

THE POWER OF NORDIC UNITY



40 YEARS OF
NORDUnet



NORDUnet
The Power of Nordic Unity
40 Years of Nordic Collaboration

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First Edition, November 2020

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Published in Denmark

Designed and created by:

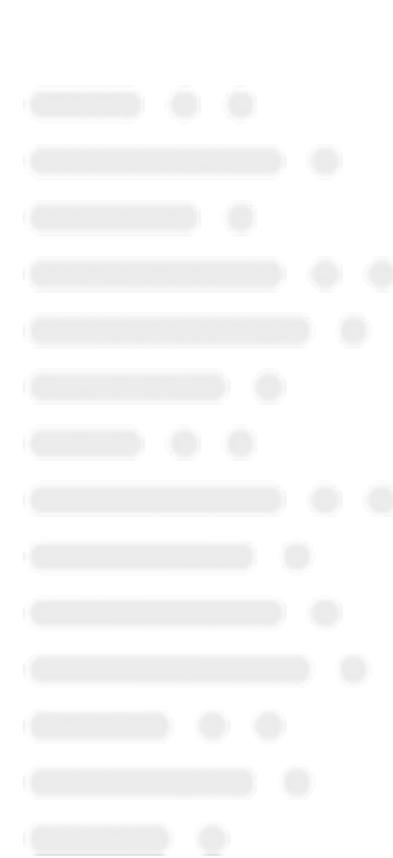
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ISBN: 978-87-990712-2-7



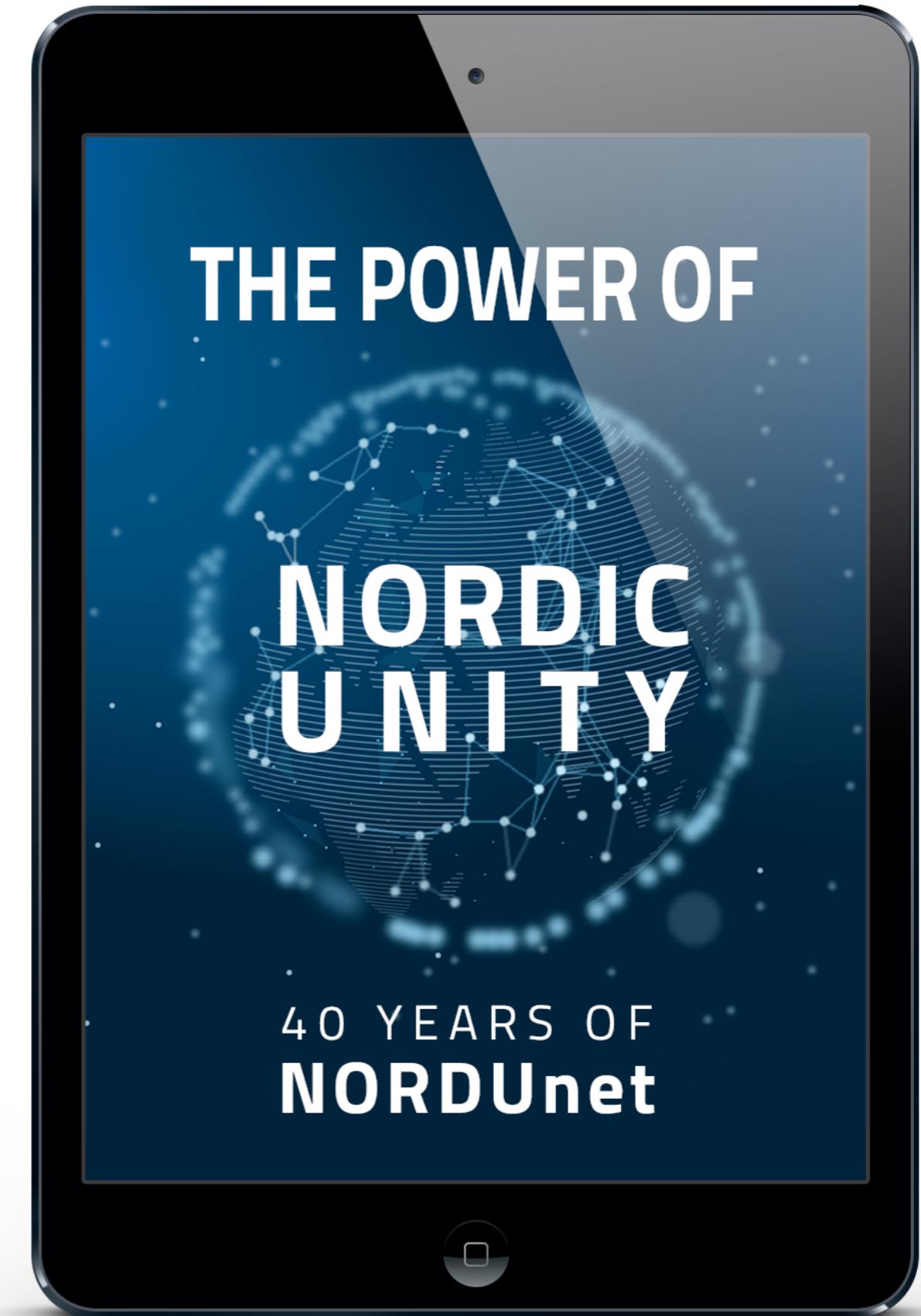


40 YEARS

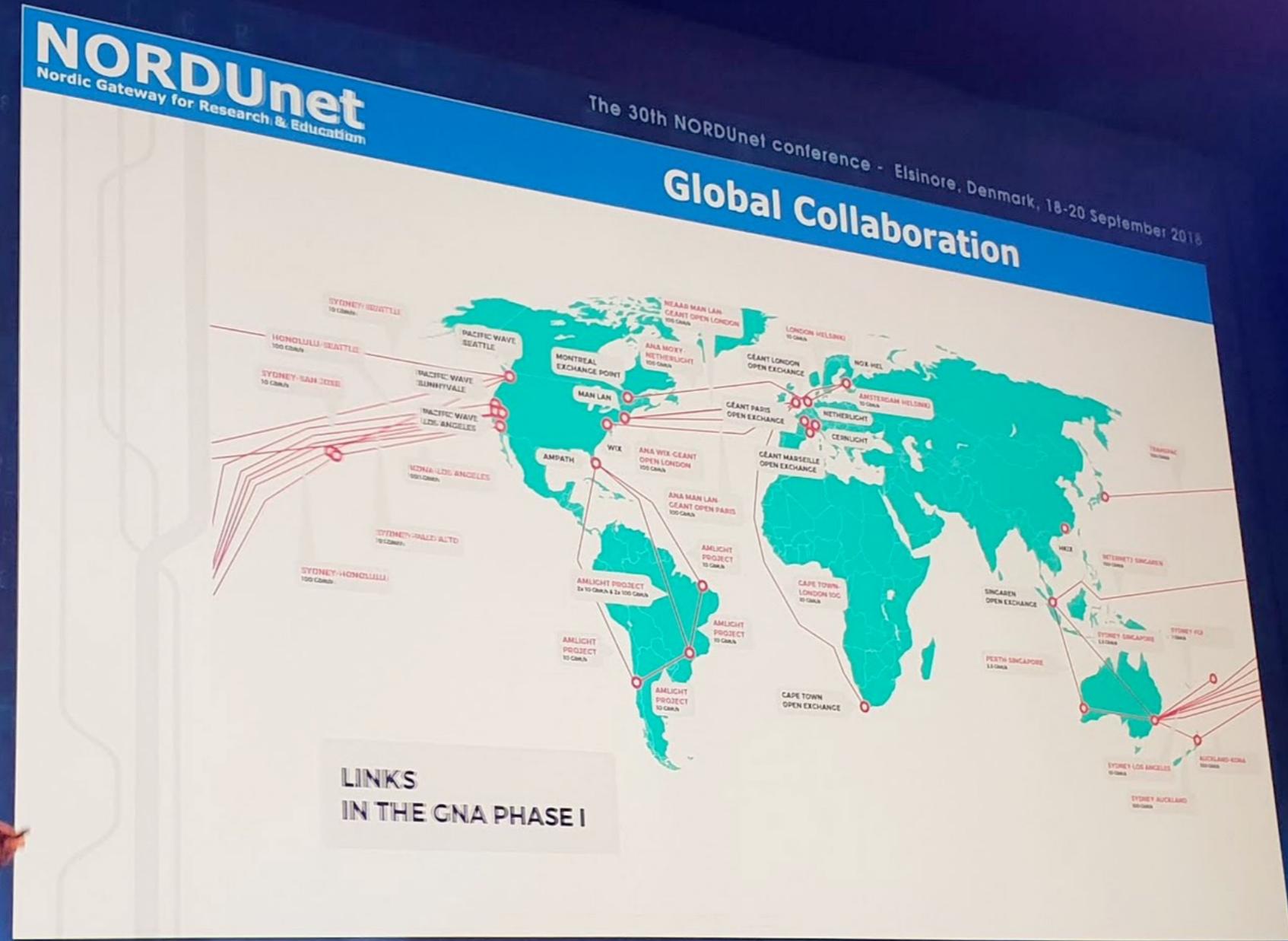
THE POWER OF NORDIC UNITY

Network connectivity and networks services for the research and education community in the Nordic countries is provided by the national research & education networks in each of the Nordic countries.

NORDUnet



30th NORDUnet CONFERENCE 2018



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FEATURE GUIDE



AUDIO

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VIDEO

Tap to watch
pinch to magnify



GALLERY

Swipe left and right
tap to magnify



TEXT

Scroll to read more

NORDUnet
40 Years of Nordic Unity

Nordic Collaboration

2.1 The Strength of Five	32
2.2 Evolution of NORDUnet Services	38
2.3 Results of the Nordic Collaboration	42
2.4 New Strategy 2020 - 2025	51
2.5 Conferences	54
2.6 NORDUnet Workshops	60
2.7 NORDUnet as Seen From Outside the Nordics	67
2.8 Never Stop Reinventing Yourself	69

Swipe between chapters



The chapter bar indicates
the number of chapters
and current selection



Nordic animals are hidden in
various parts of the book.
Can you find them?



Some interactive features
in this book require an
internet connection



WELCOME

The year 2020 will go into the history books as a remarkable one

In this year, while the world gets to know COVID-19, NORDUnet turns 40 years old.

Some of the world's most reputable organizations are much older than this. Compared to them, NORDUnet could be considered young. However, many people that have looked into the history of research & education networks have confessed that years in the **NREN** world ought to count double. Or triple.

Why, one might ask? Well, because there is so much happening in the space of digital service delivery for research & education! For one, we are working with the latest and greatest technologies, and they succeed each other quickly. The R&E Networking organizations adapt and adopt. Always on the outlook for improving service delivery at economically affordable cost levels.

Much of the exciting and innovative works of the Nordic R&E Networking community over the past 40 years, we have tried to describe in this interactive eBook.

The focus however, is on the last 15 years, as the first 25 years were described in the [**History Book**](#), published in 2005.

Erik-Jan Bos
Editor in Chief



CEO'S MESSAGE

Dear Reader,

Henry Ford once said:

“Coming together is a beginning, staying together is progress, and working together is a success.”

We can with pride say that the Nordic Research & Education Community successfully managed this for 40 years, since the initial project was kicked off in 1980, supported by the Nordic Council of Ministers and with NORDUnet being the embodiment of this collaboration.

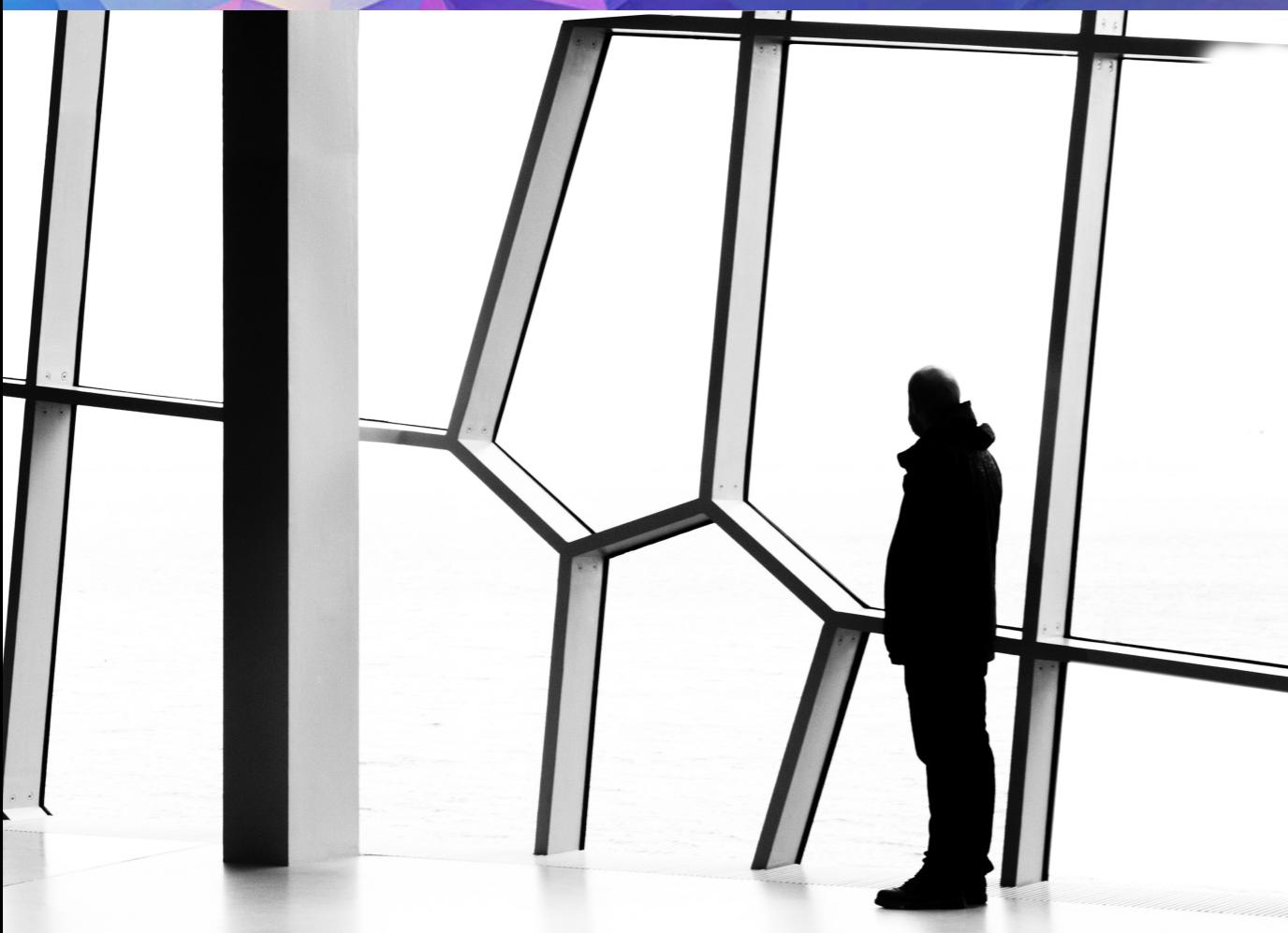
During these 40 years, the Global Research & Education Community and the commercial world have constantly been changing. NORDUnet and the Nordic R&E Community have always been in the forefront of



RENÉ BUCH

CEO, NORDUnet





**Enable
World-Class Research
& Education through
Nordic Collaboration**



**“More than ever,
there's a growing
need for
collaboration to
create financially
viable and technically
advanced solutions
to exchange big data
between research
institutions and
scientific data
facilities”**

**René Buch
CEO, NORDUnet**

IN MEMORIAM - HANS WALLBERG

Hans Wallberg was there when SUNET started in the early 1980s, while he was head of UMDAC, the computer center of Umeå University. As of 1985, Hans worked as project manager for SUNET phase 2, and soon after that he became responsible for the running and further development of SUNET, and he did so until he passed away in June 2013. Hans also lead the creation of the Swedish chapter of Internet Society, and was member of the board of the Swedish Internet exchange Netnod.

In 2012, Hans received the Swedish Network Users' Society annual prize for his many years of work with the development of the Swedish part of the Internet. But Hans was not only active in Sweden, as he was well aware that R&E Networking is an international endeavor.

In the Nordics, he was instrumental in the establishment and the further development of NORDUnet, and served as a member of the NORDUnet Board from 1989 until 2013.



*** 28 February 1946 – † 14 June 2013**

At NORDUnet, we commemorate Hans, and we are grateful for everything he did for the Internet in the Nordics.

1

INTRO TO NORDUNET & NORDIC NRENs



WHO'S NORDUNET?

The five Nordic countries each have an NREN of their own serving national institutions.

The Nordic countries have a long history of collaborating and sharing knowledge on technical solutions and strategies on the R&E network to serve the common Nordic R&E community in the best possible way, and this is embodied in NORDUnet.

NORDUnet was founded in 1985 as a result of the NORDUNET programme, that started in 1980, and is jointly owned by the governments of the five Nordic countries.

Now, 40 years later, the Nordic NRENs are still united in NORDUnet, each serving their R&E institutions on a national scale and jointly through NORDUnet on a Nordic level and connecting them to the rest of the R&E Networking world as well as to the commercial Internet.

The five Nordic owners of NORDUnet are:

- DeiC, Denmark
- Funet, Finland
- RHnet, Iceland
- SUNET, Sweden
- Uninett, Norway

WHAT'S AN NREN?

FAQ for the NREN Newcomer

Data traffic for research and higher education (R&E) is handled by providers, dedicated for this particular purpose, in most countries of the world.

That is, institutions for R&E have their own dedicated Internet, independent of, but connected to, commercial operators.

The organization providing these services is referred to as the National Research and Education Network or, in short, the NREN. NRENs differ a lot in size, reach, maturity, the way they are governed and funded, etc., but their efforts all have the same goal:

To interconnect researchers, scientists, educators, and students, no matter where on the globe they are or work.

Progress and success all depend on access to data, sharing, and collaborating, which means that a high-performant and affordable global network fabric is crucial for R&E.

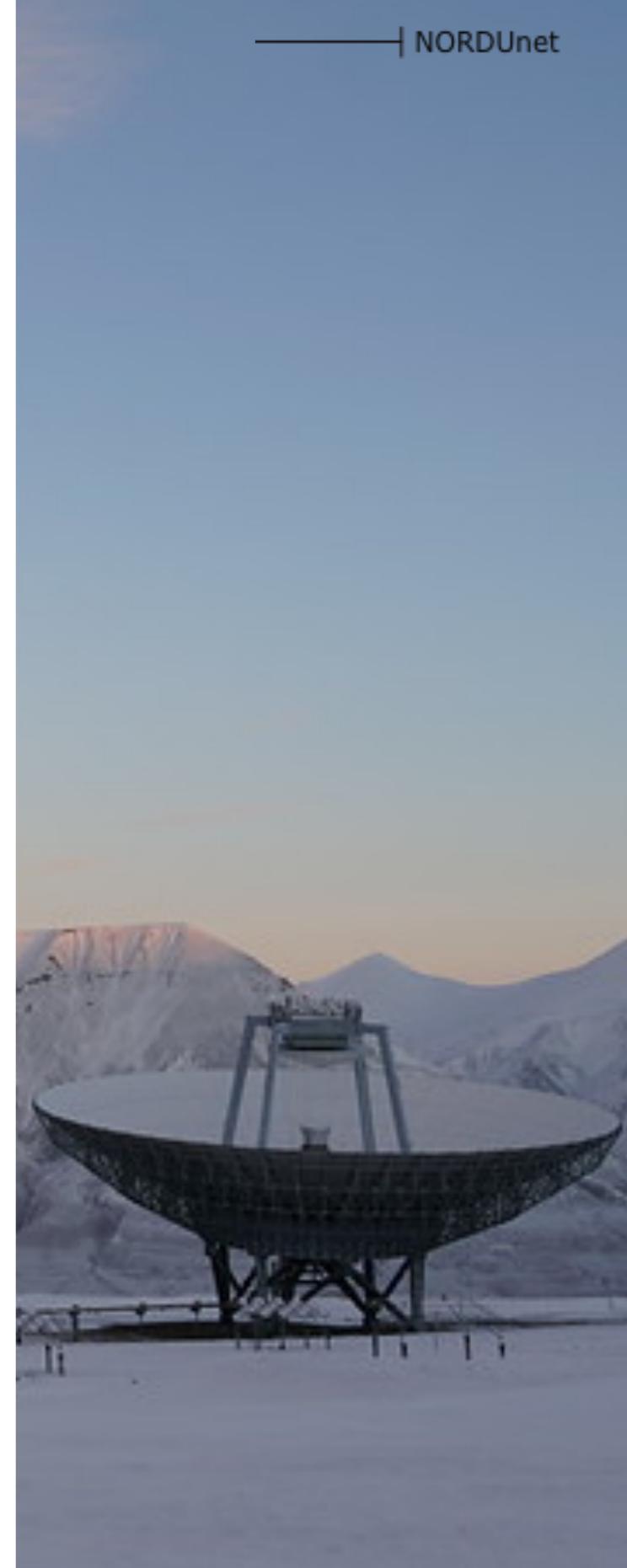
In the beginning, the role of an NREN was to provide a network infrastructure for transporting data.

