introduction of new networking technologies. A move to software-driven networking will enable R&E networks to take advantage of disaggregation of services from the hardware – the second trend.

Software-defined networking (SDN) began as the centralised control network of networks via the separation of control and data planes. This trend towards disaggregation has continued, as networking vendors disaggregate and open up their proprietary solutions. There has been a big push by networking vendors to disaggregate their hardware from their software, and disaggregate their software stacks into plug-and-play models. This shift from hardware to software is reducing the reliance on proprietary components, enabling open-built chips and off-the-shelf hardware solutions controlled by independent software. Several open source community initiatives, to build open hardware and develop open software stacks, are also feeding the need for vendors to disaggregate and open up their (previously proprietary) technology stacks before they lose market share to open solutions. In response, vendors are developing software to support other vendors’ hardware. The need to buy single-vendor, integrated solutions is disappearing. R&E networks can now harness this disaggregation to acquire “best-of-bred”, optimum-cost solutions tailored to their specific needs.

More and more NRENs across the community are opening their infrastructure to enable others to share it. This presents the R&E networking community with a unique opportunity, as it can take greater risks than commercial service providers to embrace disaggregation and drive open networking communities to deliver solutions that enable true differentiation and innovation. Disaggregation removes the dependence on vendors’ complex monolithic proprietary turnkey solutions. The move to software, coupled with disaggregation, will enable specialised services to be developed for the R&E community, facilitating take-up of network function virtualisation (NFV) and SDN technologies. The challenge facing the R&E networking community is to create a collaboration model that will realise the benefits of disaggregation, especially to gain economies of scale from exploiting open source solutions. Softwareisation and disaggregation will drive the need for and enable interoperation. Boundaries between what have previously been viewed as distinct traffic types, commercial and research traffic are diminishing as more researchers rely on cloud services. High-performance connectivity to cloud providers is becoming essential for R&E networks, driving the interoperation of public and private infrastructures. In turn, cloud interoperation and orchestration of cloud services will drive the need for GÉANT and NREN networks to seamlessly interoperate. Interoperation is where softwareisation and disaggregation come together. The movement of services from hardware to software removes the need for integrated vendor solutions. Disaggregation of the traditional networking platform stack requires interoperation between different technology and administrative domains, otherwise it simply does not work (especially if dynamic control, automation and self-service are to be achieved).

GÉANT’s challenge as a networking community is to sufficiently organise during the next 12 months to maximise the opportunity softwareisation and disaggregation to interoperate across disaggregated components and infrastructures to make them work together as a combined system and provide users with higher-value services.

3. What will the GÉANT network look like in three years?

The future GÉANT network will have greater software control, and its components will be disaggregated. In three years’ time, the problems of interoperation will have been solved, and the network should reap the benefits of automation. This means that the components chosen will be more-targeted, based on a specific need, instead of deployment of a homogeneous technology solution, as is the current situation. Heterogeneous solutions will be deployed based on traffic type, service needs, operational requirements and perhaps even affordability factors. Open technology elements, such as open optical line systems, will enable complete transport convergence and a separation of networking layers, where appropriate. For example, optical and packet convergence could be achieved using either specialised or commodity open source hardware to create a high-capacity, high-performance underlay. There could also be a smaller core of more-powerful packet-switching devices, and a larger number of specialised software controlled network elements enabling advanced services at the lowest cost.

In addition, GÉANT will work with the NREN community, other e-infrastructure and the European Commission to deliver increasingly complex and comprehensive services in support of the European Open Science Cloud (EOSC). This will bring GÉANT and the NRENs an expanded role with a greater emphasis on access/campus networks and end-to-end (E2E) monitoring and management.

4. What will have the greatest impact on the network in the next three years?

Supporting traffic growth is as fundamental to the network as is the reliable and cost-effective delivery of the R&E community’s traffic. It is even more essential as traffic is currently doubling every 12 to 15 months. Part of this provision will also include planning for Run 3 of the Large Hadron Collider (LHC), as it will generate more than 120 PB of data (up from about 20 PB during Run 2), as shown in Figure 5.10.

5. What do you anticipate the GÉANT service portfolio will look like in the future?

Generic connectivity services (IP access, private point-to-point services, etc.) will still play a role in the future network portfolio, augmented with an aligned wave service. Connectivity services will become more intelligent, with specific features defined by the requester, such as committed bandwidth, latency, jitter, preferred path and data transfer rate. FlexiEthernet (FlexE) could provide an interesting opportunity to solve the elephant flow (very large amount of traffic). With the move of services into software, VNFs and service chaining will become the foundation for how future advanced services will be built. Additional intelligence and network analytics will be used with network programmability to create more-dynamic services and service verification, and validation concepts will create new network services. Combining centralised and decentralised software control will also aid the development of intelligent security services.

There will be a larger number of “above the net” services, driven and provided by the NRENs and community and commercial providers. If the EC’s vision is to be realised, the GÉANT service portfolio could be significantly transformed through the integration of the GÉANT network into services offered through the EOSC initiative. In this landscape, new GÉANT services will be less visible to the user as they become integrated into cloud and e-infrastructure services. For example, users may sign up for access to cloud storage with the connectivity, security and monitoring services provided by GÉANT. Transparently bundled into this service, the NRENs, GÉANT and EOSC will provide infrastructure services with the potential for user services to be built on top.
6 Security and Trust & Identity


Trust & Identity: Licia Florio, Project Development Officer (GÉANT). Licia joined TERENA (now GÉANT) in 2001, focusing on Identity and Trust. Licia coordinates the AARC (Authentication and Authorisation for Research and Collaboration) project. The AARC EC-funded project aims to address the integration among different AAs operated by the various research collaborations and e-Infrastructures; the lack of ubiquity of federated credentials; and technical and policy challenges that are ultimately hindering global research collaborations.

