GÉANT
PROJECT

CONNECT

SPECIAL EDITION

INNOVATION WITH IMPACT
AN IN-DEPTH LOOK AT GÉANT'S FIRST OPEN CALL

GLOBAL EARTH OBSERVATION:
Q&A WITH BARBARA J RYAN

ENABLING USERS:
EDUGAIN SUPPORTS COLLABORATION

STAFF SECONDMENT:
BROADENING STAFF HORIZONS

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CONNECT is the quarterly magazine from the GÉANT community; highlighting key areas of interest, updates on the project and its vital work supporting European research and education. We give insights into the users who depend on the network, and the community that makes GÉANT what it is. We welcome feedback at **connect@geant.net**

CONNECT magazine has been shortlisted for the 2014 CorpComms award for best not-for-profit publication.

WELCOME TO THIS SPECIAL EDITION OF CONNECT!

Launched in April 2013, GÉANT's first competitive Open Call was highly oversubscribed, attracting 70 project proposals across 18 topic areas. Rigorous and independent selection reduced this to the final 21 projects, each benefiting from EC funding to complement and enhance existing research carried out in GÉANT, but also bringing in fresh ideas and supporting innovative uses of the network.

In a special focus beginning on page 10, we look in more detail at the work that has been done by the projects and explain the wider GÉANT Innovation Programme in which these Open Call projects operate.

As part of our ongoing efforts to shine light onto the extraordinary users of GÉANT, we were honoured recently to catch up with Barbara J. Ryan, Secretariat Director of the intergovernmental Group on Earth Observations. Starting on page 6, you can read about her incredible job bringing together dispersed users from all over the world, as part of GEO's ongoing commitment to unify Earth Observation systems.

GÉANT is certainly a diverse and growing community. In our Community and Global sections you can read contributed articles from parts of this community across Europe and further afield as they proudly share their news. It's great to see so many of you getting in touch – please continue to do so!

Editors
Paul Maurice & Tamsin Henderson

We have more plans afoot for future issues of CONNECT, but in the meantime if you have news to share, or would like to comment specifically on topics in this issue, please let us know at **connect@geant.net**

CONGRATULATIONS TO GÉANT CEO, BOB DAY, AWARDED AN MBE

Jisc

Dr Bob Day, Executive Director, Janet at Jisc and currently Chief Executive Officer of GÉANT, has been awarded an MBE as part of the Queen's New Year Honours List 2015, for services to Information Technology.

Educated as a physical chemist, it was during Bob's postdoctoral research that his interest in the application of distributed computing to scientific research was first engaged. This led him to pursue a career in the development of research and education networking. CONNECT caught up with Bob to discover more about his journey to achieving this prestigious award.

TELL US ABOUT YOUR WORK WITH UK RESEARCH AND EDUCATION?

I first joined Jisc in 1991. At that time the concept of the internet and IP was just becoming established across European R&E (research and education) networks. My first job was to bring IP into Janet, replacing the old X.25-based protocols that had served us well but were running out of steam.

This opened up a whole world of collaborative opportunities for R&E in the UK. In those days even being able to email a colleague in another country was an achievement. Suddenly all sorts of new services became possible – the development of the web as an incredibly rich source of information, the ability to use computing and access data collaboratively - that were previously fraught with difficulties.

Since then I've worked on many projects to develop Janet's capabilities, such as to upgrade the network from the tens of Mbps we had then to the hundreds of Gbps we have now. I've also had a particular interest in developing Janet's's policy frameworks, so that it can serve as wide a range of users as possible.

Part of this has been extending Jisc's benefits to the wider R&E community across the UK – as a result Jisc now has a "footprint" of around 18m users, from children just starting school to researchers making breakthroughs in particle physics, cosmology or medicine.

But it's also been about enabling Jisc to support collaboration. Internationally, of course, but also nationally in providing connectivity and services, with sectors such as health and local government. This aspect continues with increased focus as the UK Government recognises just how important it is to the economy to have a powerful and flexible NREN. Something all members of GÉANT would agree with!

WHAT DOES THE AWARD RECOGNISE?

With over 20 years of involvement with Jisc, those who were kind enough to nominate me were also thinking of our latest major initiative to refresh the Jisc backbone – the Janet6 project. Really, the combined work of all my colleagues and collaborators – has been to make access to communications and computing services an entitlement rather than a privilege.

As a PhD student I spent many hours in libraries trying to find information, waiting for a journal to be returned, or writing to potential collaborators in the hope of receiving information – on paper and by post of course. That now seems ridiculous and it's clear we're on the cusp of a revolution in providing fast and reliable access to R&E data, wherever it is.

TELL US ABOUT YOUR ROLE AT GÉANT AND WHY IT IS AN IMPORTANT PART OF YOUR WORK?

My involvement with GÉANT has been as a director and Chair of DANTE (now GÉANT). I've led some important strategic developments, working with the management team. More latterly, I led merging DANTE with TERENA. Now I'm carrying out an interim Chief Executive role to ensure we continue the momentum generated by the merger whilst our new Board settles in.

The GÉANT network has always been important to Jisc. We firmly believe R&E education is a global activity, and that we can best meet our users' global needs through strong collaboration at a pan-European rather than bilateral level. So, for Jisc, GÉANT must continue to succeed, and I and other Jisc colleagues will continue to ensure this in the ways we best can.

My time working with the staff at GÉANT is a constant reminder of the professionalism and dedication everyone has to this collaboration. I feel very lucky to have been able to be a small part of that.

2015 COMMUNITY AWARDS: NOMINATIONS WELCOME

Nominations are invited for the 2015 research and education networking Community Awards. These awards are intended to show gratitude and respect to teams or individuals who have shared their ideas, expertise and time with the community, often voluntarily and through good will. Up to three nominees may be selected by a panel of judges from the GÉANT community. The winner(s) will be presented with a small personal gift on Thursday 18 June during the closing plenary session of the 2015 Networking Conference (TNC15) in Porto, Portugal. Nominations can be submitted online until midnight on 29 March.

The nomination procedure that was introduced and proved successful in 2014 has been slightly improved for this year, with fewer questions on the submissions form and a longer period in which to nominate candidates

WHO CAN BE NOMINATED?

Nominees should meet one or more of the following criteria:

- Has shared an idea with the community that developed into something significant such as a well-used tool or service
- Has made a significant contribution to a number of community activities over a sustained period
- Has made significant contributions to important/recognisable developments within the past 12 months.

Winners could be individuals or small teams of named individuals. Winning nominee(s) should meet the same affiliation requirements as those for people submitting nominations.

WHO CAN SUBMIT NOMINATIONS?

Nominations are welcome from:

- Staff employed or sub-contracted by: GÉANT Project partner organisations; GÉANT Association Cambridge or Amsterdam offices (formerly DANTE and TERENA); GÉANT Association member organisations (associates and national or representative members)
- National or continental research and education networking organisations from outside Europe
- Individuals who participate in one or more GÉANT Association task force(s) or other GÉANT activities, whether by attending meetings or simply being on the mailing list
- Other individuals who have registered to attend TNC15.

Picture
2014 awards: from left to right, Valentino Cavalli, Stefan Winter (winner), Dorte Olesen and Jan Meijer (winner)

A maximum of two submissions per person will be accepted; if more nominations are submitted, only the first two will be taken into account. Please remember to clear your browser's cache memory before submitting a second nomination.

HOW TO SUBMIT NOMINATIONS

Nominations can be submitted using the online nomination form at **https://www.surveymonkey.com/s/9G3K3PG**.

BACKGROUND INFORMATION

Since 2012, TNC has been the place where public recognition has been given to members of the research and education networking community for their contributions to the development of relevant technologies and services or to collaborative community activities. These awards were introduced by TERENA (now the Amsterdam office of GÉANT) and received sponsorship from the GÉANT Project (managed by the Cambridge office of GÉANT, formerly DANTE) for the first time in 2014. This sponsorship primarily covers administrative costs and allows greater community say in the selection process by providing a judging procedure and a nomination system that invites nominations from and about people in Europe and other world regions.

If you have any queries, please contact: **pr@terena.org**

Information about past Community Award winners can be found at: **https://www.terena.org/about/people/awards/index.php**

GÉANT ACCELERATES EUROPEAN E-INFRASTRUCTURE AND EARTH SCIENCES PARTNERSHIPS

WORKSHOP OPENS DOOR TO BETTER COLLABORATION

On 22 and 23 January this year, GÉANT - in collaboration with European e-infrastructures EGI, PRACE and EUDAT - organised a knowledge-sharing workshop to increase dialogue with the Earth Sciences community.

The workshop, held in Amsterdam, brought together key Earth Sciences users and research infrastructures dedicated to solving some of mankind's most pressing issues.

The objective was two-fold.

• To better understand the requirements of the Earth Science community so that e-infrastructures can stay one step ahead of their needs.

• To develop and deepen a two-way dialogue so users are aware of the many e-infrastructure services and applications that can assist them in their work

With help from EIDA (European Integrated Data Archive), EPOS (European Plate Observing System) and KNMI (Royal Netherlands Meteorological Institute), the workshop addressed current topics of interest to the Earth Science community, such as Identity Management, AAI and eduGAIN; data management and computing and cloud services.

Key decision makers and scientists were represented from across the community, including: The British Geological Survey, satellite data (COPERNICUS), Solid Earth Science and computational seismology and climate organisations.

BENEFITS AND OUTCOMES

Users took away a much clearer view of the services available to them through e-infrastructures. Likewise, the e-infrastructures now have a better understanding of how Earth Sciences users and associated projects and infrastructures work - and the issues they face.

WHY GÉANT?

GÉANT is a flagship European e-Infrastructure, key to keeping Europe at the forefront of the global research race. To do this, e-infrastructures must be supported. As the essential building blocks for Europe's Earth Science community, they enable the circulation of knowledge and the shared use of important ICT tools and resources.

The GÉANT project is well positioned to coordinate knowledge exchange between other e-infrastructures and their users. The workshop brings them one step closer to better supporting global research collaborations through a seamless, open space for online research.

As a result of the meeting, solid, co-ordinated actions, including deeper investigations in to data management and Cloud Services are already underway, with plans to further foster collaboration and communication between participants.

CATHRIN STÖVER ANNOUNCED AS FINALIST IN THE 2015 FDM EVERYWOMAN IN TECHNOLOGY AWARDS

C athrin is one of four finalists to be announced in the International Leader of the Year category in the prestigious 2015 FDM everywoman in Technology Awards.

As Chief International Relations and Communications Officer, Cathrin was nominated for her work supporting the global connectivity of GÉANT. Through this she is both supporting women and inspiring them – by delivering digital opportunities to a worldwide audience.

"Before you light a fibre, or set down a single line of code, you have to network people. This is what Cathrin does." Ann Harding, GÉANT Activity Leader.

The award calls for people who can demonstrate not only that their work is supporting women, but who can also act as powerful role models. The GÉANT project offers an excellent platform to promote women in technology. Cathrin's role very tangibly shows the value a career in IT can deliver to women, and to society as a whole, and this is a key driver in inspiring women into the sector.

Cathrin was selected after a rigorous interview process, during which she was evaluated by a panel of high profile technologists from across industry. She joins a strong category including senior execs from American Express, VMware International and Credit Suisse AGE.

The winner will be announced in London on 17th March. Find out more at **www.everywoman.com**

WHY THE AWARDS?

The British tech industry is thriving, predicted to be worth £221bn by 2016. As a result it is estimated that by 2022 the UK will need at least 1.82 million new engineering, science and technology professionals.

Advances in technology have created a huge variety of fascinating new careers from mobile technology to energy requirements. Yet despite this, only one in 20 IT job applicants is female according to half of tech employers.

The reasons for this are varied, but unhelpful stereotypes and low take up of STEM subjects in schools are regularly cited as reasons why the industry lacks gender diversity.

The tech industry is crying out for fresh talent with nearly half of all technology firms seeking to hire more staff.

Research shows that role models and opportunities to network are key to countering this talent deficit and the **FDM everywoman in Technology Awards** is the industry's most influential programme that both celebrates and inspires.

Q&A WITH BARBARA J. RYAN

Barbara J. Ryan is Secretariat Director of the intergovernmental Group on Earth Observations (GEO) in Geneva, Switzerland.

Barbara leads the Secretariat in coordinating the activities of 96 Member States, the European Commission and 89 Participating Organisations. Together they are striving to integrate Earth observations into decision making across nine societal benefit areas: agriculture, biodiversity, climate, ecosystems, energy, disasters, health, water and weather.

GÉANT is a Participating Organization in GEO, recently publishing a report on how research and education networks can support the EO community as part of the project's ongoing contribution. GÉANT's key role is in the establishment of a worldwide communications network; engaging with European Earth Observations infrastructures and collaborations to assess technical and user requirements.

CONNECT spoke to Barbara about the GEO initiative, its challenges, and her ambitious vision for the future.

LET'S START WITH SOME BACKGROUND...

The GEO Secretariat comprises about 20 people. Five or six of us are on contracts and the remainder are technical experts seconded for one to three years from Member government agencies and Participating Organizations (POs). We're small, and very thankful to the Members and POs for sending us their people.

GEO was initiated following the World Summit on Sustainable Development in 2002. Industrialised nations came together and said, 'Why don't we have a better overview of the environmental challenges facing our society? We see the benefit of coordinated Earth observations. Countries need to come together - give us a better picture of the global situation'.

This is what GEO is now doing. The project coordinates the establishment of a Global Earth Observation System of Systems (GEOSS), as part of a 10-year implementation plan (2005 – 2015).

In addition to our 97 Members and 89 Participating Organisations, last year we began engaging with the private sector. All are coming together in this collaborative platform with one common purpose: to ensure coordinated Earth observations are better used in policy decisions.

WHAT ARE YOUR OBJECTIVES?

To proactively link the many existing and planned Earth observation systems around the world and support the development of new systems. This will provide decision-support tools to a wide variety of users and we need to make sure they're used in tackling the major issues. How we do that is by advancing broad open data policies, building capacity all over the world - not just developed countries, and advocating sustained observation of the Earth.

WHAT ARE YOUR BIGGEST CHALLENGES?

The challenges we face are many. For instance, getting countries to want to work together; getting organisations to recognise that no single country or organisation can do everything, and that we are stronger working together than individually; creating a mutual understanding that the whole is so much more than the sum of the parts.

There are also declining financial resources across the globe and everyone is under tremendous financial pressure. Recognising that working together to leverage each other's resources is critical to our success is key. Sometimes organisations don't see that right off the bat.

Then there are the technological challenges. Though in some ways these are easier to deal with! GÉANT is in a great position to help us. You are a critical link that provides commonality between all the other Participating Organisations in Europe.

HOW DO YOU SEE GEO IN THE FUTURE?

We're interested in how our partners organise their communities and how we can leverage the work they are already doing. In the first half of GEO's first decade, we were trying to get a handle on the community, finding every data set and getting it registered to GEO. But the fact is, we don't have to track all that work!

Instead, we have started to rely on our partners to bring their own ecosystems to the table. So when I think about the future, it's really about leveraging the work everybody is already doing and placing a much heavier reliance on organisations for their coordination abilities. GÉANT for instance is doing a lot of coordination. I want to understand how we can better tap into that.

It's also about recognising we all have our individual strengths and weaknesses. Asking ourselves: how can the strengths of one shore up the weakness of another?

When we adapted something called a Discovery and Access broker (DAB) - we started entering into interoperability agreements with institutions to make it easier for users to discover and access data.

For instance, WMO (World Meteorological Organisation) has an information system contributed by member countries. So, rather than us getting those countries to register their data in our system, we thought: why don't we just do an interoperability agreement and make sure all data is discoverable and accessible through our

system? Because of this, users are now getting access to WMO data they didn't know existed and vice versa. It's a real win-win situation.

That's just on the infrastructure side. But I think the same thing can happen on the coordination side. How can we do interoperability agreements with our partners to leverage work they are already doing, rather than us trying to account for every last piece of it?

Our strength is in this convenient, active platform with the convening ability to bring governments, private sector and other partners together in a community not mandated by anyone.

WHAT DO YOU SEE AS THE MAIN VALUE OF RESEARCH NETWORKS SUCH AS GÉANT?

It would be leveraging those research networks and exposing the research networks that we have, just like in the WMO example. Clearly all your own partners know about them, but what about those people within our network, who don't? That's where the win-win would occur, because more exposure would be coming to our partners and our partners would be exposed to your network who might not know it existed before.

IS IT JUST ABOUT CONNECTIVITY? WHAT ELSE DO YOUR USERS NEED?

Connectivity really is core for us. Whether it's connecting data resources, existing infrastructures and systems, or

whether it's connecting communities - that really is our primary motivation. When we think about services and applications, we certainly see them as important, but we see those as downstream. We think they will occur naturally in the ecosystem when people can get access to the upstream elements. So, whether it's the universities or the private sector coming in, we really do think value-added products and services will be generated, but the connectivity to make sure people know about it, is what's going to be most important.

Issues of security, trust and identity are also vitally important, however GEO's main focus has to be on connecting our partners and encouraging them to share data sets. We expect the network to look after itself, so it's invaluable to have a partner such as GÉANT to whom we can entrust the movement and security of data, as well as trusted access to it.

WHAT WOULD YOU LIKE TO SEE FROM THE GLOBAL RESEARCH COMMUNITY?

In each of our societal benefit areas there are certainly specific needs. We're happy to call them gaps. We could go in and identify those specific areas, but let's bring it up a notch. Let's look at it across the entire area. What I'd like to see is a willingness to partner internationally; to expose some of the work people are doing to a broader audience, so that we could see more international collaboration.

Lastly, a willingness by our partners and contributors to describe their work in a way that policy makers might better understand. GEO needs to focus more of its attention on the 'so what' questions. Why is this important? That often requires someone from a communications perspective to get involved to translate and highlight this important work.

In a way it takes us back to the connectivity theme. It's connecting people in the research domain with communications teams that are generally a lot better at translating the importance of that work for different audiences.

ANYTHING ELSE YOU'D LIKE TO ADD?

GEO is making great progress and the energy is palpable. We're tapping in to it - but more needs to be done. We need to see more countries and organisations adopt broad open data policies and practices. I'm optimistic, but there are still many challenges and opportunities.

I'd also like to applaud the GÉANT community and the work you are doing. Your website is very clear, very comprehensive. You face many of the same challenges that we do. If we could leverage this to make sure our respective communities are working more closely together we would welcome that.

Read more about GEO:
**https://www.earthobservations.
org/index.php**

GEO was set up to coordinate international efforts to build a Global Earth Observation System of Systems (GEOSS). It links existing and planned Earth observation systems and supports the development of new ones.

The cross-cutting approach of GEOSS avoids unnecessary duplication, encourages synergies among systems and ensures substantial economic, societal and environmental benefits. For instance:

• Forecasting meningitis outbreaks
• Protecting biodiversity
• Improving climate observations in Africa
• Supporting disaster management in Central and South America
• Managing water resources in Asia
• Promoting solar energy
• Improving agriculture and fisheries management
• Mapping and classifying ecosystems

SPECIAL FOCUS
GÉANT'S FIRST OPEN CALL

Welcome to this special section of CONNECT, in which we focus on the results of the first GÉANT Open Call initiative and examine how, as part of the GÉANT Innovation Programme, these projects and their respective Joint Research Activities (JRAs) are driving innovation in several key areas. Open Call project partners were invited to submit brief technical papers, which have been reproduced in the following pages to provide a snapshot of the innovative work being funded by GÉANT.

We asked Dr Michael Enrico, Technical Coordinator for the GÉANT Project, and Annabel Grant, Coordinator of the Open Call initiative to give some context.

THE NEED FOR INNOVATION

The Internet and the World Wide Web have their origins in the research and education (R&E) networking environment, and as a community we can be proud of that. However whilst the success of the Web has attracted enormous investment, R&E funding for research has been heavily out-spent by commercial new technology start-ups.

Network operators face a range of disruptive new technologies that have come out of the technology start-up culture. The rise of networking on mobile devices, the explosion of social networking and cloud computing are just some examples. Further, the move towards streaming of HD video and the rapid expansion of 'big data' challenge networks with what has been termed a 'data deluge'. The R&E networking world is no exception and accordingly this rapidly evolving technology environment and the service expectations of our user community are placing greater demands than ever on research networks. All of these challenges require a fresh look at how networks are delivered and managed.

A key remit for National Research and Education Networks (NRENs) is to stay at the forefront of ICT innovation. NRENs need to be generators of innovative new ideas and technologies and early adopters. It has become increasingly difficult for NRENs to embrace this at the same time as managing a wider portfolio of services and networks which have evolved to the point where they are now essential parts of the ICT infrastructure supporting the European Research Area.

Therefore R&E networks are increasingly feeling the consequences of funding constraints and are often faced with difficult decisions as to how much of their valuable people resource they put into the day-to-day provision of high quality production network services versus how much they assign for creating innovation in networking.

MICHAEL ENRICO – TECHNICAL COORDINATOR

"The e-infrastructure known as GÉANT (the combination of the NRENs and the GÉANT network backbone) has become mission critical to the research and education user community all over Europe. The survival of GÉANT is dependent on our ability to continue innovating."

WHAT IS AN OPEN CALL?

An Open Call is an EC-funded process to enable a fully transparent evaluation and selection of projects. As part of the GÉANT Innovation Programme, the Open Call initiative has been used to enhance and complement the existing research performed in GÉANT, bringing in fresh ideas and supporting new and innovative uses of the network. There are 21 projects within the GÉANT Open Call initiative – each aligned to one of the GÉANT joint research activities. Open Call projects sit within one of four subject areas:

• *Applications and Tools* – supporting advanced research activities and projects.
• *Authentication* – helping support secure end-to-end authentication of systems and people.
• *Network Architecture and Optical Projects* – studying future networking systems.
• *SDN* - exploring Software Defined Networking potential to meet new networking demands.

GÉANT INNOVATION PROGRAMME

It was into this environment that GÉANT launched its Innovation Programme – an umbrella programme and a funding mechanism to provide a way for the wider community to pool resources and collaborate on the researching and developing of innovative technologies that address the future needs of the community and its users.

The programme consists of the R&D work carried out within the GÉANT project by participants in the Joint Research Activities (JRAs); Task-Forces and Special Interest Groups which include experts from outside the project; and the GÉANT Open Call projects.

AN OVERSUBSCRIBED SUCCESS

The first GÉANT Open Call was launched in April 2013 utilising €3.3 million of funding from the EC Framework 7 programme to enable and support:

• new users and use cases for GÉANT project facilities (for example, testbeds)
• researchers working with GÉANT to undertake specific pieces of R&D work
• the future evolution of Research & Education networking

The call was highly oversubscribed with a total of 70 project proposals received across 18 topic areas. Following a rigorous evaluation process by a panel of independent academic and industrial researchers, 21 innovative projects were selected for funding and a total of 30 new partners from across Europe joined the GÉANT project consortium.

Indeed, the Open Call projects are in many cases closely tied into the work done in the JRAs and the technical coordination of these Open Call projects comes from within the JRAs. In several cases the Open Call projects are undertaking packages of R&D that have been specifically requested by the JRAs.

The funding supports these projects in their cutting edge research into advanced networking technologies, in turn paving the way to the next generation of services, applications and uses for networking and thereby supporting the aims of Horizon 2020 and the challenges of the data deluge.

It is expected that more than 20 papers will be published in peer reviewed journals as a direct result of the first GÉANT Open Call. We see this as a big step forward for innovation in GÉANT and we are very pleased with the research that has been delivered during the last two years of the GÉANT project through the Open Call initiative. We hope this special focus provides a brief snapshot of this innovative work, the effects of which we may come to see in the near future.

OPEN CALL HOT TOPICS

SOFTWARE DEFINED NETWORKING (SDN)

Broadly the SDN concept moves the control plane out of routers and switches and into a centralised application, allowing software developers to create new applications to control the network that are no-longer tied to slow-moving networking protocol standards, and enabling the rapid development cycles seen in software applications to be applied to the network. This has been made possible by the introduction of Application Programming Interfaces (APIs) which allows applications to control the network layer, typically forwarding engines in routers. Several of the Open Call projects are actively researching new innovations in SDN controllers to solve a range of networking challenges.

FEDERATED AUTHENTICATION INFRASTRUCTURES

The proliferation of web-based services has resulted in users needing to record dozens of passwords, and federated authentication is an area where the R&E community continues to lead the way with eduGAIN, proving an important tool in supporting a seamless federated identity system for Universities and other institutions. Open Call projects are looking at ways to enhance the R&E community's identity federation infrastructure.
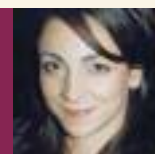
OPEN CALL: ADDING VALUE TO THE GÉANT PROJECT

LICIA FLORIO – IDENTITY AND TRUST TECHNOLOGIES

"For me, the added value of the Open Calls is twofold: first to enable organisations, not always closely affiliated with the NRENs, to participate and second to have a clear focus on a technical topic and carry out in-depth research - even if this is on a cutting edge topic. This has been something that has been difficult for us to achieve in the past".

AFRODITE SEVASTI – TECHNOLOGY TESTING FOR SPECIFIC SERVICE APPLICATIONS

"Several of the Open Call projects are making use of the GÉANT OpenFlow Facility (GOFF). Bringing together the GOFF and the Open Call research experts has facilitated novel SDN research. The strong two way exchange between JRA2 participants and the Open Flow SDN researchers has been very fruitful for all partners. For example, the JRA2 Subject Matter Experts have been able to work closely with the CEOVDS team to engineer specialized GOFF capabilities to meet their requirements."

TONY BREACH – NETWORK ARCHITECTURES FOR HORIZON 2020

"Our engagement with the IRINA Open Call project has brought a new level of research innovation to GÉANT. Furthermore, we are excited about research within Open Call projects that brings us closer to the ideal of zero-touch network access."

For more information on GÉANT Open Call see
www.geant.net/opencall

CLASSe
CLOUD-ABFAB FEDERATION SERVICES IN EDUROAM

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Abstract—To investigate the use of Application Bridging for Federated Access Beyond web (ABFAB) technology for Cloud services and VO management.