Today, most NRENs are also engaged in providing value added services to their users, ranging from trust and identity services to storage and real time communication.

“We want our researchers to be successful”



Eli Dart explains the critical role of the NREN



WHAT'S A REGIONAL R&E NETWORK?

While the N in NREN stands for national, some R&E Networks work across national borders or dedicate themselves to a part of a (often large) country. In that case, the term Regional R&E Network (RREN) is sometimes used.

NORDUnet is a Regional R&E Network, because NORDUnet serves five countries.

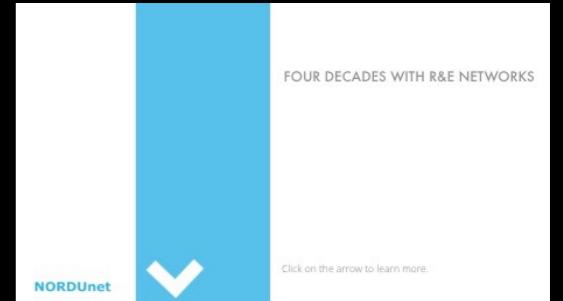


HOW DO NRENS BRING VALUE TO RESEARCH & EDUCATION?

R&E Networks differ from “regular” Internet Service Providers, particularly when it comes to:

- Amounts of data.** With a steadily growing number of research facilities creating huge volumes of data, the need for capacity is simply not met by the commercial Internet at affordable prices. Also, as the commercial providers live in a world where competition is fierce, they tend to load the fiber to the edge by oversubscription, which is okay for the bursty nature of regular Internet traffic. But not for transporting huge volumes of data across the world, as is the case with the big science facilities.
- Trust.** An NREN is, more often than not, in a unique position between governments, funding bodies, providers such as telecom operators and cloud providers, and the R&E institutes, constantly seeking to optimize services, performance and cost. The NREN staff are committed to serve R&E, and they understand the special needs of the R&E community.
- Innovation.** NRENs are positioned at the forefront of technology, often partnering with providers and suppliers, and sometimes in a position to test-drive new technology. This enhances the knowledge and skill levels for the NREN staff and enables the NREN to put into service the latest technology, often before it is used elsewhere on the Internet.
- Global Reach.** Last but not least, while science, research, and education are global endeavors, the community of NRENs is global, interacting on a regular basis, ensuring the global needs are met for R&E.

R&E NETWORKS FOUR DECADES



*explore the
journey*

In The Field Stories

A blog with amazing stories from Research & Education achievements from around the world enabled by NRENs



THE SECRET OF NORDIC SUCCESS

Martin Bech - Chief Technology Officer, DeiC

In many other regions of the world, groups of countries have wanted to copy the NORDUnet model to gain the same benefits. Some have tried, some have not. Some have various degrees of success, others not so much. So, what's the key?

Is it the climate? Is it the high degree of education? Is there a special Nordic culture of trust? Did we have more understanding and will on the political level? Did excessive funding enable us to buy everything we needed?

No - in my observation, factors like these have never existed. Of course, it plays a role that wars and struggle for independence lies (much) more than two generations ago, but the main factors, as I see them, are three things:

1. The sheer will and determination of a few individuals and their efforts to convince the national institutions to use time and resources for the purpose. This was indeed the case with Peter Villemoes and the first board of directors, as it is the case to day.
2. The focus on creating tangible results to be used today, rather than getting it perfect tomorrow.
3. Success builds more success. Most of us can recognize something attractive, efficient and trustworthy when seeing it. Therefore, it has become only natural to consider involving NORDUnet whether it's about planning for new innovative actions, initiating global strategic collaborations, or having a technical problem which needs to be solved.

Copying the success of NORDUnet will never be easy, but if I am right about this, the positive message is that you do not need things that are hard to get (like eternal peace, massive funding, an unusual culture or special weather).

The only secret ingredient you need is a few extremely committed individuals.

This is what has kept the collaboration and the successes growing throughout all the years.





STATEMENTS BY BOARD MEMBERS

MARIA HÄLL - BOARD CHAIR

SUNET, SWEDEN



"As Chairman of the Board, it is my great pleasure to write this introductory note for this publication, celebrating NORDUnet's 40th anniversary.



The collaboration between the Nordic countries is the heart of NORDUnet and NORDUnet has an instrumental role in supporting the Nordic cooperation within the Research and Education area. And, after 40 years, collaboration is still evolving.

I have been on the NORDUnet Board for seven years, and to me, it is clear that a strong community spirit and innovative mindset are essential to our progress.

The Network has been the raison d'être for NORDUnet. Its continuous evolution is key to our common success. Our ongoing Next Generation Network project is a great example of a joint community effort, securing



STEEN PEDERSEN

DeiC, DENMARK



"It is my hope, that NORDUnet in the future will continue to develop as the strong and professional facilitator of close Nordic and International collaboration it has proven to be for decades.

The recent progress in updating the NORDUnet collaboration model, and making it even more involving for the Nordic NRENs, is very promising.

I am convinced, this will make the Nordics even more competitive and make us able to cope with future technological and societal developments in the best possible way."



PEKKA UUSITALO

CSC/Funet, FINLAND



"Looking into the future, there are great opportunities for us as the world is getting more and more digitalized. There is a big focus on Artificial Intelligence which drives the data explosion.

Our world-class network infrastructure will be the key to moving big data sets closer to centralized HPC resources. The European Commission is driving the key initiatives like EuroHPC and EOSC, and together with GÉANT, we will be in the sweet spot to get all this connected.

More capacity is needed for intercontinental connectivity, and also here NORDUnet is well-positioned to drive our interests."



JÓN INGI EINARSSON

RHnet, ICELAND

in “Ever since the first NORDUnet Conference in 1980, the Nordic NREN collaboration has become stronger, culminating in a world class network in 1989 that has since then evolved. This has enabled the Nordic NRENs to offer researchers, educators and students connectivity on par with the best in the world. In later years, a few very strong commercial players have established themselves.

If we want the needs of the research and educational sector to be fulfilled in the best possible way, we must be the creators and implementers of our own environment.

We need to avoid being the "help desk" for the big companies, whose goal is to delight their investors, but not the increase of knowledge and ability of the human spirit. To fulfill the needs of our societies in the best possible way, the Nordic and global NREN communities must cooperate much closer than ever before. NORDUnet is the common denominator for that collaboration for us in the Nordics.”



TOM RÖTTING

Uninett, NORWAY

in "We at Uninett look forward to an ever-closer cooperation with the Nordic NRENs.

🌐 Through NORDUnet we have an already established cooperation arena. NORDUnet's new strategy will further reinforce this arena so that we can cooperate even better and more closely than before, both internally in the Nordic region and towards GÉANT.

Uninett looks forward to the implementation of the new strategy and believes that this will make further progress for the Nordic and European cooperative arenas."



 **DENMARK**

DeiC

DeiC coordinates the Danish digital infrastructure as an umbrella for the eight Danish universities to ensure delivery of computing, storage and network infrastructure to Danish research, teaching and innovation. DeiC coordinates Danish participation in Nordic and European e-infrastructure organisations and projects.

DeiC is an entity under the Ministry of Higher Education and Science by Act 70 of 19 April 2012. DeiC is a virtual organisation. DeiC has a board with management level representation from the eight Danish universities.

The daily management of DeiC is handled by a CEO employed by the board.

FEDERATIONS PAGE



DeiC (English)



DeiC (Danish)



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FUNET

by CSC

Funet, the Finnish University and Research Network, a super-fast data communication network in the service of research and education, is maintained and developed by CSC — IT Center for Science Ltd.

CSC is a Finnish center of expertise in ICT that provides world-class services for research, education, culture, public administration and enterprises, to help them thrive and benefit society at large.

Funet links the universities, polytechnics and research institutions improving their national and international communications. Funet has approximately 380,000 users, and is one of the most advanced research networks in the world.

FEDERATIONS PAGE



Funet (English)



Funet (Finnish)



• • • •



The Icelandic University Research Network ([RHnet](#)) was formally established on January 24, 2001. Its objective is to link together Icelandic universities and research institutions by means of a high capacity computer network, and supply services in the field of computer communications, both domestically and internationally.

RHnet is a limited company, founded with the sole aim of enhancing the level of communication within the Icelandic university and research community, and serve as its gateway to international networks.

RHnet operates from Tækniðarður, which is a part of the campus at the University of Iceland.

FEDERATIONS PAGE



RHnet (English)



RHnet (Icelandic)



• • • •



SUNET's aim is to provide Swedish universities and colleges with access to well-developed and effective national and international data communication and related services that meet their needs, whatever their geographical location. As well as offering high-capacity computer networks, SUNET also hosts a wide variety of different services for connected organisations.

SUNET started in the 1980's as a research project for Swedish computer scientists, and paved the way for the Internet in Sweden. SUNET is governed by a board appointed by the Swedish Research Council. In addition to the board, there is also a technical reference group, as well as people working at the participating universities.

FEDERATIONS PAGE



SUNET (English)



SUNET (Swedish)



• • • •



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UNINETT

Uninett is the knowledge sector's ICT infrastructure company in Norway. We develop and manage the digital foundation for research and education in Norway.

- This foundation consists, among other things, of the National Research and Education Network — NREN — a powerful and secure national network that also connects users in the knowledge sector with international research networks.
- Uninett is also the supplier of the national login solution Feide, wireless network access via eduroam, as well as several cybersecurity services and digital campus solutions. Our services are used by several hundred thousand of people in the knowledge sector every single day.

FEDERATIONS PAGE



Uninett (English)



Uninett (Norwegian)



• • • •

A photograph of a wooden boat's bow on a calm lake. The boat is made of dark wood and has a curved, pointed bow. The water is very still, reflecting the warm, golden light of a setting sun. In the background, there are small islands with trees and reeds. The sky is a clear, pale blue.

2

NORDIC
COLLABORATION



THE STRENGTH OF FIVE

THE POWER OF NORDIC UNITY

For 40 years, the five Nordic NRENs have delivered a state-of-the-art network and services for Research and Education, and collaborated extensively across the Nordic borders.

In the Nordics, we have a long tradition of war amongst each other as well as collaboration. Fortunately, collaboration has dominated in the latest century, and one of many offshoots is our common effort to serve the Nordic R&E community with a world-class network and services.

For more than four decades, under the leadership of the Nordic Council of Ministers, the five Nordic countries have consistently collaborated on IT-related projects for our R&E institutions. One of the tangible topics is the set of NORDUnet Conferences, the first one held back in 1980.

The advantages of the Nordic NREN collaboration in NORDUnet have been sustainable and carry on.



“NORDUnet has represented the whole Nordic region, giving us a much stronger voice than we could ever have as a single country”

Martin Bech
Chief Technology Officer
DeiC





2034%

Within 2 months
of COVID-19
Zoom Meetings
increased by 2034%

CUT TO THE BONE, WE GAIN

An efficient community due to joint critical mass

None of Nordic NRENs are particularly big, as seen on a global scale. Sharing knowledge and experiences, as well as harnessing the power of synergies, enable us to be an efficient R&E Network ecosystem.

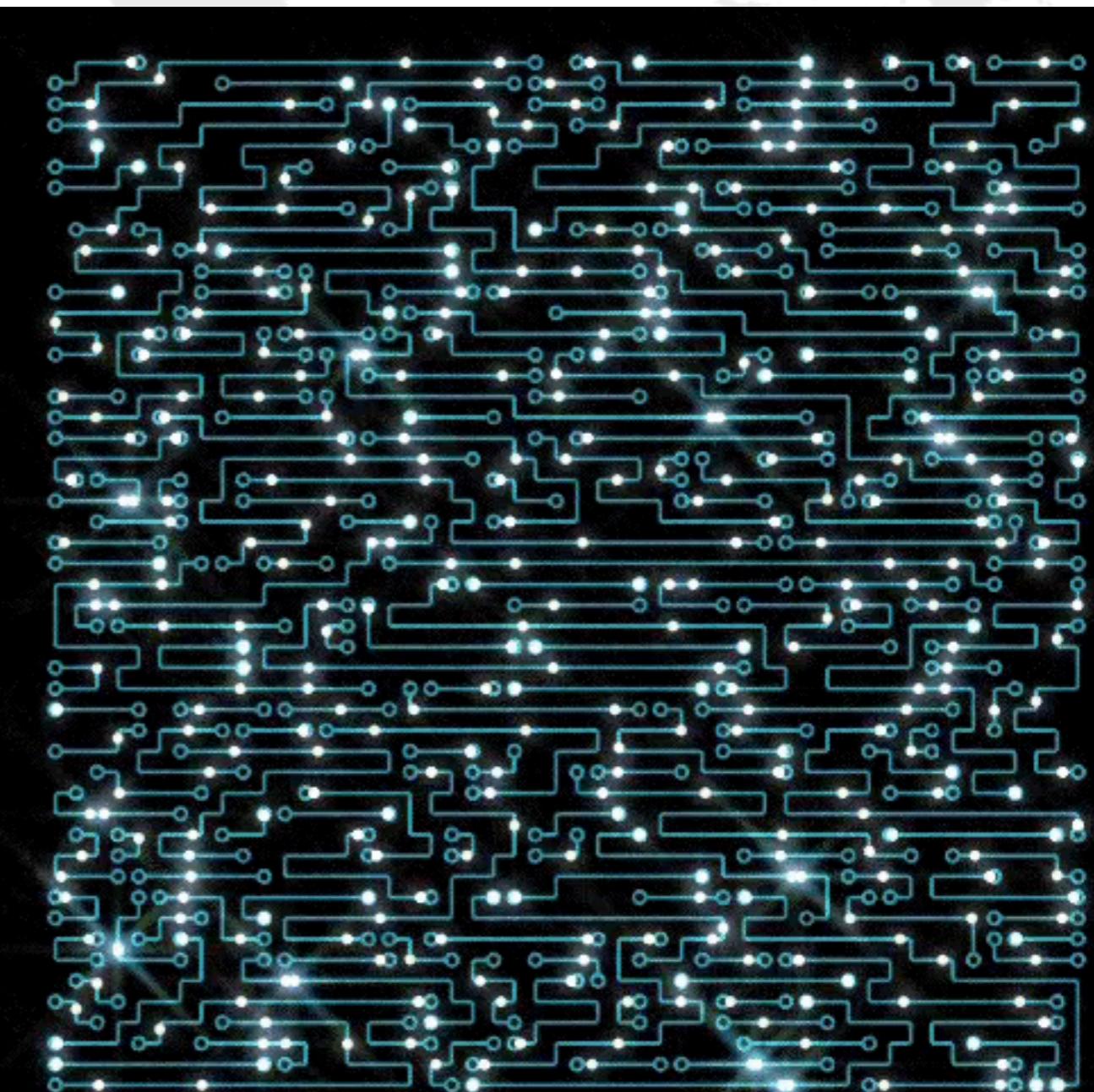
Increased purchasing power

Together, the Nordic countries are the 12th most powerful economy in the world. And the five Nordic NRENs together represent 1.5 million end users.

Increased influence and visibility

The Nordic countries cover a geographical area of nearly 3.5 million km² (which equals roughly to the size of India), housing numerous world leading scientists and engineers.

Covering 3.5 Million km² 1.5 Million End Users



“The only secret ingredient needed for many years of successful collaboration is to attract a few passionate and extremely committed individuals.”

Martin Bech
Chief Technology Officer, DeiC



HOW IS THIS POSSIBLE?

People from outside the Nordics are often curious as to how this is possible. We think it is due to the four following reasons:

1. FIVE IS A SUITABLE NUMBER

The Nordics consist of five countries. This number is small enough to form an efficient collaboration with plenty of room for people from all professions to discuss relevant issues and learn from each other, and this number is large enough to put serious weight on the scale.

2. WE WANT THE BEST

We share a high level of ambition. From the very beginning we have aimed at providing the best solutions for our R&E community. We still do, and the ambitions for the future are no less.



“The collaboration is the heart and soul of the Icelandic NREN.”

Ingimar Örn Jónsson
Network Manager
RHnet/HI



3. WE SHARE VALUES

Our cultural backbone is the same. Generally, there is a will to collaborate, and we have a lot of common goals, despite national differences and nuances. At the same time, we are a pragmatic set of people, and the Nordic attitude is tolerant towards individual needs.

4. WE ARE EQUAL PARTNERS

The five Nordic governments, through the Nordic Council of Ministers, agreed, back at the start of NORDUnet, that we are five equal partners. For the collaboration to continue to flourish, this is an optimal launch pad.







EVOLUTION OF NORDUNET SERVICES

BROADENING THE SCOPE OF SERVICE DELIVERY

From just network services in 2005 to a broad range of services in 2020

SERVICES Y2005

NETWORK

- Research Network Connectivity
- Global IP Transit



SERVICES Y2020

NETWORK

- Research Network Connectivity
- Global IP Transit
- Global IP Peering Services
- Private Circuits
- Conference Wifi
- Cross-Border Fiber Coordination



tap to
see who

MIDDLEWARE

- AAI Community Services Production
- Equipment Hosting
- Virtual Server Hosting

MEDIA

- Lecture Video Services
- VC Services
- Conference Video Production
- Conference Streaming

VALUE ADDED

- NOC
- GÉANT Project Coordination
- Project Hosting & Coordination
- Coordination of Transnational Projects
- Procurement Services
- EU Project Coordination
- Cloud Services Procurement & Integration
- Community Communication
- Software Development





SELECTION OF NORDIC ACHIEVEMENTS



KALMAR2

Kalmar2 was drive, vision, lots of hands on, and hours of fruitful discussions

The need for safe access to cross-border services was an issue the NREN community had to address. Most of the people involved found it hard to see how this would ever be possible, because the countries had very individual ways of handling access management.

To make it work, new technology was needed, and everyone had to agree and really trust each other.

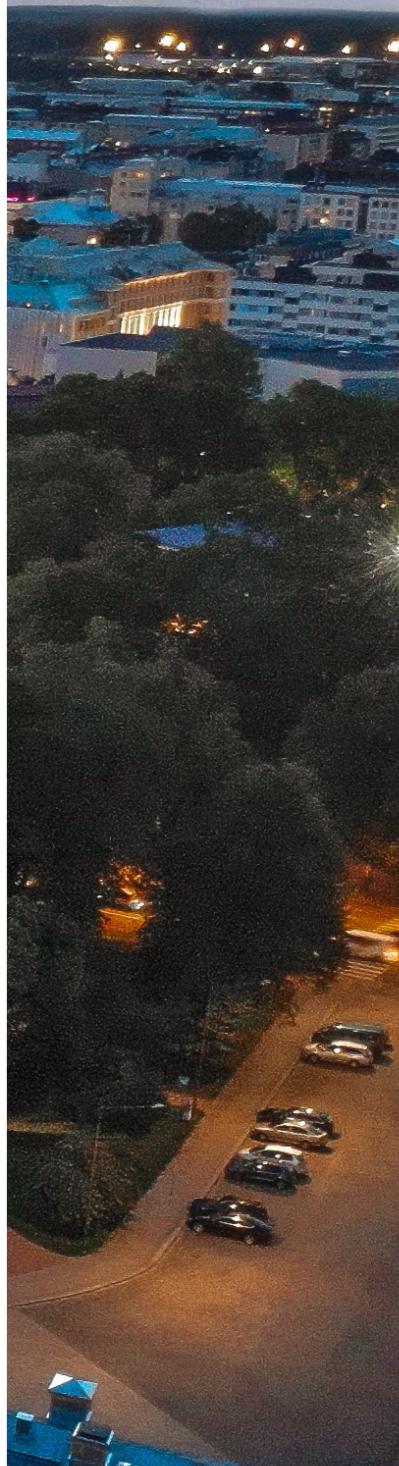
Representatives from four Nordic countries met at NORDUnet in 2006, and two years later, the world's first cross border federation saw the light of day. A joint effort by the Denmark, Finland, Norway, and Sweden, soon expanded to include all five countries.

We called it Kalmar2 with reference to the famous union between the Nordic countries, which was established and signed in Kalmar the year 1397, lasting for 126 years.



“Kalmar was putting a new layer in place, a trust layer.”