SECURITY SERVICES

As the security landscape expands with ever-increasing challenges such as the use of bring your own device (BYOD) schemes and Internet of Things, NRENs are keen to improve security services and risk management within their organisations. For example, 63% of respondent NRENs have performed or plan to perform regular risk assessments. As a result, the take-up of international security standards such as ISO 27001 (Information Security Management) and risk management frameworks (such as ISO 27005 and OCTAVE) have now become established within their organisations. Approximately 90% of the respondents utilise recognised methodologies.

Security audits are increasingly being performed within the NREN community (for instance, 32% of respondent NRENs carry out security management systems audits and 69% undertake technical infrastructure audits). NRENs use security audit results to ensure that management is aware of any security gaps in both project and corporate environments. There is also noticeable interest in security training as a means to better equip an NRENs members through a combination of community and private events.

NRENs and the GÉANT community as a whole are using well-established methodologies, such as risk management, technical reviews and training, to manage the demands resulting from a complex security landscape. Security is an important element of an NRENs organisational values.

NOTABLE TRENDS

As NRENs work to become a more secure community, greater adoption of well-established security frameworks is required (as reflected by responses to the survey). It is important for each NREN to identify the best framework and assess the viability of adhering to internationally recognised standards that provide a baseline set of controls and practices (52% of NRENs are doing this).

NRENs are also increasing security training, seeking support from a variety of training providers to help expand the security skill base of staff.

NRENs identified a number of network security threats for 2016, with the greatest threats coming from:

- Largescale DDoS attacks.
- Critical vulnerabilities, such as Heartbleed.
- •

KEY SECURITY STATS

- 52% of respondents have or plan to certify or comply with international or local standards e.g. ISO 27001 (48% do not).
- 68% of respondents stated presence of some form of a risk management plan or framework. These often include follow-up with management and strategies to help escalate issues.
- 78% of respondents have planned or intend to plan training to security staff. TRANSITS, TF-CSIRT were the most popular community event options, followed by FIRST, Black Hat and others.
- Business Continuity plans were used (or there was a plan to use them) to ensure business continuum and operations by 63% of respondents (37% did not).
- Top security services on offer included NOC, security audit, incident response and security consulting.
- 91% of respondents used or were planning to use network security controls to mitigate technical threats. Firewalls were the most popular of these controls, followed by network analysers.
- 79% used or planned to use other security controls such as anti-virus, integrity checkers and systemic firewalls to protect assets. Most popular controls included anti-virus and security checkers.
- DDoS and malware were the two most common security incidents experienced by NRENs; nearly every respondent reported at least one example of this.
- 89% of respondents implemented or planned to implement mitigation measures against DDoS and DNS Reflection/Amplication attacks.
- In terms of anticipated threats, Large-scale DDoS attacks were cited by 86% of respondents, followed by major vulnerabilities and lack of experience.

There are a number of simple controls that NRENs have found helpful, as per the NREN Compendium survey, to improve their approach to security training and risk management:

- Security training to understand the nature of the attack/security incident or security problem. This will help to prevent, mitigate and respond to a security incident or issue in the appropriate manner.
- Annual security reviews, including technical assessments (full audits of security environment) to identify any potential security gaps so they can be mitigated and or managed.
- Regular risk assessments to prioritise the risks and threats to the organisation, its assets and information enables proportional controls to the risk to be implemented.

In spite of the threats and perceived vulnerabilities, NRENs are taking positive steps towards increasing network security.

Figure 6.1: Most common type of security incidents in 2016

<table>
<thead>
<tr>
<th>Security Incident</th>
<th>Total Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>DDoS</td>
<td>35</td>
</tr>
<tr>
<td>Malware</td>
<td>15</td>
</tr>
<tr>
<td>Social Engineering</td>
<td>10</td>
</tr>
<tr>
<td>0</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td></td>
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<td></td>
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<tr>
<td>30</td>
<td></td>
</tr>
<tr>
<td>35</td>
<td></td>
</tr>
</tbody>
</table>

compendium.geant.org 34
The deployment of federated access and national identity federations for research and education has enabled NRENs to explore new service delivery models. This also included areas that, until a few years ago, were not the core business of NRENs. As a result, NRENs have expanded their boundaries to think about wider trust and identity strategies to make service offers more sustainable and attractive to NREN users. (Trends for these aspects are explored in Identity Federations and eduGAIN.)

The trust and identity activity within GÉANT and the NRENs encompasses the following areas:

- Operations of national identity federations.
- Operations of international infrastructures, such as eduGAIN and eduroam, and related inter-federation services and monitoring tools.
- Support of policy harmonisation and best practices across identity federations.
- Development of new technical and policy features to make federated access feasible for el citizen communities.
- Digital certificate services, such as the Trust Certificate Service.

GÉANT supports the work in these areas in collaboration with the NRENs and via different frameworks, such as the GÉANT and AARC projects, REFEDS and other specific projects. The picture below depicts the areas that each of these framework cover.

For a long time, security was typically associated with and defined as the means to protect the network from undesired access and consumption. NRENs were pioneers in creating many of the earliest incident response teams. With the wider use of digital identity, security has now grown to also encompass security incidents in identity federations and eduGAIN.

One of the biggest topics for everyone in the trust and identity field will be the implications of the new GDPR (General Data Protection Regulation) and how our established systems and services will support it.