Index Terms—Cloud, ABFAB, identity, SSO, VO

I. INTRODUCTION

GN3plus open call CLASSe [1] aims to improve user experience when accessing Cloud services over the GÉANT network, integrating ABFAB technology [2] with OpenStack [3] to provide federated, authenticated and authorized access based on the existing AAA eduroam infrastructure. Additionally, CLASSe improves this access in two directions. First, enabling real Single Sign-On (SSO) to provide quick access to Cloud services based on previous authentications (cloud-to-cloud and network-to-cloud SSO). Second, designing solutions to support the dynamic formation of Virtual Organisations (VOs), so that any user will be able to form their own VOs for access to their own private Cloud.

II. ABFAB AND OPENSTACK AND SSO

ABFAB proposes a new GSS-API mechanism based on the Extensible Authentication Protocol (EAP) named GSS-EAP [4]. It allows the authentication of the application client using a deployed AAA infrastructure, providing the application server with the outcome of the process and a SAML [5] assertion containing the client's identity information used for authorization. CLASSe has integrated ABFAB technology in the OpenStack Keystone module. In this manner, if user Alice has credentials in the eduroam infrastructure [7], she can potentially access any OpenStack cloud service provided by any other Institution in the federation (1).

However, one of the problems of ABFAB integration in cloud access is that it must be performed via a lengthy authentication process each time the user tries to access the cloud. Moreover, it implies that the user must re-introduce his long-term credentials for each access request.

Let us imagine that Alice, belonging to Institution-A, has successfully authenticated to access the network at Institution-B, through eduroam (1), using her long-term credentials. Afterwards, Alice decides to access CloudProv1 in Institution-B. This second access (2) should not require Alice to introduce her credentials again (network-to-cloud SSO). Moreover, Bob, belonging to Institution-A, has been successfully authenticated and authorized to access CloudProv2 in Institution-C (3) by means of ABFAB, using his credentials. When Bob access to CloudProv1 in Institution-B, this second access (4) should not require him to introduce his credentials again (cloud-to-cloud SSO).

In order to provide real SSO, CLASSe proposes to extend ABFAB to include support for ERP (EAP Reauthentication Protocol) [8]. This allows one round-trip authentication in a straightforward way, providing an improved performance and resource utilisation. By means of caching, it is also compatible with the authorisation process carried out in ABFAB.
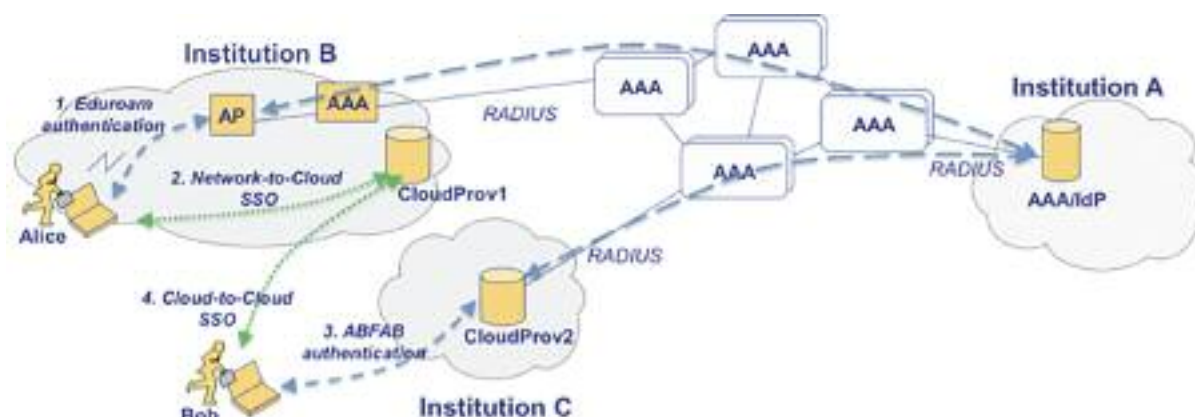
Figure . ABFAB integration with OpenStack

III. VIRTUAL ORGANIZATIONS

Once users are able to easily and securely access cloud services via eduroam, the next thing they need to do, is authorize their colleagues to access their cloud services. In ABFAB, authorization is carried out via SAML assertions sent by the user's Identity Provider (IdP) to the cloud service. The assertion provides the user's identity attributes such as those defined in eduPerson [9]. These are typically stored in or derived from the user's entry in the IdP's LDAP database. Herein lies a problem. Users are not allowed to alter their LDAP entries, and therefore they cannot change the identity attributes that their IdP asserts. So how are users able to authorize each other to access their cloud services, so that different users have different access rights? The solution used by grids is the Virtual Organisation (VO) [10] in which different users have different VO roles. Since OpenStack already uses Role Based Access Controls (RBAC) then this fits perfectly with VOs. We have implemented the ability for a user, who is the administrator of his own cloud resource (i.e. a tenant) to invite other users to join his VO in a particular role, and to give these VO roles different access rights to his cloud resources. In this way, users are able to authorize each other to access their cloud resources in different ways, without needing to change their IdP's configuration.

IV. OUTPUTS AND FUTURE WORK

To achieve the aforementioned objectives, CLASSe is working closely with standardization and open-source groups. Regarding ABFAB and SSO, we are collaborating with the ABFAB and RADEXT IETF's WGs. Regarding VOs, we are deeply involved in the OpenStack Keystone working group. Our work on federation means that support for ABFAB/Moonshot will be built into the Kilo core release of OpenStack, whereas support for VOs is likely to be an easily supported extension.

ACKNOWLEDGMENT

REFERENCES

[1]   CLASSe project: http://www.um.es/classe
[2]   IETF ABFAB Working Group: https://datatracker.ietf.org/wg/abfab/charter/
[3]   OpenStack, http://www.openstack.org
[4]   S. Hartman and J. Howlett. A GSS-API Mechanism for the Extensible Authentication Protocol. IETF RFC 7055, December 2013.
[5]   S. Cantor, J. Kemp, R. Philpott, and E. Maler (Eds.). Assertions and Protocols for the OASIS Security Assertion Markup Language (SAML) v2.0, March 2005.
[6]   The Moonshot Project. https://community.ja.net/groups/moonshot
[7]   eduroam (education roaming), url: http://www.eduroam.org
[8]   Z. Cao, B. He, Y. Shi, Q. Wu, G. Zorn. EAP Extensions for the EAP Re-authentication Protocol (ERP). IETF RFC 6696. July 2012.
[9]   https://www.internet2.edu/media/medialibrary/2013/09/04/internet2-mace-dir-eduperson-201203.html
[10] Alfieri, R., Cecchini, R., Ciaschini, V., Dell'Agnello, L., Frohner, A., Lorentey, K., Spataro, F., "From gridmap-file to VOMS: managing authorization in a Grid environment". Future Generation Computer Systems. Vol. 21, no. 4, pp. 549-558. Apr. 2005

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HEXAA: HIGHER EDUCATION EXTERNAL ATTRIBUTE AUTHORITY

ATTRIBUTES FOR COMMUNITIES

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Abstract—I. Higher Education External Attribute Authority (HEXAA) is an attribute authority that is designed and implemented for the international research and education community. HEXAA can be used as a service deployed for a variety of communities, as a national service or as a service at eduGAIN level. HEXAA provides virtual organization management for SAML2-based identity federations. It supports very fine-grained role-based access control to services with delegated management. One of the unique features of HEXAA is the support of user profile management, and the ease with which users can manage their consent to release of attributes. HEXAA's backend has a well-defined API to streamline integration with legacy or custom environments. The software components of HEXAA are available on GITHUB as "hexaaproject".

Index Terms—SAML, identity federation, attribute authority, group management, authorization

I. INTRODUCTION

Institutional access control traditionally relies on centralized, in-house authentication and authorization backend systems. SAML-based identity federations have successfully extended institutional authentication to services that can be shared between organizations. Several studies [1] have shown that simple federated authentication is far from sufficient for typical research communities. They need information that is relevant to a person's role within the community rather than to organizational identity; therefore, this information should not be managed and provided by either the home organization or by the Identity Provider (IdP). While communities still want to rely on home organizations for authentication, identity federations are typically extended by deploying external attribute providers.
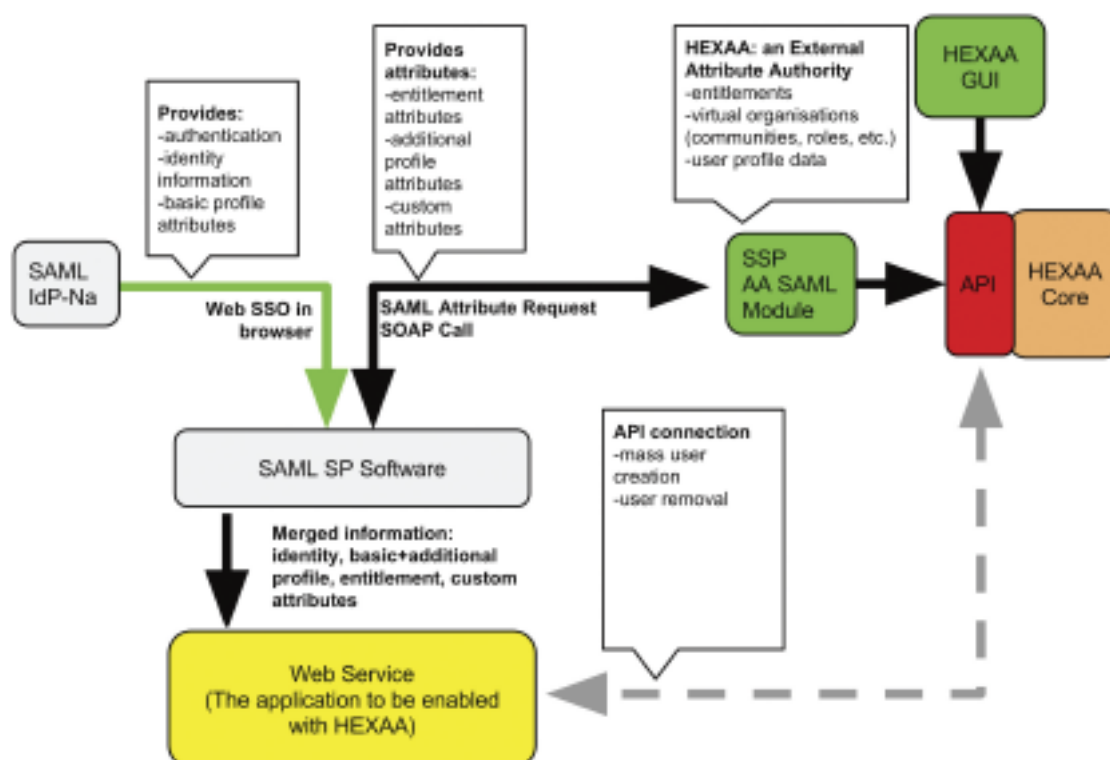
II. FEATURES AND DETAILS

HEXAA is designed to be lightweight, flexible and easy to use. In this sense, our aim is to replicate the success of simpleSAMLphp [2]. It is written in PHP and uses simpleSAMLphp for implementing its SAML Attribute Query [3] Interface, while it relies on Symfony [4] and AngularJS [5] to implement its web interface. HEXAA is intended to be a complementary, easy-to-manage tool for federations.

A key feature of HEXAA is that it enables storage and release of profile attributes. While most virtual organization software assumes that all profile data are released by the IdPs and only group information has to be communicated on top of these, in HEXAA an arbitrary number of user attributes can be managed. This is very helpful in an environment where IdPs are only releasing basic information.

HEXAA is very flexible in handling group information. In HEXAA, everyone can create any number of virtual organizations, with an arbitrary scheme of roles within these. The services are able to define precisely which users and virtual organizations are allowed to release attribute values and authoritative information to them.

The HEXAA core, the main component of the system, implements an API that makes all of HEXAA's functionality accessible. The HEXAA GUI relies solely on this API, so new custom interfaces can be created as a replacement of HEXAA default UI. The API implements functions to handle level of assurance (LoA) of attributes and provide it to service providers.

III. INTEGRATED APPLICATIONS AND OPERATIONAL STATUS

We have integrated a number of applications with HEXAA. Drupal [9], the portal system, is able to use profile and group information from HEXAA. Similarly Liferay [6] and the WS-Pgrade / GUSE portal [7] are integrated. HEXAA also supports MediaWiki, pydio [10] and others. The OpenNebula cloud frontend [8] has long been supported with HEXAA and OpenStack HEXAA integration is being implemented. The High Performance Computing portal of NIIFI uses the API interface of HEXAA and, for POP inventory management Racktables has already been integrated with HEXAA.

HEXAA runs as a production service in the EduID.hu Federation and it can be integrated into eduGAIN trivially. The HEXAA software [12] is open source, so an international research community can decide whether to implement their own instance or use HEXAA as an eduGAIN virtual organization platform.

IV. HEXAA IN CONTEXT

In compliance with EU privacy principles, the user can control which information can be released to which services. When HEXAA was designed, the legal aspects, including the TERENA Code of Conduct [15], were analyzed in order to be fully aware of the legal requirements for external attribute authorities. Since then, several cross-checks have been made all the way down to the level of database fields to fine tune the implemented code so that it fully conforms to the legal framework.

Collaboration of attribute authorities is a terra incognita, though the very first steps have been taken with PERUN [11], Unity [13], and OpenConext [14].

V. CONCLUSIONS

We have been using HEXAA at EduID.hu with great success. The analysis of use-cases, legal environment and real world requirements proved to be a good foundation for the project. The HEXAA team is happy to share the results of this GN3plus project with similar efforts with a broader community.

REFERENCES

[1] Federated Identity Management for Research Collaborations Author(s) Broeder, Daan (MPI) ; Jones, Bob (CERN) ; Kelsey, David (STFC) ; Kershaw, Philip (STFC) ; Lüders, Stefan (CERN) ; Lyall, Andrew (EBI) ; Nyrönen, Tommi (CSC) ; Wartel, Romain (CERN) ; Weyer, Heinz J (PSI, Villigen) Imprint   23 Apr 2012. - 17 p. /CERN-OPEN-2012-006/

[2] https://simplesamlphp.org/

[3] http://en.wikipedia.org/wiki/SAML_2.0#SAML_Attribute_Query

[4] http://symfony.com/

[5] https://angularjs.org/

[6] https://github.com/mheder/liferay-shibboleth-plugin

[7] http://guse.hu/about/architecture/ws-pgrade

[8] https://github.com/burgosz/opennebula-sunstone-shib

[9] https://www.drupal.org/project/shib_auth

[10] https://github.com/burgosz/pydio-shibboleth

[11] http://perun.cesnet.cz/

[12] https://github.com/hexaaproject

[13] http://www.unity-idm.eu/

[14] https://www.openconext.org/

[15] https://wiki.refeds.org/display/CODE/Data+Protection+ Code+of+Conduct+Home#DataProtectionCodeofConduct Home-NormativeDocuments

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MEAL: MULTIDOMAIN EDUROAM ACROSS LTE
SATISFYING THE APPETITE FOR MOBILE CONNECTIVITY

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The continuous evolution of mobile access technologies is radically transforming the world around us, making 'always on' connectivity an indispensable part of our daily life. This impact is particularly apparent in the education sphere. Thanks to a proliferation of choice of mobile devices, nowadays more and more staff and students bring their own devices onto campus, and demand pervasive network access. eduroam meets this need for high speed Internet connectivity through a manageable service in participating institutions by using a federated authentication approach. However, students' appetite for connectivity goes beyond the campus premises, demanding seamless connectivity and access to learning resources anywhere, anytime, across any device. 3G connectivity has been used by mobile users in the absence of any wired or Wi-Fi connectivity. However, its speed was not sufficient to deliver a truly compelling education experience from applications. In contrast, 4G technologies with its simplified packet architecture can complement Wi-Fi, leveraging the wider coverage of the mobile networks. Furthermore, the

features provided by LTE open up the opportunity to integrate mobile operators' infrastructure with that of an NREN to offer a better user experience.

Multidomain eduroam Across LTE (MEAL), a joint project between Janet and Surfnet, is exploring the possibility of using eduroam-like authorisation mechanisms to grant access to an LTE-based radio network, to bring the ease of using eduroam for mobile connectivity to locations off-campus where only cellular data provision is available. The work, funded by GEANT as part of the GN3plus project Open Call, is a proof of concept for an international deployment of this idea. The primary phase of the project, the national deployments of an eduroam-enabled LTE network in the UK and Netherlands have been completed [1, 2]. Both scenarios use the NREN infrastructure to route the users' traffic, received via an LTE access network, to the Internet or the local institution network as required. The final stage of the project deals with the challenges of international roaming between these two countries. As a prerequisite for realising this objective the required international roaming agreements have been put in place between the selected mobile operators, allowing users from each operator to access to a mobile data network of the visited operator. Regarding traffic routing, the use of a local break-out mode has been agreed between both operators. When this mode is enabled by the home operator by making the necessary changes in the user's profile stored in the Home Subscriber Server (HSS), the visited operator can provide users with direct access to the service, routing traffic through its own Packet Gateway (P-GW) on to the visited NREN's network infrastructure. According to this scenario, traffic from a SURFnet user with the chosen mobile operator SIM whilst roaming in UK on the UK mobile operator network, will have local breakout on its network to Janet (see the figure below). Similarly, the same mechanism would apply for Janet users roaming in the Netherlands. Although this is in contrast with the default Home Routing mode wherein the user's access to
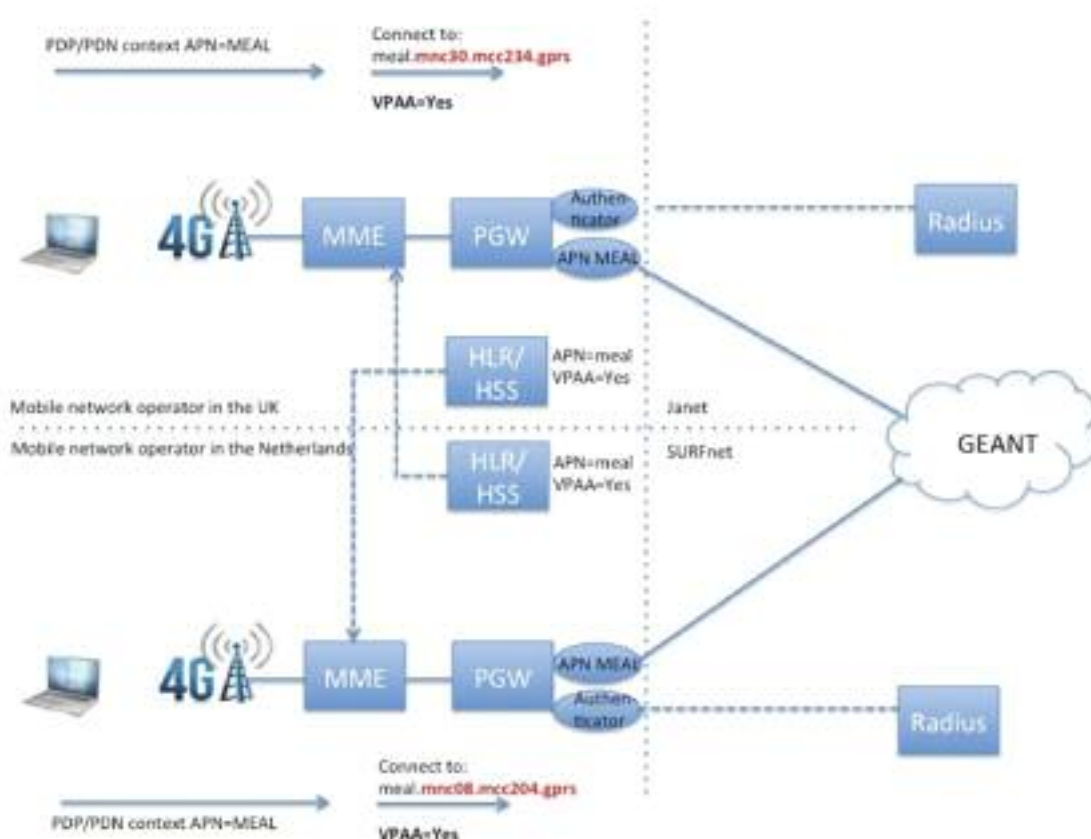
Figure 1 Users roaming between countries

service is provided by the home operator and home NREN, the roaming policy chosen for MEAL is in line with the EC current principle for roaming unbundling for Internet access.

NRENs offer a competent and reliable fixed infrastructure, and this has been sufficient to serve the community needs well for several years. However, the evolution of both wireless technologies and education practise both leading to a move away from the classroom and other fixed locations for teaching and learning delivery, mean that this is no longer enough. If integration with truly mobile technologies is not addressed, NRENs will lose great opportunities to other competitors, including the mobile/fixed network operators, in providing mobility-based services that meet our community's needs. The deliverables from the MEAL proof of concept can be used to facilitate this integration. Having proved the technological

feasibility of the solution, the opportunity exists to redeploy the design used, the processes run and the lessons learnt among other NRENs ultimately to create a truly pan-European 4G roaming solution for education.

REFERENCES

[1] E. Mirzamany and M.O'Leary, "Deliverable <4.1/MEAL>: Milestone 4.1 Janet National deployment", GN3plus MEAL14-WP4, 2014
[2] F.Panken, E.Mirzamany "Deliverable <2.1/MEAL>: Milestone 2.1 Consolidated Deployment Plan", GN3plus MEAL14-WP2, 2014

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SENSE – SECURE ENTERPRISE NETWORKS SIMPLE AND EASY
RESULTS OF THE GÉANT OPEN CALL #16

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Abstract—The SENSE Open Call project was created to improve security, usability and feature completeness of a cornerstone of eduroam and other Enterprise-class Wi-Fi networks: IEEE 802.1X supplicants. This paper presents the findings and actions taken by the project to date.

Index Terms—eduroam, IEEE 802.1X, EAP, supplicant, network, security, authentication, authorisation

I. INTRODUCTION

The IEEE standards IEEE 802.11 [1] and IEEE 802.1X [2] („Enterprise Wi-Fi") are in wide use to secure Wi-Fi networks that require maximum security.

The advantages of Enterprise Wi-Fi are manifold, most strikingly mutual authentication (users can verify that they are connecting to the genuine network before transmitting their credentials to that network), individual encryption keys per user for increased privacy and security on the wireless medium, and the ability to use credentials on more than one network (roaming).

The benefits of Enterprise Wi-Fi deployments depend greatly on software on the end-user device, the so-called „supplicant". Implementations need to offer all security relevant settings, ideally in an easily understandable and mostly automated way, and users need to comprehend and configure these settings to match the deployment's security parameters.

There are a wide variety of supplicants, and their capabilities and user-friendliness vary greatly. The SENSE project improves security and usability of supplicants, tackling the problem space from numerous angles.

II. SENSE WORK AREAS

SENSE approaches the problem space from four distinct angles. The four work areas are:

- Creation of a test and verification laboratory for EAP supplicants: EAPLab (1)
- Definition of quality criteria and subsequent assessment of EAP supplicants using EAPLab (2)
- Improvement of existing EAP supplicants regarding the defined quality criteria (3)
- Definition of a standardised EAP configuration file format for industry-wide use (4)

The work area descriptions and links to the results as discussed below can be found on the SENSE homepage at [3].

III. DESCRIPTION AND RESULTS IN THE WORK AREAS

(1) The test lab „EAPLab" is complete. It is accessible and usable without any authentication for any interested party (in particular EAP supplicant code authors) to verify proper operation of their supplicant against a „default" scenario (well-configured, genuine server). After an optional authentication, users can configure EAPLab to produce many non-default situations such as simulating a rogue network attacker, unresponsive or badly responding authentication server, etc. With this extended testing capability, the reaction of a supplicant to many situations can be tested with minimal effort (switching between scenarios is done with one click and with sub-second reconfiguration delay). Access to EAPLab is at [4].

EAPLab has already proven to be a valuable platform where network administrators tested client devices, and developers tested many aspects of their code. As an example, the Slovenian EAP supplicant ArnesLink was developed against the EAPLab test cases, the popular wpa_supplicant uses EAPLab as part of its conformance testing, and EAPLab users were able to file easily reproducible bug reports on commercial supplicants with EAPLab, with the result of those bugs being fixed (Apple iOS and Mac OS).

(2) SENSE has defined 29 criteria for supplicants in its metric: security (9 criteria), user-friendliness (14 criteria) and implementation feature-completeness (6 criteria). The evaluation of supplicants against these criteria is underway.

Target platforms to be tested include:

- PrivatOS 1.0 (done, tested on a Blackphone)
- Android 5.0 (tested on a Google Nexus device)
- iOS 8.x (tested on an iPad Air)
- BlackBerry OS 10 (tested on a Blackberry Z30)
- MacOS X 10.10 (tested on a MacBook Air)
- Several Windows versions (details TBD)
- Detailed results of the device evaluations will be available by the end of the SENSE project (03/2015).

(3) The work on supplicant improvements is currently ongoing. There are three target platforms for the improvements:

- Android 4.3+: expose all security parameters which the API provides to the user; enable Android to consume EAP configuration files which allow semi-automatic configuration of all necessary parameters without user interaction (using the configuration file format from (4) below). This is realised by writing a specialised „eduroam CAT" app.
- Plasma NM (KDE): improve user-friendliness of the interactive configuration in the supplicant by delivering a more consistent user interface
- Linux: write a wrapper for consumption of EAP configuration files and subsequent semi-automatic installation for various back ends (e.g. NetworkManager, raw wpa_supplicant), using the configuration file format from work item (4) below.

(4) SENSE has created a file format with all relevant configuration details that are needed for a secure deployment of EAP on end-user devices. The file format has been submitted to the Internet Engineering Task Force (IETF) for consideration as a Proposed Standard. The topic has been discussed in the Operations & Management Area (OPS) and has been refined to use the IETF's new network configuration language „YANG" (which automatically yields representations in the popular formats XML and JSON) in the draft's newest revision. It is available at [5].