Ingrid Melve
Senior Digital Adviser
Unit



KALMAR2

What took up most of the time was not developing and implementing the technology

Rather, it was debated on how to maximize the benefits for all parties involved.

It's told that the meetings were characterized by lively and fierce discussions.

Global standard today

The efforts of the Kalmar2 work resulted in the technology SAML2 INT, which is the global standard today.

The global inter-federation for R&E, called eduGAIN and further developed in GÉANT, uses much of the thinking and architecture that went into Kalmar2.

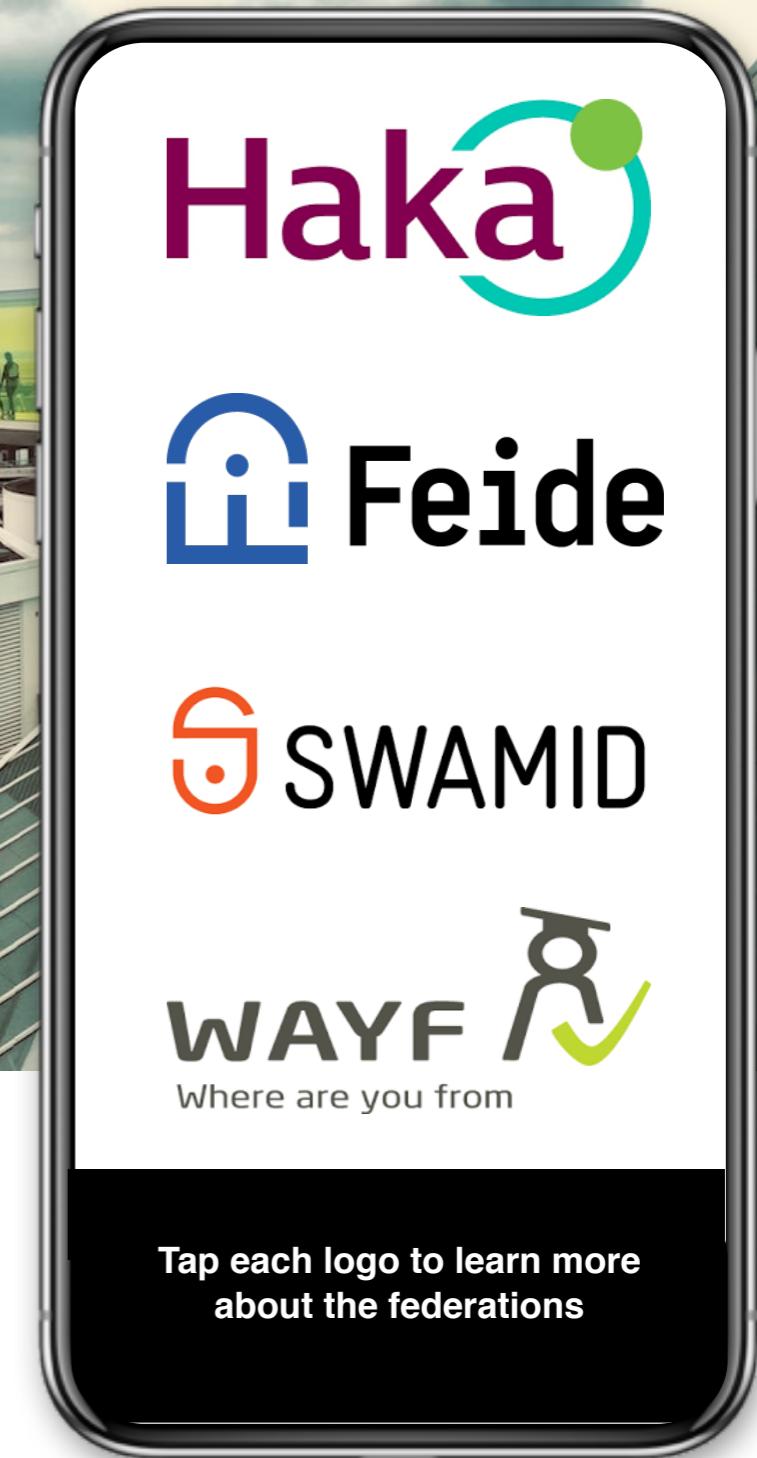
**WE MET
WE BUILT
WE IMPLEMENTED**





“An Identity federation is basically one of the key elements in making sure you can have joint procurements.”

Valter Nordh
CTO and SWAMID product owner
SUNET



TRUST AND IDENTITY MANAGEMENT

Andreas Åkre Solberg Interview

Why did you invent SimpleSAMLphp?

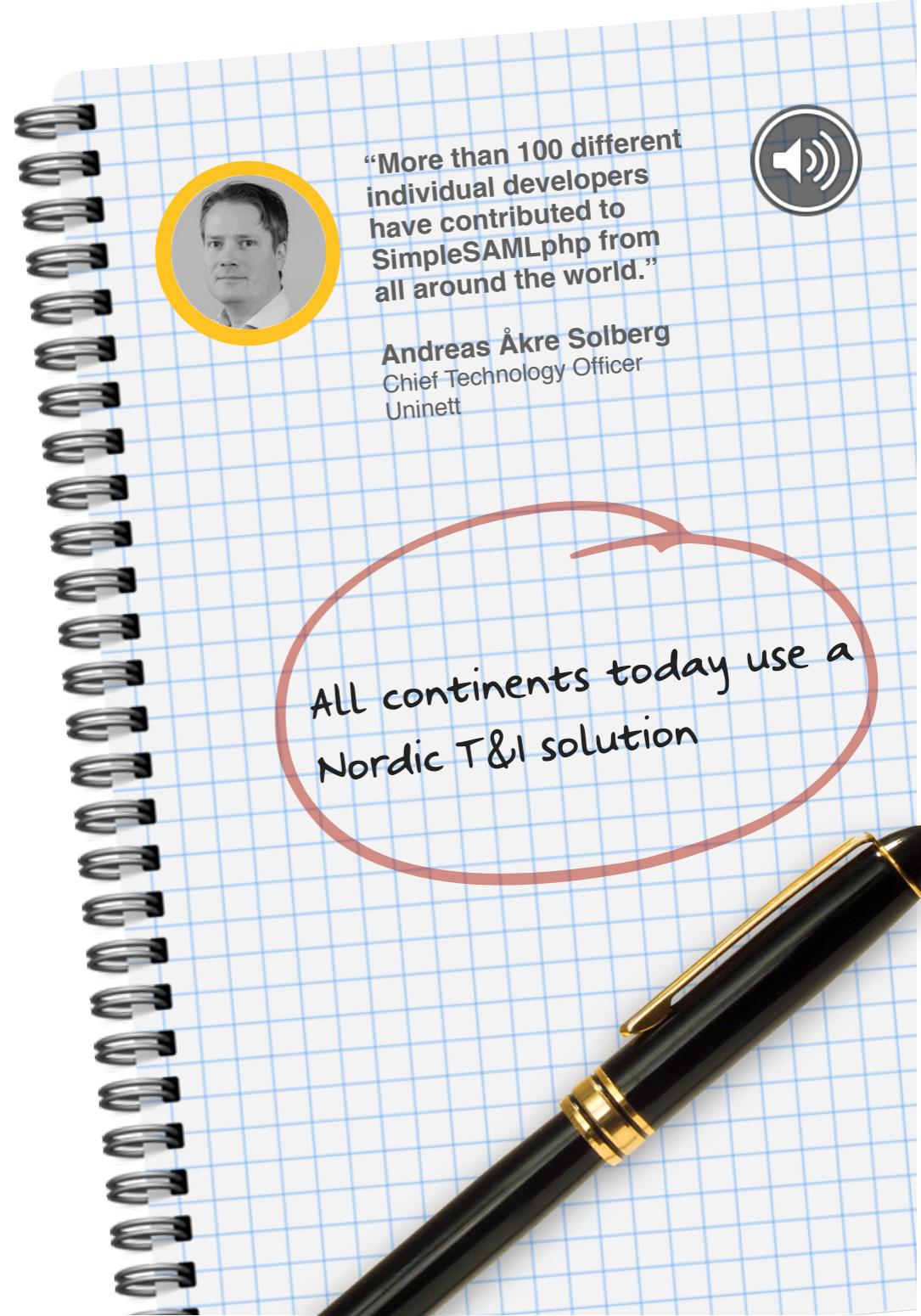
Back in those days, the availability of products for federated authentication was very limited, and there was a need for open source software that was easy to set up and use.

Education and research has been the leading sector on cross-institutional collaboration, which is the main use case for federation authentication. Therefore, we more or less had to lead the way on both standardization, technology and software.

SimpleSAMLphp is a success story about international collaboration.

Where do you see the footprints of your work with SimpleSAMLphp in the global NREN community (the GREN)?

SimpleSAMLphp is widely used across all continents. It is



EISCAT 3D

Extreme bandwidth in remote and impassable Nordic territories

Advanced scientific studies of the Earth's atmosphere and ionosphere are performed far from populated areas and standard network resources.

A huge science facility for the European Incoherent Incoherent Scatter Scientific Association, EISCAT, is in the making, and it's an ambitious project. The aim is for scientists to be able to study plasma in the Earth's atmosphere and ionosphere, for instance the matter that causes the northern lights - also known as the aurora borealis.

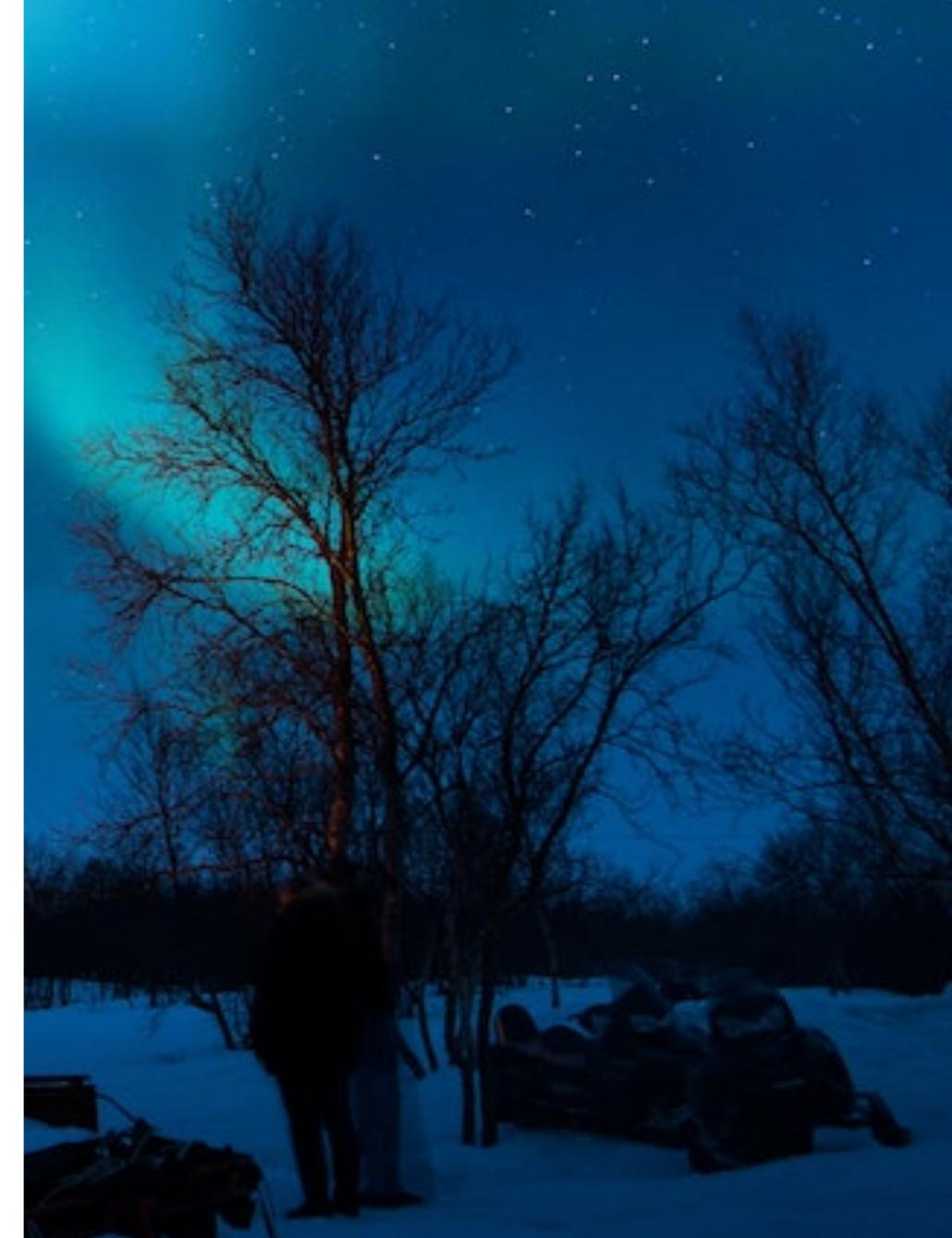
EISCAT's antennas are built to pick up very weak reflections from atmospheric plasma, appearing as a result of energy pulses sent from the earth.

To minimize the risk of interference with light or conflicting radio signals the facilities must be situated in an undisturbed environment - like the Nordic landmass close to the Arctic.



“The solution that the community has brought to table is nothing less than spectacular.”

Olaf Schjelderup
Director of department
Uninett





EISCAT 3D - CONTINUED

The first triangle of antennas will be placed near Skibotn (Norway), Kaisaniemi (Sweden), and Karesuvanto (Finland), all in the Arctic area, north of the 67th parallel.

10,000 antennas are planned for each site

This kind of research activity is bound to produce vast amounts of data, that will have to be transferred out of the Nordic wilderness onto servers at research institutions for further processing.

This is not an everyday assignment. The facilities are placed in an area where winter temperatures below minus 50 degrees Celsius are not uncommon.



“It's difficult to imagine it could be done somewhere else than in the Nordics.”

Jani Myyry
Data Communications Specialist
Funet





EISCAT 3D - CONTINUED



SUNET

EISCAT is co-funded by the European Union and has associates in:

- China
- Finland
- Japan
- Norway
- Sweden
- U.K.

FUNET

by CSC

NORDUnet

Nordic Gateway for Research & Education

UNINETT

And, with affiliated institutes from:

- France
- Russia
- South Korea
- Ukraine

[More about EISCAT](#)

Nordic collaboration ensures connectivity

A specially built network is an essential part of the advanced facility to support its activities, and it was soon clear to the network engineers that a highly dedicated approach was necessary to fulfill this task.

Open minds were necessary to innovate on cross-border issues and to secure

- Fiber connectivity to the remote instrument locations
- Access to large amounts of bandwidth
- Affordable solutions for all involved

An exemplary collaboration between Nordic network engineers from Funet, Uninett, SUNET, and NORDUnet has led to a common agreement ensuring connectivity at 100 Gbit/s to every site from the beginning, scaling up to terabits per second.

The setup is viable only because the parties were able to agree upon sharing resources, such as spectrum, across country borders in the far north of Europe.

As soon as buildings and power supplies are up and running, the research can begin. The network is built and ready to go.



NEW STRATEGY 2020 - 2025



NORDUnet

NEW STRATEGY 2020-2025

The NORDUnet Board, in close consultation with the NORDUnet CEO, sets the direction for the Nordic NREN collaboration, and hence for NORDUnet as a company, by creating a multi-year strategy.

The most recent version was finalized in Q1 2020 and governs the period from 2020 until 2025.





THE NORDUNET STRATEGY 2020-2025

The main ingredients of the 2020-2025 Strategy are that we add value for the National Research & Education Networks (NRENs) and Research & Education communities through Nordic collaboration in providing:

NETWORK INFRASTRUCTURE
SERVICES
SUPPORT

learn more ↗

2020 2021 2022 2023 2024 2025

1. INCREASE VALUE FOR CUSTOMERS

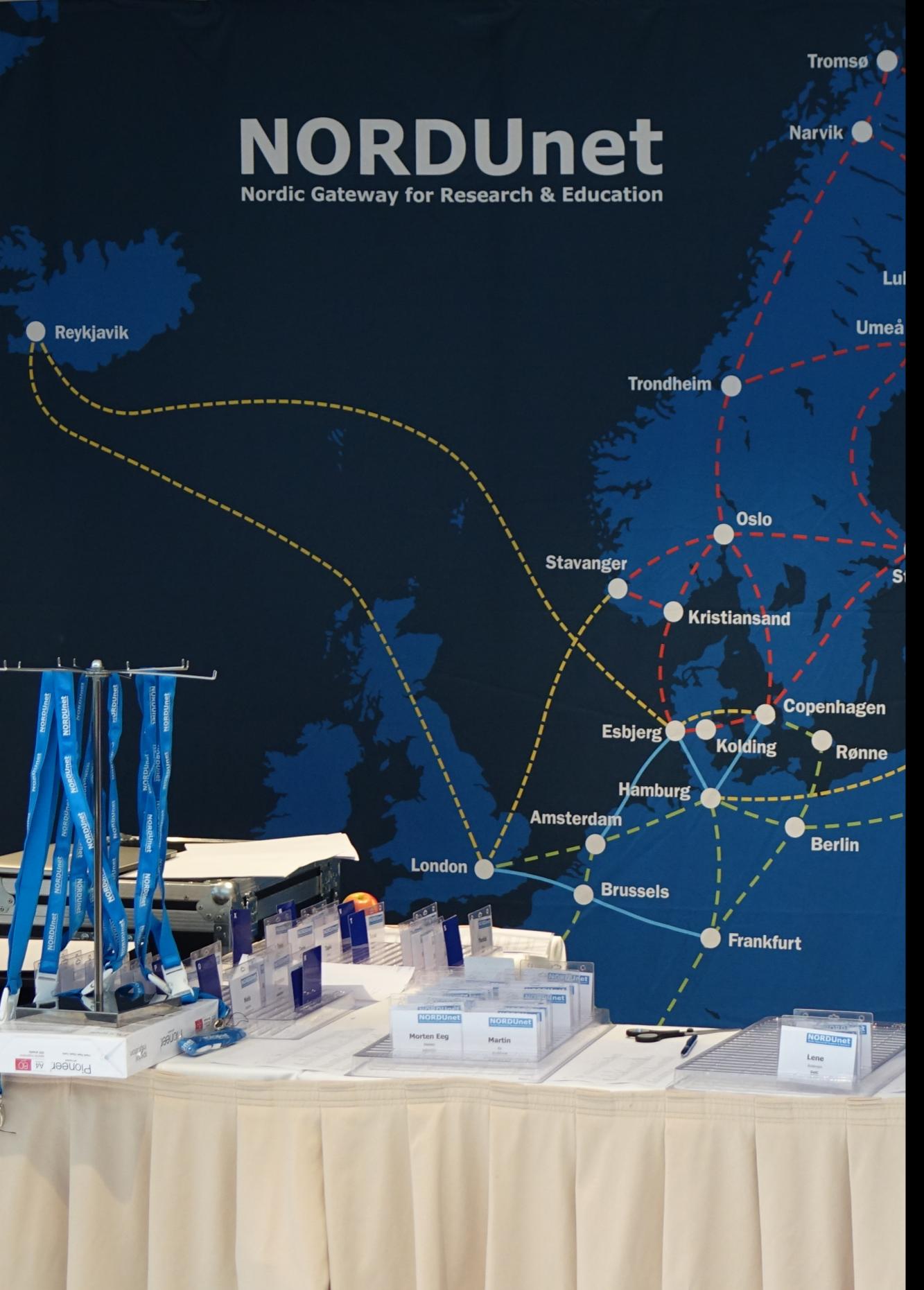


2. LEVERAGE NORDIC STRENGTH



3. DEVELOP FUTURE COMPETENCES





CONFERENCES

PERPETUATING THE NORDIC COMMUNITY AND REACHING THE WORLD!

People from the Nordic R&E community meet and catch up at the NORDUnet Conferences

The number of participants keeps rising - underlining the importance of this event.

The conferences are professional forums for sharing ideas and working on the collaboration, and where we meet to discuss tactical issues, as well as innovative strategies and initiatives. They offer plenary sessions, breakout sessions, ample room for hallway conversations, receptions, gala dinners, and lots of side meetings!

At the NORDUnet Conference, there's room for many different topics, all aimed at furthering support for research and education.

The chance of presenting a great idea to the community, and inspiring others, is always available.