One of the largest areas of interest for everyone in the trust and identity field is the new GDPR (General Data Protection Regulation), published in April 2016, and which will enter into force in May 2018. The new GDPR replaces the Data Protection Directive 95/46/EC and it is the most important change in data privacy regulation in the last 20 years. Main questions around the new GDPR revolve around the impact on federated authentication in relation to transferring user data to access services located in countries different than the country in which the user authorizes; and how NRENs and GÉANT established systems and services will need to change to support the new legislation.
What is the next big AAI service that will be coming out of SWITCH?

It is SWITCH eduID: https://projects.switch.ch/eduid. We are evolving from SWITCHaai to an approach which allows the user to own and manage their identity on a lifelong basis, but to combine this with information from the organisations where they are working or studying etc. The idea is to provide the user with more control and flexibility, provide easier interface points for the service providers consuming identities but also to remove the burden of managing non-organisationally scoped information about users from the campus organisation.

- What impact will this have on Swiss users?
  Swiss users will have an academic identity which moves with them when they change institution or role. They’ll be able to declare and prove links to researcher identities like ORCID or them when they change institution or role. They’ll be able to declare and prove links to researcher identities like ORCID or social identities and to have the value of individual attributes sourced via eduID from the appropriate campuses. As SWITCH are not alone in adopting this model, eduID has the edukIND initiative to investigate and make recommendations for how such models should operate within eduGAIN and develop best common practice and harmonisation so that the integration of these models is effective.

- What impact do global initiatives like GN4, AARC, REFEDS have on your national plans?
  They are feeding our national plans with ideas, and we can use them as platform to spread our ideas and find potential followers. We also contribute very heavily to GEANT because our users in Switzerland are also very global in outlook and if collaborations can’t. This is something I talk about a lot, and you can see more at https://www.switch.ch/stories/aai_geant/.

We also contribute not only to those initiatives but also to the Shibboleth Consortium as it is very important to secure long term sustainability and ability to respond to the changing environment for the underlying software in use in campuses and service providers.

- What impact will this have on eduGAIN or any other international collaboration?
  An important aspect of this is that the SWITCH eduID will appear in eduGAIN with the user’s academic affiliations sourced via eduID from the appropriate campuses. As SWITCH are not alone in adopting this model, eduID has the edukIND initiative to investigate and make recommendations for how such models should operate within eduGAIN and develop best common practice and harmonisation so that the integration of these models is effective.

eduID in Switzerland

Ann Harding has worked for SWITCH since 2007 and is currently in the AAI team. She leads the GEANT project’s Trust and Identity Development Activity and works with a particular focus on supporting research communities. Ann has gained third-level qualifications in Arts and Humanities and Computer Science and a Master’s qualification in Cultural and Media studies.

eduID (education roaming) is the secure, worldwide roaming federated access service developed for the international research and education community (eduGAIN). eduID allows students, researchers and staff from participating institutions to connect to the Internet when they are at their own campus or institutions, as well as when visiting other participating institutions. This seamless access is possible via a technical architecture and a number of policy agreements that enables eduID participating institutions to trust the result of the authentication of a user that takes place at the user’s home organisation. The authorisation required to allow access to local network resources is carried out by the visited network. eduID is built on one of the most secure encryption and authentication standards in existence today. Its security by far exceeds typical commercial hotspots.

Having started in Europe, eduID has gained momentum throughout the research and education community and is now available in 80 countries worldwide. eduID is deployed as hierarchy of national eduID federations; GEANT operates the regional level service for members of the European eduID confederation. This alliance is comprised of 48 autonomous roaming services which agree to a set of defined organisational and technical requirements that ultimately constitute eduID.

Although the rate of increase of participating countries is slowing, with only two additional countries or territories having joined since 2016, the number of authentications supported by eduID shows remarkable growth. In May 2016, eduID recorded one billion国际 authentications (either in-country or international) since the beginning of the year, as well as the one billion international authentication (when users are connecting from outside their home country) since the service was launched. This is a remarkable achievement.

Service locations are becoming increasingly broad to include airports (Geneva in Switzerland and multiple airports in Norway and Sweden), train stations (Sweden) and municipalities (Zagreb and Rijeka in Croatia, supporting the 2015 European University Games, and Vienna and Innsbruck in Austria).

Up-to-date information on eduID is available at www.eduid.org.

govroam

Reaching further than campuses and research institutions reflects the expectations of users to be connected anywhere, at any time. This coverage of eduID beyond the borders of research and education is also reflected in the growing interest of deploying the technology in different policy environments, e.g. government, the schools sector or public associations such as the Wi-Fi Alliance.

Following the success of eduID as a service within the global NREN community, several organisations are exploring the potential of replicating this service more broadly within the public sector as government roaming (govroam). The govroam service uses the RADIUS protocol to facilitate secure data sharing between public entities. This is a great opportunity as many NRENs have some remit for serving and supporting government departments (RADIUS).

13 out of the 18 NRENs involved in other roaming initiatives are involved or offer support for govroam initiatives. 4 NRENs out of the 18 are also supporting roaming in secondary schools.

Behret and the Dutch govroam foundation (govroam-NL) have recently agreed to operate jointly with the further development and cooperation of govroam within their respective countries, and have approached GEANT to provide coordination support to this effort.
IDENTITY FEDERATIONS AND eduGAIN

To avoid NRENs having duplicate responses to the same questions, the information provided in this section is taken from the annual REFEDS survey and from the eduGAIN technical website [REFEDS][eduGAIN].

Identity federations simplify inter-organisational access to web resources, by allowing users to access, with one login, resources offered by participating organisations in the identity federation.

Identity federations (and eduGAIN, built on national identity federations) are built on the standardised SAML protocol and resources, by allowing users to access, with one login, identity federations simplify inter-organisational access to web technical websites [REFEDS][eduGAIN].