IV. SUMMARY

The SENSE project provides a significant benefit for developers and administrators in the network access niche of the IT industry by having created tools to verify operations and performance of EAP supplicants, by providing metrics to assess security and usability, and by providing guidance and standardisation for the industry regarding network authentication configuration metadata. Many of its ideas and results are genuinely new and push the envelope in this area of the IT industry.

V. COPYRIGHT

ACKNOWLEDGMENT

REFERENCES

[1] IEEE 802.11-2012, IEEE Standard for Information Technology - Telecommunications and Information Exchange between Systems - Local And Metropolitan Area Networks - Specific Requirements Part 11: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications, 2012

[2] IEEE 802.1X-2010, IEEE Standards for Local and Metropolitan Area Networks: Port based Network Access Control, IEEE Std 802.1X-2010, 2010.

[3] S. Winter, T. Wolniewicz, M. Wolniewicz, et. al. Secure Enterprise Networks Simple and Easy (SENSE). https://www.supplicants.net . 2014.

[4] S. Winter, T. Wolniewicz, M. Wolniewicz, et. al. Secure Enterprise Networks Simple and Easy (SENSE) – EAPLab. https://eaplab.supplicants.net . 2014.

[5] S. Winter. „Internet Engineering Task Force - A Configuration File Format for Extensible Authentication Protocol (EAP)". https://tools.ietf.org/html/draft-winter-opsawg-eap-metadata-01 . Work in Progress. October 2014.

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GÉANT-TRUSTBROKER: DYNAMIC VIRTUAL FEDERATIONS

CLOSING THE GAP BETWEEN NREN FEDERATIONS AND EDUGAIN

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Abstract—GÉANT-TrustBroker puts users in control of accessing remote services with their home organization's credentials across NREN federations' borders. It allows international research projects to easily set up virtual federations and prepares the involved organizations to join eduGAIN.

Index Terms—Federation, Identity Management, Inter-Federation, SAML, Metadata.

I. INTRODUCTION

Federated Access Management (FAM) is an elegant solution when users from several organizations, referred to as identity providers (IDPs), need access to common IT services, which are operated by a so-called service providers (SPs). SPs can delegate user authentication and authorization to the IDPs; this means that SPs do not need to manage their own user database and users can access services with their IDP credentials in a single sign-on fashion. This saves costs and increases usability at the same time.

Technically, FAM requires that IDPs and SPs know details about how to communicate with each other, typically based on the Organization for the Advancement of Structured Information Standards (OASIS) Security Assertion Markup Language (SAML) standard. European National Research and Education Networks (NRENs) have successfully established national federations in the past decade to facilitate the exchange of this so-called SAML metadata and to foster the trust-building process between IDPs and SPs. Unfortunately, national federation borders hamper collaboration, e.g., in international research projects, which has motivated the eduGAIN inter-federation approach, which is one of GÉANT´s flagship services.

Although eduGAIN is remarkably successful, it comes with a few challenges that cannot easily and quickly be solved in practice: Joining eduGAIN must be triggered by each SP or IDP as a whole, comes with certain contractual and organizational overhead, and exchanging user information across federation boundaries is often limited to what could be called the greatest common denominator of all national federation user data schemas. Smaller international research projects, however, often want to get up and running with minimum organizational overhead and exchange user information whose data format has not yet been standardized internationally.

II. GÉANT-TRUSTBROKER

ÉANT-TrustBroker (GNTB) [1] therefore complements eduGAIN by providing a new technical service that allows users, not only IDP or SP operators, to connect SPs to their IDPs in what is called a dynamic virtual federation. GNTB triggers the required SAML metadata exchange between the relevant IDPs and SPs. It also provides a mechanism for user attribute conversion in case that a pair of IDP and SP does not use the same data format. GNTB therefore automates the required technical steps for setting up the successful communication between IDPs and SPs, which is a tedious task that had to be done manually previously. However, it covers the technical aspects only. Depending on the users' and organizations' requirements for contractual agreements, using GNTB is only intended as a quick first win on the longer road to join eduGAIN.

The GNTB protocol [2] is an extension to SAML, which has been submitted to the Internet Engineering Task Force (IETF) for standardization in June, 2014. In a GN3plus Open Call project, the new GNTB service along with its functionalities for exchanging SAML metadata and converting user attributes is specified in detail and a proof-of-concept based on the open source Shibboleth software is implemented. GNTB-supporting versions of the Shibboleth IDP and SP software will be made available and serve as the basis for preparing GNTB for production use in the upcoming GN4 project.
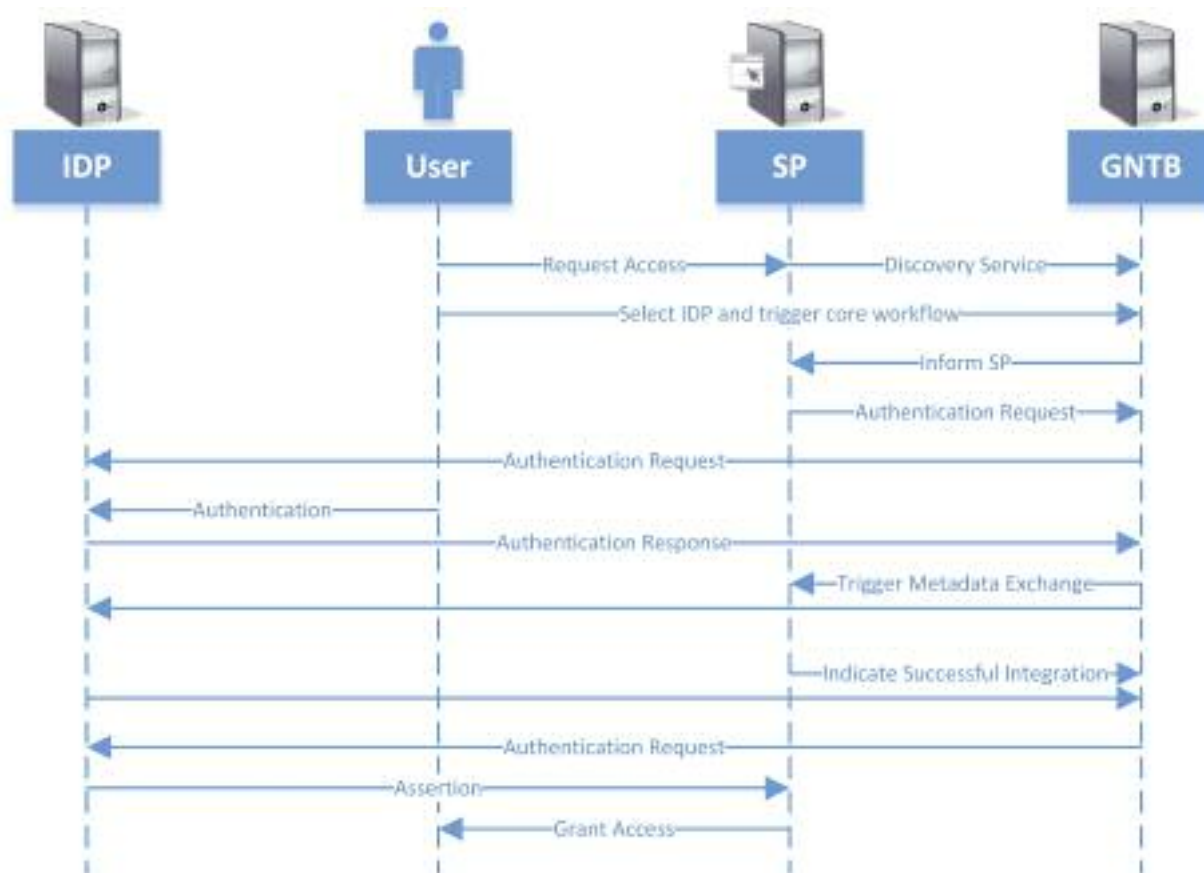
Figure 1: GÉANT-TrustBroker core workflow

Figure 1 gives an overview of the so-called GNTB core workflow [3]. The user experience when using GNTB is almost identical to using the well-known discovery services (a.k.a. Where Are You From?) of NREN federations and eduGAIN. IDPs and SPs need to indicate their preparedness for using GNTB by performing a one-time registration on the GNTB website. Any further actions, such as updating an IDP´s or SP´s SAML metadata, can be fully automated by using a small set of simple command-line tools that are also developed as part of the prototype. User attribute conversion rules created by other IDPs can be re-used, so manual intervention is only necessary when a new user attribute is required to use a SP but the IDP can neither provide it out-of-the-box nor use any of the already existing conversion rules.

III. CONCLUSION AND OUTLOOK

The GÉANT-TrustBroker project has published several papers for both scientific audience and practitioners; they are linked on the GN3plus Open Calls website. Together with the Open Calls partner projects WoT4LoA and HEXAA, common scenarios and business cases are being worked out and will be presented in 2015.

ACKNOWLEDGMENT

REFERENCES

[1] GÉANT-TrustBroker website: http://www.geant.net/opencall/Authentication/Pages/TrustBroker.aspx/ [retrieved December 9th, 2014]

[2] Daniela Pöhn, Stefan Metzger, Wolfgang Hommel: Integration of Dynamic Automated Metadata Exchange into the SAML 2.0 Web Browser SSO Profile - draft-poehn-dame-02. I-D (Work in progress): https://datatracker.ietf.org/doc/draft-poehn-dame/, 2014

[3] Daniela Pöhn, Stefan Metzger, Wolfgang Hommel: GÉANT-TrustBroker – dynamic identity management across federation borders. Networking with the World, in: The 30th Trans European Research and Education Networking Conference, Selected Papers, Dublin, Ireland, 2014

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COFFEE – COHERENT OPTICAL SYSTEM FIELD-TRIAL FOR SPECTRAL EFFICIENCY ENHANCEMENT

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Abstract—The scope, aims, and contributions of the COFFEE project for spectral efficiency enhancement and market exposure are presented.

Index Terms—Time Frequency Packing, Nonlinearity mitigation, multi-user receiver.

I. PRESENTING COFFEE

Every telecom bandwidth provider would like to maximize its investment in already installed optical fibre links before replacing them with new types of fibres or overlaying another link. Spectral efficiency (b/s/Hz) characterizes the optimum utilization of spectral resources and defines overall transmission capacity of a link. The COFFEE project aims at demonstrating, through field trial experiments, the coherent optical data transmission of a single superchannel at the high capacity of 1Tbps using a reduced bandwidth (<200 GHz) over long-haul testbed routes. In order to fulfil such requirements, innovative techniques, already developed in laboratory, is being introduced in a field trial environment. Time-Frequency Packing (TFP) is used to increase the spectral efficiency [1]. With respect to other commonly used techniques like orthogonal frequency division multiplexing (OFDM) and M-ary quadrature amplitude modulation format (M-QAM), TFP can guarantee for lower transceiver complexity and bandwidth requirements, higher tolerance with respect to fibre propagation nonlinearities, reduced power consumption, and larger flexibility. Channel shortening (CS) [2], enhanced split step Fourier Method (ESSFM) [3], and multi-user processing are key enabling techniques [4] for these features. The implementation of such advanced techniques represents a strong innovation in the area of telecommunications, and the

use of GÉANT infrastructures also pushes the relevance of the COFFEE objectives toward market visibility. GÉANT installed link between Milan and Finkenstein shown in Fig. 1 is being used to evaluate the 1Tbps transceiver prototypes in a real network infrastructure.

Figure 1: Milan-Finkenstein 675Km link for Tbps field trial

II. UNDERSTANDING SPECTRAL EFFICIENCY AND INFORMATION CAPACITY

Most of currently installed transmission links in core networks carry 10Gbps OOK channels on the ITU-T fixed grid occupying 50GHz or 100GHz of spectrum. In the past few years 40Gbps and 100Gbps channels have also been installed to increase the overall link capacity. To ensure the optimum utilization of spectrum the ITU-T G.694.1 flex-grid standard [5] has been defined allowing 12.5GHz spectral slices. Figure 2 shows different data rate channels along with their spectral occupancies. Table I shows how optimized use of spectral resources increases the overall link capacity for different channels.
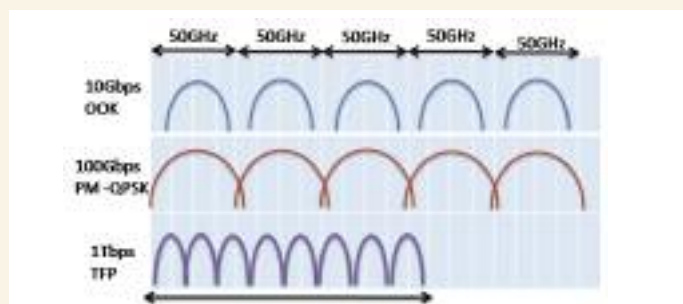

Figure 2: Different data rate channels and spectral occupancy. Each column represents a 12.5GHz flex-grid slice.

III. LINK DESCRIPTION

The fibre optic link chosen for the field trial connects Milan, Italy and Finkenstein, Austria over a length of 675km. The link consists of ten spans of ITU-T G.655 fibre with lengths between 45 and 80km, with amplification provided by Erbuim Doped Fibre amplifiers (EDFAs) as shown in Fig 1. The installed fibre is Corning LEAF on all spans, with a short length of 13km of G.652 Corning fibre. Alcatel 1626LM DWDM equipment is installed in all the nodes.

Data Rate	No. of 12.5GHz slices	Occupied BW (GHz)	No. of Channels in C-Band	Total C-Band Capacity (Tbps)
10Gbps OOK	4	50	80	0.8
100Gbps PM-QPSK	4	50	80	8
1Tbps TFP	13	162.5	24	24

TABLE I. Different data rates and total C-band capacity

IV. NETWORK EMULATION IN LAB

Three nodes of Alcatel LM1626 equipment were installed and re-commissioned in the CNIT lab to characterize each component of a node and to emulate the network conditions before making the actual field trial. The network emulation helped to understand the compatibility issues with 1Tbps transceiver and node component parameters such as the gain of amplifiers were optimized. Moreover, the amplifier loop back configuration at Finkenstein was also ascertained after evaluating different possible configurations.

V. ENHANCING THE SPECTRAL EFFICIENCY- KEY COFFEE CONTRIBUTIONS

The overall transmission capacity of a link can be increased by transmitting more bits per second per Hz of spectrum. But as we place channels closer to each other we increase the inter-channel interference (ICI) degrading transmission performance. TFP employs several innovative techniques to mitigate ICI and other linear and non-linear impairments and thus allows reduction of the spacing between different channels. Figure 3 shows three 160Gbps PM-QPSK channels packed together in 63GHz bandwidth using TFP. Table II shows achieved transmission distance for different spectral bandwidths of a 1Tbps superchannel consisting of 8 sub-channels.
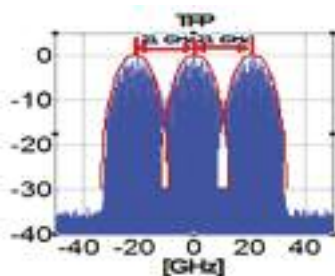

Figure 3: Three adjacent PM-QPSK channels in 63GHz using TFP

No. of sub-channels	Occupied BW [GHz]	No. of 12.5GHz Slices	Distance (Km)	Spectral Efficiency (b/s/Hz)
8	162.5	13	760	6.24
8	175	14	1520	5.80
8	200	16	1900	5.07

TABLE II. Achieved Transmission distances for different spectral bandwidths for 1Tbps PM-QPSK superchannel

In the COFFEE project, a discrete time model of the transmission channel has been derived to evaluate propagation over the link through simulations using a numerical tool built in CNIT. Both linear and nonlinear channel models have been implemented. The key techniques incorporated in TFP in the scope of the COFFEE project include:

- Channel Shortening [2].
- Nonlinear Impairment Mitigation [3].
- Multiuser processing at the receiver [4].

The system performance both in a single user and multi-user scenario has been tested and optimised by emulating the Milan–Finkenstein fibre optic link with a re-circulating loop in the lab. Use of multi-user processing will reduce the penalty due to ICI, and thus will enable a more tight binding of optical sub-channels.

VI. FUTURE PLANS

Based on system optimizations achieved in the lab, a field trial is now under way. As a fundamental outcome within the GN3plus community the COFFEE project allows to build expertise in innovative transmission techniques for next generation optical networks.

ACKNOWLEDGMENT

REFERENCES

[1] G. Colavolpe et al., J. Lightwave Tech., vol. 27, n. 13, pp. 2357-2369, July 2009.
[2] D. D. Falconer et al., Bell System Tech. J., vol. 52, pp. 1541–1562, Nov. 1973.
[3] Secondini, Marco; Marsella, Domenico; Forestieri, Enrico, "Enhanced split-step Fourier method for digital back propagation," Optical Communication (ECOC), 2014 European Conference on , vol., no., pp.1,3, 21-25 Sept. 2014.
[4] Colavolpe, G.; Fertonani, D.; Piemontese, A., "SISO Detection Over Linear Channels With Linear Complexity in the Number of Interferers," Selected Topics in Signal Processing, IEEE Journal of , vol.5, no.8, pp.1475,1485, Dec. 2011.
[5] http://www.itu.int/rec/T-REC-G.694.1/en.

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IRINA: INVESTIGATING RINA AS THE NEXT GENERATION GÉANT AND NREN NETWORK ARCHITECTURE

ADVENTURES OUTSIDE OF THE TCP/IP COMFORT ZONE

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Abstract—IRINA is a project in the GÉANT Open Call that sets out to study the use of the Recursive InterNetwork Architecture (RINA) as the foundation of next generation NREN and GÉANT network architectures, building on an open source RINA prototype. The success of IRINA could lead to field trials of the Recursive InterNet Architecture, pave the way for increased security, reliability and scalability of research networks and, ultimately, provide a safer and improved networking experience.

Index Terms—Future Network Architectures, GÉANT Open Calls, RINA.

I. INTRODUCTION

A lot has been written about the "ossification" of the Internet: the core technologies residing in the "narrow waist" are so ubiquitously deployed that they are almost impossible to change. Therefore, most research progress is being made where it can be easily deployed: below L3, e.g. by improving bandwidth efficiency through optimized modulation formats and advanced medium access control (MAC) protocols and above L3, adding custom protocols are on top of the Internet.

The two dominant "Future Internet" technologies - i.e. SDN and NFV - are oriented towards managing (the cost of) complexity in the current network. On the one hand, SDN is (logically) centralizing the network state and control functionalities; on the other hand NFV aims at shifting network functions from expensive dedicated hardware to virtualized environments running on commodity servers. However, in order to scale the Internet to the hundreds of billions of devices, as predicted to connect to it by 2050, research on fundamental aspects of networking may be needed.

Recently, a potential candidate for an Internet architecture has emerged in the form of the Recursive InterNetwork Architecture (RINA), championed by John Day [1]. Its core principle is that the endpoints of any communication are processes, and by applying a complete naming and addressing scheme as advocated by Saltzer [2], challenges such as end-user mobility and multi-homing can be more readily addressed.

Currently, the EC is funding a number of innovative projects focusing on RINA. The FP7 IRATI project [3] is developing a first prototype [4] implementing the core functions of the RINA architecture and providing a framework that allows developers to directly bind their applications to RINA [5]. FP7 PRISTINE [6] is tackling important issues such as security and QoS. The GN3+ Open Call project IRINA [7] is investigating the benefits of RINA to NRENs by developing a traffic generator over the IRATI prototype, in order to evaluate an NREN use case.

II. IRINA: DESIGNING NREN NETWORKS IN THE RINA FRAMEWORK

IRINA performed an analysis using SWOT and PEST techniques to assess and evaluate the impact of deploying RINA within the NRENs and GEANT context. Identified opportunities in deploying RINA are: speeding up service development and provisioning, thereby lowering both CAPEX and OPEX. The main threats are that it may face resistance from incumbent technologies with inherent deployment risks The analysis highlighted a common weakness between current approaches in that they primarily focus on fixing specific networking issues rather than providing an all-encompassing solution, which is the strength of a a a clean-slate approach such as RINA.

The results of a survey among NRENs, to which 24 have responded, were used to shape the project's use case focusing on three aspects: the network topology comprising of the NREN networks interconnected via the GEANT backbone, the services currently deployed on these networks and the impact of future requirements over the selected services. The topology is abstracted into three different NREN types - a Large NREN (based on RENATER), a medium NREN (based on RoEduNet2 and SURFnet), and a small NREN (based on AMRES). The survey identified the most important technical challenges for NREN IP networks: maximizing throughput, reducing latency, decreasing provisioning times, improving mobility and improving energy efficiency. Currently NRENs provide mobility via Wi-Fi (e.g Eduroam) but there is growing demand for 3G and 4G services. In terms of bandwidth, several NREN customers have higher and higher bandwidth demands (for specific services). In terms of security, DDoS attacks are frequently encountered and mitigated by specific countermeasures.

The IRINA use case encompasses three different services - HD Video conferencing (based on RENATER SeeVogh/RMS), p2p VPN services and Cloud storage (based on SURFDrive+[8]).

IRINA is developing an appropriate schema for this use case, providing the services above in a secure manner. This schema focuses on specific areas, representing common configurations used in the NREN architecture:

- Internal NREN design
- Peering with other NRENs (via GEANT or directly via CBF) and commercial ISPs
- Interconnecting customers and internal datacenters

A lab trial using the IRATI prototype and the experimental facilities contributed by the project partners will provide a proof-of-concept demonstration.

ACKNOWLEDGMENT

REFERENCES

[1] Day, J., "Patterns in Network Architecture, a return to Fundamentals", Prentice Hall, 2008
[2] Saltzer, J., On the Naming and Binding of Network Destinations, IETF RFC1498
[3] The FP7 IRATI project. Available online at http://irati.eu
[4] Vrijders, S.; Staessens, D.; Colle, D.; Salvestrini, F.; Grasa, E.; Tarzan, M.; Bergesio, L., "Prototyping the recursive internet architecture: the IRATI project approach," Network, IEEE , vol.28, no.2, pp.20,25, March-April 2014
[5] The IRATI stack. Available online at http://irati.github.io/stack
[6] The FP7 PRISTINE project. Available online at http://ict-pristine.eu
[7] GN3+ Open Call project IRINA. http://www.geant.net/opencall
[8] SURFdrive, https://www.surf.nl/en/services-and-products/surfdrive/surfdrive.html

MOMOT: DESIGNING AN ALIEN WAVE MODELLING TOOL

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Abstract—This article describes the concept of using alien waves, also called spectral sharing, in the GEANT community. The open-call project MOMoT has through a comprehensive survey investigated the need and interest of using alien wavelengths. Furthermore, an alien wave modelling tool is currently being developed. The tool is being designed to assist NRENs in planning and setting up alien waves.

Index Terms—Alien wavelength, modelling, spectral sharing.

I. INTRODUCTION

Although Alien Waves (i.e., wavelengths which are unknown to the network domain and that share the spectrum with native wavelengths) has been discussed within the NREN community for a number of years it remained unclear what the actual interests were. Furthermore, as the support from vendors is typically limited, NRENs are faced with technical challenges in the process of planning and setting up alien waves.

The MOMoT project was created to take on both these issues. First, to investigate the need and interest for alien waves within the community, and secondly, to develop a modelling tool and user interface that will assist NRENs in planning and setting up alien waves across their networks.

II. THE MODELLING TOOL

The modelling tool is based on a series of analytical equations that will consider effects such as optical noise and non-linearities. Coupling these effects with the modulation format, bit rate, transmission distance, fiber type and other factors will enable the model to predict the bit-error-rate (BER) performance of both the alien and the native waves. Moreover, it is vital to assure that the existing channels are kept undisturbed when setting up an alien wave , for example by limiting the launch power of the alien wave.

Figure 1 illustrates how an alien wave is set up between two domains and how the link parameters (either through the management system or manually) are given to the modelling tool, which in turn will model and evaluate the native and alien wave transmission. Details on the BER model on which the modelling tool is built can be found in [1].

1. Illustration of an alien wave setup between two domains running different equipment. The alien wave is a native wave in one domain but alien in the other. The MOMoT tool can assist in evaluating if the alien wave can be successfully set up.

2. Results generated from the modelling tool, showing low- and high input power effect on the signal quality (BER). The green area indicates the best chosen alien wave input power range.

III. SURVEY

As a first step in MOMOT, a survey with 11 questions was distributed to NRENs collecting their knowledge, interest and customer demand related to alien wavelength services. The answers, coming from 47 NREN members at CTO level, revealed that there indeed is an interest in alien waves within the community.

Of the NRENs that answered the survey, 60% are involved in alien waves activities, either in the planning, trial or production phase. 50% were interested in alien waves for reasons of saving money on new equipment, 43% were interested as they believed it could possibly bring in a new set of client services and 33% had concrete plans of interconnecting with neighbors using alien waves on cross-border fibers. Finally, 30% had received customer requests for services requiring alien waves. The full report on the survey can be found in [2].

IV. FIELD TRIAL MODELLING

Dante and Surfnet are currently planning an alien wave setup where two Infinera channels from the GEANT node in Hamburg will be transmitted through Surfnet's network to Amsterdam. Surfnet is using Ciena 6500 so the two 50Gb/s PM-QPSK waves will be alien in the Surfnet network.

The MOMoT modelling tool has been used in this trial to characterize the communication link. The 626-km link between Hamburg and Amsterdam is amplified with 10 optical amplifiers. Figure 2 shows the input power analysis that was made using the modelling tool. It shows how the signal quality, the pre-FEC BER (pre-Forward-Error-Correction Bit-Error-Rate) changes with the launch power of the alien wave. If the power is low, the bit errors will increase due to low signal-to-noise (SNR) ratio and if the power is too high, the alien wave signal will suffer from non-linearities (red zone).