Susanna ensures that everything runs smoothly. To see how, tap on her laptop



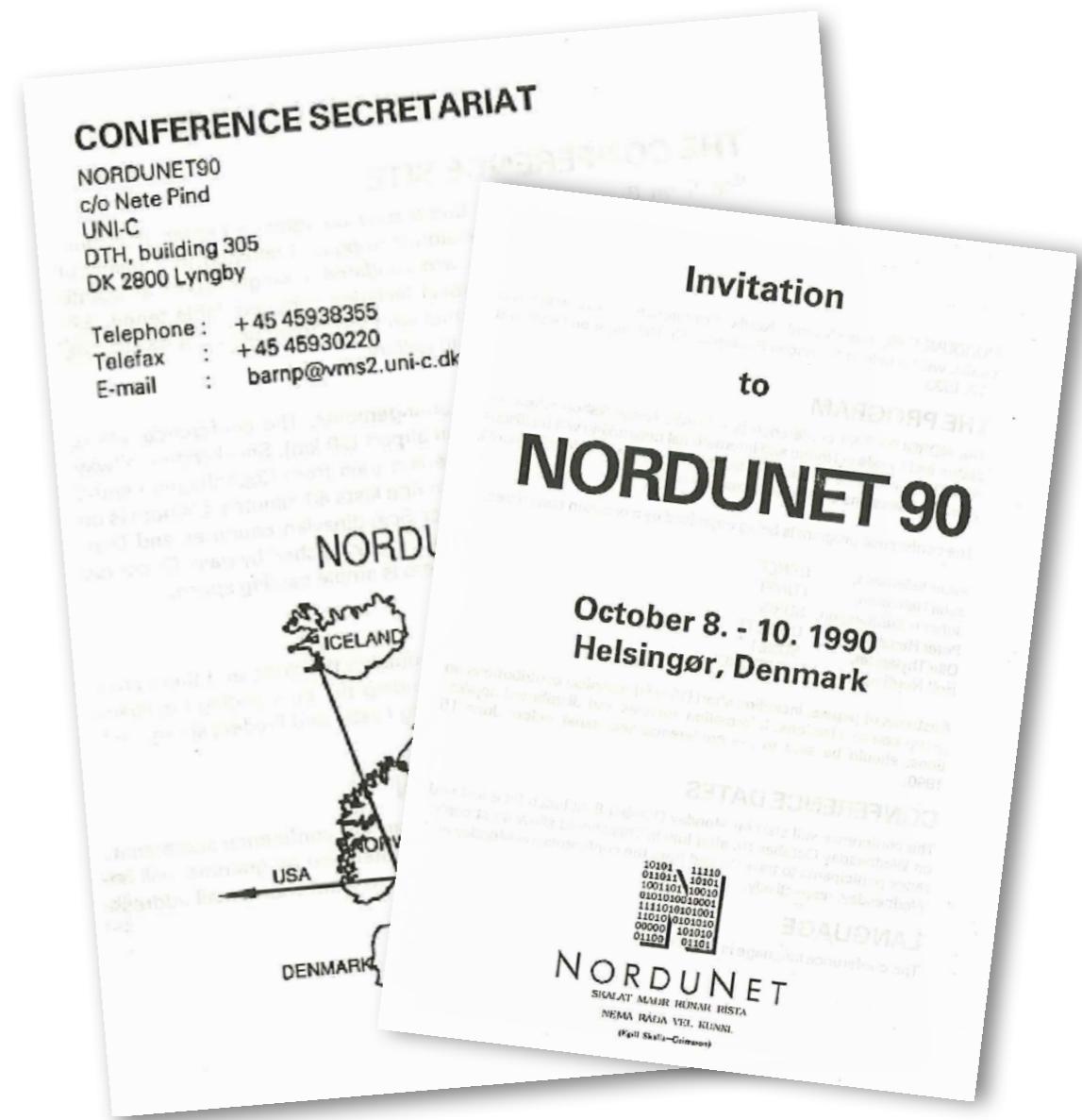
IN THE BEGINNING

2020 Marks the 40th anniversary of NORDUnet

The historical first conference was held in Tällberg, Sweden, marking the birth of NORDUnet based on the collaboration between the Nordic countries.

NORDUnet Conferences aim to

- Create an open and collaborative atmosphere
- Provide delegates with access to leading technical and innovative topics about R&E networking and services
- Give room for delegates to discuss networking, services, and furthering the collaboration
- Have a programme that is of high interest to the community
- Engage commercial entities, relevant to our community, to attend with a stand, meeting the community, and at the same time sponsoring the event



Check out this 1990 conference invite

CALL FOR PAPERS



NORDUNET-87

Hanasaari, Espoo, Finland
21st - 23rd October 1987

BACKGROUND

NORDUNET is a cooperative effort between the academic networking activities in the Nordic countries Denmark, Finland, Iceland, Norway and Sweden. The NORDUNET-87 conference is a follow-up in the series of annual NORDUNET conferences. The previous conference NORDUNET-86 was held in Røros, Norway. NORDUNET-87 is arranged by Finnish University and Research Network project, FUNET.

The theme of the NORDUNET-87 conference is "Moving towards OSI". The major objective is to discuss the protocols, products, problems and introduction of the upper OSI-levels. There is interesting development in the standardization work of, for example, X.400, FTAM, VT and JTM. New OSI-products are emerging but still we have the interconnection problem of for example X.400 and RFC822. Of course, other related topics are also welcome.

NORDUNET-87 will offer a forum for all those engaged in academic networking in the Nordic countries to exchange views and experiences and to present results and achievements.

The main invited speaker is "Larry" Lawrence H. Landweber from the Computer Science Department of the University of Wisconsin-Madison. He will talk about the OSI-work done at the University of Wisconsin and how the academic world in the USA will move towards the OSI-protocols.

There will be also some other invited talks outside the Nordic countries.

NORDUNET-87 invites you to submit draft papers or proposals for presentations to be given at this conference. These should be sent to the

SECRETARIAT FOR NORDUNET-87 EAN: nordunet-87@opmvax.usd.fscf.funet
FUNET c/o VTKK EARN: nordunet@finfun
P.O.Box 40 FUNET DECNET: OPMVAX::NORDUNET-87
SF-02101 ESPOO, FINLAND

IMPORTANT DATES

paper and proposal submission deadline 3.6.1987
notification of acceptance 1.8.1987
due date for the final version of the accepted presentation 15.9.1987

INFORMATION

For any further information on NORDUNET-87 please contact

Lars Backström FI	backstrom@fscf.funet	+358-0-410566
Johann Gunnarsson IS		+354-1-25088
Klaus Hansen DK	khan@dku.uucp	+45-1-396466
Mats Brunell SE	matsh@qz.sunet	+46-8-654500
Roald Torbergse NO	torbergse@vax.runit.unit.uninett	+47-7-592014

Moving towards OSI

SAMTÖK UM UPPLÝSINGANET RANNSÖKNARAÐILA Á ÍSLANDI

Stofnað hefur verið félag með þessu heiti í þeim tilgangi eins og segir í lögum þess:

"að koma á samvinnu um rekstur íslensks tölvunetkerfis og upplýsingaþjónustu á sliku neti fyrir rannsóknaraðila. Einnig að annast erlend samskipti fyrir hönd Íslands og stuðla að bættum netsamböndum við útlönd. Félagið er aðili að RARE (Réseaux associés pour la Recherche Européenne) og styður markmið þess."

Aðild eiga flestar rannsóknastofnanir á vegum ríkisins, svo og æðri menntastofnanir. Einnig hefur nokkrum fyrirtækjum, sem selja tölvubúnað verið boðið að gerast styrktarfélagar. Félagið verður opíð stofnunum, sem hafa með höndum rekstur upplýsinganeta, og tölvufyrirtæki eða hugbúnaðarframleiðendur, sem áhuga hafa fyrir netmálum eru einnig velkomin sem styrktarmeðlimir.

Hugmyndin er að starfsemi félagsins verði tvípátt:

í fyrsta lagi að vera fulltrúi landsins í erlendu samstarfi um upplýsinganet, svo sem RARE, COSINE og NORDUNET, og að standa fyrir samræmingu og stefnumótun innanlands á grundvelli opinna samskiptakerfa (Open systems interconnect, OSI) samkvæmt yfirlýstri stefnu í félagslögum. Almenn upplýsingasöfnun og -miðlun verður einnig á dagskrá.

í öðru lagi að koma upp og reka, eitt sér eða í samvinnu við aðra, gáttir á milli helstu alþjóðlegu netanna og notenda hér á landi. Í fyrstu er talað um þrjú netkerfi, sem mikilvægust eru talin: EARN-BITNET (styrkt af IBM til áramóta 1987-88), UUCP-EUNET (tengir saman UNIX-notendur) og MHS (tilraunanet, byggt á OSI-hugmyndum og X.400-staðli alþjóða-póstmálastofnunarinnar, CCITT, um boðflutningskerfi. Þáttur í þessu starfi er að samræma eftir fögum netvæðingu félaganna innbyrðis.



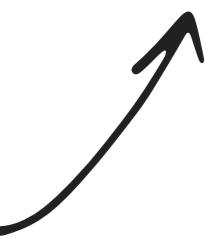
CONFERENCE LOCATIONS AND YEAR

- Helsingør, Denmark, 2018
- Helsinki, Finland, 2016
- Uppsala, Sweden, 2014
- Oslo, Norway, 2012
- Reykjavik, Iceland, 2011
- Copenhagen, Denmark, 2009





*Nordic conference
collaborations create
lucrative opportunities*



CONFERENCE FACTS

NORDUnet Conferences (in recent years), take place every second year in September.

The Nordic NRENs take turns in hosting the conference.

NORDUNET WORKSHOPS

NORDUNET TECHNICAL WORKSHOPS

At NORDUnet we further stimulate Nordic community building, discussion, and sharing of technical achievements. To this end, we have introduced the NORDUnet Technical Workshop (NTW).

The NTW will have a different scope and focus than the NORDUnet Conference - smaller and focused on technology and collaboration.

Participant profiles are still dominated by the technically savvy staff, with the content very much defined by the participants themselves, and with an atmosphere that encourages lengthy discussions and workshop-like activities, all with a grassroots approach to R&E Networking.

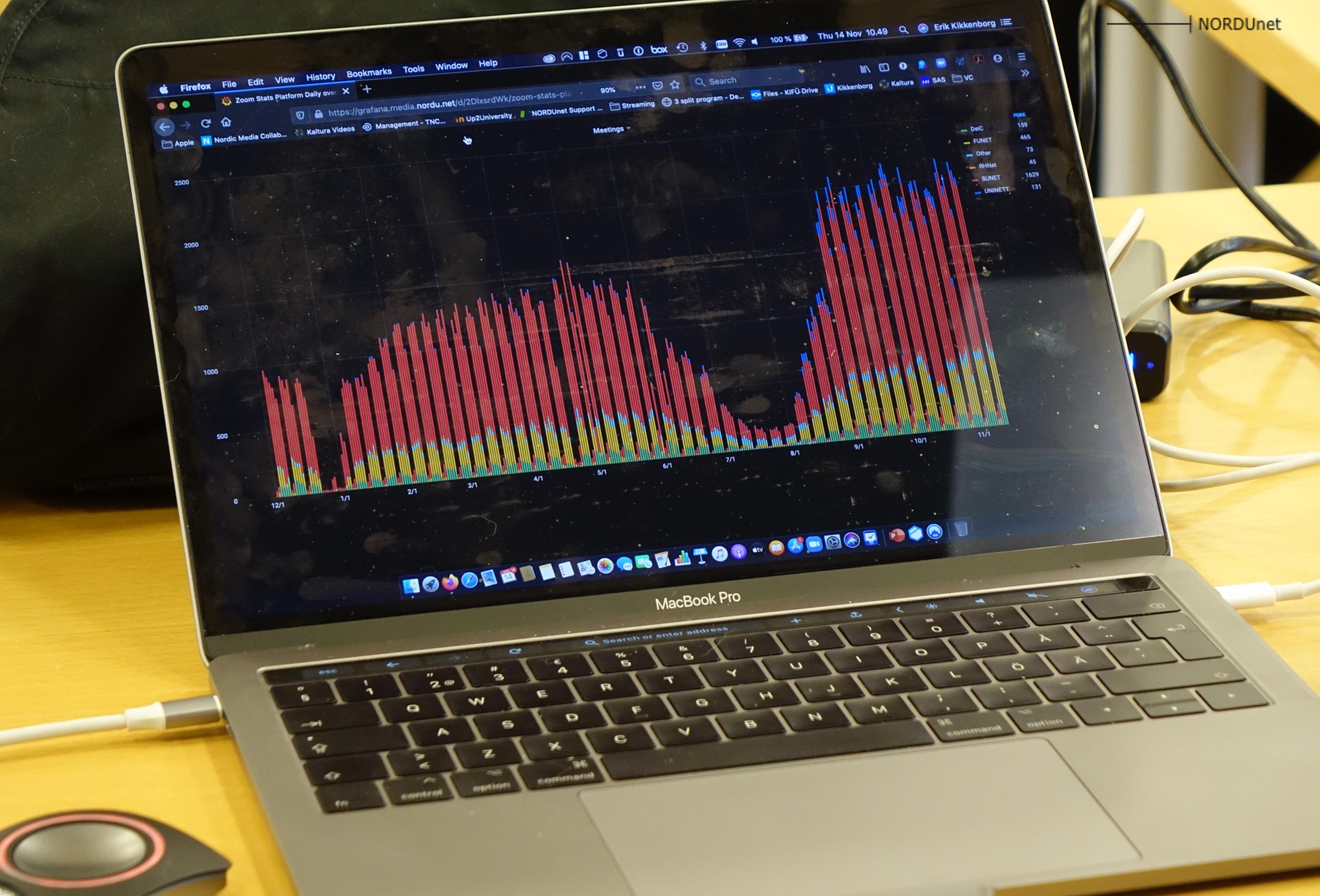




What has changed from the initial event is the number of participants, which has risen from 50 in 2013 to more than 200 in 2019



See why! ↗





TOPICAL WORKSHOPS



*tap to hear more about
community building*



NORDUnet regularly organizes a workshop on a focused (technical) topic, e.g. on Zoom management or on using Science DMZ.



• • •

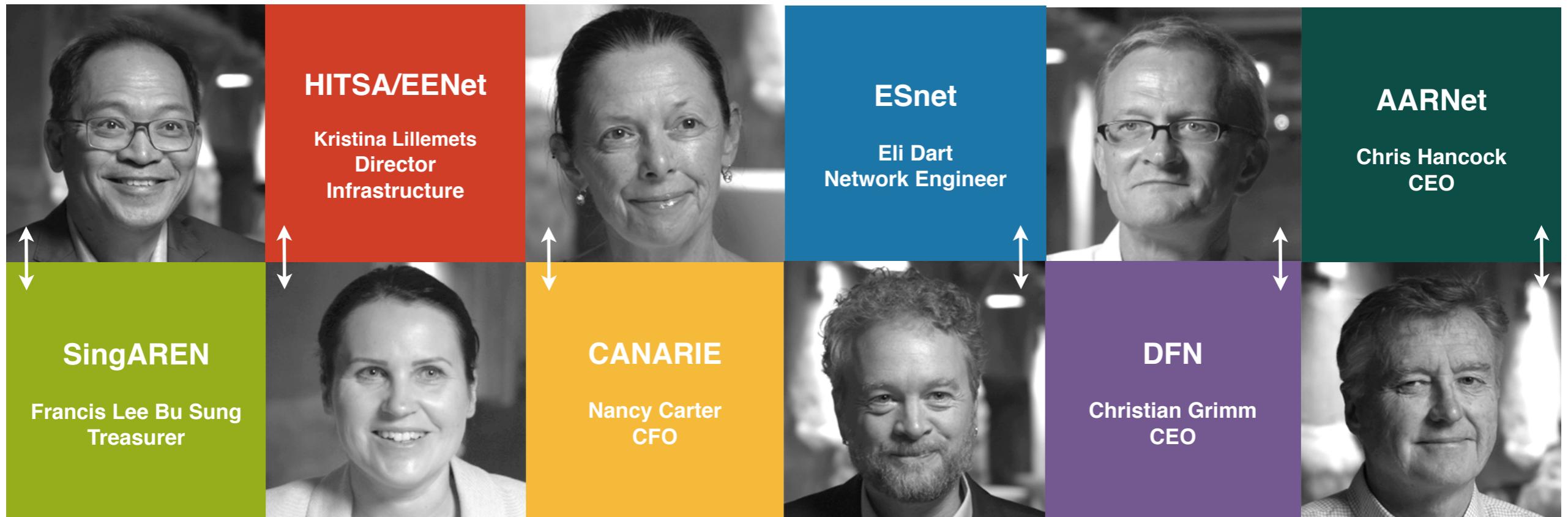
“Here we can look each other in the eyes and agree that something is very interesting, and we can start to build a collaboration with real commitment.”

Thorkild Jensen
Project Manager, DeiC



NORDUNET
AS SEEN FROM OUTSIDE
THE NORDICS

NORDUNET AS SEEN FROM OUTSIDE THE NORDICS



tap to hear what
they have to say



NEVER STOP
REINVENTING
YOURSELF



EMBRACING CHANGE

Never stop reinventing yourself

NORDUnet and the Nordic NRENs have people working for them that are eager to spot new opportunities, promising ideas and innovative trends, and want to work on that.

Often, this leads to a new and innovative service. Or a new way to use existing hardware or software. Or, as we saw during the beginning of the COVID-19 pandemic, an incredible and rapid media services ramp up for the Nordic universities that started teaching online, almost overnight.

Sometimes you chase something that looks promising, but leads to nothing. That is also fine, as you learn a lot on the journey.

Successful NRENs are used to being on the forefront of technology, and play an innovative and pro-active role in service delivery for research and education.



3

NETWORK





NEXT GENERATION NETWORK

NORDUnet's Next Generation Network

SHARING PROVIDES MORE CAPACITY AND IMPROVED REDUNDANCY FOR LOWER COST

Since the start of NORDUnet, the NORDUnet Network has been the tangible asset that interconnects the five Nordic NRENs and connects us to the outside world.

Now is our time to transition to a new network, which will deliver more capacity and more redundancy for less money. Back in November 2018, the five Nordic NRENs and NORDUnet agreed on the architecture as well as the cost, and how to share it.

This was the green light to start the project, that will take a few years to fully materialize.



One of the eye-catching features of the new NORDUnet network is that the present dedicated NORDUnet fibers in the Nordics will be eliminated. The Next Generation Network will be built using Nordic NREN spectrum only - shared with NORDUnet.

This is a ground-breaking way of implementing the new network, allowing us to achieve more for less.



A NEW LADDER STRUCTURE CREATES OPTIMAL REDUNDANCY

The NORDUnet Next Generation Network is built on a "ladder architecture" with long legs running in the north-south direction.

The vertical steps of the ladder across avoid network segmentation in case of one or more outages in the underlying optical networks.

It also secures fast re-route and opens up multiple locations for the Nordic NRENs to connect to the NORDUnet network.



"We have been removing redundant infrastructures."