The main characteristics of identity federations are:

- **Authentication of the user always takes place at the user’s home organisation (identity provider).** The identity provider authenticates users, while ensuring that only a limited number of personal information necessary about the user is shared with the services.
- **Users are registered in the identity management system of a university or a home institution**. Using federated access, they can access services provided either by that university or by other institutions participating in the identity federation.

Service providers offer services to users authenticated by the identity providers, minimising the amount of user management they have to do.

In 2016, the number of identity federations increased from 55 in 2015 to 66 (see REFEDS, [https://refeds.org/federations](https://refeds.org/federations)). From the Compendium survey it emerges that only two of these federations are not directly operated by the NRENs: Of those operated by NRENs, the majority are delivered using a combination of self-built or self-integrated systems, indicating a strong connection with specific requirements of research and education.

Most of the identity federations operators gather in REFEDS, the global forum to articulate the needs of identity federations managed by GEANT. REFEDS, thanks to the sponsorships (see [https://refeds.org/sponsor](https://refeds.org/sponsor)) and the many volunteers, offers a home for several working groups, as well as manages processes to agree on policy best practices.

In 2016, the REFEDS Sirtfi working group published the Sirtfi specifications. Sirtfi addresses the concerns of some organisations regarding the lack of well-defined and shared security practices to handle potential security incidents. Sirtfi describes practices and attributes that identify an organisation as being capable of participating in collaborative incident response and stipulates preventative measures to protect an organisation from attack, and behaviour to adopt in the event of an incident. Figure 6.4 shows the adoption of Sirtfi.

At the time of writing, there are 132 entities (of a total 3746 entities in eduGAIN) that assert Sirtfi:

- 6 SPs: RCAuth (operated by Nikhef in the context of the AARC project), CERN, EGI, the Service Proxy operated by Nikhef (NL) and 2 services in two UK universities.

There are 108 entities that assert Sirtfi that belong to SURFconext (the Dutch federation). The current preponderance of SURFconext entities is the result of pre-existing strong incident response coordination within SURFnet and the way how the Dutch federation is operated, enabled SURFconext to assert Sirtfi compliance on behalf of the connected institutions.

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REFEDS is promoting entity categories as a scalable approach to ease attribute release. Entity categories define certain criteria for federation entities i.e. identity providers and service providers, for the purpose of grouping them into clusters where all entities share the same characteristics. Two categories are relevant for the purpose of the compendium:

- **Research and Scholarship (R&S):** Group services that are operated for the purpose of supporting research and scholarship interaction.
- **Data Protection Code of Conduct (CoCo):** that describes an approach to meet the requirements of the EU Data Protection Directive in federated identity management.

Figure 6.5 and Figure 6.6 below show the adoption of R&S and CoCo.

![Figure 6.5: Research and scholarship adoption](https://technical.edugain.org/entities)

*Note: 147 IdPs support R&S within eduGAIN. This is 6.6% of the total IdPs (2235). 125 SPs support R&S within eduGAIN. This is 9% of the total SPs (1384)*

![Figure 6.6: Code of conduct adoption](https://technical.edugain.org/entities)

*Note: 103 IdPs support CoCo within eduGAIN. This is 4.6% of the total IdPs (2235). 103 SPs support CoCo within eduGAIN. This is 7% of the total SPs (1384)*

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While federations have traditionally been operated as a mesh or hub and spoke model, the REFEDS survey has highlighted an increase in federations taking an hybrid approach, as shown in Figure 6.8.

Priorities in 2017

<table>
<thead>
<tr>
<th>Priorities in 2017</th>
<th>Federations</th>
</tr>
</thead>
<tbody>
<tr>
<td>OIDC</td>
<td>9</td>
</tr>
<tr>
<td>Hosted IdP</td>
<td>8</td>
</tr>
<tr>
<td>Multifactor</td>
<td>8</td>
</tr>
<tr>
<td>Adding new institutions/organisations</td>
<td>7</td>
</tr>
<tr>
<td>Entity categories</td>
<td>6</td>
</tr>
<tr>
<td>Operations</td>
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<tr>
<td>Documentation</td>
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<tr>
<td>New infrastructure</td>
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<td>Helpdesk</td>
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<td>Sirlf</td>
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<td>Per-entity metadata</td>
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<tr>
<td>Error handling</td>
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</tr>
<tr>
<td>Joining eduGAIN</td>
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<tr>
<td>Attribute authority and aggregation</td>
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<tr>
<td>SP support</td>
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<td>Assurance</td>
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</table>

Figure 6.7: Priority areas for NRENs in 2017

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<td>OpenID Connect (OIDC)</td>
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<td>Entity Categories</td>
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<td>Operations</td>
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<td>Documentation</td>
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<tr>
<td>New infrastructure</td>
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<td>Helpdesk</td>
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</tr>
<tr>
<td>Sirlf</td>
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</tr>
<tr>
<td>Per-entity metadata</td>
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</tr>
<tr>
<td>Error handling</td>
<td>2</td>
</tr>
<tr>
<td>Joining eduGAIN</td>
<td>2</td>
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<tr>
<td>Attribute authority and aggregation</td>
<td>2</td>
</tr>
<tr>
<td>SP support</td>
<td>2</td>
</tr>
<tr>
<td>Assurance</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 6.8: Responses by federation type

eduGAIN

Research and education is becoming increasingly borderless. The purpose of the eduGAIN infrastructure and the accompanying inter-federation services is to enable users from one federation to access services from other federations and to enable services offered in one federation to be accessed by users from other federations. The eduGAIN service has now achieved critical mass having been almost universally adopted by established research and education identity federations worldwide.