All in all, the results from the tool suggest to keep the power of the alien wave in the green zone, above -5 dBm and up to 0 dBm, in order to achieve a good signal quality. The zone between 0 dbm and 7 dBm, currently marked yellow, can be used as well if there are no native neighboring channels. Also, in this trial a BER down to 2×10^{-3} can be accepted as Forward-Error-Correction (FEC) is used. Without FEC the minimum requirements to BER would usually be 1×10^{-12}.

V. FUTURE WORK

In the final phase of the project attention will be focused on improving and expanding the functionality of the modelling tool, developing a user friendly interface and finally, through collaboration with one or more NRENs, do a field-trial evaluation of the tool. Applying the tool for an actual alien wave planning and setup case would assess the tool and allow for final touchups at the end of the project.

ACKNOWLEDGMENT

REFERENCES

[1] N. Sambo, M. Secondini, F. Cugini, G. Bottari, P. Iovanna, F. Cavaliere, and P. Castoldi, "Modeling and distributed provisioning in 10-40-100 Gb/s multi-rate wavelength switched optical networks," J. Lightwave Technol., vol. 29, no. 9, pp. 1248–1257, 2011.
[2] MOMoT milestone report M2.1 is available through the GEANT Intranet: https://intranet.geant.net/JRA0/MOMoT

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REACTION:

RESEARCH AND EXPERIMENTAL ASSESSMENT OF CONTROL PLANE ARCHITECTURES FOR IN-OPERATION FLEXGRID NETWORK RE-OPTIMIZATION

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Abstract—The REACTION project proposes, designs, and validates flexi-grid elastic optical networks enabling software-controlled high-rate transmissions. In this paper, the main project objectives are reported, together with a brief summary on two main REACTION studies.

Index Terms—EON, Flexi-grid, PCE, ABNO, RSA.

I. INTRODUCTION

The continuous increase of users' bandwidth requests, combined with the need to adequately address data center connectivity requirements, is driving the evolution of ultra-high speed optical networks, enabling transmission rates beyond 100Gb/s. These networks are expected to rely on flexi-grid optical cross-connects, enabling finer granularity and flexibility in the use of the optical spectrum compared to that of the fixed grid. Moreover, a new generation of transponders, called sliceable bandwidth-variable transponders (SBVTs), is expected to provide advanced adaptation capabilities enabling elastic network operations (e.g., modulation format and code adaptation, network de-fragmentation, etc).

The REACTION project aims at investigating the benefits of flexi-grid optical networks, specifically considering advanced provisioning and adaptation capabilities. The project is carried out by three partners, CNIT (Pisa, Italy), the Optical Communications Group (GCO) of the Universitat Politècnica de Catalunya (UPC, Barcelona, Spain) and Telefonica Investigation y Desarollo (TID, Madrid, Spain).

II. REACTION ACTIVITIES

The project investigates the benefits of flexi-grid elastic optical networks by addressing three main networking aspects: enabling data plane technologies, routing and spectrum assignment (RSA) algorithms, and control plane architecture.

These three aspects are investigated through both simulative and experimental studies. A specifically designed OPNET Modeler has been also implemented to reproduce a comprehensive flexi-grid control plane. Moreover, a distributed testbed has been setup to experimentally validate the most effective REACTION solutions.

III. OUTCOMES

To provide a hint of the REACTION outcomes assessing the benefits of the flexi-grid technologies, two specific research studies are here reported. Additional REACTION research outcomes are detailed in [1]-[7].

A. Example of adaptation capability: sliceable functionality

1 shows a network scenario applying the sliceable functionality. A 400Gb/s super-channel composed of four contiguous 100Gb/s sub-carriers is considered. The sub-carriers can be configured either to be co-routed along the same path (1b/c) or, when the sliceable functionality is applied, independently routed along multiple paths (1d). In the latter case, more spectrum resources are required (i.e., four frequency slots of 37.5Ghz rather than a single slot of 100GHz, see 1a).

To exploit the benefits of the sliceable functionality, specific routing strategies have been proposed and evaluated through simulations, showing that provisioning blocking probability can be reduced if the sliceable functionality is properly applied, e.g. when there are no more network resources to accommodate an entire super-channel. Further details and application scenarios (e.g., recovery) can be found in [2].
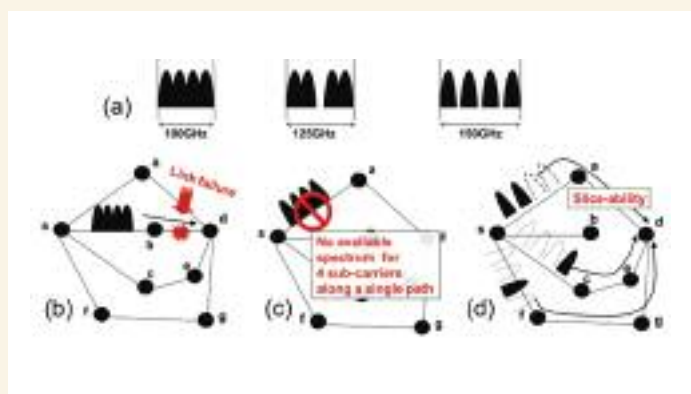

Fig. 1 : Example of sliceable functionality applied to a 4 sub-carrier super-channel in the case of failure recovery.
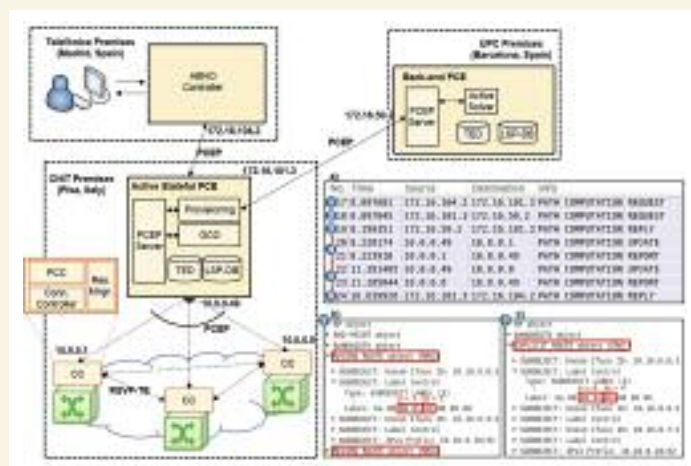

Fig. 2. Distributed field trial set-up and exchanged messages

B. Sliceable functionality in provisioning and recovery

A use case of in-operation network planning is considered. When a link fails, multipath restoration can be used to increase restorability of affected connections at the cost of worse resource utilization and spectral efficiency.

After the link is repaired, the multipath after failure repair optimization (MP-AFRO) problem can be used to aggregate multiple sub-connections serving a single demand using shorter routes, thus releasing spectrum resources that now can be used to convey new connection requests.

The MP-AFRO problem has been addressed within REACTION by proposing a specifically designed mathematical formulation and a heuristic algorithm, successfully providing good feasible solutions in practical computation times.

The algorithm has been experimentally validated on a distributed test-bed connecting premises in Telefonica, CNIT, and UPC. After a link is repaired, network re-optimization is requested from the Network Management System (NMS). The Application-Based Network Operations (ABNO) architecture controls a flexgrid-based optical network, where the Path Computation Element (PCE) architecture consists of a front-end PCE (fPCE) and a back-end PCE (bPCE). The ABNO controller is in charge of initiating the MP-AFRO workflow, requesting re-optimization to the fPCE, which delegates complex computations to the bPCE. The relevant PCE Protocol (PCEP) messages are reported in Fig. 2. The results of the path computation trigger network re-optimizations performed through the Generalized Multi-Protocol Label Switching (GMPLS) protocol suite, extended for flexi-grid optical networks. This way, MP-AFRO is successfully performed.

Further details can be found in [4].

IV. CONCLUSIONS

This paper briefly reported the main REACTION project objectives and activities. Two examples of project achievements are summarized, showing the benefits of flexi-grid technologies due to the introduction of advanced transmission adaptation capabilities, effective RSA algorithms, and innovative control plane architectures.

REFERENCES

[5]   M. Dallaglio et al, "Impact of slice-ability on dynamic restoration in GMPLS-based Flexible Optical Networks", OFC Conf., March 2014.

[6]   M. Dallaglio et al, "Provisioning and Restoration with Slice-ability in GMPLS-based Elastic Optical Networks [Invited]", Journal of Optical Communications and Networking (JOCN), in-press

[7]   L. Velasco et al, "First experimental demonstration of ABNO-driven in-operation flexgrid network re-optimization", OFC Conf., Post-deadline Paper, March 2014

[8]   Ll. Gifre et al, "First Experimental Assessment of ABNO-driven In-Operation Flexgrid Network Re-Optimization", Journal of Lightwave Technology (JLT), 2014.

[9]   F. Paolucci et al, "Multipath restoration and bitrate squeezing in SDN-based elastic optical networks [Invited]", Journal of Photonic Network Communications, May 2014

[10]   Ll. Gifre, A. Castro, M. Ruiz, N. Navarro, L. Velasco, "An in-operation planning tool architecture for flexgrid network re-optimization", ICTON Conf., July 2014

[11]   M. Dallaglio et al, "Impact of SBVTs based on Multi-wavelength Source During Provisioning and Restoration in Elastic Optical Networks", ECOC Conf. Sept. 2014

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ARES: ADVANCED NETWORKING FOR THE EU GENOMIC RESEARCH

GENOMIC ANALYSIS IN GÉANT: A DISTRIBUTED CLOUD APPROACH

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Abstract—This paper shows the service architecture implemented in the framework of the project ARES (Advanced networking for the EU genomic RESearch). It is designed for providing both delivery of genomic data set over the GÉANT network and relevant processing in a distributed cloud fashion. This paper summarizes the vision of the project, and presents some interesting experimental results.

Index Terms—Content distribution network, network function virtualization, cloud computing, big data, genomic data analysis

I. INTRODUCTION

The increasing scientific and societal needs of using genomic data and the parallel development of sequencing technologies have made the access to genome processing services necessary everywhere. In a few years, different fields will make an intensive use of the information stored in genomes of living bodies. Access to this information, which is a typical big data problem, requires redesigning procedures used in sectors, such as biology, medicine, food industry, and others. Since it cannot be expected that any potential user owns the processing capabilities for massive genome analysis in-house, a cloud approach is envisaged. In addition, due to the large file size (a single raw genome file is in the order of 3 GB), it is necessary to control the impact massive genome analyses have on transport networks, which could cause bottlenecks.

For this reason, the strategic objective of the project ARES (Advanced networking for the EU genomic RESearch) is to create a novel Content Distribution Network (CDN) architecture supporting all activities making a large use of genomics data. This CDN is implemented through network function virtualization (NFV) caching modules, suitable for handling the rapidly increasing diffusion of genomic data.

We present the main concepts (Section II) and some experimental results of ARES (Section III), highlighting how the proposed innovative CDN can limit the network footprint of such bandwidth-hungry services.

II. SERVICE ARCHITECTURE

The technological pillars of ARES are (see II):

- infrastructure as a service (IaaS) for implementing processing of genomic contents in data centers by virtual machines (VMs), managed through OpenStack tenants;
- software as a service (SaaS) for managing the access of end users to the processing platform (web interface);
- NFV caching modules in routers and in data center VMs, implemented through the NetServ platform ;
- a central orchestration engine (genome CDN manager, GCM), making use of the NSIS signaling for collecting the status of computing resources and caches.

Fig. 1. ARES: a big picture.

Fig. 2. Benefit introduced by the ARES approach versus a randomized data center selection, as a function of service request rate.

Processing services, implemented in VMs, are usually organized in "pipelines".

The main novelty of ARES consists of network data management, optimized for genomics processing needs. It is based on caching of both VMs and large auxiliary files (like reference human genomes), required by genomic processing. For selecting the data center that will execute the computation, the GCM collects information, about data center availability and cached contents, through specific NSIS signaling. The policies used for allocating computing resources are implemented in the GCM, that executes ad hoc optimization problems, involving content location (both original and cached ones), data centers with sufficient resources, and the location of the genomes to be processed. The optimization problem consists of minimizing either exchanged network traffic or processing time. The relevant solutions indicate the locations from which contents are downloaded and the data center which will host the desired processing. The GCM can thus orchestrate data transfer and computation services. In this way, it is possible to tightly control the impact of the genomic services being delivered over network resources.

III. EXPERIMENTAL RESULTS

Experiments in ARES have been done by referring to the GÉANT topology, composed of 40 points of presence (PoPs, January 2014), 32 of which include a co-located data center, candidate for hosting a processing VM.

In the set of experiments shown in what follows, up to five concurrent pipelines can be executed in each data center. In the legacy approach requests are distributed randomly over nodes. In the ARES strategy, service requests are allocated by following the approach described in sec. II, for example minimizing the traffic exchanged, including not only the patient genomes, but also VM images and auxiliary files, which can be stored in the ARES network caches. The sample results shown in IIIdemonstrate a marked decrease, of about 6 times, of the aggregate traffic.

REFERENCES

[1] DNA Sequencing Costs. Data from the National Human Genome Research Institute (NHGRI) Genome Sequencing Program (GSP). <http://www.genome.gov/sequencingcosts/>

[2] Yandell M., Ence D., "A beginner's guide to eukaryotic genome annotation," Nature Reviews Genetics, 13(5), 2012.

[3] O'Driscoll A, Daugelaite J., Sleator R.D. "'Big data', Hadoop and cloud computing in genomics," Journal of Biomedical Informatics, 2012, vol. 46, pp. 774–781.

[4] EE Schadt et al., "Computational solutions to large-scale data management and analysis," Nature Reviews Genetics, September 2010, 11(9), pp. 647-657.

[5] "Network Functions Virtualisation (NFV) Network Operator Perspectives on Industry Progress", ETSI, October 2013, http://portal.etsi.org/NFV/NFV_White_Paper2.pdf.

[6] Femminella M., Francescangeli R., Reali G., Lee J.W., Schulzrinne H., "An enabling platform for autonomic management of the future internet," IEEE Network, 25(6), 2011, pp. 24-32.

[7] Femminella M., Francescangeli R., Reali G., Schulzrinne H., "Gossip-based signaling dissemination extension for next steps in signaling," IEEE/IFIP NOMS 2012, Maui, US.

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AUTOFLOW: AUTONOMIC OPENFLOW

EXPERIMENTATION FRAMEWORK FOR AUTONOMIC SOFTWARE DEFINED NETWORKS

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Abstract—Autonomic Network Management (ANM) and Software Defined Networking (SDN) have appeared as promising technologies for simplifying the management and control of today's highly interconnected and complex networks. Although it seems that there is a strong link between these two technologies that can result in an efficient and useful interplay, consistent justification and positioning is still missing in the existing literature and industrial/research studies. The AUTOnomic openFLOW (AUTOFLOW) project aims at validating the synergy and interworking of ANM and SDN for the management and control of Future Networks by experimenting with the instantiation of an OpenFlow/SDN based ANM prototype, integrated with the OpenFlow/SDN testbed of GÉANT.

Index Terms—Autonomic Network Management; Software Defined Networks; OpenFlow; Experimentation Framework; GÉANT;

I. INTRODUCTION & MOTIVATION

The rapid technological progress and unforeseen increase of highly dynamic and stringent users' traffic demands have brought a remarkable complexity in today's telecommunication networks and services. In consequence, progressively more complex and interconnected networking infrastructures are leading to an increasing difficulty in managing multi-vendor environments and services. Resorting to closed, proprietary solutions and patches on top of traditional management and control approaches cannot provide a viable way out for handling such complexity. What is really needed is an intelligent, flexible and cost-effective network and service management solution so that the network could be better controlled and efficiently operated. To this end, several profound and emerging technologies are currently discussed in international research projects and standardization bodies.

Two of the most important ones comprise the main subject of the AUTOFLOW project namely, Autonomic Network Management (ANM) and Software Defined Networking (SDN) . AUTOFLOW intends to study and shed light on the relationship among ANM and OpenFlow/SDN and make a position statement with respect to their possible synergy and interworking for the management and control of future networks (Figure 1). Furthermore, the project aims at validating and strengthening the above positioning by experimenting with the instantiation of an OpenFlow/SDN based ANM prototype in scenarios covering autonomic traffic engineering in core networks.

Figure 1: AUTOFLOW introduces ANM to the GÉANT OpenFlow-enabled facility

Figure 2: Transmitted bits per second for the two high level policies (energy efficiency and load balancing), experimenting over the GÉANT testbed.

II. SYNERGY OF ANM AND SDN

These two emerging technologies share motivation and have confluent goals i.e. better and more efficient control and operation, simplification of network management and control, focus on innovation and differentiation aspects for vendors, CAPEX/OPEX reduction for providers etc. SDN/OpenFlow can be seen as an enabler for simplifying the introduction of autonomics into networks and network management i.e. it can be used to inject and track autonomic functions/loops into the networks, purpose-wise and freely, but at the same time in a well-defined manner (API). On the other side, ANM technologies can provide a management platform for managing SDNs and software network applications featured with autonomics and/or for providing guidelines for developing such autonomic software applications.

III. EXPERIMENTATION FRAMEWORK AND OUTCOMES

AUTOFLOW's experimentation framework includes three ANM core blocks and two Autonomic Control Loops (ACLs), which interact with the Floodlight controller through the developed Northbound API. Governance, Knowledge and Coordination are realized from the ANM core blocks, while the ACLs are responsible for traffic engineering and load prediction. The ANM Core / ACLs components can be considered in this case as "SDN applications", where the complete control of the programmable network is rendered feasible with the use of the controller.

The conducted experiments have shown that the proposed integration of ANM/SDN allows operators to manage their networks efficiently, (un)deploying ACLs in a "plug and play" way, monitoring network elements in real time and enforcing decisions on run time. There isn't a strict constraint on the number of ACLs that can operate concurrently, while the enforcement of new rules in the network can be considered as instantaneous (within just a few seconds). Operators may choose the desired high level policy (e.g. energy efficiency, load balancing) and steer the network's operation respectively (Figure 2).

IV. CONCLUSION

The GN3plus project offers a great opportunity for expanding know-how and research achievements in the area of SDN/OpenFlow, through experimenting on a widely recognized, realistic testbed. Taking advantage of this opportunity, AUTOFLOW intends to extend the GÉANT testbed and perform focused research and experimentation in order to demystify the relationship between ANM/SDN and showcase that SDN/OpenFlow capabilities can bring "customizable ANM" into reality.

ACKNOWLEDGMENT

REFERENCES

[1] AUTOFLOW project website, http://tns.ted.unipi.gr/autoflow/
[2] Autonomic Network Management Principles: From Concepts to Applications, Edited by N Agoulmine, ISBN 978-0-12-382190-4, Elsevier Academic Press Publications 2011
[3] Open Networking Foundation. (2012, Apr.). Software-defined networking: The new norm for networks [Online]. Available: www.opennetworking.org/images/stories/downloads/whitepapers/wp-sdn-newnorm.pdf
[4] Floodlight project web site: http://www.projectfloodlight.org/floodlight/, last accessed 31st of January, 2014

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CEOVDS: EVALUATION OF AN SDN-BASED VIDEO-ON-DEMAND DISTRIBUTION SERVICE

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Abstract—High quality online video streaming, both live and on-demand, has become an essential part of many consumers' lives. The popularity of video streaming, however, places a burden on the underlying network infrastructure. This is because it needs to be capable of delivering significant amounts of data in a time-critical manner to users. The Video-on-Demand (VoD) distribution paradigm uses an independent unicast flow for each user request, resulting in multiple duplicate flows carrying the same video assets repeatedly. To address this problem we designed and implemented OpenCache: a highly configurable, efficient and transparent in-network caching service that aims to improve the VoD distribution efficiency by caching video assets as close to the end-user as possible. OpenCache leverages Software Defined Networking technology in order to reduce network utilization whilst increasing the Quality of Experience (QoE) for the end-user. Our evaluation on the GÉANT OpenFlow Facility (a pan-European OpenFlow testbed) uses adaptive bitrate video to demonstrate that with the use of OpenCache, streaming applications play back higher quality video and experience increased throughput, higher bitrate, and shorter start up and buffering times.

I. INTRODUCTION & MOTIVATION

Online video streaming (live and on-demand) has seen a huge growth in popularity during recent years. In 2013, Internet video traffic represented 66% of all global Internet traffic, and is predicted to increase to 79% by 2018 [1]. At the same time, High Definition (HD) video traffic has already surpassed that of Standard Definition (SD) [2]. Undoubtedly, high quality online video streaming has become an essential part of many consumers' lives.

In a Video-on-Demand scenario, individuals are able to retrieve content for playback after the initial broadcast. The growth in VoD traffic, coupled with the trend towards content of higher resolution and quality, presents significant challenges. Currently, VoD requests are handled individually, leading to an independent flow in the distribution network serving each user's request. Using such a unicast content delivery paradigm naively ignores that much of the content, in the order of gigabytes for a typical HD film, is identical to transmissions minutes, hours or days earlier. In order to efficiently support such VoD streaming, the end-to-end capacity of the network must continuously match the increasing number of Internet video users and the growing popularity of higher resolution content. Mechanisms are therefore sought to improve the efficiency of VoD distribution.

II. OPENCACHE

To address the problem of efficient VoD content distribution we designed and implemented OpenCache (Fig.1); a transparent, flexible and highly configurable in-network caching service for VoD streaming [3]. OpenCache's contribution is to provide a programmable service that allows any caching strategy to be easily deployed within network infrastructure. To achieve this goal, OpenCache uses Software Defined Networking (SDN) to provide a cache as a service for media content in an efficient and transparent fashion. This is achieved through powerful interfaces, designed to directly benefit last mile environments. By leveraging SDN, and OpenFlow in particular [4], we provide a control plane that orchestrates the caching and distribution functionalities, and transparently pushes the content as close to the user as possible without requiring any changes to the delivery methods or the end-hosts. OpenCache does not only increase the video streaming Quality of Experience (QoE) for the end-user, but also provides a white-box content caching approach that enriches the network administrator's management capabilities.
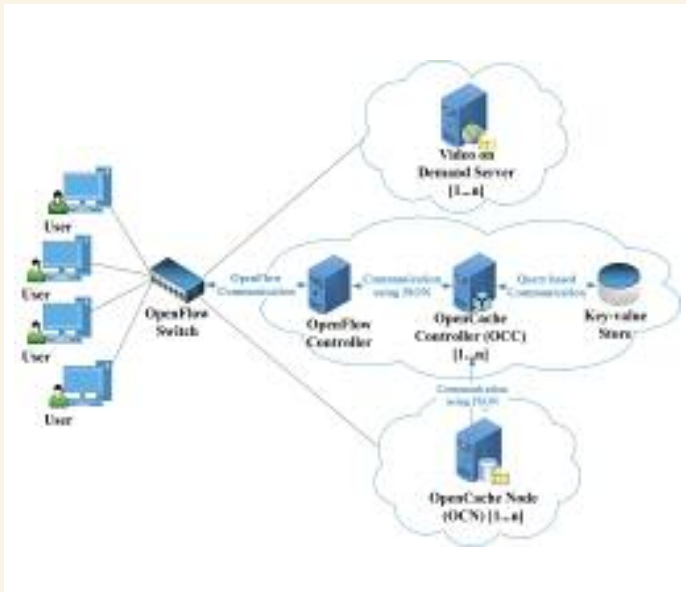
Fig. 1. OpenCache Architecture

Fig. 2. Experimentation Deployment on the GÉANT OpenFlow Facility

III. EVALUATION ON THE GÉANT OPENFLOW FACILITY (GOFF)

In order to evaluate the efficacy of OpenCache, we carried out a number of single and multiple client VoD streaming experiments representing different scenarios over the GOFF (one experimentation deployment is depicted in Fig. 2). During our experiments the video files are streamed using an adaptive video streaming technology, namely DASH (Dynamic Adaptive Streaming over HTTP) [5].

The main aim of our tests was to evaluate OpenCache's impact on the network link utilisation and its potential impact on the QoE of the end-users. To this effect, and influenced by related work [6-8], we defined four key QoE metrics, namely, (a) startup time, (b) bitrate changes during playback, (c) average bitrate achieved during playback (weighted based on its duration) and (d) minimum bitrate requested during playback. The results from our experimentation clearly demonstrate the benefits of OpenCache that provide two to six times quicker start up time (depending on the scenario) and significantly less bitrate oscillation during playback. In addition, the results show that OpenCache increases both the average weighted bitrate up to three times and the minimum bitrate up to six times, depending on the network link characteristics.

IV. CONCLUSION

As is being demonstrated through extensive experimentation on GOFF, OpenCache provides caching very close to the user with three important contributions. Firstly, the external link usage is reduced leading to lower transit traffic costs and improved network utilisation as end-user requests are now served locally. Secondly, OpenCache reduces the distribution load on the origin content provider and all the transient networks along the path between the origin and the end-user. Thirdly, by transparently caching the content closer to the end-user, OpenCache minimises the distance between the VoD streaming server and the user. This provides significant improvements to the Quality of Experience of the end-user. Our evaluation on GOFF demonstrates that the end-user's streaming application observes higher minimum and average streaming bitrate, less bitrate oscillation and finally, quicker start up and buffering times; key QoE differentiators [6-8].
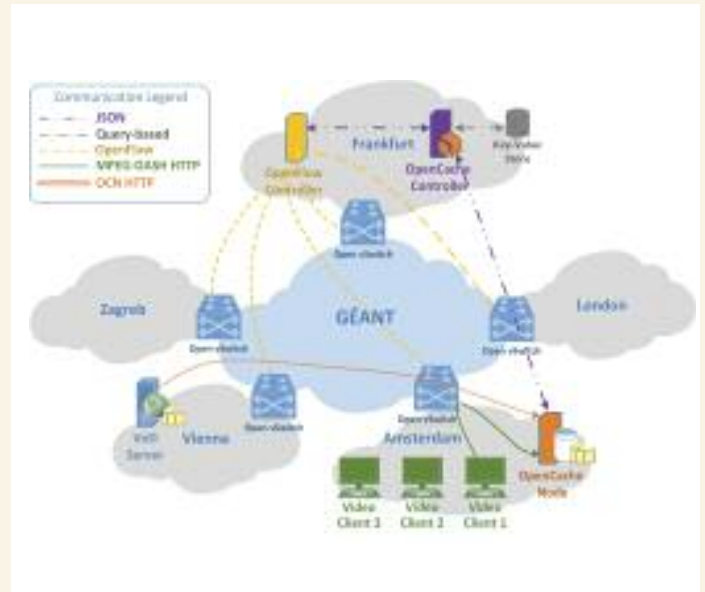
ACKNOWLEDGMENT

REFERENCES

[1] "Visual Networking Index: Forecast and Methodology, 2013-2018," CISCO, Tech. Rep., June 2014.