Per Nihlén
Chief Technology Officer
SUNET



TRANSITION TO SHARING SPECTRUM

NORDUnet's Next Generation Network

Map key

Point of Presence



Capacity or spectrum



Fiber footprint



Q2-Q3-19



Q3-Q4-19



Q4/19-Q1/20



Q1-Q2-20



Q2-Q3-20

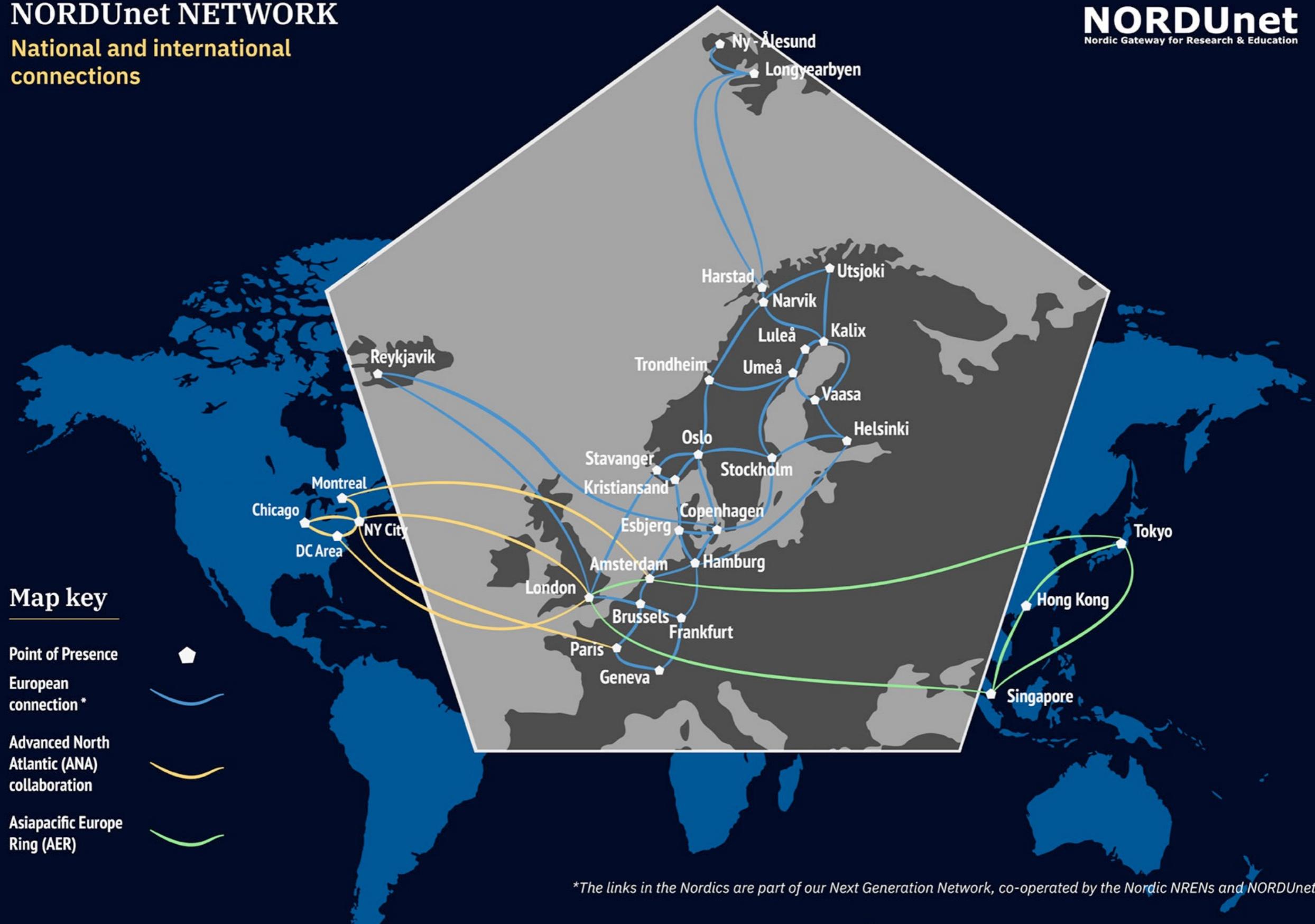


Q4-21



NORDUnet NETWORK

National and international connections





THE NEED FOR BANDWIDTH IS RADICALLY INCREASING

New research infrastructures are being built at many places around the world, and they all need to be accessed by researchers from all over the world, for instance:

- the [European Spallation Source](#) in Lund and Copenhagen with its data center in Copenhagen
- the [EISCAT 3D](#) radar located in the northernmost parts of Norway, Finland, and Sweden, and
- the EuroHPC Center in Kajaani, Finland, home to [LUMI](#)

The new network is designed to meet the demands of increased capacity and redundancy, related to big science activities.



COST IS SIGNIFICANTLY REDUCED

The Nordic NRENs and NORDUnet agreed upon an incremental cost sharing model for the new network, that allows everybody to save money.

According to this model, the Nordic NRENs provide NORDUnet with the needed spectrum in their respective country-wide optical networks. NORDUnet covers the cost of getting access to the spectrum, leaving the cost of housing equipment to be the only additional expense on the transmission layer.



“The additional network redundancy is achieved by sharing the resources in the Nordic NRENs' optical networks.”

Jørgen Qvist,
Chief Network Operating & Service
Development Officer, NORDUnet



DOWNTIME IS TO BE AVOIDED

While availability is often expressed as 99% or 99.9%, the target availability for the new NORDUnet network is simply 100%. This is a must, due to the trend in the uptake of cloud services upon which universities and research institutes are increasingly dependent.

Furthermore, digital tools have become the norm at universities, used by large numbers of students in their core learning processes. No downtime is allowed.

**No
downtime
is allowed**



ACHIEVING THE GOALS



By adding much more redundancy to the network, one or even several failures do not take out a connection to any of the Nordic NRENs or the connection of NORDUnet to the rest of the world.

NETWORK SERVICES

MULTIPLE NETWORK SERVICES SUPPORTING SCIENCE, RESEARCH AND EDUCATION

Choosing the optimal set of international network services for the Nordic research and education community, in close collaboration with the Nordic NRENs, is one of the core activities in NORDUnet.

It is not straightforward. New technology pops up everywhere, making identification of the right, fulfilling network components a challenge, if you want them to be implemented timely, and at an affordable price.

NORDUnet's network services come in two flavors:

1. IP routed services (also known as connectionless services):
 - a) High-speed, high-quality IP connectivity to R&E Networks around the world
 - b) Connectivity to the Public Internet



2. Connection oriented services:

- a) **Dedicated transmission**
(also known as *lambdas*)
- b) **Point-to-point services**
(also known as *lightpaths*)
- c) **Point-to-multi-point services**

On top of the above-mentioned basic network services, NORDUnet offers a range of value-added network services to the Nordic NRENs and their users.



NOX



eduVPN



MD-VPN



Science DMZ

NETWORK SECURITY



The Invisibles

COMPUTER EMERGENCY RESPONSE TEAMS ARE ON THE JOB

We aim to provide fast and accessible internet for our users at Nordic universities at all hours. Our security teams live behind the scenes, assessing the continuously evolving threat landscape.

Their efforts should remain unnoticed, because it's all about preventing an incident. If you are just reacting to incidents, it is mostly too late to avoid irregularities.

Here is a peek into the world of network security describing a fraction of the work done to keep research and education data safe.



“By collaborating, we are able to secure the NREN communities in the North.”

Josva Kleist

Chief Software Engineering
& Integration Officer
NORDUnet



THE THREE PILLARS OF NETWORK SECURITY

Confidentiality

Data is protected from unauthorized users, for instance by access control.

Integrity

Data is only changed during storage by its owner, in an intended way, and is never changed on the way from source to destination.

Availability

Availability is the core of every network and associated services, and any attempt to affect this must be prevented.

NETWORK SECURITY

THE CYBER DEFENSE

Global Security Communities Add Safety

An active, collaborative approach in the global community facilitates knowledge build-up and provides valuable contacts between security experts.



Josva Kleist
CSEIO
NORDUnet

Learn Our MANRS

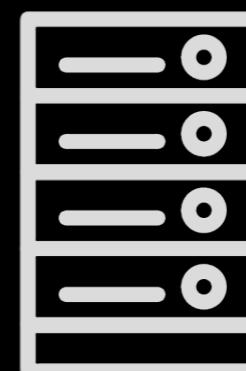
By applying good manners, NRENs (and Public Internet providers) can contribute their part for a safer Internet.



MANRS

Study a DDoS Attack

A successful DDoS attack completely blocks internet availability of the victim or puts the victim's systems into a state where attacks to gain access are easier – see how the hacker harms.



WHEN DDOS TOUCHED NORDUNET

The Mirai Botnet Story - How We Mitigate DDoS Attacks

On 12 October 2016, access to the internet was denied for people on the entire east coast of the USA. It was a massive distributed denial of service (DDoS) attack, which later got the name Mirai botnet.

The creators never imagined its potential. They were just trying to have fun and make some money on Minecraft.

Instead they invented a powerful intruder, challenging the security systems of every network it hit. NORDUnet's network was also touched.

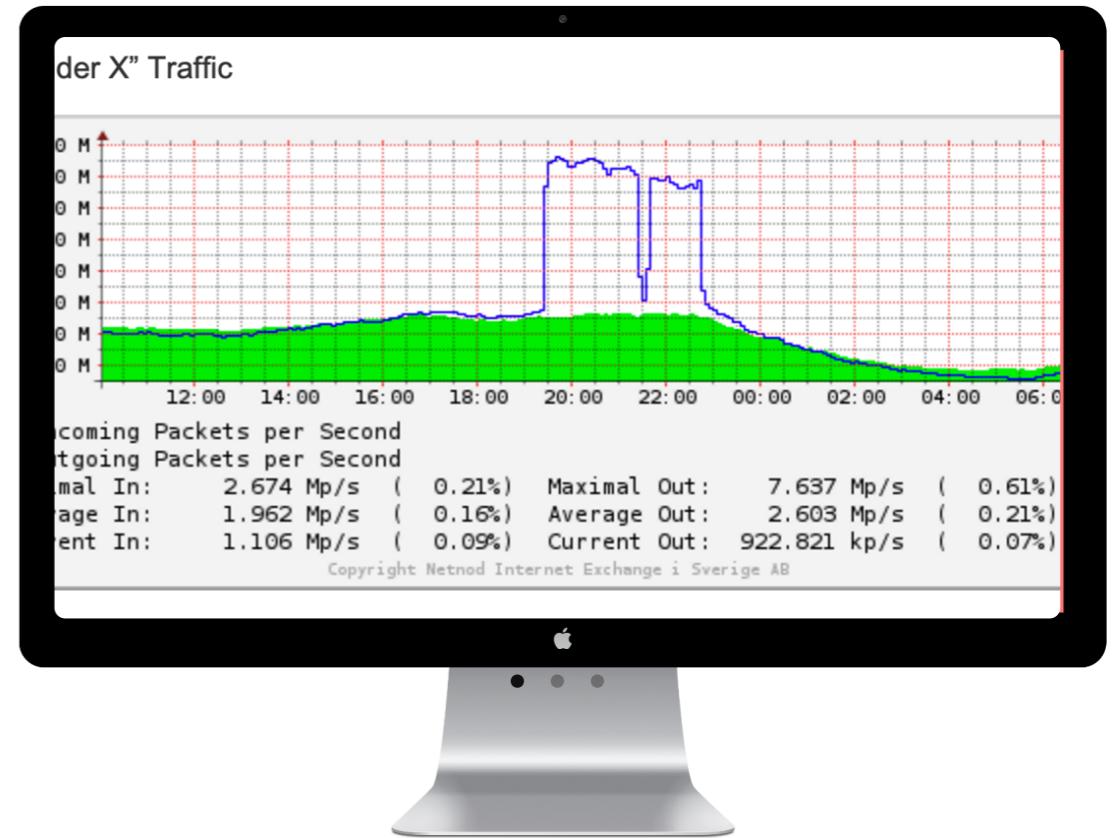
This is what happened...

One day the alarm went off in the global security community: a new and powerful botnet had hit a blogger.

In NORDUnet, the botnet was analyzed to prepare a defense for whenever it would hit our system. The thing is, that when someone starts using a new botnet everyone will turn their eyes on it. They will find out how it attacks and try to use it wherever they are able to spot a vulnerable setup.

The code of the Mirai botnet was easily available, as it was used on pretty much anything – not on specific targets.

After hitting the blogger, the attack went on to banks and to insurance companies, and we got it at NORDUnet ten days later. It hit our Internet Relay Chat, and we were prepared and stopped the attack before any damage was done.



What's a Botnet?

A botnet is a group of computers or devices connected in a coordinated fashion for malicious purposes. Each computer/device in a botnet is called a bot.

The bots form a network, which is controlled by a third party and used to transmit malware or spam, or to launch attacks. The Mirai botnet primarily used cheap home security cameras.

THE MIRAI BOTNET STORY - CONTINUED

International collaboration helps NORDUnet to prevent hacker attacks

To successfully prevent a DDoS attack, several things are needed, but cut to the bone the prerequisites are:

1. Be informed – to protect and to take counter measures, security employees and aficionados all over the world must know about an attack as soon as possible
2. Follow up - it's necessary that a serious incident like the Mirai botnet is discussed and analyzed as soon as possible to minimize the damage of potential later incidents

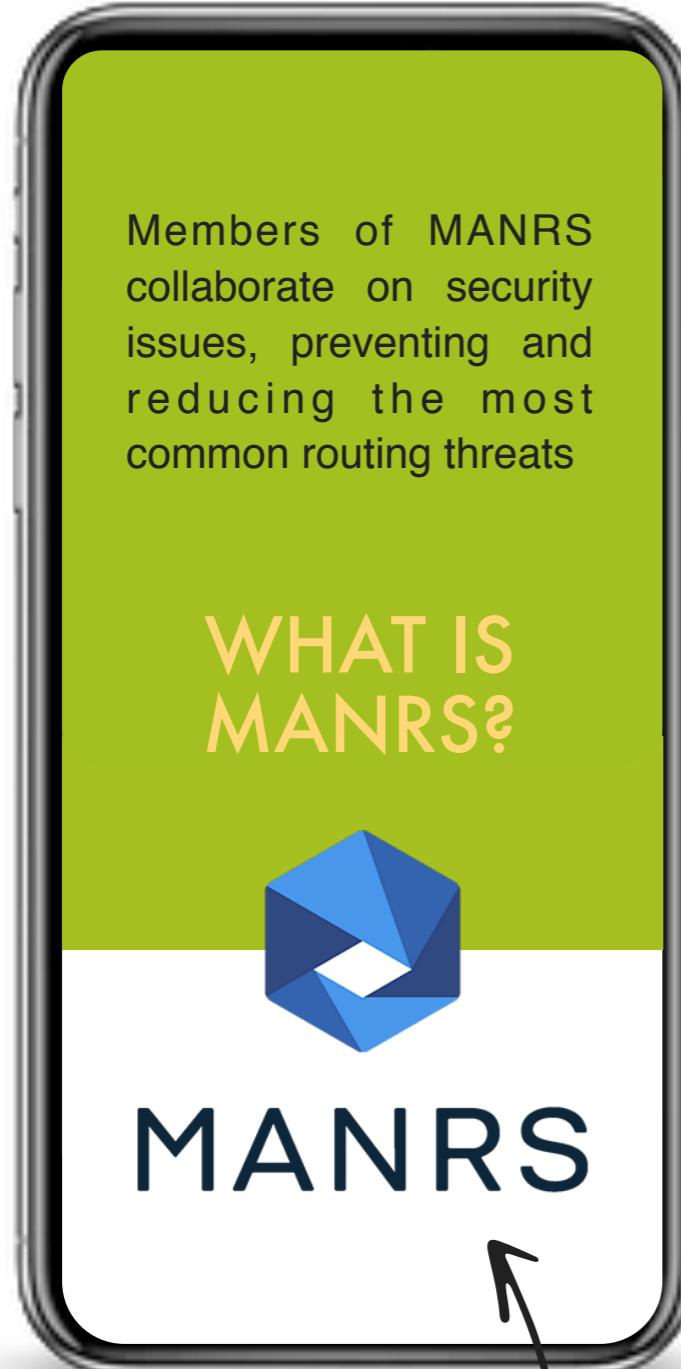
The global security community interacts a lot among themselves. To the outside world, not much is disclosed. It takes gained trust and active participation to be in the inner circles.



“We can steer a large DDoS attack away from the Nordic network to where it makes no harm”

Magnus Bergroth
Senior Network Architect
SUNET





Members of MANRS collaborate on security issues, preventing and reducing the most common routing threats

MUTUALLY AGREED NORMS FOR ROUTING SECURITY - MANRS

A global initiative defining do's and don'ts on the Internet, intended towards all Internet Services Provider (ISPs) and Internet Exchange Points (IXPs)

Applying some clever but rather simple rules and behavior makes the Internet a safer place for the end user and easier to manage for service providers.

But what is good behavior in the cyberspace universe?

A number of security-minded NRENs are among the many Internet Service Providers that consider themselves responsible Internet citizens, and NORDUnet is one of them.

Like any other society, this requires agreement on a set of standards and values for everyone to follow.

Therefore, a global initiative, supported by the Internet Society, has led to MANRS – an initiative that established a set of good routing manners on the Internet. For NRENs – and all other ISPs and IXPs.

In NORDUnet, we value our commitment to MANRS, and we were one of the first NRENs to implement MANRS.

The real power of MANRS only shows if the majority of global ISPs are in on it.

We therefore actively advocate for other NRENs to come forward and join **MANRS** – to jointly show commitment for a safer Internet.

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Digitized by srujanika@gmail.com

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the first time, the author has been able to demonstrate the presence of a single nucleolus in the nucleus of a single cell.

WE MEET, SHARE AND SECURE

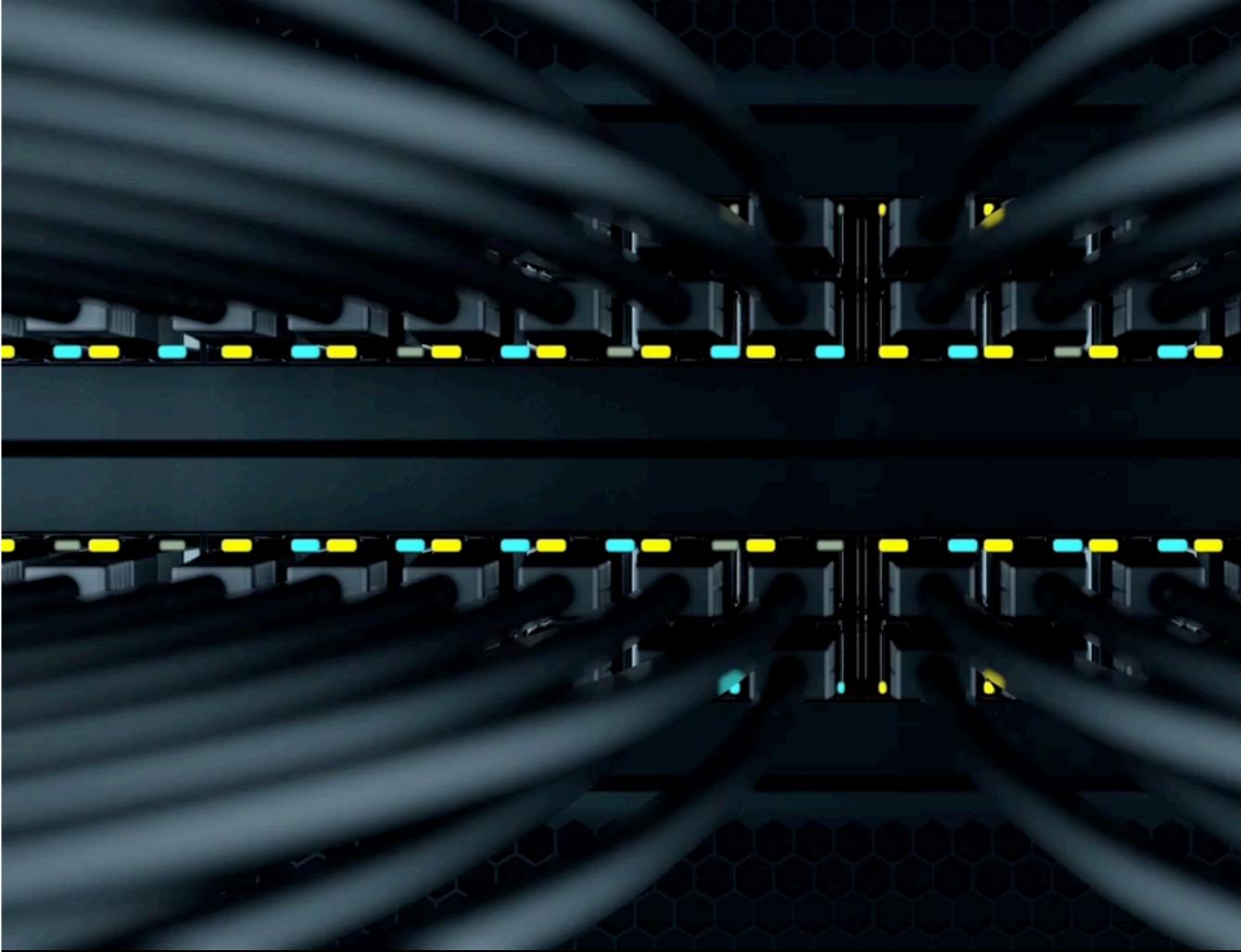
One of the most important issues, when dealing with internet safety, is exchange of knowledge. Here, country borders are unimportant - a global commitment is a must.

Therefore, groups of people responsible for R&E Internet security have joined forces from several places worldwide, and these communities add a sophisticated level of safety to the R&E Networks.

Each community has their own set of rules. In some, anyone can join, others have dedicated purposes, and admittance is therefore restricted to certain organizations or individuals.

You might have to be recommended by an insider to be even considered a member, and if you fail to follow the code of conduct, you're no longer welcome.

It's a special environment based on trust and individual commitment.