It is widely recognised that eduGAIN is the foundation to enable federated access globally, and there is strong interest among the eScience community to use it widely.

Figure 6.9: eduGAIN global footprint
Cloud Services: Karl Meyer, Product Marketing and Management Officer, (GÉANT).

Karl has spent the past 20 years working within the Internet Industry in both Technical and Sales and Marketing Roles and was Director of Channel Marketing Strategy. Karl has an MBA from The Open University with emphasis on International Enterprise Development and Knowledge Management. Karl has over 17 years’ experience in the development and marketing of cloud services including the launch of the MessageLabs virus scanning service, one of the first European cloud services, in 1999. He is a Fellow of Cambridge Marketing College, focusing on Digital Strategy.

Collaboration Services: Peter Szegedi Project Development Officer, (GÉANT).

Peter Szegedi joined TERENA (now GÉANT) in January 2008. He develops and manages task forces, special interest groups and contributes to technical projects and strategic programmes. He is currently Project Officer for the Up2U programme. Peter received his MSc degree in Electrical Engineering at Budapest University of Technology and Economics, in Hungary, in 2002. He then worked towards a PhD at the Department of Telecommunications.

Although the first cloud services were implemented over 16 years ago, it is really only in the past 5 or 6 years that this delivery model for services has started to gain traction. In fact, in 2016, 70% of NRENs provide some form of cloud services to their users, compared to 56% in 2015.

Within the commercial sector and R&E, take-up of cloud services has been slower than anticipated, due to concerns over data protection, privacy and security. These issues are still a concern to 62% of respondent NRENs, demonstrating the need to deliver secure and trusted services.

Collaboration services are key to ensuring connection between researchers and educators alike, using services such as videoconferencing and virtual learning environments to bridge geographical divide.

This section provides an overview of NRENs’ perception of cloud services and their views on how they can have an impact on users as well as the range of services used to support collaborative working.

NREN PERCEPTION OF CLOUD SERVICES

The vast majority of NRENs consider the development of cloud-based services to be an opportunity for their service portfolio. All (100%) of the respondent NRENs (35 NRENs) consider that cloud services will add value to their users and enhance their service portfolio. Of these, 71% (25 NRENs) believe that cloud services will enable them to be more responsive to their users’ needs.

However, only 20% consider cloud services to be a source of increased revenue opportunities for their NREN – showing that supporting users, rather than revenue, is the key driver for the majority of NRENs.

Cloud and Collaboration Services

Cloud Storage is the most common service provided by NRENs, with 62% currently delivering or planning to deliver cloud storage in the next 12 months. However, Infrastructure as a Service (IaaS) (general-purpose cloud computing services) is, or will be, offered by 61% of NRENs, indicating that these two service types are and continue to be vital to the R&E sector.

Software as a Service (SaaS) and Platform as a Service (PaaS) complete the normal service portfolio for the majority of NRENs.

NREN PE RCE PTION OF CLOU D SE RVICE S
THREATS AND CONCERNS

This is not to say that NRENs are completely satisfied with cloud services, as many NRENs have concerns about the use of cloud services in their environment.

The three primary concerns for NRENs are:

- Security and privacy.
- Vendor lock-in and incompatibility.
- Data location (this concern is strongly correlated with concerns over security and privacy).

These three concerns are primarily external issues (focused on the services/support offered by the providers), and so, can only be managed through working together with the suppliers to reduce risk (or perception of risk) involved in using cloud services.

IMPLICANT OF CLOUD SERVICES ON NRENs

As cloud service use grows then the usage model for Campus and NREN networks will, in turn, change. As data and services move off-site, network traffic will shift, not only in volume, but also in shape (multiple low volume interactions compared to low numbers of high traffic transfers). The download once, use many times approach will be replaced by access on demand. The directionality of flows may also change from that of limited numbers of external users accessing internally located data and services, to a model where internal users are largely accessing external data and services.

It is not yet possible to track and measure the changes, however, all NRENs expect the adoption of cloud services to increase the usage of their network, with over 85% expecting an increase of network traffic.

The anticipated effect of cloud services on peering traffic is also significant, with 79% of NRENs expecting an increase in peering volumes, as shown in Figure 7.4.

Most NRENs expect the provision of cloud services to increase data volumes to GEANT, with 70% expecting an increase in data to GEANT (Figure 7.5).

These increases in data volumes, both internally and externally, could have an effect on the cost model of the NREN networks over the next few years.

IMPACT OF CLOUD SERVICES ON NREN REVENUE STREAMS

Many NRENs who responded consider cloud services to be a potential revenue stream: 45% agree or strongly agree that cloud service will offer a revenue stream (33% agree, 12% strongly agree), with 33% currently having no opinion.

Many (64%), however, think that users will increasingly bypass organisational IT departments and self-provide cloud services. As a result, 90% of NRENs feel that they will need to offer a range of delivery models for cloud services in the future to support this level of flexibility.

SUMMARY

In summary, the development and implementation of cloud services is likely to have significant effects on NRENs, with substantial opportunities to improve service portfolios, increase or develop new revenue streams and to add value to their users.

These services, however, are likely to have substantial effects on the NREN core networks as traffic volumes and the shape of that traffic evolves. This may result in additional costs to the NRENs and potentially to their campus users. It is not clear if this evolution will negate the cost savings offered by migrating to cloud services, therefore more research is likely to be needed to understand the impact.