[2] "Visual Networking Index: Forecast and Methodology, 2011-2016," CISCO, Tech. Rep., May 2012.

[3] P. Georgopoulos, M. Broadbent, B. Plattner, and N. Race. "Cache as a Service: Leveraging SDN to Efficiently and Transparently Support Video-on-Demand on the Last Mile". In: 23rd International Conference on Computer Communication and Networks (ICCCN) 2014, pp. 1-9, August 2014.

[4] N. McKeown, T. Anderson, H. Balakrishnan, G. Parulkar, L. Peterson, J. Rexford, S. Shenker, and J. Turner. "OpenFlow: Enabling Innovation in Campus Networks". In: ACM SIGCOMM CCR 38 (2) pp. 69-74, 2008.

[5] ISO-IEC 23009-1:2012 Information Technology, Dynamic Adaptive Streaming over HTTP (DASH).

[6] S. Krishnan, and R. Sitaraman, "Video Stream Quality Impacts Viewer Behavior: Infer-ring Causality Using Quasi-experimental Designs". In: ACM SIGCOMM IMC, pp. 211-224, 2012.

[7] F. Dobrian, V. Sekar, A. Awan, I. Stoica, D. Joseph, A. Ganjam, J. Zhan, and H. Zhang. "Understanding the Impact of Video Quality on User Engagement". In: ACM SIGCOMM 2011, pp. 362-373, 2011.

[8] X. Liu, F. Dobrian, H. Milner, J. Jiang, V. Sekar, I. Stoica, and H. Zhang. "A Case for a Coordinated Internet Video Control Plane". In: ACM SIGCOMM 2012, pp. 359-370, 2012.

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COMMUNITY CONNECTION SERVICE FOR E-SCIENCE

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Abstract—This paper describes the current results of our work in the GN3plus Open Call project CoCo (Community Connect). CoCo is a proof of concept for a novel on-demand connectivity service for research and education communities, connected through participating NREN networks and the GÉANT network. The CoCo prototype service will enable scientists from multiple organizations to dynamically create virtual private networks for sharing resources (compute, data, etc..) and scientific instruments.

I. INTRODUCTION

Conducting eScience research is a community effort in which the importance of networked services and facilities, e.g. medical and genome databases, remote microscopes, visualization facilities, cloud computing and storage, is increasing. Discussions with eScience users revealed that due to privacy and security issues, services and facilities may not always be exposed via the public Internet. Currently, the setup of virtual private networks (VPNs) involves manual processes at a NOC or multiple NOCs if the services and facilities are located in different domains. CoCo will enable scientists to dynamically create a L3VPN for sharing resources without manual intervention of the NOCs and users don't need to have extensive networking knowledge.

A CoCo service can be setup by an end user through a simple and easy to use web portal, which also includes a REST API that developers can use in their applications. CoCo automatically sets up and manages a virtual network for a community across multiple domains, considering mobility and fail-over of network connections. CoCo's proof of concept is developed on existing testbeds, such as GÉANT's and SURFnet's

OpenFlow testbeds, and uses existing state-of-the-art open source SDN frameworks where possible.

Figure 1 shows such a virtual network in blue, which is called a CoCo instance (1). End users, eScience services, and facilities are located and associated with various organisations (2). The CoCo service will make sure that networks of the organisations (3), participating NRENs and GÉANT (4) are properly configured to provide a CoCo instance.

II. DNA SEQUENCER USE CASE

In 2014 we organised a workshop for researchers in various disciplines and interviewed some of them in order to understand the added value of on-demand, multi-domain VPNs created with SDN technology and useful applications for eScience. These were the starting point for the design and implementation of a prototype. One specific use case, "DNA sequencer as a Service" was more elaborately investigated to illustrate the business value of the CoCo service in the field of expensive eScience instruments where sharing of DNA sequencers is key to the progress in that research field. Extensive resources are needed for a DNA sequencer as a service, such as storage, processing and connectivity. The CoCo
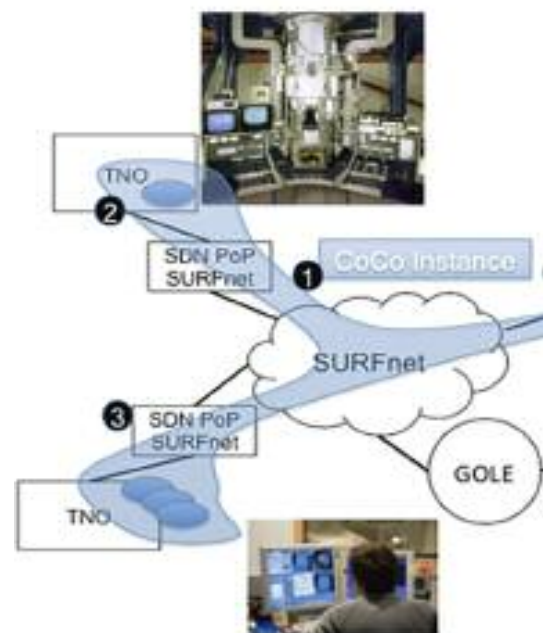

Fig. 1. CoCo Architecture

service is a good candidate for providing the on-demand, multi-domain connectivity incorporated in such an integrated resource management solution [1]. Isolation from the internet of the connected equipment in multiple domains, such as the DNA sequencer, the data storage and processing equipment, is a prerequisite. Common VPN technology could be used to achieve isolation, but that requires manual configuration by experts in each domain. A valuable aspect of the CoCo service the eScience researchers mentioned is the ease-of-use to create connectivity themselves. Also, the increased reusability of the SDN-based solutions for other eScience projects is mentioned as a promising improvement.

Figure 2 presents an overview of a technical solution for a DNA sequencer as a Service. It shows the inter-domain architecture of CoCo. Each domain has an OpenFlow based infrastructure and runs its own CoCo-agent. The CoCo-agents are extensions of the OpenDaylight SDN controller and are responsible for topology discovery within a domain and do intra- and inter-domain path calculations. The inter-domain path calculations are based on BGP path information being exchanged between neighbouring domains. The CoCo network core consists of OpenFlow switches. MPLS based forwarding is used in the core of the network.
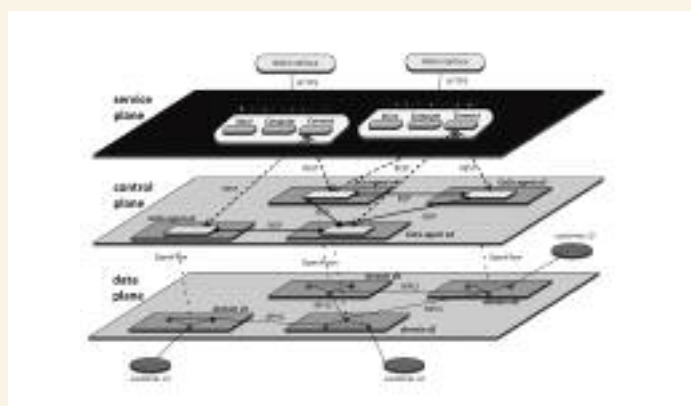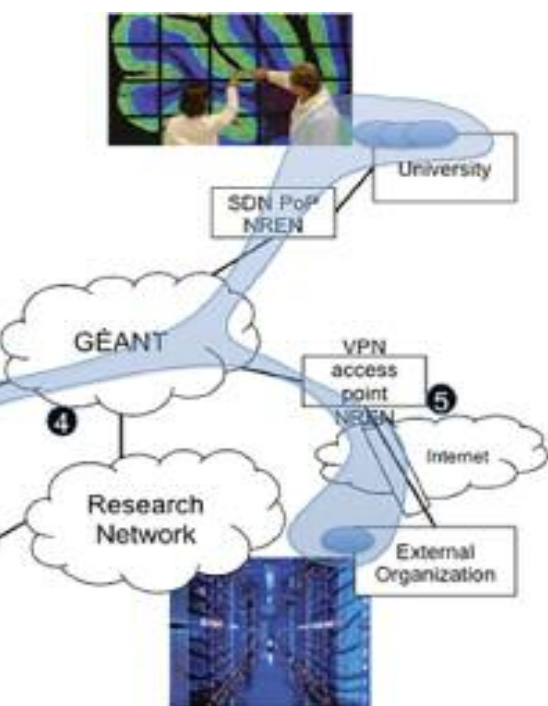

Fig. 2. CoCo Layers Architecture

The CoCo architecture is based on BGP/MPLS VPNs (RFC 4364 [2]). CoCo offers a L3 IP VPN service. Customer traffic is aggregated and encapsulated with an MPLS label and sent to an egress switch. The core switches forward based only on that MPLS label. IP prefix and VPN information is exchanged between domains via BGP running in the control plane.

III. FIRST COCO PROTOTYPE AT SC14

The first prototype of CoCo service was demonstrated during the Supercomputing 2014 conference [3] and the collocated INDIS workshop [4]. This prototype demonstrated that a user with minimal knowledge on communication networks can easily create, access, detach or modify a VPN that spans over several sites. This is done via a user-friendly CoCo web portal that hides the required network switch and controller configuration actions for the user. To simplify the set up process even more an overall network topology is depicted, where the links for the user's VPN are highlighted (Fig. 3). Via the reachability matrix the user can easily verify the connectivity of the sites and check that no information can leak to non-participants. The OpenDaylight northbound REST API is used to send the required forwarding rules to the OpenFlow switches.
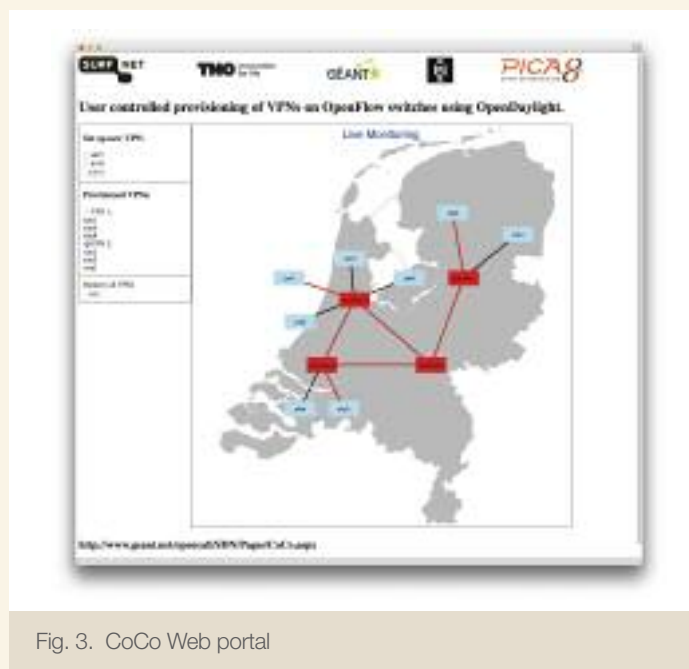

Fig. 3. CoCo Web portal

The communication towards the (virtual) switches is handled using the OpenFlow Protocol (southbound interface).

The next release of CoCo prototype will enable operations between multiple domains, offering its users more flexibility and functionality. That will require information exchange between CoCo agents residing in different domains. At the end of the project, the code of the prototype will be released as open source.

REFERENCES

Intermediate use cases for the Community Connect (CoCo) service. September 2014,
http://www.geant.net/opencall/SDN/Pages/CoCo.aspx
RFC4364 BGP/MPLS IP Virtual Private Networks (VPNs).
The International Conference for High Performance Computing Networking, Storage and Analysis:
https://scinet.supercomputing.org/workshop/
https://scinet.supercomputing.org/workshop/?q=papers

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MINERVA: NETWORK CODING IN TRANSPORT NETWORKS

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Abstract—Trading redundancy for decreased latency and/or recovery time is a common trend in today's transport networks. Although bandwidth resources in backbone networks are often assumed to be unlimited, we argue that optimal resource planning is essential. However, optimal resource efficiency and instantaneous recovery for disrupted connections upon a network failure can be reached only with complex core network operations such as network coding. In the MINERVA framework we identified a practical scenario that is resilient against single link (and storage) failures, where simple operations at the edge nodes are sufficient to reach all benefits that network coding provides. We implemented the necessary virtual network functions for this scenario and deployed them in the GÉANT OpenFlow Facility to demonstrate their benefits for video streaming and distributed storage use cases.

I. INTRODUCTION

The recent trends in hardware design of network devices opened the way for involving in-network modification of user data (i.e., network coding). This allows increased throughput, better resource efficiency, lower complexity, robustness against failures and security. However, the existing implementations of network coding either place the coding/decoding functionality into the application layer of the end hosts or they need to substantially modify the software running in routers, neither of which is applicable in transport networks. On the other hand, the Software-Defined Networking (SDN) paradigm complements the resilient network coding architectures in a simple way, such that the logic can be moved to an external controller rather than inside the networking devices.

In our proof-of-concept implementation we demonstrate instantaneous recovery of connections by deploying network coding capable virtual network functions (NFs) at the edge nodes of the SDN network. This does not require packet retransmission or flow rerouting (i.e., we can completely eliminate the time-consuming post-failure signaling from the recovery process [1]).

II. THE MINERVA FRAMEWORK

A survivable routing scheme has three utmost important features: fast recovery time, simplicity (i.e., low computational and operational complexity) and efficient capacity allocation. For the most widespread single edge failure resilient protection method, the 1+1 path protection - which sends the user data along two disjoint paths (primary and backup) - it is simple to calculate a routing (i.e., disjoint path-pair) and it provides fast recovery from any single edge failure. On the other hand, it consumes twice as much capacity as the primary path. Several survivable routing schemes were introduced in the past decades which could significantly reduce the bandwidth utilization of 1+1. However, they sacrifice either its fast recovery time or, most importantly, its simple operation.

In the MINERVA framework, we brought together these merits, and we propose an algorithm based on network coding to reach near-optimal bandwidth utilization, while maintaining simplicity and fast recovery. We proved that both the optimal capacity allocation and optimal network codes for single edge failure resilient connections can be found in polynomial time [1]. Furthermore, each optimal solution can be routed if we split the data at the source node into two parts A and B, we incorporate redundancy through A⬅B (⬅ denotes the exclusive OR (XOR) binary operator), and we send the three flows on three carefully chosen end-to-end directed acyclic graphs (DAGs). Figure 1 shows such DAGs as part of the well-known butterfly network.
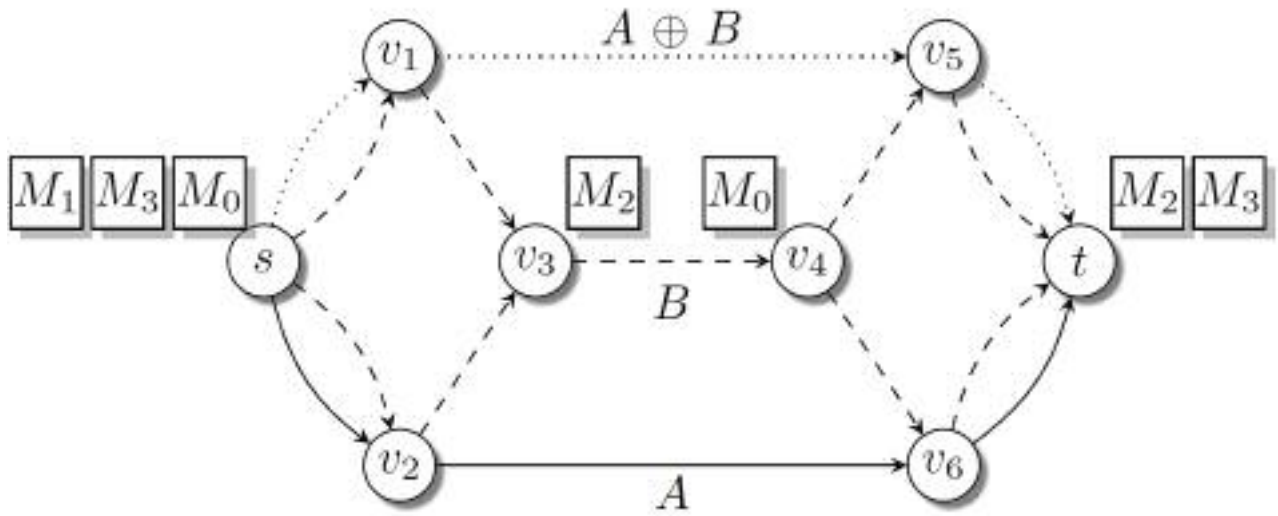
Fig. 1. A single link failure resilient connection with source s, destination t. The two data parts are denoted as A and B.

III. IMPLEMENTATION DETAILS

We identified the following key NFs in order to deploy an arbitrary resilient MINERVA architecture [2]:

- Splitter (M0): forwards incoming packets through two different edges. Placed in s and v4 in Figure1.
- Sequencer (M1): splits the input stream at the source node s into parts A and B and mark each flow with its own MPLS label.
- Merger (M2): receives the same data (i.e. with the same MPLS label) on two incoming edges and forwards a merged, corrected output (in case of missing data at the edges) through its single outgoing edge. See nodes v3 and t in Figure 1.
- Coding/Decoding (M3): both NFs are very similar, as they perform fast packet processing using a simple XOR operation and queues to handle the incoming packets. In an optimal solution, they are always placed at s and t, respectively.

We have deployed the resilient architecture in Figure 1 on the GÉANT OpenFlow Facility, along with two application scenarios, i.e., video streaming and distributed storage.

In both scenarios we have demonstrated single edge-failure recovery, as the video stream originating at source s can be recovered without any noticeable disruption at destination t and also by the data flows A, B and A⬅B being recovered from distributed storage nodes.

Furthermore, single storage failure is also demonstrated in the distributed storage scenario, where the whole data is recovered even under the circumstance of a failed storage node

IV. CONCLUSIONS

We believe that the MINERVA framework is a real alternative to 1+1 protection in resilient networking, as it not only preserves the simplicity in the network operations and the recovery time, but it also reduces the capacity consumption of 1+1 by 20-30%.

REFERENCES

[1] Péter Babarczi, János Tapolcai, Lajos Rónyai, and Muriel Médard, Resilient Flow Decomposition of Unicast Connections with Network Coding, in Proceedings of the IEEE International Symposium on Information Theory (ISIT), pp. 116-120, Honolulu, HI, USA
[2] Péter Babarczi, Alija Pasic, János Tapolcai, Felicián Németh, Bence Ladóczki, Instantaneous Recovery of Unicast Connections in Transport Networks: Routing versus Coding, submitted to Elsevier Computer Networks

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MOTE: MULTI-DOMAIN OPENFLOW TOPOLOGY EXCHANGE

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Abstract—In this paper we describe an architecture for Multi-domain OpenFlow Topology Exchange (MOTE). We present the issues, define the requirements and describe proposed architecture. We briefly discuss implementation challenges within the OpenFlow environment and conclude the paper with directions for future work.

Index Terms—Software Defined Networking, OpenFlow, Multi-domain, Topology Exchange, Network Markup Language, Network Services Interface.

I. INTRODUCTION

The services and capabilities offered by the large-scale multi-domain networked environment implies that management of these networks is essential. The (controlling) network elements need to have sufficient information to take management decisions in an optimal and cooperative way. This information therefore needs to be exchanged between different domains in an efficient and secure way.

One of the most promising SDN technologies currently is based on OpenFlow protocol and the adoption of multi-domain solutions is one of the main challenges. The OpenFlow-based networking solutions do not properly support multi-domain scenarios, although there are some solutions such as FlowVisor that can partition multiple OpenFlow-enabled switches over several users. However, this solution is applicable to switches that belong to a single domain only.

On the other hand, an upcoming solution for automated inter-domain network services is the OGF Network Service Interface (NSI). This standardized interface allows communication between different networks bandwidth-on-demand or circuit reservation systems. Several supporting services are also defined in NSI, e.g. a Discovery Service. The NSI Framework provides a way to do automated inter-domain bandwidth reservations. These inter-domain network services are mainly implemented on VLANs. However, the NSI Framework is initially derived without support for OpenFlow.

In this article we present the Multi-Domain OpenFlow Topology Exchange (MOTE) architecture. Besides topology exchange among OpenFlow domains, the architecture bridges the intra-domain operations of OpenFlow with the inter-domain provisioning in the Network Service Interface (NSI) Framework. The methods for describing and exchanging topology descriptions will allow users to create and tune end-to-end network connections, even those crossing multiple OpenFlow domains. In this article we focus on the topology exchange, and therefore, the main contributions are as the following:

- The topology exchange architecture that supports topology exchange within a multi-domain OpenFlow/NSI environment.
- The support for different topology representations and formats by individual (OpenFlow) domains.

II. TOPOLOGY EXCHANGE ARCHITECTURE

The architecture presented here is based on a generic topology exchange architecture described in . The main requirements addressed within the scope of MOTE are as the following:

- Every administrative domain exclusively controls the way it shares its own topology information
- Domains have the possibility of providing representations of the same topology based on e.g. requesting party
- The topology documents exchanged among different domains are using the same data model.
- The architecture supports security for document exchange and multiple disclosure levels

Our architecture distinguishes three main components:

- **Topology Index** (TI) is a database that holds pointers to the topology providers and summary information.
- **Topology Provider** (TP) hosts the topology descriptions.
- **Topology Consumers** (TCs) are the components that use topologies, e.g. path finding component or lookup components (lookup service).

The architecture supports push/pull model as TCs could register to receive notifications from TI about the topology updates from particular domains. Once a notification is obtained, TC uses the topology pointer (URL) from TI, and requests the topology from the domain itself.
The topology documents themselves are therefore not stored at a centralized server, but are rather kept by individual domains. Only the location (URL) of the topology document is kept at the central location. Once a request for topology document is obtained, a domain decides based on the requesting party what topology information (e.g. full/partial, version) would be provided. The architecture is flexible as the implementation of our solution may be deployed in different scenarios.

III. OPENFLOW TOPOLOGY DOCUMENTS

One of the challenges to exchange topologies from OpenFlow domains is that these documents may be in different formats. This stems from the fact that different OpenFlow controllers may be deployed at different domains. In order to overcome this we use the OGF Network Markup Language (NML) . The controllers need to parse and interpret received NML documents in order to use them locally. Similarly, the controllers need to convert the local topology representation into NML in order to exchange them.
We have verified the topology exchange architecture by implementing the prototype at our MOTE testbed. This testbed consists of a number of OpenFlow-enabled switches deployed at participating partners' laboratories. The deployed controllers are Floodlight and Ryu which were extended with the described topology conversion functionality.

IV. CONCLUSIONS AND FUTURE WORK

We successfully deployed the topology exchange solution that embraces OpenFlow domains. We plan to extend our work (OpenFlow TC) such that it accommodates end-to-end network connections across multiple OpenFlow/NSI domains.

ACKNOWLEDGMENT

REFERENCES

[1] Open Networking Foundation, "Software-Defined Networking: The New Norm for Networks", published online at https://www.opennetworking.org/images/stories/downloads/sdn-resources/white-papers/wp-sdn-newnorm.pdf

[2] R. Sherwood, G. Gibb, K.-Kiong Yap, G. Appenzeller, M. Casado, N. McKeown, G. Parulkar† "FlowVisor: A Network Virtualization Layer", Technical report, 2009.

[3] Open Grid Forum (OGF) https://www.ogf.org/

[4] G. Roberts, T. Kudoh, I. Monga, J. Sobieski, C. Guok, J. MacAuley "Network Services Framework v2.0", http://www.ogf.org/documents/GFD.213.pdf

[5] R. Koning, M. Živković, S. Konstantaras, P. Grosso, C. de Laat, F. Iqbal, F. Kuipers, "Architecture for Exchanging Topology Information in Multi--domain Networked Environments", unpublished.

[6] J. vd. Ham, F. Dijkstra, R. Lapacz, J. Zurawski, "Network Markup Language Base Schema Version 1", http://www.ogf.org/documents/GFD.206.pdf

[7] Floodlight, Open SDN controller http://www.projectfloodlight.org/floodlight/

[8] Ryu, http://osrg.github.io/ryu/

EDUROAM, ENABLING A GLOBALLY INTERCONNECTED R&E VILLAGE

Figure 1 – International eduroam authentications by destination

Wi-Fi access has rapidly become an essential service for anyone working or travelling. The ability to turn-on and instantly connect is now expected and places where Wi-Fi is unavailable are the exception. Everywhere from coffee shops to buses can now offer Wi-Fi but frequently these services are hard to find, harder to connect to and offer uncertain performance and security.

In this Wi-Fi enabled world, the eduroam® service has rapidly grown to become the default access method for students and researchers. With its rapid, automatic connections and the ability to connect to a hotspot without needing to find and enter usernames and passwords, many millions of R&E users are taking advantage of the service every day.

In the last quarter eduroam supported over 450 million successful access authentications – nearly 5 million every day and most importantly over 50 million of those were international users connecting to eduroam outside their "home" country – that's over 500,000 international authentications a day! As the authentication map shows, eduroam is supporting R&E across the whole continent.

These "roaming" connections demonstrate how eduroam is helping to support a global R&E village with students and researchers working together whenever, and wherever they need to be.