Basically, the currency in the groups is

HUMBLENESS
and a
DEDICATION TO
SHARING KNOWLEDGE
AND EXPERIENCE

FIRST FORUM

FIRST.ORG

**GOAL:**

Global forum of incident, response and security teams with more than 400 members

WHO'S WELCOME:

All organizations and enterprises are welcome

WHO'S BEHIND:

Self-sustained organization

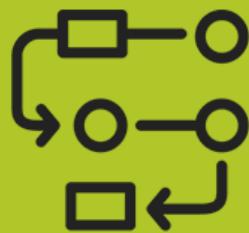
NORDUNET STATUS:

Full Member

Global Security Communities

TF-CSIRT

TF-CSIRT.ORG

**GOAL:**

A platform for security teams in Europe to share and learn

WHO'S WELCOME:

Computer Security Incident Response Teams in the European NREN community

WHO'S BEHIND:

GÉANT

NORDUNET STATUS:

Certified Member

GLOBAL SECURITY COMMUNITIES ADD SAFETY

Each community has their own set of rules

In some, anyone can join, others have dedicated purposes, and admittance is therefore restricted to certain organizations or individuals.



eduVPN

eduVPN



“NORDUnet has been key to avoid too much centralization in the governance of eduVPN in order to remain free and flexible.”

Tangui Coulouarn
Project Manager
DeiC



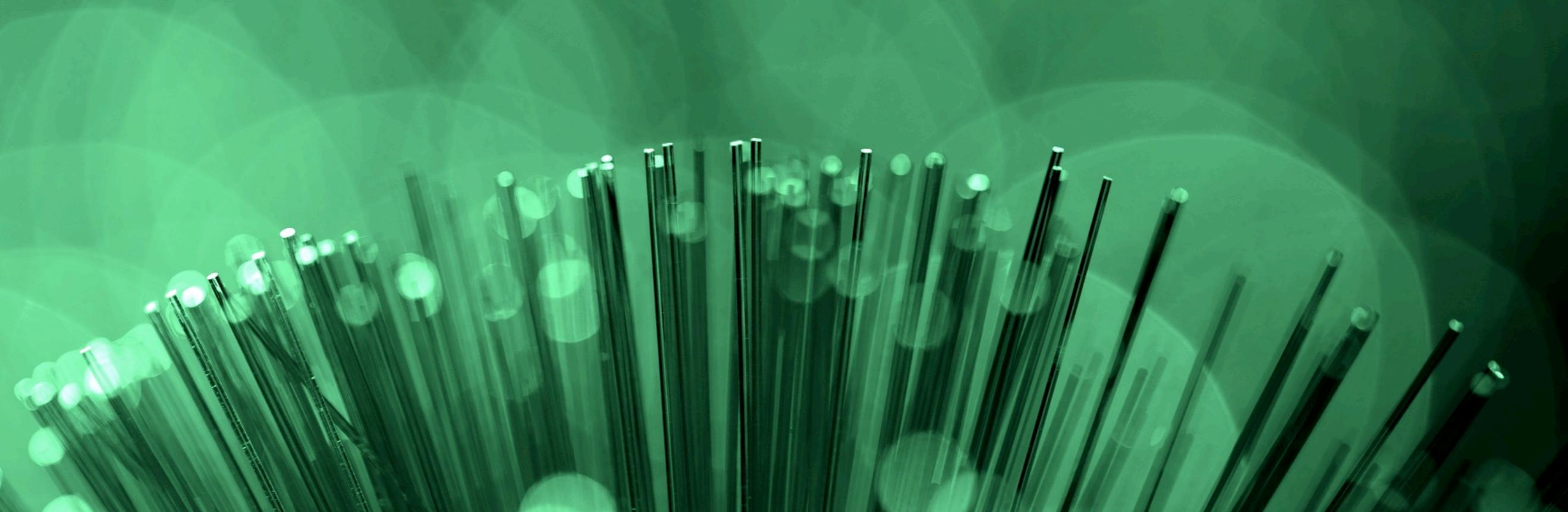
tap to
learn more







ALIEN WAVES



Introducing Alien Waves

SETTING FUTURE STANDARDS FOR SHARING RESEARCH NETWORK RESOURCES

In 2008, some dedicated souls met during a coffee break at the TNC conference in Bruges, Belgium and hatched a plan

They discussed the rapidly increasing bandwidth demands on the research networks in Europe. Something had to be done in the near future to ensure the capacity would be available in an efficient and cost effective way.





2009, A year later...

The plans made in Bruges had become a reality. In 2020, the concept of alien waves is used throughout the world.

Main ingredients of coming to such success of the alien wave concept are:

- Technical skills and distinct curiosity
- Defiance (they say we can't – we'll show them otherwise)
- Room to operate in the respective organizations

and last but not least:

- Trust as a basis for excellent collaboration

WHY CALL IT ALIEN WAVES?

The term “alien wave” was given to this concept, as it was a wavelength we are dealing with

But alien it was: The idea was to accept wavelengths on the optical fiber without the usual control when entering another optical domain. This, indeed, was an unfamiliar way of thinking in the field of international long-haul fiber optic networks.

Without the usual control you really have to trust your network partner. You make a common agreement of how to administer the wavelengths, and rely on careful planning, technical capabilities of the equipment, and, of course, technical skills of the parties involved. While you trust each other, equipment failure or human error could easily hamper the correct operations.

Many optical vendors have, in the meantime, embraced the concept of the alien wave. New generations of equipment come with features that ease the use of alien waves.





ALIEN WAVES ARE ROLLING ALL OVER THE WORLD

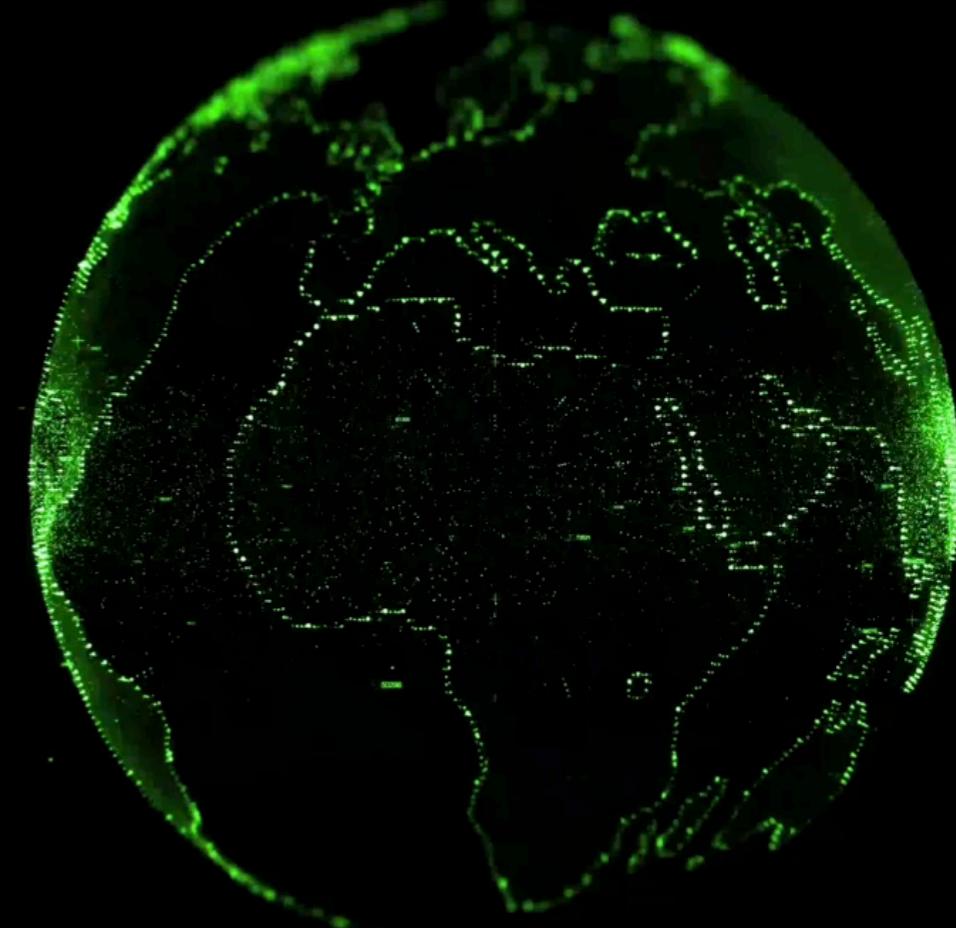
The alien wave project between Copenhagen and Amsterdam was a trial, but still, the Amsterdam-Hamburg part operates like this today, in full production, with waves from NORDUnet, PSNC, and GÉANT

But since the early trials, many other fibers have been equipped with gear that allows for the transmission of alien waves.

Today, NORDUnet is involved in eight lines with alien waves, and there are many more on the way in the Nordic NREN community. The alien waves technology has become general practice, today often referred to as *spectrum sharing*.

Spectrum sharing is no longer frowned upon and, as a consequence, optical equipment manufacturers now design their network equipment to allow for it – they call it Open Optical Systems.

Also, equipment manufacturers for subsea cable system have embraced the concept of spectrum sharing.



**EQUIPMENT
MANUFACTURERS
HAVE EMBRACED
SPECTRUM SHARING**

Alien Waves - The concept of alien waves created a new need for collaboration, defining common standards, safeguarding that the wavelengths do not interact with each other on the fiber.



THE OPEN OPTICAL CONFERENCE

The first conference on this actual topic was held in November 2017, called The Open Optical Conference. Attending were delegates from Facebook and Google, among many others.

Today, in 2020, the giants have integrated alien wave technology in numerous ways in their network solutions - breathing over the shoulders of small pioneers.



MACHINE LEARNING & OPERATIONS

Machine Learning and Operations

THE FUTURE NETWORK IS INTELLIGENTLY AUTOMATED

A well-run network needs to be monitored and maintained in order to fix issues before the network service degrades or becomes unavailable. The number of man hours spent on these tasks is significant. Therefore, network engineers and software developers consistently seek new ways to improve the network operations and the procedures involved.

An obvious way to go is automation, and this is an area with much attention from the NORDUnet crew.

One of the newest trends in network automation is to automate the automation itself, often using artificial intelligence (AI) and machine learning (ML) to react to situations in order to solve problems before they occur or reduce the impact of them.

NORDUnet has already developed network automation software that fits into this category.





AI FOR OPERATIONS AT NORDUNET

The system continuously monitors the number of prefixes seen from border gateway protocol (BGP) peerings and raises the limit of accepted prefixes if the peering is close to reaching its limit. This allows NORDUnet to use prefix limits for BGP peerings that protect the network against route leaks and attacks.

Maintaining these limits for thousands of BGP peering sessions would usually require a lot of manual work. With the automation in place, NORDUnet achieves stable operations without using heaps of human time.

Developing predictions and automated adjustments is still in its early phases, and the use is still limited in the network. We are continuously working on this, as the potential is big, and we closely follow any interesting initiatives and developments in this area.

Cisco blog:



[How to improve networks with artificial intelligence.](#)

NORDUnet Pathfinding

NORDUnet started using the automation framework network control system (NCS) from Tail-f in 2012 and was the first customer to use the product.

Tail-f was later bought by Cisco, and NCS renamed to NSO.

Today NSO is in use by hundreds of network operators across the globe, including some of the largest networks in the world. NORDUnet has used NSO to automatically configure and provision the network.

This includes the setup of BGP peerings, customer sessions, and VPN tunnels.

4 DELIVERING VALUE FOR MONEY





COST EVOLUTION

DELIVERING VALUE

VALUE FOR NORDIC NRENs

Despite an ongoing and most of the time exponential growth in the demand of network bandwidth over the years, and the broadening of NORDUnet's services portfolio to above the net services, NORDUnet's cost for the Nordic NRENs has been more or less stable over the many years.

This is due to a consistent focus from all five NRENs, jointly with NORDUnet, on exploring innovative and creative ways to lower cost for all involved. Besides NORDUnet running joint network services for the Nordic NRENs and their users, the collaboration also actively pursues interesting volume contract negotiations in the many areas in which the Nordic NRENs are active.

This is done when there is economy of scale, e.g. when two or more of the Nordic NRENs want to buy at roughly the same time, in the same category of hardware, software, or services.



WORKING TOGETHER ON SYNERGIES

Areas in which NORDUnet and the Nordic NRENs work together to deliver optimal value for money include:

- The extensive peering fabric
- Joint procurements
- Media services

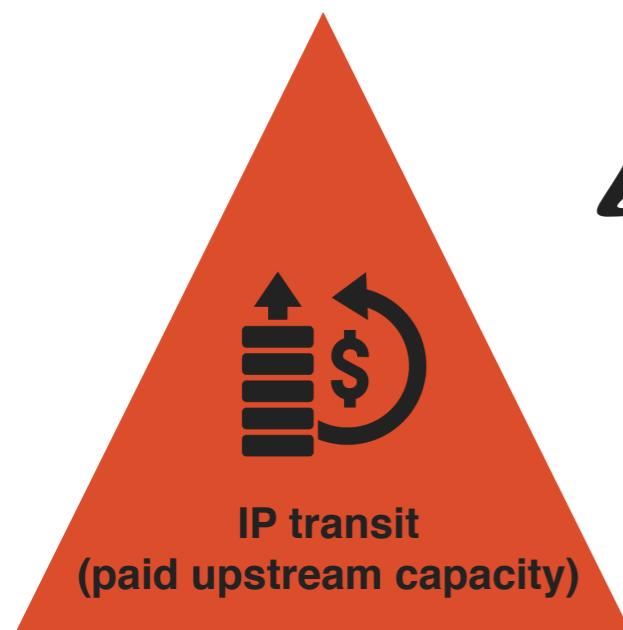
NORDUnet aims at

HIGH-QUALITY, COST EFFECTIVE SOLUTIONS

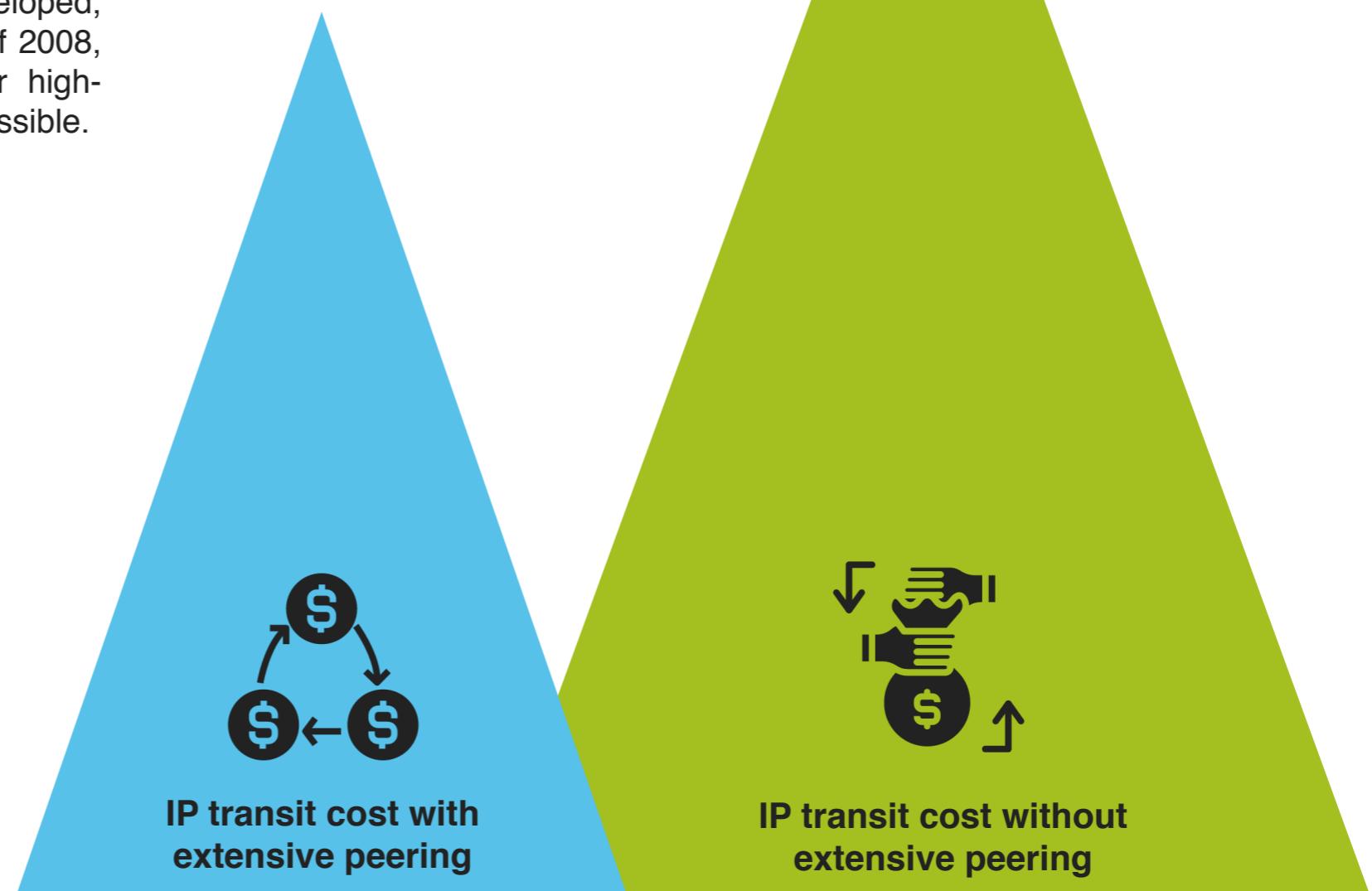
Managing the cost of the network sometimes calls for out-of-the-box thinking and innovative solutions.

Through an extensive peering fabric, developed, implemented and actively maintained as of 2008, we have managed to keep the cost for high-quality worldwide connectivity as low as possible.

*tap the icons
to learn more*



2008



2020



PEERING

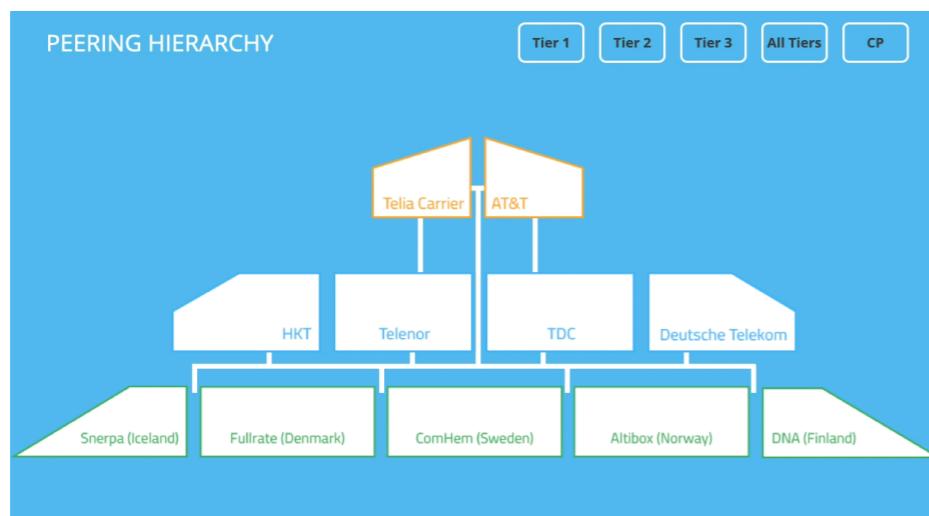
PEERING IS ALL ABOUT...

Basically, settlement-free peering is about exchanging traffic

If I accept your routes, you will accept my routes. And no money is involved. As long as you peer with equal partners it's straightforward. But many times, this is not the case, and hence a peering hierarchy has evolved.

Play by the rules or leave

The peering setup is almost entirely based on trust and reputation. If you don't behave, you will be de-peered immediately, and getting back will not be easy. NORDUnet has achieved a peering rate of 95% of the external traffic, and this number is still increasing.



AN ATTRACTIVE PEERING PARTNER PROVIDES

- Enough routing space
- Presence at many locations around the world.
(NORDUnet is present in Europe, North America, and Asia)
- Quality of operations, proven over time
- General reputation

Our result of extensive peering: Global connectivity for the Nordic NRENs is kept at high-quality for the lowest possible cost.

DO YOU WANT TO EXCHANGE TRAFFIC WITH US?

Peering: The Nordic R&E network peers with more than 500 other providers worldwide

In the beginning of the century, big content providers flooded the market with initiatives involving cloud services. Amazon Webservices, Google Drive, Box, and Dropbox, for instance. All became highly popular within a few years – also among scientists, despite the sometimes less than optimal connectivity.

Members of the NORDUnet Board spotted the need and asked NORDUnet to implement direct peerings with some of these big actors on the US market. So, we did, and thus NORDUnet became present at some of the larger Exchange Points in the USA, and started direct peerings with some of these large cloud providers. We quickly found our way around and started peering with other providers, present at these Exchange Points as well, and ever since, we have been peering extensively on a global scale.

Today, we are present on 3 continents. We peer with more than 500 providers, maintaining approximately 3,000 peering sessions.