In general, NRENs consider cloud services positively, however, concerns over security, privacy and vendor lock-in still remain, and will need to be addressed by both vendors and NRENs.
Joint Delivery of Cloud Services

Andres Steijaert, Program Manager and GN4-2, JRA4 Activity Leader, (SURFnet). Andres coordinates the efforts from the higher education institutions to jointly benefit from cloud services. He initiated and directed the cloud brokerage and vendor management activities at SURF. Andres is a frequent presenter, nationally and internationally, on cloud computing and one of the speakers in a Masterclass Cloud, part of the Executive Education track at the Nyenrode Business University.

The adoption of cloud services through the NRENs has reached an important new phase. Many NRENs are active in this area, with concrete service offerings. The cloud delivery model is disruptive, as it empowers users and changes the traditional service delivery chain. The NRENs have delivered online services for many years in the “pre-cloud era”, and are uniquely positioned, as the trusted partners for their Research and Education communities, to offer cloud services that are safe/secure and easy to use. Many NRENs have assumed one and often more of the following roles:

- Build and operate community cloud solutions.
- Aggregate community demand and apply economies-of-scale to establish favourable conditions of use with cloud providers (broker agreements with providers, which meet the community’s needs).
- Connect clouds to the NREN networks and federated identity management ecosystem.
- Help institutions to consume these offerings (adoption support).

The European NRENs continue their collective cloud approach within the GEANT project, developing new skills and services and offering these to their communities more quickly and cost effectively than they would be able to do on their own. The joint, pan-European tender for infrastructure as a Service (IaaS) solutions in GN4-1, resulted in Framework Agreements with over 20 suppliers and established a digital single market for cloud consumption with favourable conditions of use. In addition, NRENs exchanged knowledge and plans on a global scale, on technical cloud matters and in areas such as cloud procurement, business development, legal and vendor management.

The hybrid cloud approach of many NRENs, of bridging the demand and supply sides and offering both in-house as well as well as outsourced solutions, puts the NRENs in a unique position within the cloud ecosystem.

COLLABORATION SUPPORT SERVICES

Online communication and collaboration is crucial to research and education. Students, researchers and institute staff rely on e-learning services and video conferencing to learn and share. This is a rapidly developing area and GEANT is working to support NRENs as they foster innovation for their communities. A number of services were discussed as part of the NREN Compendium survey, including videoconferencing, WebRTC, cloud solutions, unified communications and e-learning initiatives.

Videoconferencing

By 2016, it has become clear which NRENs consider videoconferencing services strategically important for their business. The penetration of centrally managed videoconferencing services into the community has been stable for years now, with around 60% of NRENs offering such a service to their constituencies. However, there is a significant change in the way how users prefer to consume such services. The focus has been shifted from traditional MCU-based videoconferencing rooms and room-based systems to dynamically-created virtual meeting URLs that can be accessed via popular web browsers directly from the desktop or mobile devices. At least 65% of the NREN solutions now provide some kind of web-based access (mostly via downloadable browser plug-ins) to their videoconferencing rooms.

Advent of Mature WebRTC Technology

With the advent of the standard-based WebRTC technology, more and more vendors’ solutions provide “clientless” access to their conferences, which means that no clients or plug-ins have to be installed on the end-user devices in order to connect to the virtual meeting rooms. There is a significant interest in the NREN community to invest in and deploy such native web real-time communication solutions: 40% of them already have WebRTC support and another 30% are planning to have this feature in place very soon.

65% OF NREN VC SOLUTIONS NOW PROVIDE WEB-BASED ACCESS

Moving to the cloud

For the first time in 2016, the NRENs were asked whether they plan to remain using the traditional on-premises video/web conference platforms or they will rely on third-party cloud providers, and consume services from the cloud. Cloud-based solutions account for 28% of NREN solutions, and this type of hosting model is expected to grow in the near future.

Significant Growth in Web Conference use

In today’s typical video-based real-time interaction use cases, the voice and video quality of the novel videoconferencing products. Moreover, videoconferencing “ease of use” is significantly higher compared to previous approaches, with no need to worry about client interoperability, booking and scheduling of conference rooms, or sending out call-in details in advance – that motivates the users to move their meetings to the virtual space.

The overall average of 1000 traditional MCU sessions per month across the NREN community has been stable for years, now though the highest peak ever reported was about 11,000 session per month in average at RENATER in 2016 (22% growth compared to 2015 figures). Surprisingly or not, these usage numbers are try if compared to use of the webconference sessions. About 8,500 webconference sessions per month are happening community-wide, and the largest number of 12,500 session per month reported by DeIC in 2015 Compendium has been hugely beaten by SUNET, reporting 73,500 sessions in average per month during 2016. This constitutes a significant, almost six-times the growth in peak numbers.

Unified Communications and VoIP

Most of the NRENs still do not find it strategically important or economically beneficial to invest in the unified communications space (UNIFIED), Country-specific and European regulations on the voice market, traditionally dominated by legacy telecommunications providers, are still not changing in favour of the NRENs, despite the strong lobby of Internet giants, such as Google and Microsoft, on our side. This leads to the current situation where only 24% of NRENs are active in the VoIP services arena (a decreasing trend compared to 2012). The use of GEANT’s global NRENunet.net telephone number mapping service has also plateaued in Europe, with the only driving forces now coming from Latin America and Central Asia. The foreseeable convergence between Unified Communications and WebRTC-based videoconferencing solutions (i.e. the broader Skype for Business movement) is yet to be seen.
Around 30% of NRENs provide multimedia content presentations with voice, video, chat and notes features, collaboration tools that allow webcasting of slide-based Virtual Learning Environment.