For more information on how eduroam is supporting global R&E visit **www.eduroam.org**

CYPRUS AND ITS ENVIRONMENTAL IMPACT

Words
Nikoletta Tsioroli & Petros Ioannou, Special Scientists, CYNET

Cyprus is a small and adaptable free-market economy with a positive long-term outlook despite the current challenging environment. The island, strategically located at the crossroads of three continents, promotes itself as the business gateway between Europe, Asia, the Middle East and Africa especially with its ICT infrastructure. Cyprus has made significant advances in its environmental infrastructure. Its island status, results in significant challenges for water supply, waste management and energy supply which constitutes one of the most important sectors as far as the economy is concerned, but also with regards to the national strategy/security.

The environmental policy of Cyprus has been revised in recent years, as a result of the harmonization process with the European Union. Cyprus has ratified the Kyoto Protocol on climate change and the Cyprus Institute of Energy (CIE) was founded in 2000 and is involved in several programs, cooperates with other international organizations with common goals, undertakes applied research and offers technical guidance and information. Generally, it conducts a wide range of activities regarding information, promotion and utilization of new Innovative Energy Technologies and especially Renewable Energy Technologies.

Cyprus Research and Academic Network - CYNET, is in an ideal position to utilize Information and Communication Technologies (ICT) to improve the environmental sustainability of the organization, as well as of the wider community.

CYNET participates in the GEANT project particularly "The Greening of Services" activity which is seeking to make the environment greener. For the first time CYNET created an Environmental Sustainability Policy and is committed to facilitate its gradual implementation. The policy includes dissemination and sharing of information among CYNET employees/subscribers on environmental issues, implementation of Green House Gas (GHG) audits, promotion of the use of appropriate ICT services/infrastructures as an environmentally positive alternative, explore new innovations in Green ICT as well as the reduction of the overall power consumption and increase energy conservation and energy efficiency. The information and goals will then be presented to the CYNET subscribers in an effort to raise awareness thus improving the environment in a larger scale as well as reduce the Carbon Footprint.

For more information visit
http://www.cynet.ac.cy

ENABLING USERS – EDUGAIN WORKING WITH THE R&E COMMUNITY TO SUPPORT COLLABORATION

Lukas Hammerle, Project Leader "Enabling Users", GÉANT was interviewed by Karl Meyer

SHORT BIO OF LUKAS

Lukas Hämmerle studied electrical engineering and information technology at the Swiss Institute of Technology (ETH Zurich). After graduating in 2004, he joined SWITCH to help build and operate the national authentication and authorization infrastructure SWITCHaai. Lukas has been involved with GÉANT since the GÉANT 2 project, where the initial planning and development for eduGAIN started.

LUKAS, WHY DO WE NEED A TEAM FOCUSED ON ENABLING USERS AND WHAT DOES THIS MEAN?

An increasing number of federations are becoming members of eduGAIN and its overall coverage is growing but until the users and service providers understand how to use eduGAIN, the benefits can be limited. Our team worked with the various research communities to help them get the most out of eduGAIN, benefit from the opportunities it offers and in particular work on some more complex use-cases.

WHAT DID THE TEAM DO?

In brief, the task's main objectives are:

- To act as an expert partner for research communities wishing to use eduGAIN
- To build a knowledge database focused particularly on supporting the needs of user communities;
- To promote the increased use of federated login via eduGAIN.

WHAT HAVE YOU LEARNED?

Our team worked closely with five European research communities. This helped us understand the technical and organisational needs of these communities.

Our work highlighted that many of the issues can be technically solved today, but the deployment of these solutions, and the decision-making process preceding it, often takes longer than expected. Many research communities first need to familiarise themselves with the fundamental concept of federated identity management and authentication and authorisation infrastructures (AAI) before they can understand their advantages and limitations.

WAS THE PROJECT VALUABLE?

All parties involved found the collaborative and consultancy process to be beneficial, clearly showing that there is a demand for GÉANT to offer a permanent consultancy service.
The requirement for access management for research has become a major issue in science. AAI providers need to understand the needs of the scientific communities, while scientific communities should develop their understanding of the benefits of federated identity management and AAI and what providers can be expected to deliver.

This approach therefore involves GÉANT becoming a collaborative partner of research communities to actively help them make use of AAI technologies to benefit Research and Education collaboration across Europe and worldwide.

CERN

CERN, the European Organization for Nuclear Research [CERN], is active in high-energy physics research. A large community consisting of over 10,000 physicists from more than 60 countries collaborate to process the huge amount of data produced. Most of these scientists, who are located all over the world, require remote access to the data that these experiments generate.

The Enabling Users Task helped CERN to:

- Connect their ADFS-based identity management via the Swiss identity federation to eduGAIN to allow bilateral access to and from CERN services and identity providers operated in eduGAIN.
- Contribute to formulating a new policy for a more formalised incident handling in eduGAIN.

The main benefit for CERN employees will be the possibility of using their CERN user account to access and use web services operated by universities and research institutions. At the same time, CERN collaborators could use the user account issued to them by their home institution to access some of CERN's web services

BOX – WORKING WITH RESEARCH AND EDUCATION ACROSS EUROPE

David Quantrell, SVP and GM of EMEA, Box is Interviewed by Karl Meyer, Product Marketing and Communications Officer

WHAT DOES BOX OFFER AND HOW CAN RESEARCH AND EDUCATION COMMUNITIES USE THE SERVICE?

Box offers easy collaboration between students, teachers, and faculty. Users can collaborate and share information from anywhere, work together on team projects, audit, monitor and control information without worrying about losing content. Specifically BOX enables:

- granular authentication
- team collaboration
- easy integration with applications
- document management
- and security

WHAT WOULD YOU SAY ARE THE KEY BENEFITS OF THE BOX SOLUTION?

With Box, you get secure cloud storage, sharing and collaboration on any device. Companies and education institutions rely on Box because it's secure, works on any device and scales to meet the needs of small businesses and Fortune 500 companies as well as specific vertical sectors - like the Education space. Our recent agreement with Jisc demonstrates how Box is committed to working with R&E providers to support their staff, researchers and students.

BOX ISN'T JUST ABOUT FILE STORAGE AND SHARING, TELL ME ABOUT BOX APPS AND HOW CAN R&E BENEFIT FROM THIS APP MARKETPLACE?

More than 35,000 developers are building services on the Box platform today. Every month, 1 billion third-party API calls are made to the Box platform. Box's OneCloud ecosystem of mobile productivity apps passed 1,000 platform partners in 2014. Over the last year, usage of third-party apps by Box customers has increased significantly.

WHERE DO YOU SEE THE CLOUD SERVICES INDUSTRY DEVELOPING OVER THE NEXT FEW YEARS?

Every industry is experiencing information-driven transformation differently. The first wave of the cloud empowered people to be more mobile, productive and collaborative. Now we have an opportunity to move beyond organic, user-driven productivity gains, and change the very processes and even businesses models that define the way organizations and institutions across verticals operate and compete.

Traditional legacy IT solutions no longer meet the needs of the education sector, which is looking to collaborate and manage critical documents more easily and securely from anywhere and on any device. Our partnership with Jisc removes the barriers to cloud adoption within the education sector by delivering a platform that supports education programmes and strategies." Jisc places a strong emphasis on creating environments that foster productivity through user-centered and secure tools. Box met the criteria set by Jisc and has become the preferred collaborative cloud platform for UK universities. Box makes it easy for more than 27 million individuals at 240,000 businesses around the world to share and collaborate across devices, while providing IT departments with unparalleled insight and control. With today's announcement, Jisc joins a growing number of industries that have chosen Box, including the UK government, which deployed Box to its G-Cloud portal in 2013. The Box platform is available today to universities in the UK, exclusively through Jisc.

In September 2014 Jisc launched Box as its first ever file sync and share (FSS) cloud solution, on its Dynamic Purchasing System (DPS). Having completed a rigorous pre-screening, Box is now available through the Jisc portal to more than 134 Higher and Further Education institutions in the UK. "Research and education organisations across our community want access to collaborative sync and share facilities and there is an increasing need for security, particularly for IP protection and data storage within the education sector," said Daniel Perry, director of product and marketing at Jisc."Box addresses this need and we are encouraging suppliers to use the platform not only for FSS but also for it's rich collaborative capabilities." David Quantrell, Box senior vice president and general manager of EMEA, said:

Jisc places a strong emphasis on creating environments that foster productivity through user-centered and secure tools. Box met the criteria set by Jisc and has become the preferred collaborative cloud platform for UK universities. Jisc now joins a growing number of industries that have chosen Box, including the UK government, which deployed Box to its G-Cloud portal in 2013. The Box platform is available today to universities in the UK, exclusively through Jisc.

DAVID QUANTRELL, SVP AND GM OF EMEA, BOX

David is Senior Vice President and General Manager of EMEA at Box, where he is driving the company's continued expansion across Europe. Most recently, David was President, EMEA, for McAfee which was sold to Intel in 2011. Prior to joining McAfee, he was Vice President EMEA for HP software, led all aspects of EMEA business for Mercury Interactive, served as President EMEA NetIQ, and held the role of Vice President EMEA for Nortel Networks and Vice President of EMEA at Clarify.

David received his Bachelor's degree in Electrical and Electronic Engineering from Liverpool University.

ABOUT BOX:

Box's mission is to make businesses of all sizes more productive, competitive, and collaborative by connecting people and their most important information. More than 32 million people at 275,000 businesses, including 99 percent of the Fortune 500, use Box today to share, manage and access their content globally. Content on Box can be securely shared and easily accessed on the web, through iOS, Android and Windows Phone applications, and extended to partner applications, such as Google Apps, NetSuite and Salesforce. Headquartered in Los Altos, CA, Box is privately held and backed by several leading venture capital firms and strategic investors.

For more information check out the Box Education webpage - **https://www.box.com/en_GB/industries/education** and visit **http://clouds.geant.net** to find out how Box can support your teams.

netskope

NETSKOPE – CLOUD WITH CONFIDENCE

Higher education and research institutions are adopting the cloud in a big way. From streamlining university operations to collaborating on research, higher education employees and researchers are using the cloud to work faster and more flexibly than ever before. However, while IT has responsibility for managing some cloud services, individuals and departments are now more than ever able to procure, administer and use cloud services without involving IT, and without jumping through hoops to find budget.

Increased productivity is a good thing, but it can present new problems. The popularity of the cloud has led to app "sprawl", with an average organisation running 613 cloud services, only about 10% of which are known to IT. The unmanaged cloud service usage can disguise or hide risky or non-compliant behaviour, which can lead to the exposure of sensitive content such as proprietary research or intellectual property.
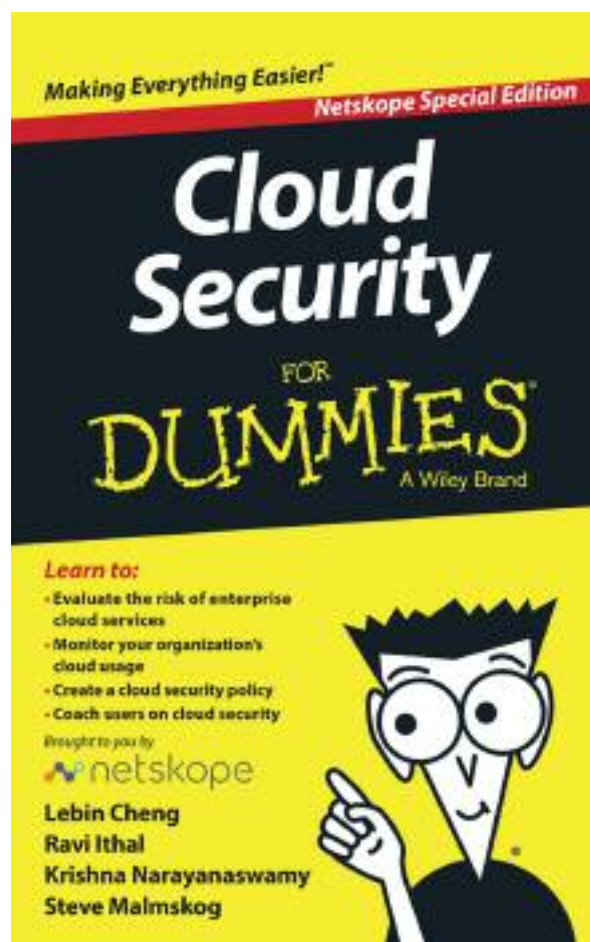
Netskope provides organisations with solutions to safely enable sanctioned cloud services, such as Box, Azure and Amazon Web Services, as well as to gain visibility into unsanctioned ones. Netskope allows IT to find all the cloud services that are in use across the institution, understand usage of those services at a detailed level, and secure usage by enforcing granular policies such as "Don't allow content upload to any file-sharing service if the content is marked "Confidential".

With Netskope, IT can now take a scalpel, rather than a sledgehammer, to unfettered cloud usage. Instead of saying "no," they can say "yes" to cloud services while cutting out the risky activity and keeping sensitive content secure. By helping IT to safely enable sanctioned apps while discovering and securing usage in unsanctioned ones, Netskope helps institutions to move at the pace of research and collaboration while keeping data safe.

Find out how Netskope can help your organisation manage Cloud Services at **www.netskope.com** or read our handy guide Cloud Security for Dummies. Email Sue Goltyakova (**sue@netskope.com**) for your free copy.

Cloud with Confidence™ with Netskope. We wrote the book on Cloud Security.

BANDWIDTH ON DEMAND EXPANDS ITS REACH

NSI - A KEY ENABLER OF SDN

In recent years the Software Defined Networking (SDN) concept has become a hot research topic. In SDN, network intelligence is moved out of network switches and into a centralized controller, empowering the user to build virtualized network capabilities on demand. NSI has become a key enabler supporting software defined networking in the NREN community.

When NSI was first envisaged, the objective was a system that would allow existing dynamic circuit services to interoperate via a well-defined and standardized interface. It is now possible to request circuits that can transit networks using diverse technologies such as OSCARS, GÉANT BoD and Japan's G-lambda. Another objective of NSI was to provide an API for user applications to directly request this end-to-end connectivity – this is now also supported by NSI v2.0

The global collaboration of bandwidth on demand services (which includes GÉANT Bandwidth on Demand) reached another milestone with over 300 connections now being created every month. With over 23 domains across the globe now incorporated into the scheme (including Japan and the USA) the BoD service provides a hugely flexible service for regional and international research collaboration efforts.

The primary benefit of BoD is that it gives the power and control over the networking to the researchers rather than relying on NREN support teams to manage connectivity. This increases the flexibility of the services and allows the network to respond to the needs of R&E.

CERN WORKING WITH GÉANT

GÉANT is an active player to serve the network needs of the WLCG (Worldwide LHC Computing Grid) for the analysis of the data produced LHC experiments. The WLCG is composed of nearly 500 sites across the globe with CERN and 13 other major sites at the core. The LHCONE network has been developed to connect from the centre to the smaller sites. Within the LHCONE, ESNET is coordinating the development of a dynamic bandwidth allocation service. This new service, using the NSI protocol, is built on top the BoD service and other similar services. This lets applications control network resources in a much more efficient and deterministic way.

"Bandwidth on Demand is going from strength to strength with more and more domains being added and new users discovering how to benefit from its flexibility and global reach". Tangui Coulouarn, Product Manager Bandwidth on Demand, GÉANT.

To find out more about the GÉANT Bandwidth on Demand service and how it can help you go to **http://bod.geant.net**.

PARTICIPATE IN TNC15!

TNC15
THE LARGEST NETWORKING CONFERENCE
FOR RESEARCH AND EDUCATION

15 - 18 June 2015, Porto, Portugal

CALL FOR PROPOSALS

DEADLINES

Lightning talks, posters, full papers
Midnight CEST, 15 APRIL 2015

NEW! IMPROVED SUBMISSION PROCESS

CONNECTED COMMUNITIES

tnc15.terena.org

The GÉANT Project will play an important role in the upcoming annual networking conference, TNC. With fifteen papers across multiple sessions, various hot topics will be discussed, such as 'Open Calls – Generating Innovation with Impact'; One Stop Shop: Bringing Scientific Communities Together' and 'Networking the Square Kilometre Array'.

The Project has been a long-time supporter of TNC, which over the years has become the largest networking conference for research and education, attracting ever more decision makers, managers, network and collaboration specialists, and identity and access management experts from research organisations, universities and industry.

TNC15 will be held in Porto, Portugal from 15-18 June. You are welcome to participate by:

- submitting a proposal for a 5-minute lightning talk or a poster presentation (deadline 15 April);
- sending demonstration proposals to: **horvath@terena.org** (deadline 15 April);
- registering to attend in person (early bird discount until 23 February);
- following live streams online if you can't attend in person;
- following **#TNC15** on social media during and before the event.

'CONNECTED COMMUNITIES' THEME

Today, national research and education networks are at an exciting crossroads in society. They provide the basic infrastructure on which big science and big data build, but they also address the requirements of ever-increasing and more diverse communities of Internet users. Many questions remain a challenge, at a time when privacy and security are not a given. This year's TNC will address such topics through keynote speeches, technical sessions, lightning talks and demonstrations. The programme is now available online.

KEYNOTE SPEAKERS:

- John Day, University of Boston, United States - Connected communities need strong foundations
- Manfred Laubichler, Arizona State University, United States - Detecting innovation in networks of collaboration: a graph theoretical approach
- Sarah Kenderdine, National Institute for Experimental Arts, Australia - Cultural data in the age of experience
- Timo Lüge, Social Media For Good - Disaster response in a connected world
- Avis Yates Rivers, Technology Concepts Group Intl. - Unconscious Biases: Addressing Stealth Barriers to Innovation & Productivity
- João Paulo Cunha, University of Porto, Portugal - Porto: A living lab for future Internet in future cities

SPONSORS AND EXHIBITORS

If you would like to become a sponsoring partner / exhibitor, please contact Gyöngyi Horváth at **horvath@terena.org**, or call +31 (0)20 530 4488.

FURTHER INFORMATION

Visit **https://tnc15.terena.org** for registration and all other information.

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THE MANY BENEFITS OF SECONDMENT AND WHY IT MIGHT BE FOR YOU!

In every aspect of its development, management and how it is used, the GÉANT network is founded on and driven by collaboration. From the services that support it to the world-class science it enables, GÉANT is a collective effort, connecting teams of talented people across the networking industry and throughout European research and education.

Bringing networks and people together is therefore central to the GÉANT project. This year the project is enthusiastically encouraging people to take up secondments across the community.

Experience shows that the movement of people is one of the most effective ways to transfer knowledge, and the benefits to all involved are myriad.

CONNECT caught up with GÉANT secondees - past and present - to find out what it's like to take this bold career step, how it facilitates the exchange of best practice and the benefits it delivers to both the host and original employers.

We hope it will inspire the National Research and Education Network (NREN) community to join our interviewees Jan and Ivan, who are increasing the transfer of skills, camaraderie and know-how across research and education networking.

JAN KOHLRAUSCH

Jan Kohlrausch is Senior Incident Handler and Researcher at the DFN-CERT, Germany. Over the last few years his main objectives have been incident handling, disclosure of security advisories and the coordination and work on national and European research projects.

TELL US ABOUT YOUR SECONDMENT

From July to December 2014, I was a Security Officer - part of the Information & Infrastructure Security Team, at GÉANT in Cambridge, UK. The role comprised the review and formulation of security policies, planning for an ISO 27001 certification process and establishing a trust relationship with the European CERT community (Trusted Introducer certification).

WHAT MADE YOU DECIDE TO TAKE PART?

I had previously worked on the Security Activity of the GÉANT project and wanted to take the chance to extend the close collaboration between DFN/DFN-CERT and GÉANT. Personally, it was an exciting opportunity to gain new experiences and to live in a renowned British University city.

BENEFITS TO YOUR CAREER?

I was able to increase my experiences in the area of Information Security (e.g. ISO 27001) and network operation and to establish new contacts.

HOW DO YOU THINK IT BENEFITS YOUR NREN?

The protection of the internet which includes the infrastructure of GÉANT and DFN is a collaborative effort. The secondment opens the door to extend this and helps initiate new projects, for example, improving the detection and mitigation of multi-domain attacks such as distributed denial of service (DDoS) attacks.

BEST BITS?

The combination of gaining new experiences and living in Cambridge. It was an exciting opportunity for me. It was very well organised and supported and I particularly enjoyed the work and environment. I would definitely recommend it to others.

IVAN GARNIZOV

Bulgarian Ivan Garnizov works for RRZE Friedrich-Alexander-Universität Erlangen, Germany a subcontractor of DFN. He is engaged with perfSONAR deployments and support, implementation of GÉANT products and in participating and leading many organisational tasks.

TELL US ABOUT YOUR SECONDMENT

I received an inquiry from GÉANT 'Cambridge CIO, Anand Patil asking if I was interested in a secondment. It wasn't an easy decision for me, with family and my two princesses at home. However, knowing it would help my current tasks and hoping I could put my existing GÉANT knowledge to the test, I decided to go for it.

We agreed it should not overlap with the next project, so we arranged a secondment for five months (which was later extended by one month).

Working closely with GÉANT IT and Operations teams in Cambridge, I have discovered a lot of open minded professionals, who are also considerate, caring and patient. I always find myself very welcome in meetings and was pleased to be invited to the office Christmas party.

From the beginning, the team really put me at ease and are flexible with fairly regular visits home. GÉANT took care of arranging the whole secondment, which made the decision much easier.

BEST BITS ABOUT IT?

The ability to work and share ideas with open minded experts and get inside the processes. It is really easy to work with all the teams.

I wouldn't be able to list them all, but I also enjoy being able to talk with the CTOs, PMO, Training, Partner Relations and Support teams. I especially like the big, sociable kitchen, where you could easily find yourself with the CTO, CIO and people at all levels, chatting over coffee or a lunch break.

HOW DO YOU THINK IT WILL BENEFIT YOUR NREN?

It's a little early to make conclusions. However, I believe the benefit will come from my well established contacts and good connections within the various GÉANT teams.

ANY RECOMMENDATIONS?

Get on your bike and get in touch (**http://linkd.in/1I7CjhM**). I know plenty of tracks and interesting places around Cambridge!

NETWORKING PEOPLE

Says Linda Mesch, GÉANT Programme Management Officer

"When implemented effectively, the potential benefits of secondment to all parties is great. The secondee employee enjoys valuable personal and career development and gets the opportunity to acquire extensive experience, confidence and skills.

The secondee's home NREN gains enhanced employee skills and wider, improved networks, which can be built upon at GÉANT events throughout the year. This opens the door to new opportunities for collaborative ideas and problem solving.

The host organisation – in this case GÉANT - attains immediate skills, opportunities to increase and share knowledge and an external perspective. In all cases, cross-functional communications are likely to be hugely improved.

We hope more members of the NREN community will create and take advantage of secondments across the GÉANT consortium wherever possible."

For more information about seconding at GÉANT in Cambridge, please contact **pmo@geant.net**

TRUST AND FEDERATED ACCESS IN ROADMAP TO PRESERVING DIGITAL CULTURAL HERITAGE

The DCH-RP (Digital Cultural Heritage-Roadmap for Preservation) project delivered a 'Roadmap for Preservation' that fundamentally addresses the use of existing and emerging e-infrastructures for the purpose of long-term, reliable data and metadata preservation. It could become instrumental when approaching policy makers and national authorities to get support for the creation of an e-infrastructure that is able to meet the requirements of the cultural heritage community.

Defining the Preservation Roadmap for DCH encompassed a number of activities including exploring the state of the art in cultural heritage and e-infrastructure, developing a registry of services and tools, investigating how Infrastructure as a Service (IaaS) can contribute to digital preservation services for DCH and considering how standards and interoperability principles can be adopted by the cultural heritage and e-infrastructure communities. In addition, the Roadmap was supplemented by practical tools for decision makers, including best practices to promote future interoperability and the adoption of common standards, tools, approaches and business models.

One of the aspects identified in the Roadmap is the need for a mechanism for creating trust between the DCH-RP institutions and the e-infrastructure providers. This is to be achieved by agreeing on policies as well as on the adoption of specific technologies, one of which is federated access.

GÉANT's Amsterdam office (formerly TERENA) was a DCH-RP project partner whose role was to provide a set of recommendations on the adoption of federated access. Federated access provides the technical and policy framework to allow services to be shared in a trustworthy fashion across borders. How authentication is carried out by the institutions and how access management is carried out by the service providers is left up to the respective parties.

Considerable technical expertise is required to set up the infrastructure allowing federated access (installing an identity provider [IdP] or a service provider [SP]). This is a potential barrier in the digital cultural heritage context, due to the lack of technical resources in this sector. However, federated access can also bring a number of benefits, such as scalability, increased security, and mechanisms to establish trust among the participating parties. To facilitate the adoption of federated access in this community, it is important for the digital cultural heritage stakeholders to act as a community as much as possible, and to engage with the R&E federation operators.

The main recommendations from the report can be found in the table below.

Recommendations	Actors
Use a managed service to operate your IdP, whether a commercial offering (such as **OpenAthens**, **Gluu**, **Ping Identity** and equivalent) or one offered by the NRENs (such as GARR's IdP in the Cloud).	DCH-RP community
Engage more actively with national R&E federation operators and ensure that funding is allocated to the federations for support activities.	DCH-RP community
Avoid the use of digital certificates; if services require a digital certificate (i.e. grid facilities), use solutions like the e-CSG to hide the complexity.	Resource providers
The use of social network identities should not be discarded; there may be applications for which a social network account is sufficient.	Resource providers
Applications should use simple graphic interfaces, rather than command line, to encourage wider use.	Application developers and resource providers
Especially if federated access is provided, best practice guidelines should be followed to improve user satisfaction	Resource providers
Consider adding a cost/benefit analysis in the roadmap, which also includes considerations around reusing/sharing applications (federated access) versus managing services at institutional level.	DCH-RP partners

ABOUT DCH-RP

DCH-RP (Digital Cultural Heritage Roadmap for Preservation) was a 13-partner project supported by the EC FP7 e-Infrastructures Programme. It aimed to harmonise data storage and preservation policies in the digital cultural heritage sector; to progress a dialogue and integration among institutions, e-Infrastructures, research and private organisations; and to identify models for the governance, maintenance and sustainability of the integrated infrastructure for digital preservation of cultural content. The project concluded in October 2014.
http://www.dch-rp.eu/

THE PRESIDENT DECORATES ARNES

On 17 November 2014, the President of the Republic of Slovenia decorated ARNES with the Order of merit for development and research in the field of introducing new information and communications technologies in Slovenia.