Peering is much more than economies

NORDUnet has put in a lot of effort to peer off as much traffic as possible, as this:

- Enhances quality
- Lowers latency
- Improves resilience
- Minimizes asymmetric routing effects
- Saves money

Access to peering partners

In order to achieve this, NORDUnet is present at a number of key Internet Exchanges (IXPs) and Global R&E Exchanges (GXPs) around the world

An Internet eXchange point (IX) is a marketplace or hot spot for ISPs that flock together to make peering easy. A GXP is a similar concept in the R&E Networking world.



Peering:
[To learn more about peering, please read this 'What is Peering?' blog](#)

NORDUNET IS PRESENT AT

Europe

- AMS-IX in Amsterdam
- CERNLight in Geneva
- DE-CIX in Frankfurt
- DIX in Copenhagen
- ECIX in Frankfurt and in Hamburg
- GÉANT Open in London
- NOX-HEL in Helsinki
- Interxion in Kista
- LINX in London
- NetherLight in Amsterdam
- Netnod in Stockholm
- NIX in Oslo
- NL-IX in Amsterdam
- RIX in Reykjavik
- STHIX in Stockholm

USA

- Equinix in Ashburn and in Chicago
- MAN LAN in New York City
- NYIIX in New York City
- Pacific NorthWest GigaPOP in Seattle
- WIX in Ashburn

Asia

- HKIX in Hong Kong
- SOE in Singapore
- SGIX in Singapore

In addition, NORDUnet has established a number of PoPs in hosting centers to exchange traffic directly using Private Network Interconnects (PNIs) with major content and service providers, like Google, Amazon, Microsoft, Facebook, Netflix, etc..



JOINT PROCUREMENT



THE ADVANTAGES OF BULK BUYING

NORDUnet is a wholesale entity for the Nordic R&E Community

Vendor advantages:

- Reduce the number of tenders
- Get bigger sales volumes

**NORDIC COUNTRIES
ACHIEVE**

**BETTER PRICES
BETTER CONDITIONS
BETTER SERVICE**

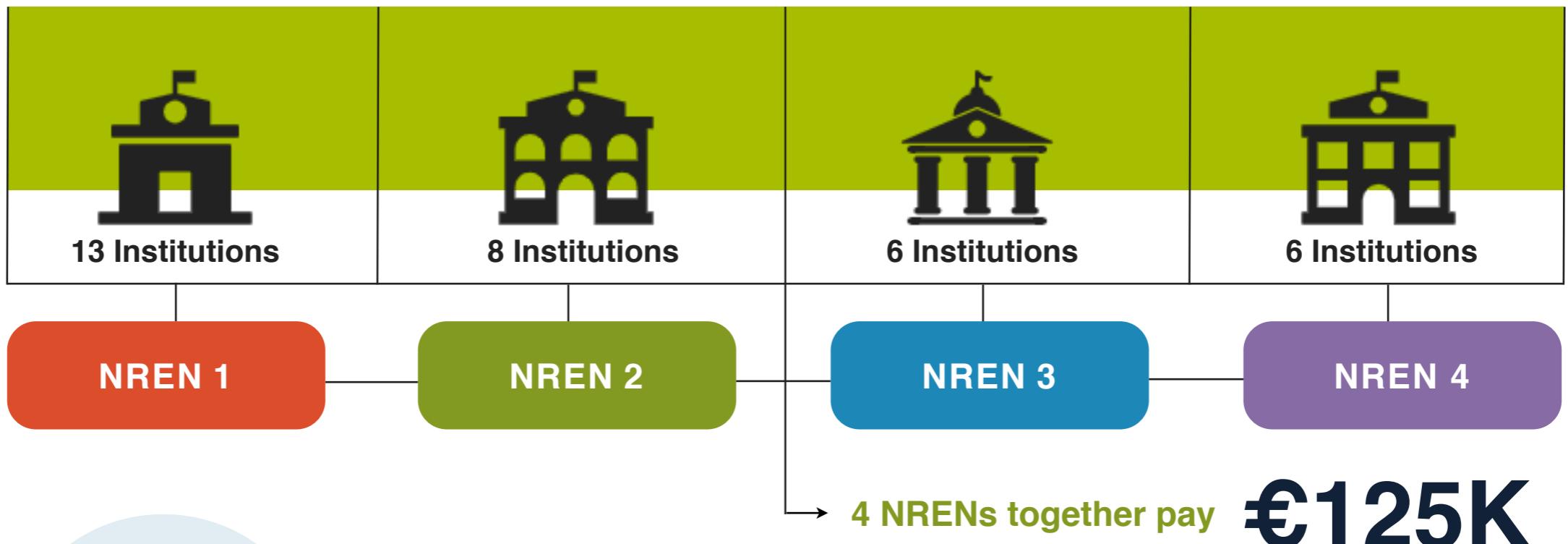


1

8

| AN EXAMPLE OF THE BULK BUYING ADVANTAGE

33 Institutions without partnering as a collective will pay €825K



NORDUnet $\rightarrow \text{€50K}$ The advantages of bulk buying

NORDUnet's tender will be more complex, and the total cost will be €50K all together. Example assumes a tender at national level costs €25K to run.



MEDIA SERVICES



MEDIA SERVICES FOR NORDIC R&E COMMUNITY

NORDUnet offers a range of media services, on request of the Nordic NRENs, including live streaming, media management, and real time communication.

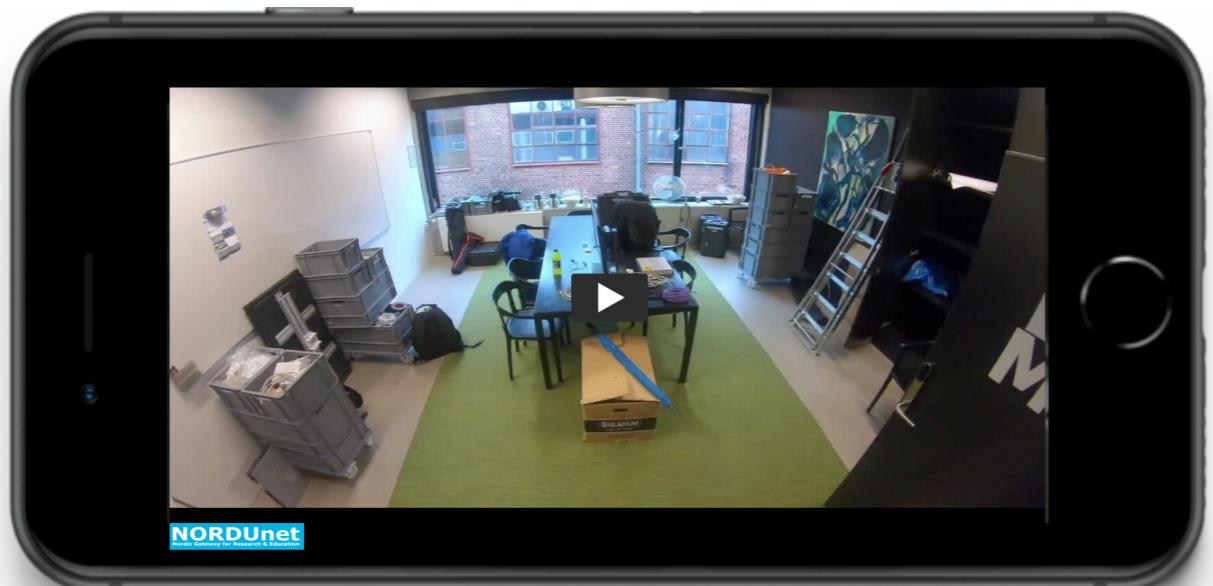
Here's a peak into some of them:

Live streaming and media management

- Mediasite
- Panopto
- Kaltura

Real-time communication

- Zoom
- Adobe Connect



*tap to see our field
crew in action*





ZOOM

See you (on) Zoom

In 2015, our five Nordic NRENs met to find the best of class virtual meeting room platform for the Nordic R&E Community.

Numerous services were tested meticulously and Zoom came out with the highest score. Everyone agreed on Zoom, because it does what it says and says what it does. It just works intuitively.

ZOOM

- Is easy to use
- Has good video and audio quality, even when a user's bandwidth is constrained
- Has a rich set of features
- Works across almost any operating system and device

In less than two years, our Zoom platform became the favorite choice of video/audio communication services within the Nordic R&E Community.

We now run a large on-premise Zoom installation that delivers services to the Nordic R&E Community.

Zoom use in spring 2020

**NORDUnet passed
1.3 million licensed users &
110,000 concurrent users**



“In November 2019 we had 5,000 concurrent users; now we passed 1.3 million licensed users and 110,000 concurrent users. All the Nordic universities can conduct their education, exams, teaching online.”

CONNECT MAGAZINE INTERVIEW
René Buch, CEO NORDUnet

CONCURRENT USERS



November 2019
5,000



March 2020
110,000



ADOB E CONNECT

Around 2008, the Nordic NRENs embraced the first media service in the region, based on Adobe Connect.

At SUNET, the first servers running Adobe Connect were instantiated, serving Swedish universities, and quickly after that Norwegian and Finnish as well.

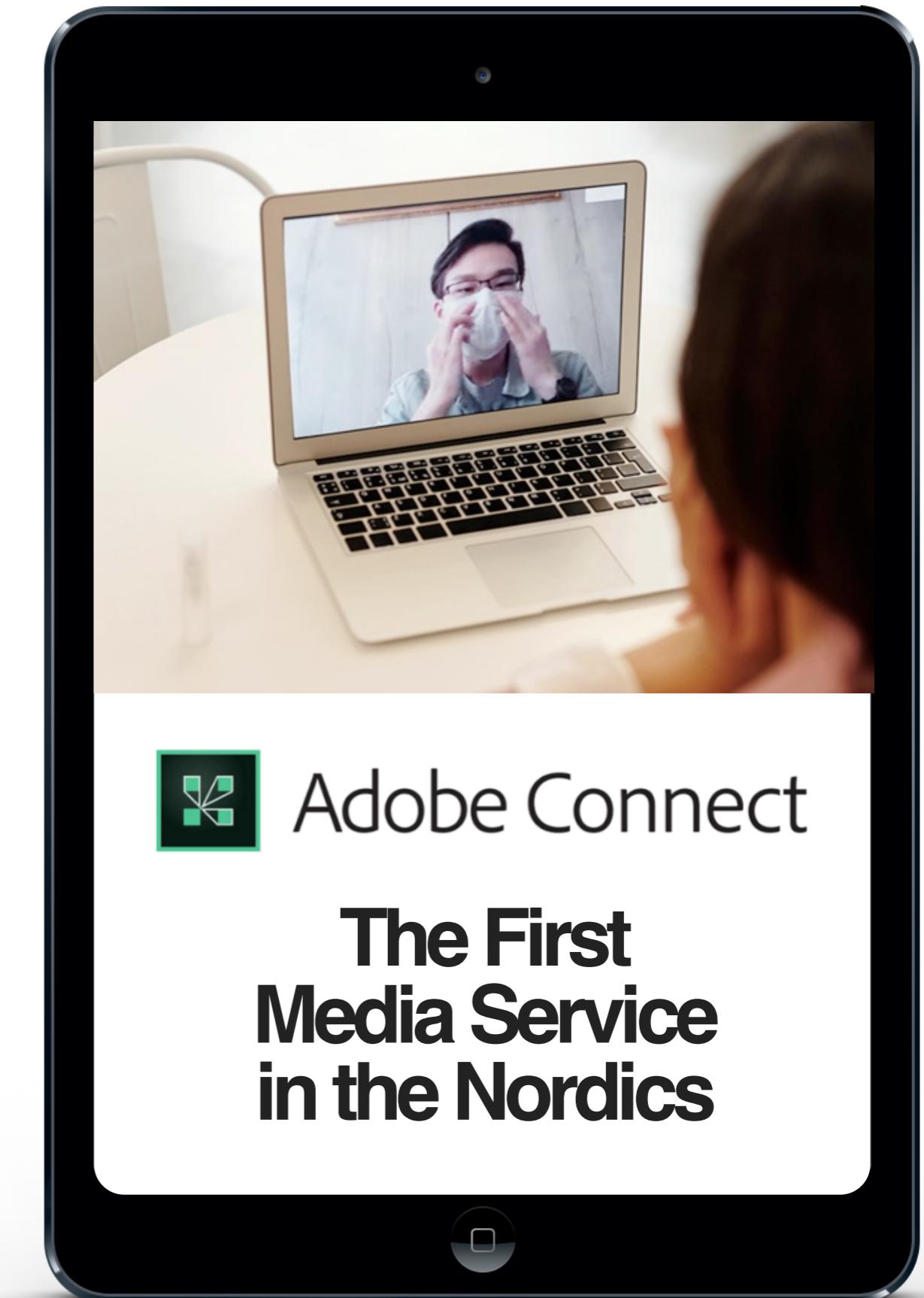
In Denmark, DeiC started their own Adobe Connect installation, serving their own users and later also the Icelandic universities started using the DeiC instance.

In 2010, the required coordination of Adobe Connect is what led to the Nordic Media Group, with media experts from all Nordic NRENs and NORDUnet.

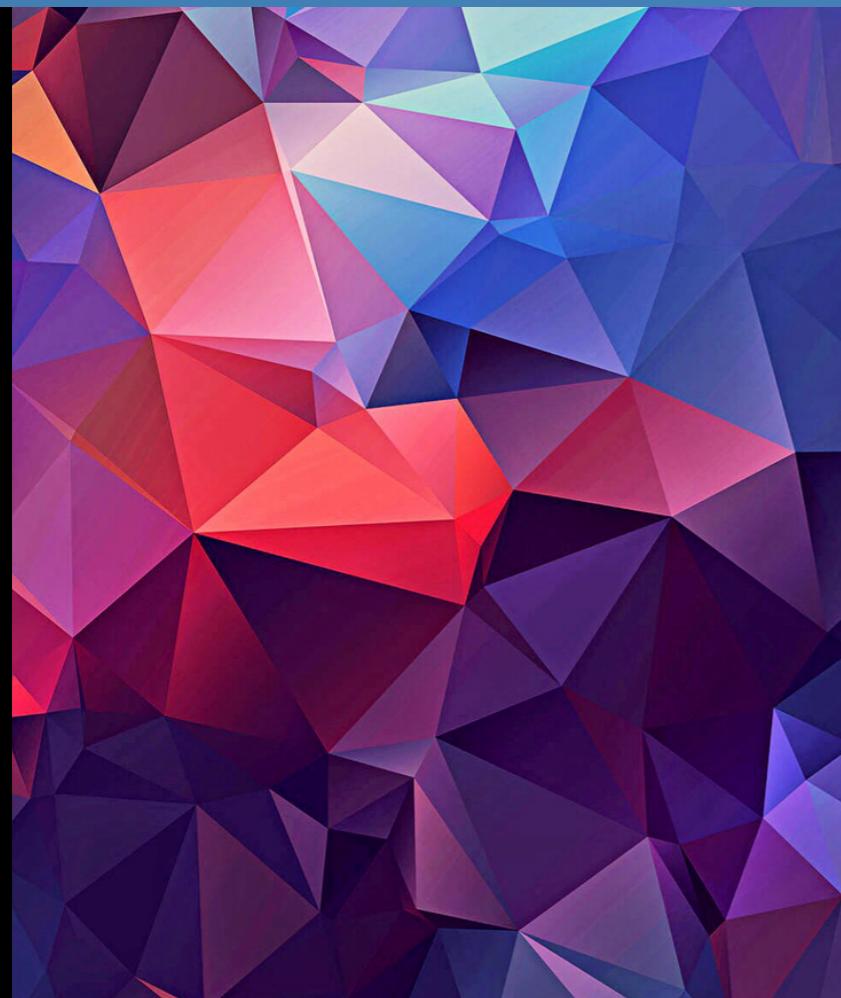
Adobe Connect had some 4,000 concurrent users at the start of some of the academic years. Until, at some time, the Nordic NRENs and NORDUnet agreed to look for a different tool for media services.

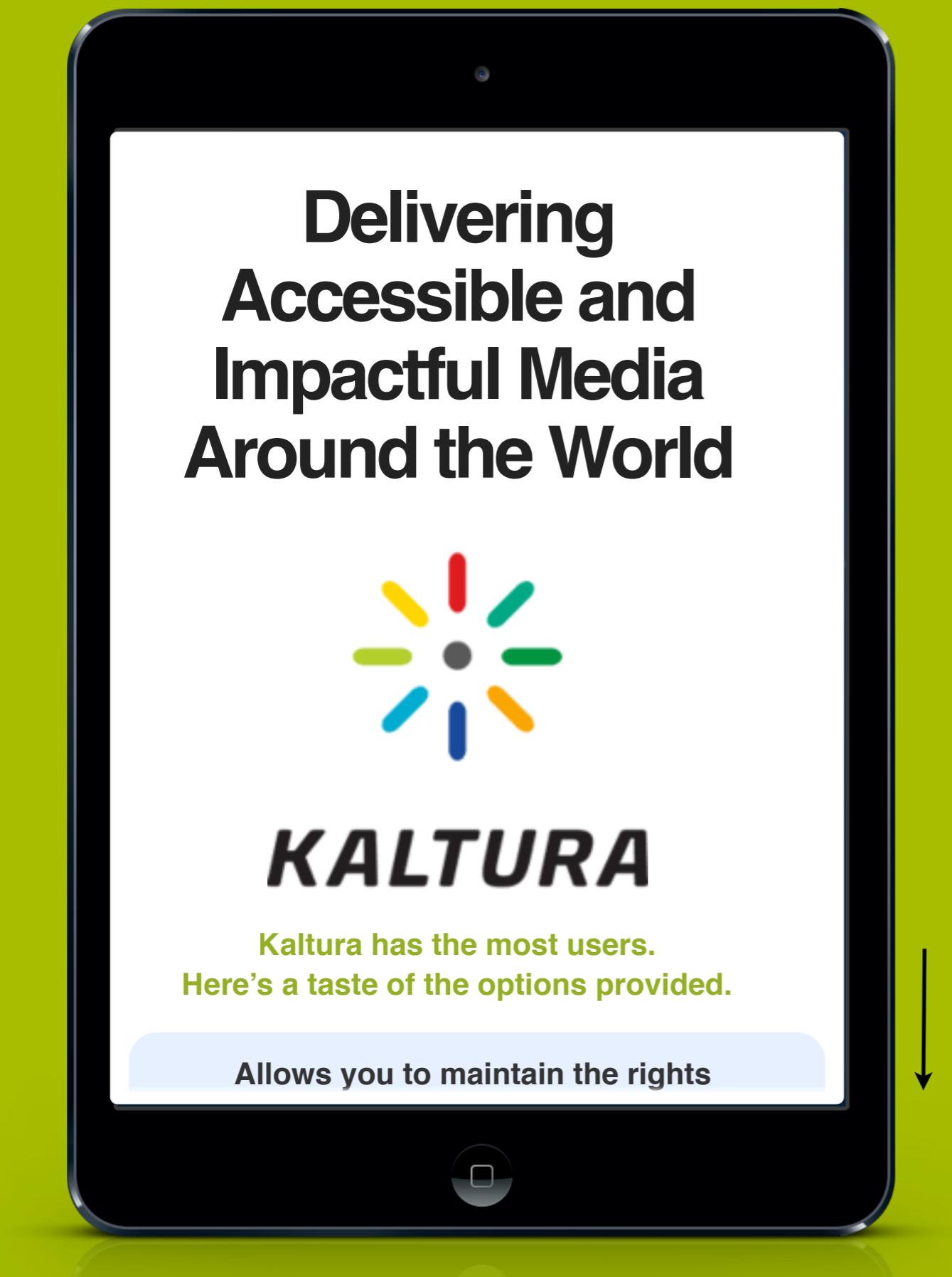
After thoroughly testing various candidates, Zoom was selected as the tool of choice for the Nordics. This happened around 2018.

It is expected that the usage of Adobe Connect will continue for some time, although we expect these numbers to further decrease.



**Video has become
the communication
choice within the
Nordic R&E
Community**





**Delivering
Accessible and
Impactful Media
Around the World**



KALTURA

Kaltura has the most users.
Here's a taste of the options provided.

Allows you to maintain the rights

KALTURA

Secure gates to media management and a next generation learning platform

Not too many years ago, a university student was forced to meet at the university for almost any activity.

Today, online learning adds extensive flexibility for students as well as professors at institutions for higher education.

In theory, any platform for media management could be used for this, but universities have special needs which are not supported by the free options available.

Kaltura is a video management system for videos and audios. Besides storing, the system allows for embedding on web pages and integration with various LMS (Learning Management Systems).