Three areas of service development have improved the e-learning landscape, including:

**Virtual Learning Environment**

The definition of the VLE service type covers the web collaboration tools that allow the webcasting of slide-based presentations with voice, video, chat and notes features, typically incorporated for a large number of session attendees. Such popular solutions include Adobe Connect and Cisco WebEx. This service type shows a significant growth. Penetration of these services grew 12% in the last five years, to 42% in 2016. The average number of 10 000 virtual rooms per month – optionally streamed and/or recorded – across the community is already significant. Adobe Connect still dominates, but the community is looking for alternative solutions based on the HTML5 and WebRTC standards.

**Content Management System**

Around 30% of NRENs provide multimedia content management systems. In the 2016 NREN Compendium survey, 10 GEANT NRENs reported in total 93 000 objects to be stored, which represents 180 TB of data. A large portion of these are aggregated by the GÉANT eduOER service that aims to make Open Education Content searchable and located across the connected repositories.

**e-Learning Support**

Supporting education is one of the core missions of an NREN. In 2016, DeIC and SUNET joined forces under NORDUNET and ran a tender for Learning Management Systems to be purchased by the Nordic research and higher education community. According to the latest 2016 survey, 12 GEANT NRENs already have a Learning Management System (LMS) platform and other 5 NRENs are planning to deploy one. As a result, a joint European GÉANT effort is foreseen. The preferred platforms are mostly open source solutions, such as Moodle and Mahara, which have LTI (Learning Tools Interoperability) standard-based interfaces.

It is important that when we speak to users, we ask first about service needs, and not about technology. Technology is important, but the end user does not expect technology, but instead, services (i.e. applications) that are good, simple, easy-to-use, and reliable. The essential point is that NRENs will have to adapt their services and portfolios if we are to remain relevant. To only continue with what we have had until now would be unsustainable. We may also look towards getting more involved in pre-commercial procurement projects while focusing on industries.

**Multimedia Strategy**

At PSNC, multimedia is covered by several departments and embraces the whole organisation. We are looking at scientific visualisation in an immersive 3D environment made possible by support from our HPC facilities. We also have the television studio, running a service of HD scientific programmes that are made available to the academic community over PIONIER Content Delivery Network developed at PSNC. A joint strategy for our multimedia sections is also work in progress. Our aim is to identify as many as possible new areas where visualisation can help in addressing research challenges or extending our service portfolio. One example of new service is a comprehensive visual event management service for conferences, which includes all the technical support that this requires. PIONIER has already proudly delivered this service for TNC-conferences.

Since 2016 PSNC has been able to enlarge its offering with 15 hardware laboratories for different areas of research and development, encouraging networking and energy efficiency, but also the digitisation of film tape and reels as well as written resources (e.g. news publications). Thanks to new infrastructure we were able to develop and deliver the whole workflow, including motion capture space or 3D scanners of surroundings, to enable an immersive environment to be built for the making of interactive television.

**Future Directions**

In recent years the greatest impact for development of our multimedia services and academic television has been made through competences we gathered in different multimedia technologies. Recording, post-production and storage possibilities and the new broadcasting equipment for 8K have also been very important. The next big challenge will be to obtain software-defined broadcasting equipment, e.g. Epix addressing, to enable streaming from the recording to site to the location where it is processed, e.g. in the cloud. This is not a solution for home users of course, but for broadcasters, as it will eliminate the need for very expensive equipment at the recording site and provide for greater flexibility.

Integrating different services is important. For instance, we have combined our television platform with VC service and medVC technology (moved to a start-up PSNC research work) to deliver the European Laryngological Live Surgery Broadcast (els Livesurgery.net). This has enabled us to show, in parallel, sessions of up to ten separate surgical operations.
NRENs in other Regions and Continents

Tom Fryer, Senior International Relations Officer joined the GEANT community in November 2008. His work involves supporting international dialogue between GEANT and GEANT’s global R&I networking partners. He is also a member of the GEANT Partner Relations Team. Tom has a degree in modern languages and linguistics from the University of Essex.

R&I is global – geographical borders and oceans do not, and should not, hamper collaboration. GEANT’s international partners are incredibly important and form part of many global initiatives.

As previously stated, the Compendium survey is open to all NRENs to complete. Due to its origin and history, the majority of the content is from GEANT Association members, however, there is a consistent and growing amount of data from outside this group.

The GEANT network carries traffic from all regions. The graph below shows a network snapshot from early 2017. The volume of traffic received from each region is reflected in the size of links. A map showing GEANT’s interaction and the size of these links is now available [MAP].

GEANT exchanges the most international traffic with Internet2, followed by Esnet (about 50% of the Internet2 volume), then, at some distance, RedCLARA (about 14% of Internet2). The first two networks, Internet2 and Esnet (both US-based), account for about 80% of all international traffic exchanged on the IP/MPLS network.

From an organisational perspective we can see from Figure 8.2 that the size of each NREN varies greatly – in a similar manner to that of GEANT partners.

<table>
<thead>
<tr>
<th>NREN</th>
<th>Uni</th>
<th>FE</th>
<th>Research Ins</th>
<th>Secondary School</th>
<th>Primary School</th>
<th>Library</th>
<th>Hosp</th>
<th>Gov</th>
<th>Intl Res</th>
<th>For-Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARNet (Australia)</td>
<td>100</td>
<td>20</td>
<td>80</td>
<td>0</td>
<td>0</td>
<td>40</td>
<td>10</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>CÉDIA (Ecuador)</td>
<td>80</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>KREONET (Korea)</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>REANNZ (New Zealand)</td>
<td>100</td>
<td>80</td>
<td>100</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>SARNET (Bosnia &amp; Herzegovina)</td>
<td>100</td>
<td>0</td>
<td>40</td>
<td>0</td>
<td>0</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Table 8.1: Approximate market shares of non-GEANT Association member countries (%) (no survey response received for this question from TAREN.A (Tajikistan)

Figure 8.1: NREN traffic into GEANT [Source: Deepfield]
This chart shows the average traffic into the GEANT network from international research networks in Gbps. This data is the average for 30 days in Jan/Feb 2017. It includes both R&I and commodity IP.