ARNES was established 22 years ago as a national "academic network" and today connects over 1000 organisations with more than 200,000 users in the fields of research, education and culture to the GÉANT pan-European research and education network. With its network and services, its management of an ISP hub and the .si domain as well as providing security, it is one of the key elements in Slovenia's e-infrastructure, and ensures the transfer of knowledge when new technologies are introduced.

ARNES's general manager **Marko Bonač**, who has led ARNES since its inception, points out that "22 years ago we were real pioneers in the field of ICT and we remain one of the key organisations to ensure the introduction of new network technologies in Slovenia".

In the 90s, simple dial-up connections at schools provided a turning-point for communication with their counterparts all over the world - 20 years on, the Academy of Music can stay in tune with its international colleagues through a dedicated optical fibre connection. ARNES's vision is to use its networks and computing cloud to provide researchers and educators in small towns with access to the highest technology and equal opportunities for collaboration on the advanced international projects available to their peers in Sweden, Switzerland or England. Let us not forget that 4% of the calculations required to prove the existence of the Higgs boson were performed in the relatively small Slovenia.

When the topic is the development of e-Slovenia, ARNES is an integral part in these discussions.

NEXT EGI CONFERENCE – BUILDING THE OPEN SCIENCE COMMONS

The EGI Conference 2015 will be held in Lisbon, Portugal between 18-22 May, as a first opportunity to push forward the Open Science Commons, a new vision proposed by EGI where researchers from all disciplines have easy, integrated and open access to the advanced digital services, scientific instruments, data, knowledge and expertise they need to collaborate and achieve excellence in science, research and innovation.

The event is organised by EGI.eu and IBERGRID, a partnership between the Portuguese National Distributed Computing Infrastructure (INCD) and the Spanish National Grid Initiative (NGI-ES). Jorge Gomes, INCD's Services and Technology Director, says: "We are delighted to host the EGI Conference 2015. The event will join users, developers and providers in the distributed scientific computing domain and we look forward to welcome them next Spring in Lisbon."

The event will also be the first EGI meeting in the post-EGI-InSPIRE project era and will kick-off the work for the coming years, focusing on new challenges and new engagement opportunities through a successfully evaluated follow-up project within the European Commission Horizon 2020 funding programme, called EGI-Engage.

Tiziana Ferrari, EGI-Engage Project Director and EGI.eu Technical Director says: "In EGI-Engage, we will work together to make the Open Science Commons happen. Our main goal is to expand the capabilities of a European backbone of federated e-Infrastructure services for research."

More information about the event is available on the EGI Conference 2015 website: **http://conf2015.egi.eu**

HEANET DELIVERS 100 MBPS FOR IRELAND'S 780 POST-PRIMARY SCHOOLS

Every post-primary school in Ireland now has high speed broadband as a result of a €30 million, three year programme rolled out on behalf of the Irish Government by HEAnet - Ireland's NREN.

The broadband programme, which represents one of the most ambitious technology roll-outs to the Irish education sector, was delivered within budget and a highly challenging three year schedule. It was completed in collaboration with the Department of Communications, Energy and Natural Resources and the Department of Education and Skills in Ireland.
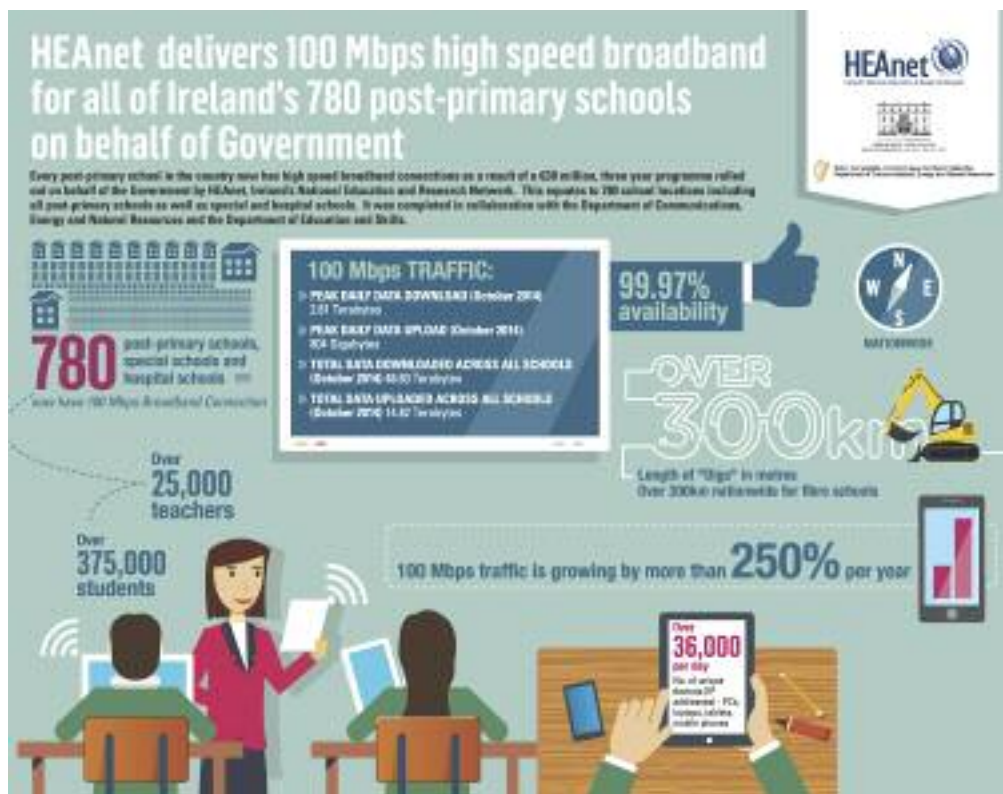
"HEAnet is very pleased to have successfully delivered this programme on behalf of the Irish Government and Irish post-primary schools", **said John Boland, HEAnet Chief Executive**.

"We believe that the provision of high-speed broadband to post-primary schools will have very meaningful benefits for pupil learning outcomes in the years ahead. It will support the development of ICT and STEM related learning in Irish post-primary schools which will ultimately deliver real benefits for Irish society and its future economic prosperity."

The national reach of the programme has required building new infrastructure in locations where there was extremely limited high-speed broadband availability, including school communities on four coastal islands.

The broadband service is of an extremely high quality and delivers symmetrical bandwidth connectivity meaning it provides equal upload/download speeds simultaneously; an important consideration in cloud computing and two-way communications such as video conferencing.

The programme was achieved in co-operation with technology vendors including: AirSpeed Telecom, Digiweb
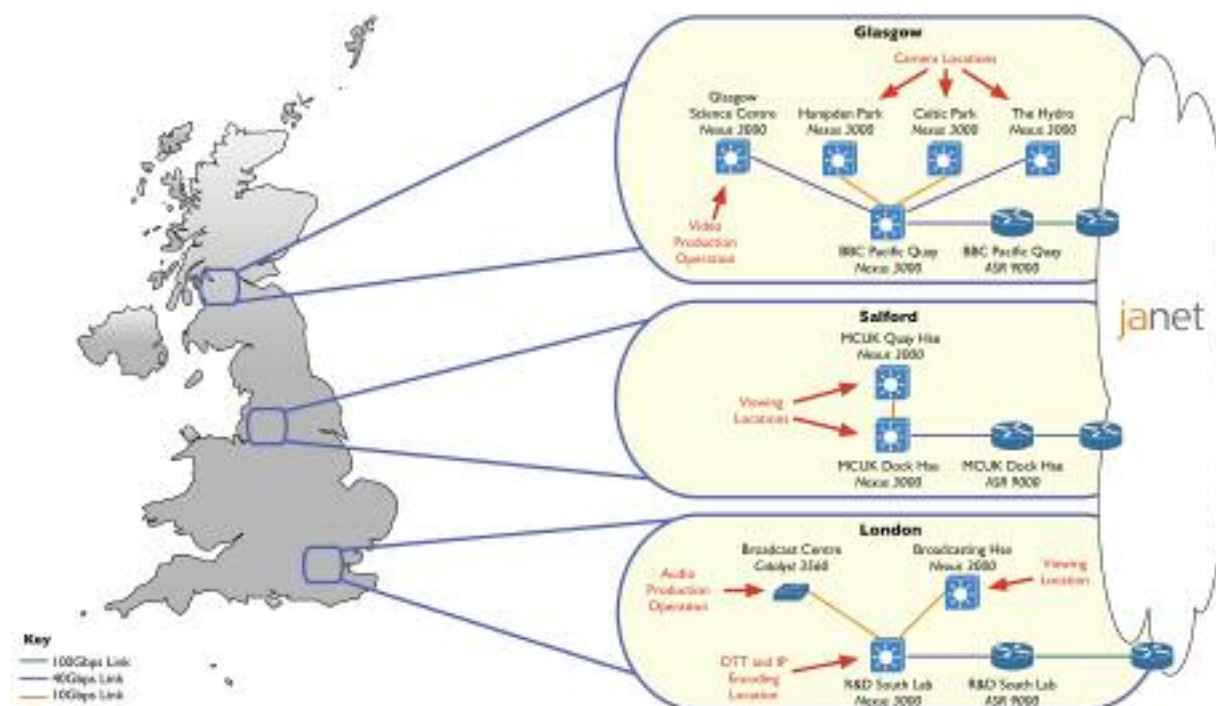

(Viatel), eircom, enet, Imagine Communications, UPC, Vodafone, and Agile Networks. HEAnet also acknowledge the support of the ESB whose fibre underpins a significant portion of the national education network.

Picture 04/12/14: Jan O'Sullivan (Minister for Education), Alex White (Minister for Communications) and John Boland, (HEAnet Chief Executive) announce completion of 100Mbps rollout to all post-primary schools in Ireland.

The programme is funded by the Department of Communications, Energy & Natural Resources and the Department of Education & Skills, supported by Ireland's EU Structural Funds Programme and the European Regional Development Fund.

GOING FOR GOLD AT NETWORKSHOP43

Attendees to this year's Networkshop43 – the annual technical event for education and research hosted by Jisc – will be able to hear how the 2014 Commonwealth Games was broadcast in ultra-high definition, using the Janet network. Martin Nicholson, Project Technologist, BBC Research and Development, discusses:

V ideo needs a lot of capacity to be carried on a network. Traditionally broadcasters sent large teams and vast quantities of kit to event locations so that the production can be handled on-site, with only a small number of production feeds having to be sent elsewhere for further production and transmission – but traipsing staff and equipment round is obviously a significant and costly exercise.

If broadcasters used IP cameras and also had access to enough network capacity such that all camera feeds could be brought back to production centres from across the country, then this could help overcome these challenges.

This is exactly what BBC R&D and our partners – Cisco, Jisc, and Virgin Media Business – did for the 2014 Commonwealth Games, courtesy of a 100Gbps network spanning three cities across the UK.

Rather than most of the workflow being handled at the event location, the video production took place elsewhere in Glasgow whilst the audio production happened in London, with the resulting production stream being received at another London site to encode it for Digital Terrestrial Television (DTT) and IP streaming. Salford was also receiving the streams for monitoring purposes and, if necessary, was able to become the backup production location.

To transport the video and audio, we used Source-Specific Multicast (SSM) so that feeds could be received anywhere on the network and the bandwidth operated efficiently. We also used multicast to allow all the feeds to be available on-demand at any site.

Each video stream was compressed to around 1Gbps to ensure that the video remained high quality.

What we did was highly innovative and understandably not without a few teething issues, but with the support of our partners we were able to fix some initial problems with the network, and after that the performance was exceptional. It truly helped BBC R&D to demonstrate several exciting technologies in a high profile live event watched around the world.

Networkshop43 takes place at the University of Exeter from 31 March – 2 April. The event offers a place for network managers and technical staff in UK education and research to engage with peers and service suppliers, as well as hearing expert talks. Other speakers include Chris Lintott, professor of astrophysics and citizen science lead at the University of Oxford. Visit the **event site** for more information.

Jisc

EDUROAM IN THE UK REACHES NEW MILESTONE

Seamless, robust connectivity is a must for effective collaborations across institutions and even countries, but this should never be at the expense of security – as evidenced by the growing popularity of eduroam, the single sign-on network service for education and research, amongst UK higher and further education institutions.

In October 2014 eduroam reached a landmark when more than 600,000 unique devices owned by users roaming between participating organisations were successfully authenticated over the UK national infrastructure at least once during the month. The 608,131 figure reached was a huge increase even on the month before, when 487,437 were counted. In fact, over the past few years the number of devices counted roaming between eduroam's member organisations in the UK has been growing exponentially, almost doubling year-on-year.

If we take an annual view, the number of roaming users is even more impressive. From December 2013 to November 2014 a count of 2,263,576 devices (each authenticating on multiple occasions) was recorded.

This growth can be partly attributed to the increasing number of eduroam member organisations. At the time of writing there were more than 225 operational services – a number that includes 95% of UK universities, but also 20% of further education colleges, and many other leading bodies that support UK education and research. But it's also reflective of how people are choosing to access services, often using their own devices or working on the go.

The increasing popularity of eduroam can be quite easily understood. For the user, it ensures that they can gain authenticated login and internet access using a single Wi-Fi profile wherever the eduroam service has been made available by a participating organisation. This can save them time and head off some of the frustrations that can arise in getting network access away from the home network. Member organisations make efficiency savings too, not least because this type of service significantly reduces the admin workload in managing guest network access accounts for visitors.

Often, though, the downside of strategies to foster wider connectivity can be compromised security.

Words
Ed Wincott, who manages the eduroam service in the UK for Jisc

Certainly, the explosive growth in numbers of users bringing their own devices has brought with it heightened concerns about cyber security. We know that education and research organisations have very clear requirements when it comes to the security and reliability of connectivity services.

Security is a central component of eduroam. Users are never prompted to enter their credentials onto web pages that are vulnerable to being hijacked and used for 'man-in-the-middle' exploits. Instead, 802.1X standards technology, which represents best current Wi-Fi deployment practice, results in encryption of user credentials and enables secure authentication tunnels to be established right back to RADIUS systems at users' home organisations.

GET HELP FROM THE EDUROAM COMMUNITY

Often, organisations find it relatively straightforward to implement eduroam because in many cases their existing infrastructure is already 802.1X-ready and can be reconfigured easily to provide the service. A good example of this is Leeds Trinity University, which has adopted eduroam to improve end user experience for its 3,000 students and 400 staff.

Partial wireless coverage and 'hotspots' of availability were some of the restrictions of the previous service, compounded by having to use different networks for different devices. Overall there was no consistent experience for the end user.

Matthew Collins, Leeds Trinity University's IT infrastructure specialist – networking and security, says that removing those frustrations was an important driver. In addition it was found that eduroam dovetailed neatly into the university's ongoing development plans for its infrastructure and security services: "We already used Microsoft's NPS RADIUS solution, and we could easily configure it to eduroam as it was an extension of what we were already doing.

"We did research, had an implementation plan and ran user testing. We tested every device we possibly could, and invested a lot of time in creating events around eduroam, in a way users would understand."

Matthew says that what really helped was learning from others: "I would advise anyone making the move to find another institution that uses a similar technology platform, and use it as a resource. We found a local university which had a similar infrastructure to us, and got help from them when setting it up."

A key measure of success has been positive feedback from end users about how easy it now is to connect their devices to the network, both on campus and on the move. Those benefits have been evident from day one. But looking a short distance into the future, eduroam will also provide a platform for the delivery of other services. Matthew says it is already being used to add value for students in the form of enabling easier access to Apple TV, and will support unified communications and video conferencing at minimal cost when the campus is extended.

THE CITY OF CACERES HOSTED THE 25TH REDIRIS TECHNICAL CONFERENCE

The 25th RedIRIS Technical Conference took place from 24th to 27th of November in the Caceres San Francisco Cultural Complex.

The event was supported by the University of Extremadura and the City Council of Caceres and welcomed more than 400 people from Spanish universities, autonomous region networks and research centres.

The opening ceremony was hosted by the Deputy Rector of the Digital University of the University of Extremadura, Carmen García González, accompanied by the Deputy Director General of Science and Infrastructure Planning of the Ministry of Economy and Competitiveness (MINECO), José Doncel; the Director of RedIRIS, Tomás de Miguel; the Secretary General of Science and Technology of the Government of Extremadura, María Guardiola; and the Deputy Mayor and Councillor for Innovation of the City Council of Caceres, Jorge Carrasco García.

THEMES:

- Models of Institutionally Shared Services
- The University and Global Sciences, a glimpse of the future
- Cloud Storage
- Campus Networks and Mobility Services
- Big Data and Open Government

Two plenary sessions were led by the Director of Communications and Security of the Spanish National Research Council (CSIC), Víctor Castelo, and the surgeon specialising in minimal invasive surgery, Jesús Usón. There was also a round table organised by the Conference of Rectors of Spanish Universities (CRUE) entitled, "RedIRIS and the Universities" and a Networked Music Performance with musicians playing in Triestre and Caceres.

This edition of the RedIRIS Technical conference is partnered by fifteen companies, including sponsors Alcatel-Lucent and Teltek. They will take part in the event by giving lectures and demonstrating their products.

The Technical Conference sessions were preceded by Working Groups focussed on the technical staff of the institutions affiliated to RedIRIS.

WATCH THE VIDEO SESSIONS:

The Working Groups:
http://tv.rediris.es/es/gt2014/index.html

The Technical Conference:
http://tv.rediris.es/es/jt2014/index.html

More information:
http://www.rediris.es/jt/jt2014/

THE REFIMEVE+ PROJECT

The REFIMEVE+ project (in French, Metrological Fiber Network with European Vocation +), is based on a scientific innovation, the ability to transfer an ultra-stable optical frequency on Internet over long-distances without any traffic disruption.

Currently the transfer frequency faces the difficulty of transporting information without degradation when clocks are separated by hundreds or even thousands of kilometers. This can be made if one of the clocks is transportable, but this solution is mostly not flexible and hard to organize. Otherwise, they are made through one or more satellites of the GPS (Global Positioning System) or telecommunication satellites.

The French teams of LPL and SYRTE showed that the clock signal transmitted on RENATER's network between Villetaneuse and Reims (roundtrip: 540km) had an exceptional uncertainty of 2x10-19 which is equivalent of 0.1s in the relation to the age of the universe! This requires creating a noise correction system inserted in the link while the signal is propagating over the optical fiber.

This system will give us the possibility to compare the ground clocks all across the continent and whose relative accuracy reaches some 10-16 and 10-17 soon.
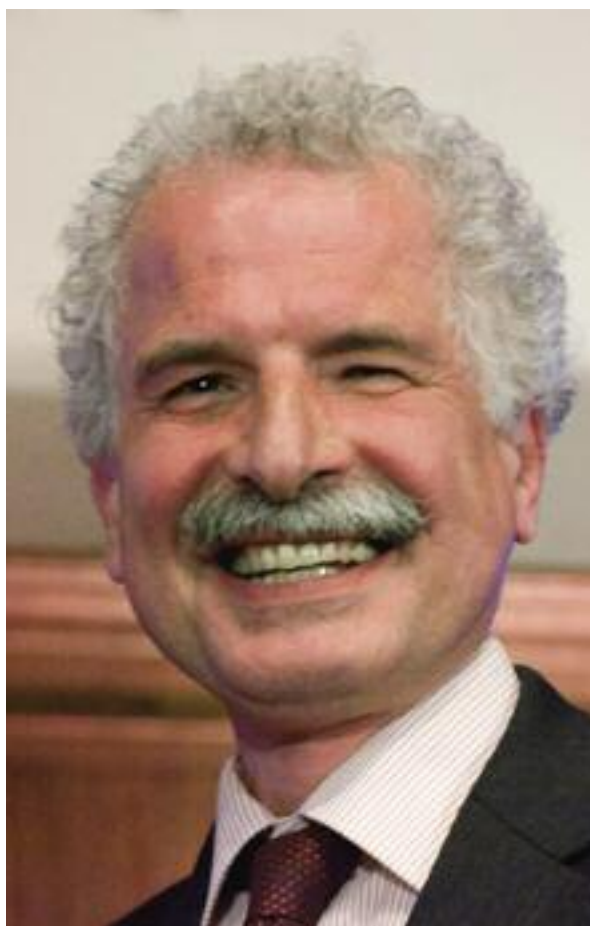
This project is to generalize this concept through close collaboration with RENATER, to distribute throughout France an ultra-stable frequency generated at the Observatoire de Paris. REFIMEVE+ will be funded until 2020, under the label "Future Investments" and involves many laboratories: besides the LPL, the SYRTE, RENATER and industrial partners who design, build and oversee the network, 17 other laboratories including the CNES in Toulouse will receive the metrological signal.

REFIMEVE + is a first step to build a network at European level with a first extension considered to Germany with the support of the DFN (German Academic Network). Many other countries are already interested in this possibility. Effective management of equipment at European level could be achieved by including the GÉANT Association and the GÉANT network that interconnect networks such as RENATER and DFN.

For more information, please contact Emilie Camisard at **emilie.camisard@renater.fr** and Nicolas Quintin at **nicolas.quintin@univ-paris13.fr**

http://www.refimeve.fr/

NEW CHALLENGES FOR DUTCH SCIENCE AND SOCIETY

Big Data is changing both science and society. Anwar Osseyran and Wilco Hazeleger, directors of SURFsara and the Netherlands eScience Center respectively, have joined forces to help reap its harvest.

"Big data doesn't provide answers by itself", says Osseyran. "People pose the questions first, when they discern patterns in the data." Hazeleger adds: "eScience is not fundamentally different from traditional science, but now we can provide access to computing and storage power – like that at SURFsara – that used to be prohibitivily expensive."

An example is NLeSC's Biomarker Boosting project: multiple academic medical centers are pooling their collections of brain scans to find signs that predict the onset of Alzheimer's or Parkinson's disease. To make this possible, tools are developed to harmonize their data, plus a network platform for secure sharing of patient data for analysis with SURFsara's cloud technology. "Projects like this pose lots of technological challenges", says Hazeleger. "But their tools can be adapted to other disciplines, and also for government and industry."

NLeSC is staffed with the people to do just that: eScience research engineers who are deployed to assist researchers in their projects, and who share the resulting insights with their colleagues so the seeds of innovation can be spread around.

But is it enough? Osseyran sighs: "Well... Big Data is indeed gigantic. And R&D spending in the Netherlands is now below the EU average." Therefore cooperation is vital. In addition to SURFsara and the NLeSC, several universities have set up data research centers. "We have a national role", says Hazeleger, "but they often have specialized knowledge in fields such as health or life-sciences. We could share resources through a federated infrastructure and also rotate staff... That would be a great step forward in creating a biosystem to nurture eScience in this country."

Pictures
Prof Anwar Osseyran (right), Wilco Hazeleger (left) Credit: Martijn van Dam.

"WHAT ARE THE ODDS FOR ACADEMIC CLOUDS"

Edouard Bugnion is a Professor of Computer Science at EPFL. He states: "There will be blood", looking at the current dramatic changes in the IT supplier industry. Companies like HP, IBM etc. are losing market share in the server business. In contrast direct sales from Original Design Manufacturers – the whitebox market – are rising by 25% year-on-year. The buyers are cloud operators like Microsoft and Amazon who build new data centers at a tremendous pace. With these big players what are the odds for a Swiss academic Cloud?

Patrik Schnellmann from SWITCH (left) spoke to Edouard Bugnion (right).

PATRIK SCHNELLMANN: GIVEN THE BIG GLOBAL CLOUD PROVIDERS, WHAT ARE THE ODDS FOR A SWISS ACADEMIC CLOUD?

Edouard Bugnion: There is a big opportunity to address research problems with such a cloud, located in Switzerland and operated locally. Optimized for academic use, it would be a powerful tool for data scientists. They would use it to analyze large datasets and meet all legal obligations regarding data protection. This is particularly important in sensitive applications such as personalized medicine that processes genome data.

HOW WOULD SUCH AN INFRASTRUCTURE BE BUILT?

Virtualization is essential. Computing, storage and networking need to be virtualized consequently, moving essential functions from the hardware to the software resulting in a "software defined data center". The use of whitebox components provides cost-effectiveness, efficiency, and scalability within each data center location.

CAN A SWISS CLOUD FOR THE ACADEMIC COMMUNITY COMPETE WITH THE BIG PLAYERS?

Yes, definitely, because the academic community is not trying to compete with commercial solutions. Instead, the goal is to serve the specific data science needs of the academic community. One specific differentiated goal is to make available interesting and relevant data sets to be shared within the community while ensuring the appropriate data protection.

DO THE NATURE OF SWISS DATA PROTECTION LAWS INFLUENCE THE CHOICE BETWEEN THE USAGE OF PUBLIC CLOUDS VERSUS COMMUNITY CLOUDS?

The Swiss data protection laws are quite comparable to those in the EU, but they are just different. Therefore the Swiss are not a special case building their own academic cloud. Similar projects are being done in Ireland by HEANET (while having Amazon, MS data centres in the same country), the Dutch are also going this way as well. It is more of a case of finding the best solution to the needs rather than enforcing one solution.

Q&A WITH ANN HARDING

Ann Harding currently heads up Trust and Identity work in the GÉANT project and is a member of the AAI team at SWITCH, the Swiss NREN (National Research and Education Network). She joined in 2007, after working for seven years at Irish NREN HEAnet, first as a network engineer and then as Network Operations Manager.

In November last year, Ann attended the Lusaka UbuntuNet Conference as a speaker on GÉANT's Trust and Identity services. She was inspired by the fresh spirit of the African community – and returned to Switzerland motivated to encourage more people to experience events, like this, in developing countries.

CONNECT caught up with Ann to find out why the trip was so rewarding and how it offers opportunities for cross-pollination of ideas and forging valuable, mutually-beneficial partnerships.