Internet2 25G
ESnet 10.1G
CANARIE 1.9G
UBUNTUNET 579.4M
SINET 499.2M
ORIENTplus 474.9M
ASGC 391.4M
TRF 297.1M
NSN 132.2M
CLARA 104.3M
TEIN2 100.6M
KAUST 8.3M
QNREN 159.3K

All of these respondent NRENs connect universities, institutes of further education, research institutes, and libraries. A large majority are also eligible to connect primary and secondary schools. As discussed in Who Can Connect, for-profit organisations are, in general, not covered by the AUPs of these countries, (with the exception of New Zealand). This, as we’ve seen, is mirrored in the GEANT responses.

In addition to completing the Compendium survey, we asked NRENs about their views on future network development and services. The following quotes provide an indication of upcoming trends.

We see the growing demand for cloud services and the development of cloud carrier network service to enable access the services. Also to move big data, building the science-driven high-capacity data freeway like PRP and GRP is continuously required for supercomputers, big data centers, large-scale science facilities.

Buseung Cho, KREONET/KISTI

I think in the next 12 months there will be an increase in the use of massive cloud platforms for collaboration, the ‘XaaS’. Everything as a Service, and the use of big data in the educational environment.

Claudio Chacón, CEDIA
CANARIE’s stakeholders are asking us to support their use of cloud-based services, so providing connectivity to these vendors is a high priority. Security is also regularly discussed, and CANARIE and our partners are taking steps to strengthen the security position of Canada’s NREN.

Kathryn Anthonisen, CANARIE

We think the top-three trends across R&E networks over the next twelve months will be security, increasing use of cloud providers, and continual building of NRENs’ value proposition beyond connectivity.

Kim Partridge, REANNZ

The typical bandwidth of countries outside the GEANT Association member area is shown in Figure 8.3 and Table 8.2.

Figure 8.3: Connectionspeed

Table 8.2: Typical bandwidth

<table>
<thead>
<tr>
<th>Country</th>
<th>Typical speed</th>
<th>Highest speed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Australia</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Canada</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Tajikistan</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>New Zealand</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Sweden</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Greece</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Belgium</td>
<td>≤ 1 Gbps</td>
<td>≤ 10 Gbps</td>
</tr>
<tr>
<td>Japan</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Korea</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
<tr>
<td>Norway</td>
<td>≤ 1 Gbps</td>
<td>≤ 10 Gbps</td>
</tr>
<tr>
<td>Canada</td>
<td>1 Gbps</td>
<td>10 Gbps &amp; above</td>
</tr>
</tbody>
</table>

Note: Numbers represent institution types connected at each speed e.g. if Universities and Further Education institutions typically connect at 1 Gbps this is shown as a number 2. See table 8.2 for the different institution types.

Contact List

The list of GEANT Association Members and other international respondents below contains links to their respective websites.

<table>
<thead>
<tr>
<th>Short Name</th>
<th>Full Name</th>
<th>Country</th>
<th>Website</th>
</tr>
</thead>
<tbody>
<tr>
<td>AARNet</td>
<td>Australia’s Academic and Research Network</td>
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<tr>
<td>ACNet</td>
<td>Vienna University Computer Centre</td>
<td>Austria</td>
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</tr>
<tr>
<td>AIRERG</td>
<td>Akademiya mizhi Republike Sljepje / Universitet u Biogradu</td>
<td>Serbia</td>
<td><a href="http://www.airer.org.rs">www.airer.org.rs</a></td>
</tr>
</tbody>
</table>
Section 1

Federica Tanlongo holds an ICT Master’s degree in New Media and Communication from the “La Sapienza” University of Rome. Since 2004, she has been with GÉANT, where she currently holds the position of Communication and External Relations Coordinator. She has managed different campaigns and has developed the GÉANT brand. Federica is responsible for GÉANT’s communications and media relations activities, as well as for GÉANT’s social media platforms. Federica leads the GÉANT’s social and digital media strategy and has been instrumental in establishing and maintaining GÉANT’s public image and reputation in the European Research and Education domain. She has been a key player in the development of the GÉANT4 brand and has contributed to the successful framing and positioning of GÉANT. She is currently developing the GÉANT5 brand strategy and ensuring its effective implementation across GÉANT’s activities. She has managed a wide range of communication and media initiatives, including press releases, media briefings, media reports, and social media campaigns. She is a member of the GÉANT Community Engagement Board and is responsible for ensuring that the GÉANT community is well informed about the organization’s activities and services. She is also a member of the GÉANT Security Board and is responsible for ensuring that GÉANT’s security policies and procedures are effectively implemented. She is a member of the GÉANT Governance Board and is responsible for ensuring that GÉANT’s governance and decision-making processes are effective and efficient. She is a member of the GÉANT Management Board and is responsible for ensuring that GÉANT’s strategic goals and objectives are effectively implemented. She is a member of the GÉANT5 Management Board and is responsible for ensuring that GÉANT’s strategic goals and objectives are effectively implemented. 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The research leading to these results has received funding from the European Union’s Horizon 2020 research and innovation programme under Grant Agreement No. 731122 (GN4-2).

The GÉANT Compendium provides an authoritative reference source for anyone with an interest in the development of research and education networking in Europe and beyond. Published since 2000, the Compendium provides information on key areas such as NREN users, services, traffic, budget and staffing.

The GÉANT NREN Compendium may be found online at: https://compendium.geant.org/