TELL US ABOUT THE CONFERENCE?

I went to Lusaka to the 7th Annual UbuntuNet-Connect conference on Infrastructure, Innovation and Inclusion on 13 and 14th November 2014.

The UbuntuNet network is the result of the AfricaConnect project, which is establishing points of presence in major African cities and interconnecting them with broadband cross-border links. Thanks to this high speed data communication network, African researchers, educators and students are now connected, creating opportunities for innovation and inclusion.

My role was to present on GÉANT's Trust and Identity services - in particular eduroam and eduGAIN - and the

national and regional development considerations needed to deploy and take part. I also took part in a panel discussion on what NRENs can do to support researchers.

WHAT WAS YOUR OBJECTIVE?

While connectivity is important, it's only part of the toolkit needed for a modern campus, NREN or student. The UbuntuNet Alliance have had an excellent track record in deploying the regional network and connecting globally.

Increasingly, these NRENs are looking to develop and offer other services e.g. the local host for the conference, ZAMREN recently deployed eduroam, with the help of colleagues from the Netherlands NREN, Surfnet.

At the same time, their researchers are increasingly demanding facilities so that their research can compete at a global level. Trust and Identity services are the next big infrastructure requirement after the network, but it can be hard initially to see the potential. I was able to share some of the successful stories from GÉANT members to show the value of these services.

WHAT WAS THE EXPERIENCE LIKE?

It was great. Participants in the conference were interested, engaged and practical. There was a really good atmosphere aimed at sharing knowledge and then going back home to get things done. Everyone seems to understand that results will take work and are willing to do it.

I already received several follow-up contacts, for example looking to see how the Federation as a Service model could be adapted to work locally in West Africa. I really liked how people were focussed on solving real problems and getting things done collaboratively.

On the other side, I also got some interesting and valuable contacts for evolving eduroam as a service to cover increasingly hard to deploy locations, so the benefit was definitely in both directions.

WOULD YOU GO AGAIN?

I'd love to, travel budget permitting! I think important seeds have been sown for a globally interoperable trust and identity infrastructure and it is important for GÉANT to continue collaboration with other world regions.

WHAT WOULD YOU RECOMMEND THE EU COMMUNITY DOES TO HELP THE UA COMMUNITY?

It's not just GÉANT activity or task leaders who have something to offer or can develop some new outlooks.

I really like the type of partnership approach such as for the deployment of eduroam in Zambia. With experts working closely together, it eases the deployment challenges at new sites and also provides interesting challenges for the existing services that help us develop.

It is also a very sustainable way of working and allows the community to really own their services. A lot can be done remotely, supported by attendance at group events such as UbuntuNet Connect or the WACREN conference.

It doesn't require a very long term commitment from the EU partner and offers staff a professional challenge and a perspective on the pioneering spirit representative of the early days of NRENs and that still continues to drive innovation.

OPEN CALLS PROJECT PROFILES

Throughout the last three issues of CONNECT we've been profiling the 21 Open Call projects under the GÉANT innovation programme. We've seen an incredible array of innovative ideas and exceptional people who are helping to shape the networks of the future. Last but not least, here are the final three…

EMUSIC

BOD FOR LOW LATENCY, HIGH BANDWIDTH APPLICATIONS

The world class GÉANT network is increasingly used to support applications requiring very low latency and high bandwidth, such as LoLa and even 4K TV streaming. Trials in these areas have been successfully conducted in several countries.

In some cases, however, it is more difficult to satisfy the high performance requirements of these applications, for instance where the current GÉANT topology does not allow the shortest possible path. In such cases a special network path must be set up – an operation that is costly and not always feasible.

The idea at the core of the eMusic project is to use Bandwidth on Demand services, as a cheaper and more widely available option to overcome these limitations.

eMusic brings together three European academies – the Academy of Performing Arts in Prague, Conservatorio di Musica Giuseppe Tartini in Trieste, and the Edinburgh Napier University – and their respective NRENs: CESNET, GARR and JANET.

The team has run experiments with networked musical performances between the three schools, comparing a best effort network path to one set up with the BoD service. As it happens, the standard GÉANT connection has so far held up quite well, but there are more tests to come.

Ultimately, the option of using BoD for these applications brings us a step closer to widespread remote collaboration between teachers, students and artists in music, dance or performing arts in general across Europe.

NSI-CONTEST

HELPING BOD DEVELOPERS BRING NSI TO PRODUCTION

The Network Service Interface (NSI) by OGF is emerging as the standard inter-domain interface for Bandwidth on Demand. The NSI Connection Service version 2.0 has already been released by OGF NSI-WG, bringing new features and significant updates to the previous version of the protocol. This has given rise to numerous development efforts; however, the challenge in developing production-ready BoD implementations of NSI is all but trivial. A reference implementation is not available and thorough testing is needed for current efforts to be sure that when a service is delivered in production, it will work as expected.

The NSI-CONTEST project is providing a framework for validating these efforts. It is working on the development of a NSI CSv2.0 reference implementation and a Conformance Test Suite. The project is a joint effort by PSNC and the Italian research center Nextworks.

"Software development is not an easy process," says Bartosz Belter, project coordinator, "we are here to support NSI developers with testing of their BoD systems, and compliance with the standard. If you set up testing in advance, then you can have early feedback from the platform. This way I think you can reduce effort and potentially cost for testing external implementations."

WOT4LOA

ENHANCING AUTHENTICATION WITH WEB OF TRUST

One core issue in the area of authentication is how to guarantee high levels of assurance (LoA) while containing costs – in particular, user registration costs.

In person registration is more secure but very expensive and not user friendly. Remote registration is relatively cheap but more vulnerable to threats and technically complex, generally relying on the availability of trusted sources to cross-reference and validate the identity assertions provided.

The WoT4LoA project, a joint effort between SURFnet and the dutch organization InnoValor, is working on a solution based on the concept of web of trust (WoT).

The web of trust concept is used to establish the authenticity of the binding between an authentication solution and its owner via third party user attests. It can be considered a kind of "crowdsourcing of trust".

"The idea is to let other people attest claims of a user's identity, so we can improve the quality of that identity and raise the level of authentication," says Bob Hulsebosch, coordinator of the project. "So for instance, I could use my mobile phone as a second factor authentication solution, and then other users could confirm that this mobile phone really is mine, so I don't have to go to the registration desk to prove that this is my identity and this is my mobile phone."

GLOBAL NEWS

By Tom Fryer and Helga Spitaler

WHAT DOES THE FUTURE HOLD FOR THE EUMEDCONNECT3 PROJECT?

Words
David West,
EUMEDCONNECT3
Project Manager

Picture
EUMEDCONNECT3
partners at project
meeting in Muscat,
December 2014

Between 2004 and 2011 the first two phases of the EU-funded EUMEDCONNECT project provided a dedicated Internet network for the research and education (R&E) communities across the southern rim of the Mediterranean. This was the first regional R&E project outside Europe funded by the EU and paved the way for similar projects in other world regions.

EUMEDCONNECT successfully connected the national research and education networks (NRENs) of Algeria, Egypt, Jordan, Morocco,

Palestine, Syria and Tunisia with each other and the European R&E community connected to GÉANT. The collaboration has been especially strong with EUMEDCONNECT's European partner countries also bordering the Mediterranean: Cyprus, France, Greece, Italy and Spain. It has also provided a gateway for these Southern and Eastern Mediterranean countries' researchers and students to collaborate globally in many fields including tele-medicine, e-learning, big science, and environmental research and monitoring programmes.

THE EFFECTS OF THE ARAB SPRING

The current phase, EUMEDCONNECT3, has been severely challenged by the events of the Arab Spring. The effects of the widespread political instability varied from country to country but, throughout the region, the NRENs have faced challenges as relationships with their governments, and particularly with funding ministries, have had to be re-booted. Sadly the specific situation of Syria currently rules out any participation in normal civil society

actions in the foreseeable future. It also for a while put on hold Lebanon's plans for developing an NREN and becoming a EUMEDCONNECT partner.

As a result, currently only Algeria is connected to EUMEDCONNECT3 with EC co-funding. While Egypt has managed to re-connect to Europe at its own cost, the NRENs of the other ENPI South countries currently have no international connectivity at all for R&E networking. Consequently, their user communities are deprived of opportunities for collaborating internationally and the digital divide between the two shores of the Mediterranean has been increasing again.

RENEWED SUPPORT AND INTEREST

However, not all is doom and gloom, there are encouraging signs. With the exception of Syria, there is renewed interest amongst the beneficiary countries for R&E networking as new ministries are coming to understand the value for their scientific and higher education programmes and that high capacity connectivity is essential for participation in global research and education programmes.

These developments have been further accelerated and encouraged at a recent meeting of ICT ministers in the Mediterranean region and the EU supporting the development of the digital economy. This has concluded with explicit support for EUMEDCONNECT as a facilitator of international R&E collaborations and the need for further EU resource to be injected to enhance its further development (see excerpts of summit declaration in the box). Options for increased EU support for the southern

and eastern Mediterranean are now being actively pursued, and for them to take effect from April 2015 to follow on directly from the current stage of EUMEDCONNECT. It is foreseen that detailed plans will be formed during the first quarter of 2015.

Last but not least, EUMEDCONNECT continues to count on the active support of ASREN. The Arab States Research and Education Network which was incubated by the EUMEDCONNECT2 project is a project partner in the current phase with the remit to provide long term sustainability and develop a pan-Arab regional network. Of the EUMEDCONNECT3 beneficiary countries Egypt, Jordan, Morocco and Palestine are now ASREN shareholders and the others are interested in joining. ASREN has recently started to establish its own e-Infrastructure supported by EUMEDCONNECT3. It has set up its first hub in London for EUMEDCONNECT and other Arab partner circuits, has just announced the first connection from Jordan to this London PoP, and is planning further hubs within the region. ASREN remains a strategic partner for EUMEDCONNECT across the Arab region and will play an important role in the plans being prepared for further R&E development for the southern and eastern Mediterranean.

COMMITMENT TOWARDS THE MEDITERRANEAN PARTNERS

In conclusion, after a challenging period for the region I see renewed interest in R&E networking to support higher education and scientific programmes, renewed support from Europe for its Mediterranean

neighbours, and a major opportunity for EUMEDCONNECT to facilitate regional R&E networking. Through EUMEDCONNECT my organisation has a long history of supporting the region. As DANTE we are proud of having brought EUMEDCONNECT into being; now merged with TERENA and re-named GÉANT Association we are committed to playing our part, alongside ASREN, for the next stage of this journey to support a pan-Arab regional research and education community, and foster cohesion in the region at a time of considerable instability.

EXCERPTS OF THE MINISTERIAL DECLARATION ON THE DIGITAL ECONOMY

The Ministers expressed their explicit support to the ongoing work streams and projects related to the Digital Economy of the Mediterranean such as:

The connections between Mediterranean countries, in particular through the jointly funded project **EUMEDCONNECT**, and the Arab States Research and Education Network (**ASREN**). The Ministers agreed that the connection of the research and education networks to the European network **GÉANT** is highly beneficial and that increased funding for this purpose is necessary in order to develop ultra-high speed connectivity between the EU and the Mediterranean.

FROM PLANS TO DEPLOYMENTS: FOCUS ON PAN-ARAB R&E NETWORK CONSTRUCTION AT E-AGE 2014

ASREN
Arab States Research and Education Network

The 4th "International Platform on Integrating Arab e-Infrastructure in a Global Environment" – e-AGE 2014 – took place 10-11 December 2014 in Muscat under the patronage of HH Sayyid Taimur Bin As'ad Al Said, Assistant Secretary General for Communication, The Research Council, Oman. Running alongside the 6th annual meeting of the Arab Organization for Quality Assurance in Education (AROQA) the conference attracted over 200 high-profile participants from over 40 countries spanning all world regions.

Ministers and senior EC officials emphasised the importance of e-infrastructure for the development of research and education across the Arab region, as well as cooperation with Europe and the importance of supporting the work of ASREN (the Arab States Research and Education Network). Building on EUMEDCONNECT, ASREN sets out to provide Arab scientists, students and academics with a gateway to participation in world-class research and education.

At e-AGE 2013 in Tunis the previous year, ASREN had announced ambitious plans to construct a regional R&E network and secure long-term sustainability of e-Infrastructures in the region, including becoming a R&E network provider in its own right. A year on, ASREN used e-AGE 2014 to take stock of progress to develop regional high-speed connectivity and open exchange points, such as the Arabian Global Education Open Exchange (AGE-OX) in Fujairah and the ASREN PoP in London which has recently seen ASREN's first 155 Mbps link from Jordan becoming operational. Further peering contracts are currently being negotiated with several Arab partners.

David West, EUMEDCONNECT3 project manager at GÉANT, commented: "e-AGE 2014 demonstrated growing commitment for R&E across the Arab region, and concrete actions now being taken. My organisation will provide operational assistance for ASREN's London PoP and is also intending to help realise the potential of the exchange point in Fujairah. This also reflects the interest of many European universities in R&E connectivity from Europe to UAE in support of their remote campuses."

Picture
ASREN Chairman Dr Talal Abu-Ghazaleh opens e-AGE 2014

For more information, including the Muscat Declaration and a full set of presentations, please visit **http://asrenorg.net/eage2014/**

GLOBAL PARTNER VISITS STRENGTHEN GÉANT INTERNATIONAL RELATIONSHIPS

Visits to partner R&E networks around the world are adding a new dimension to GÉANT's global outreach and its commitment to supporting the increasing needs of European global research collaborations. Represented across almost every continent, these global partners include Internet2, ESnet, CANARIE; RedCLARA, CKLN, the UbuntuNet Alliance, TEIN*CC, WACREN, ASREN and CAREN.

Dialogue between the GÉANT community and global partners, supported by GÉANT's Global Liaison function, focuses on topics such as connectivity provision, user support mechanisms, service collaboration and other areas of common interest (e.g. future internet research).

Day-to-day liaison work is conducted virtually and made easy using high-resolution videoconferencing. Global conferences such as TNC also provide excellent forums for discussions and meetings. Now, face-to-face meetings are playing an increasingly important role in GÉANT's global strategy.

In 2014 global partner visits were made to RNP (Brazil), Internet2 (USA) and CANARIE (Canada), complementing the usual attendance of R&E networking conferences around the globe. Beyond sharing updates on our respective networks and organisations, the meetings provided an opportunity to focus on user groups with specific support needs, develop common practices to support users' connectivity and other requirements, and explore other areas of mutual interest for future collaboration.

Following the success of these visits, further global partner visits for 2015 are planned, starting with the South African NREN, where the SKA will feature highly in the discussion.

GÉANT
AT SC14

An overview, by the GÉANT events team

The GÉANT project secured an exhibition booth in the research area of the SC14 conference for high performance computing, networking, storage and analysis delegates. Held in New Orleans, USA the conference attracts over 10,000 attendees.

With the GÉANT project providing high-speed connectivity and services to the Square Kilometre Array (SKA) via its 500Gbps pan-European network and truly global reach, it seemed an opportune time to explain to an

enthusiastic New Orleans crowd the current status and future plans to manage the vast amount of data soon to be generated by SKA.

GÉANT Association is a member of the SADT consortium which designs the data transport networks between the elements of SKA. The consortium is helping to design the high capacity network that supports the large data generated.

The main demo was compered from the SC14 exhibition floor by Dr Keith Grainge who leads the Science

and Data Transport consortium. Keith introduced via live link to astronomers from the CSIRO's Astronomy and Space Science division in Sydney, Australia. They remotely drove the telescopes at the Murchison Radio-astronomy Observatory (MRO) in Western Australia to the delight of passing delegates.

The viewers were then shown the incoming data in real time as it appeared. Questions from the floor ranged from people wanting to know to how many telescopes will eventually

be in position in the Australian desert to one seeking a definition of dark matter. All were answered with good humour!

In the hours of darkness in Australia we viewed live images of the Mullard Radio Astronomy Observatory in Cambridge, England. Keith was able to control the roboticized telescope via email, creating an interesting talking point to those also drawn to the booth by the presence of a decommissioned radio receiver we had on loan from Jodrell Bank.

Several other GÉANT services were featured at the booth including NSI based multi-domain connection provisioning, to showcase connections crossing three OpenFlow domains: EHU-OEF test domain located in Spain, PSNC test domain located in Poland and one geographically distributed domain created in the GÉANT testbed.

A demo featuring GÉANT Open Call project Community Connection (CoCo); one of 21 pioneering projects exploring new and innovative uses for collaborating over networks.
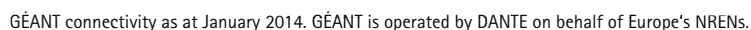
A prototype of the CoCo service was demonstrated. Jerry Sobieski, Activity Leader of the GÉANT Testbed Services project talked about how this service simplifies and streamlines the research process, to allow scientists to focus on their research objectives rather than the infrastructure.

Also on show was the GÉANT Open Cloud eXchange which provides a framework and facilities for higher QoS cloud services delivery from the

Cloud Service Providers (CSPs) to the NREN's customers (universities, research institutes and other organisations) and to end-users.
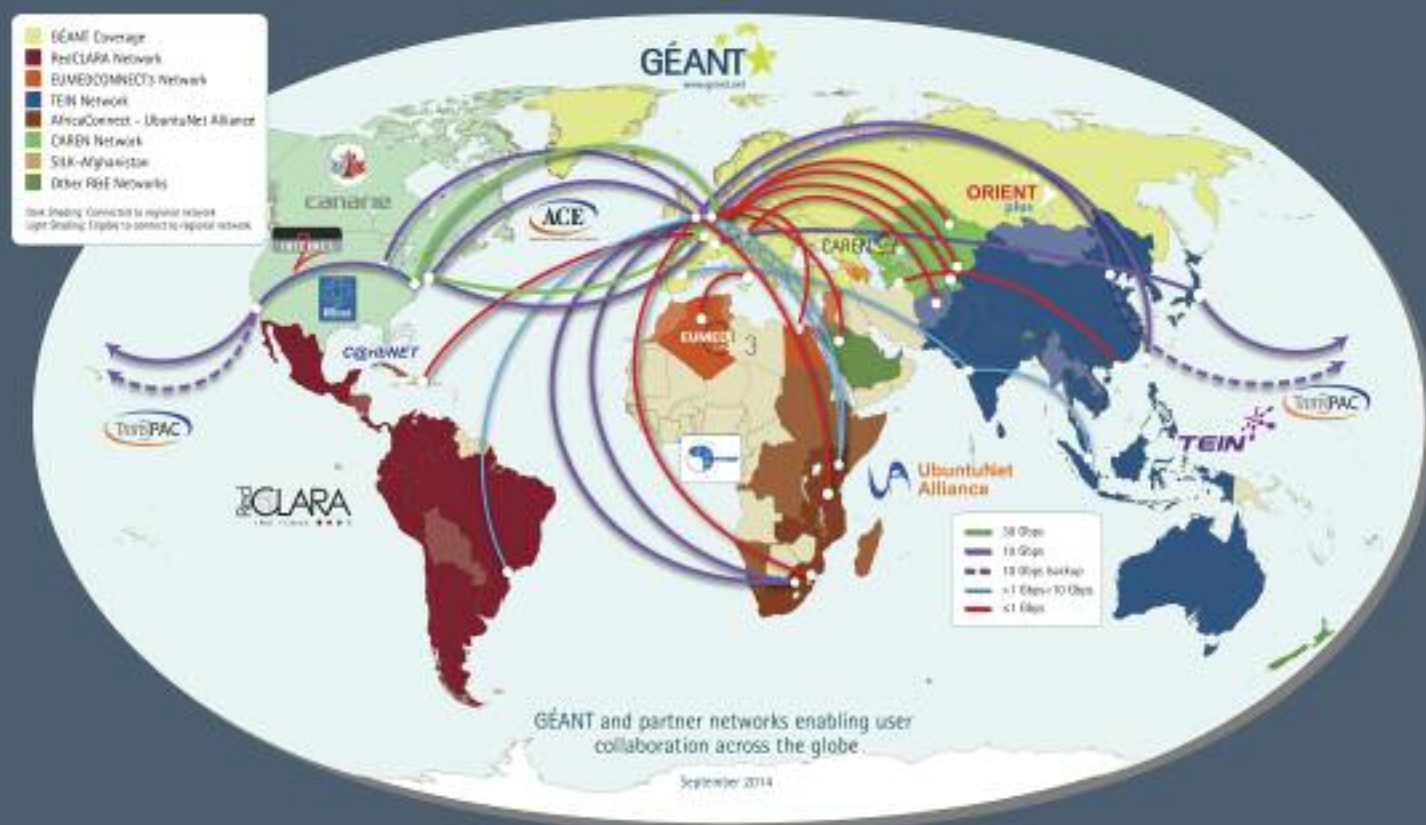
The annual event attracts an unprecedented array of scientists, engineers, researchers, educators, students, programmers, system administrators, and developers many of which stopped by the booth and collect their CONNECT magazine and learn a little bit more about GÉANT.

ABOUT GÉANT:
AN AT-A-GLANCE GUIDE

GÉANT is the pan-European research and education network that interconnects Europe's National Research and Education Networks (NRENs). Together we connect over 50 million users at 10,000 institutions, supporting research in areas such as energy, the environment, space, health and medicine.

EUROPE'S RESEARCH AND EDUCATION DATA NETWORK

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

GÉANT
PROJECT

AT THE HEART OF GLOBAL RESEARCH NETWORKING

The GÉANT network has extensive links to other world regions through collaboration with further networks, including those in North and Latin America, the Balkans, the Mediterranean, Black Sea, South Africa, Central and Eastern Asia.

GÉANT and partner networks enabling user collaboration across the globe.

September 2014

JOIN THE CONVERSATION

www.geant.net

www.facebook.com/GEANTnetwork

www.twitter.com/GEANTnews

www.youtube.com/GEANTtv

SERVICES

ENHANCING YOUR EXPERIENCE OF THE NETWORK

The GÉANT project delivers innovative services to enhance users' experience of the network. We're here to support you with a portfolio of advanced connectivity, network support and access services, designed to meet the needs of NRENs, institutions, researchers and students. Discover more here: http://www.geant.net/Services/Pages/home.aspx

Networking Services	GÉANT IP	Core IP connectivity between NRENs. Cost effective, reliable, open and independent.
	GÉANT Plus	Layer2 point-to-point connectivity. Assured bandwidth, secure.
	GÉANT Lambda	Layer2 ultra-high capacity point-to-point connections for demanding applications
	GÉANT Peering	Layer3 IP interconnectivity with 3rd party providers.
	GÉANT Open	Flexible, open Layer2 interconnectivity between organisations
	GÉANT L3 VPN	Logical virtual IP networking – ideal for one-to-many or many-to-many connectivity.
	GÉANT Bandwidth on Demand	Flexible "on-demand" layer2 connections to provide high performance networking
	GÉANT OpenFlow Facility	A flexible testbed facility to help develop new networking services.
User Application Services	eduroam®	National and International wi-fi roaming. Secure, simple and global.
	eduCONF	An easy to use directory of VC facilities across Europe.
	eduGAIN	Federated AAI services offering assured, simple single sign-on.
Tools and Management Services	perfSONAR	Multi-domain monitoring service. Enabling NREN NOCs and PERTs to collaborate in providing seamless network performance for their users.
	eduPERT	Federated Performance Enhancement Response Teams - helping network users get the best performance from their connections.
	eduPKI	Supporting service developers by helping manage digital certificates.

THE GÉANT INNOVATION PROGRAMME

SHAPING THE INTERNET OF THE FUTURE

Part of GÉANT's role is pushing the boundaries of networking technology to shape the internet of the future. The GÉANT Innovation Programme exists to develop an advanced portfolio of technologies, to develop into services, tools and network capabilities for tomorrow's researchers.

Here are just a few ways the GÉANT Innovation Programme is driving discovery in networking technology.

RESEARCH PROGRAMMES

The research elements of the GÉANT project focus on three core areas:

- Network architectures for Horizon 2020
- Technology testing for advanced applications
- Identity and trust technologies

By being technology and supplier neutral, these research activities contribute greatly to thought leadership in networking services across Europe.

STANDARDS

The use of standards and information from standards bodies are essential to the development of GÉANT services to ensure interoperability with services of other networking organisations. Members of the GÉANT project have leadership roles in the OGF (Open Grid Forum) and IETF (Internet Engineering Task Force) standards organisations and make significant contributions to the formation of standards.

TESTBEDS

"Testbeds as a Service" provides two types of testbed capabilities to support the network research community. Dynamic Packet Network Testbed Service supports upper layer network research, and the Dark Fibre Testbed provides photonic layer long haul facilities for testing novel optical/photonic technologies in the field.

OPEN CALL

The Open Call projects bring in fresh ideas and support new uses of the network. €3.3m is being invested into 21 independent projects for research into advanced networking technologies. In support of the Horizon 2020 aims, each project is aligned to one of the GÉANT Joint Research Activities.
The four subject areas are:

- **Applications and Tools** – supporting advanced research activities and projects.
- **Authentication** – helping support secure end-to-end authentication of systems and people.
- **Network Architecture and Optical Projects** – studying future networking systems.
- **SDN** - exploring Software Defined Networking potential to meet new networking demands.

ASPIRE FORESIGHT STUDY

ASPIRE (A Study on the Prospect of the Internet for Research and Education) provides recommendations to policy and decision makers on topics likely to have a significant impact for the future of research and education (R&E) networking. For instance:

- The adoption of cloud services
- The integration of mobile services into NRENs service portfolios
- Middleware and managing data and knowledge in a data-rich world
- The future role of NRENs

The final report can be downloaded from the TERENA website:
www.terena.org/publications

TASK FORCES

Task forces (TFs) and special interest groups enable experts from the wider GÉANT community to share knowledge in such areas as security and mobility. These provide input to the definition of new R&D project activities and Open Calls, and offer feedback on existing project developments. They provide an agile way for GÉANT to capture emerging ideas and a fast and efficient mechanism to pilot them before assessment and formal inclusion in the project work-plan.

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