NORDUnet's On-Prem Kaltura solution is used by approximately 60 universities and research organizations throughout the Nordics, reaching almost 400,000 end users.



Kaltura use in 2019

400,000 videos

30,000,000 plays

**1,200,000 Gigabytes
streamed**

=2 million billion bytes





5

ACTIVE EUROPEAN ENGAGEMENT

EUROPEAN ENGAGEMENT

OUR NEIGHBORS TO THE SOUTH

The Nordic R&E network community is avidly engaged in European collaborations

In the early days of NREN formation in European countries, the interconnects between them were established without much coordination, which resulted in an unstructured mesh. On top of this, a digital divide was emerging.

In the early 1990's, the European NRENs decided to establish an organization to grow and maintain the pan-European network services for R&E. DANTE was born, and was merged with TERENA in 2014 to become the current GÉANT Association.



NORDUNET REPRESENTS THE FIVE NORDIC NRENs IN THE GÉANT ASSOCIATION

The activities of GÉANT are, in part, funded by the European Commission through Framework Programmes and organized in GNx Projects. NORDUnet has participated actively in all editions, from GN1 that started in 2000 until today in GN4-3. Employees from the Nordic NRENs, universities in the Nordics, and NORDUnet have had a vast number of roles related to European activities in the context of GÉANT and its predecessors.

Here's a sample.

TNC – the networking conference for the European R&E network community.

Once a year, in the spring, TNC (The Networking Conference, formerly known as the TERENA Networking Conference) takes place.

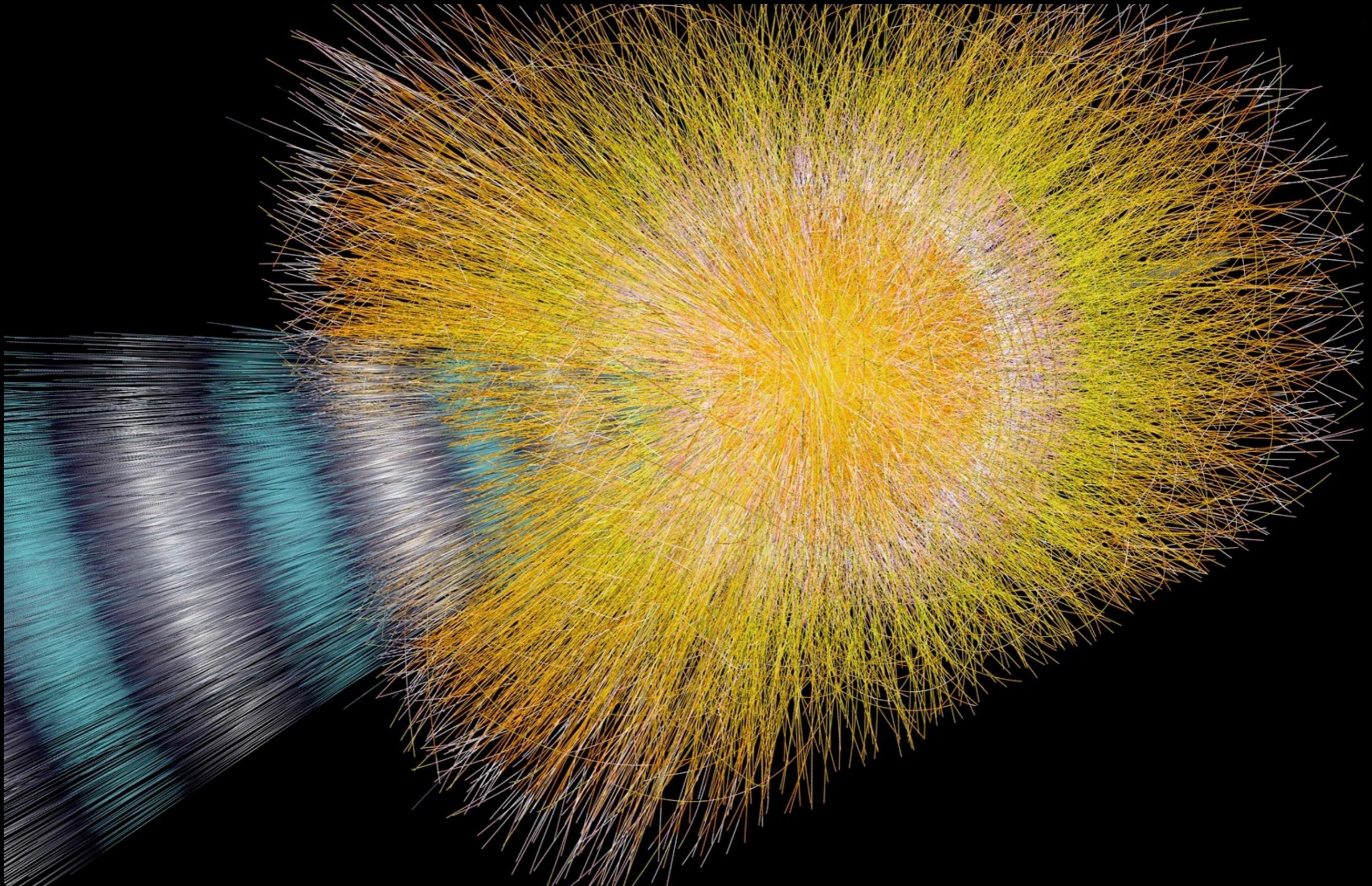
Since 2011, WiFi access for the participants of TNC and live streaming from the event have been provided by the NORDUnet Media Group, in close collaboration with PSNC from Poland. NORDUnet also has had a booth at TNC, showcasing the Nordic R&E community. An ideal place to meet and exchange ideas with other conference delegates on matters that are close to the hearts of the Nordic NRENs.

Today's Framework Programme is called Horizon2020 and the project is GN4-3.

RENÉ BUCH
CEO, NORDUnet
Interview in GÉANT's Connect Magazine



"I think EU has a strong potential to make a very big impact, especially in the realm of digital sovereignty."



Quark-gluon plasma created by the collision of heavy atomic nuclei.

• • • • •

HISTORY OF NORDIC POSITIONS IN GÉANT 2005-2020 BY PERSON

Peter Villemoes:

NREN PC

Dorte Olesen:

President of TERENA

TNC2007 Local Host

Janne Kanner:

President of TERENA

TNC2005 Programme Committee Member

René Buch:

NREN PC

GÉANT Association General Assembly

DANTE Board

GN-x Exec

Jørgen Qvist:

NIAC

Lars Fischer:

NREN PC

GÉANT Association General Assembly

GN3 Executive Committee

GPPC

GN3 Project Preparation

TNC9 and TNC10 Programme Committee Member

TNC11 Programme Committee Chair

SIG-NGN chair

Valter Nordh:

TERENA VP Community Programme

GÉANT Association Board Member

Erik-Jan Bos:

NREN PC

GÉANT Association General Assembly

TNC15 Programme Committee Member

TNC16 Programme Committee Chair

Josva Kleist:

TNC19 Programme Committee Chair

Erik Kikkenborg:

Media Support for many TNCxx Conferences

Lars Lange Bjørn:

Tender evaluation

Kurosh Bozorgebrahimi:

Tender evaluation

Arne Sundström:

TNC2005 Programme Committee Member

Ingrid Melve:

TNC2006 Programme Committee Chair

TNC2007 Programme Committee Member

TNC17 Programme Committee Member

TNC18 Programme Committee Chair

HISTORY OF NORDIC POSITIONS IN GÉANT 2005-2020 BY PERSON - CONTINUED

Tor Holmen:

TNC18 Local Host

Mikael Linden:

TNC2006 Programme Committee Member

TNC2007 Programme Committee Member

TNC2008 Programme Committee Member

Dan Mønster:

TNC2006 Programme Committee Member

TNC2007 Programme Committee Member

Brian Vinter:

TNC2007 Programme Committee Member

Jan Meijer:

TNC2010 Programme Committee Member

David Simonsen:

TNC2011 Programme Committee Member

Jón Ingi Einarsson:

TNC2012 Local Host

Ymir Vigfusson:

TNC2012 Programme Committee Member

Martin Bech:

GÉANT Strategy Committee Chairman

TNC2007 Conference Organizer

Cost Sharing Committee Member

Gitte Julin Kudsk:

TNC2007 Conference Organizer

SIG MARCOM Chair

Leif Johansson:

TNC2014 Programme Committee Member

Johan Bergström:

TNC16 Programme Committee Member

TNC17 Programme Committee Member

Roland Hedberg:

TNC16 Programme Committee Member

Jari Miettinen:

TNC16 Programme Committee Member

TNC17 Programme Committee Member

Damien Le Carpentier:

TNC17 Programme Committee Member

Mikael Berglund:

TNC18 Programme Committee Member

Lars Fuglevaag:

TNC18 Programme Committee Member

Tony Breach:

GN3 Activity Leader

GN3+ Activity Leader

GN4 SGA1 Activity Leader

Tender Evaluation

Brian Bach Mortensen:

Activity Leader

Jerry Sobieski

GN4-1 Activity Leader

GN4-2 Activity Leader

Ulf Tonelid

Cost Sharing Committee Member

ARAC Member



Besides these key positions on governance and in projects, in GÉANT and its predecessors, Nordic R&E Community people have been active in many other projects, related to the above activities.

Examples include:

- ORIENTplus
- NEXPReS
- Up2U





NORDIC-EUROPEAN PROJECTS

NORDIC NRENS ACTIVELY COLLABORATING WITH EUROPEAN COUNTERPARTS

Members of the Nordic R&E Community engage in collaborations with the rest of Europe through a variety of projects and initiatives

Numerous experts from the Nordic NRENs and R&E institutions in the Nordics have been active in the European community over many years.

Collaboration within the European R&E networking community almost always involves a large number of partners, many nationalities, and even more national stakeholders. The community is characterized by a strong desire to collaborate, while stakeholders also have their own and national interests to look out for. Maneuvering here is not always straightforward, also due to the fact that in some collaborations, significant EC funding is at stake.

NORDUnet has built extensive experience within his landscape, many contacts and a position of strength derived from a NORDUnet and Nordic NREN reputation of getting things done and making significant community contributions. Overall, the European NREN community has a long history for joint activities, obtaining significant results together.



“In many ways, we see the community program as the most important and valued work of GÉANT”

Lars Fischer,
Strategy & Policy Officer
NORDUnet





FUNDING

Funding and Framework Programmes

In many cases, community projects are co-funded by the European Commission (EC) under Framework Programmes for research and technological development (FPs).

The current FP is called Horizon2020, co-funding the present-day pan-European Research and Education network project, GN4-3, which is managed by the GÉANT Association, with all European NRENs participating.

Since the 1990s, the FPs have funded pan-European projects to interconnect the European NRENs, ensuring a consistent level of service throughout Europe.

The majority of the funding went to cross-border network connectivity, but also to the development of services such as eduroam, eduGAIN, and eduMEET.



GN4-3

The current GÉANT project

Objectives of the [GN4-3](#) project include the development and operation of a pan-European network that connects all the NRENs in Europe and service development, evolution, and operational activities.

Through separate funding, the accompanying GN4-3N Project enables the European NRENs and GÉANT to do an upgrade and expansion of the pan-European optical network footprint, serving two goals:

1. Prepare for the current developments in data driven science and High-Performance Computing (HPC)
2. Ensure a level playing field for all European countries, lowering the digital divide in Europe

The Network Infrastructure Advisory Committee (NIAC) is overseeing the design and development process in GN4-3N. NORDUnet is represented in the NIAC.

GÉANT is important to NORDUnet, as it assures connectivity for Nordic researchers to NRENs in all European countries, and helps the development of additions services. NORDUnet and the Nordic NRENs are active in both GN4-3 and GN4-3N.



"The GÉANT projects are a key contribution to the success of NORDUnet"

Lars Fischer,
Strategy & Policy Officer
NORDUnet





EUROPEAN HIGH-PERFORMANCE COMPUTING (EUROHPC)

High performance computing is all about extraordinary computer power, with vast amounts of storage and state of the art network facilities. This is costly business, hence out of range for a single European country to buy on their own.

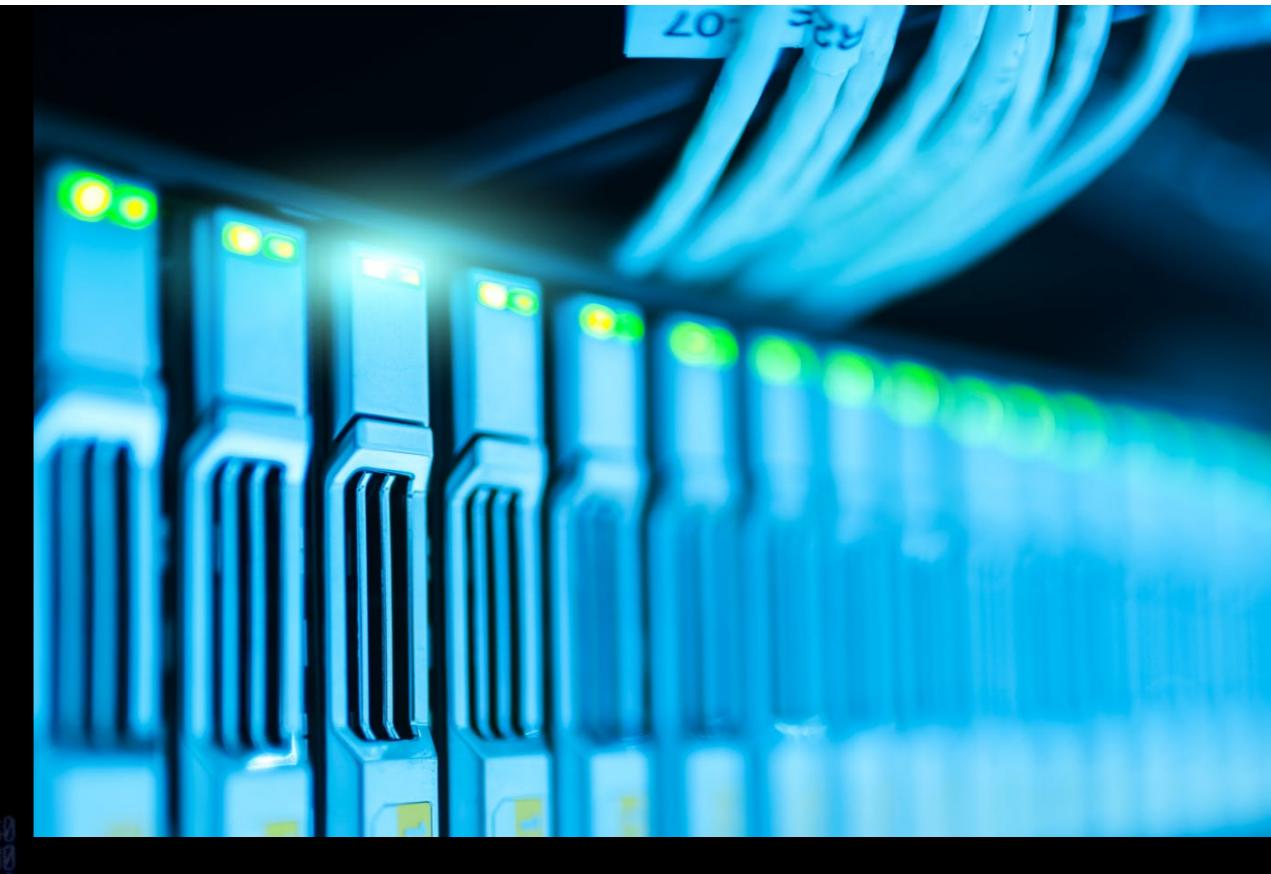
Moreover, the European Commission has voiced the ambition to come to develop top-of-the-range exascale supercomputers for processing big data, based on competitive European technology.

Therefore, the EC has funded three new computer centers to pave the way for the building of future exa-scale computing facilities.

One of these, called LUMI, is under construction in Kajaani, Finland, led by CSC. The LUMI consortium countries are Finland, Belgium, Czech Republic, Denmark, Estonia, Iceland, Norway, Poland, Sweden, and Switzerland.



Visit LUMI:
[The pre-exascale supercomputer being built in Kajaani.](#)





EUROPEAN OPEN SCIENCE CLOUD (EOSC)

Scientific papers, conferences, personal meetings, and a wide range of Internet solutions today help scientists to share ideas and results from their research.

However, the Internet offers solutions, providing much more flexibility, and one challenge has become more and more exposed: vast amounts of data are produced every year, but there is no common strategy on how to save and protect this information, and keeping it findable and accessible at any time, for all European scientists to share with each other.

This has become an area of increased focus. In fact, still more research grants are conditioned by a demand for loyalty to the already agreed open science policies encouraging scientists to share their research achievements.

European Open Science Cloud (EOSC)

The central objective of [EOSC](#) is to facilitate the reuse and sharing of research data among European researchers and the public.

The collaboration will:

- Define common policies for all European countries dictating how to tag and store the data, so that they can be found and used by others
- Provide the needed services for managing and storing research data

```
1 | the immutable result of running an experiment.
2 | class Scientist::Result
3 |   # An Array of candidate Observations.
4 |   attr_reader :candidates
5 |   # The control Observation to which the rest are compared.
6 |   attr_reader :control
7 |   # An Experiment.
8 |   attr_reader :experiment
9 |   # An Array of observations which didn't match the control.
10 |  attr_reader :ignored
11 |  # An Array of observations which didn't match the control.
12 |  attr_reader :mismatched
13 |  # An Array of Observations in execution order.
14 |  attr_reader :observations
15 |
16 |  # Internal: Create a new result.
17 |
18 |  # experiment - the Experiment this result is for
19 |  # observations: - an Array of Observations, in execution order.
20 |  # control: - the control Observation
21 |
22 |  def initialize(experiment, observations = [], control = nil)
23 |    @experiment = experiment
24 |    @observations = observations
25 |    @control = control
26 |    @candidates = observations - [control]
27 |    evaluate_candidates
28 |
29 |    freeze
30 |
31 |  end
32 |
33 |
34 |
35 |
36 |
37 |
38 |  # Public: the experiment's context
39 |  def context
40 |    experiment.context
41 |  end
42 |
43 |  # Public: the name of the experiment
44 |  def experiment_name
45 |    experiment.name
46 |  end
47 |
48 |  # Public: was the result a match between all observations?
49 |  def matched?
```

EOSC NORDIC

The first step on the way

A collaboration between the Nordic and Baltic countries has been going on for years, and when the EC called for proposals on how to address the EOSC challenge, the partners submitted a proposal, which obtained high marks.

EOSC Nordic is a consortium funded for three years by the EC. Through use cases, we are working on demos of how to implement EOSC locally in a successful way – aiming at a spin-off all over Europe.

It's a huge assignment with many unknowns, and no one expects it to be done overnight. But the first steps are taken – right here in the North.



EOSC NORDIC
IS A
CONSORTIUM
FUNDED FOR
2019-2022
BY THE EC





6 INTERNATIONAL ENGAGEMENT



CREATING A
GLOBAL COMMUNITY

INTERNATIONAL COLLABORATION IS OUR BASIS

NORDUnet serves the Nordic countries, and we rely on other R&E Networks to serve their country or region

A phrase often heard is that research is a global endeavor. And education is becoming global as well with remote university campuses in other countries and continents, online classes, and remote teacher – student interaction.

If you drill one level deeper, and look at how modern science works, you realize there is more to this:

The scientific instruments get larger and more complex, and we tend to build fewer of them, because they are large, expensive and more difficult to produce.

E.g., there is only one large hadron collider, only one LSST, only one EISCAT 3D instrument – you end up with very large enterprises, very large projects for the global community, and using them is to collaborate.



WE LEARN FROM EACH OTHER

I build my work on top of yours, and vice versa

“The two of us are now twice as productive. This way, we can move the field forward, further than ever before.

Data sets and computing resources need to follow the structure of the scientific collaboration, in order for them to be useful tools.

If you produce datasets, I’m not allowed to work with them on your computer.

The datasets need to be moved to mine, maybe even fused with some data I have already. If I publish, you can do the same thing.”

The Nordic NRENs and NORDUnet together build the platform that is essential to make the above a reality.

We strive to make all resources easily available – wherever the facilities or the researchers might be located.

We strive to make all resources easily available

Hence, we rely on other R&E Networks elsewhere in the world to do their share in delivering the necessary infrastructure and services.

R&E Networks collaborate on a global scale to continuously enhance the services and performance, for the benefit of Research and Education. Jointly, they form the Global R&E Network, also referred to as the GREN.







GNA-G & GREN

COORDINATING THE INTERCONTINENTAL R&E NETWORK SYSTEM

A joint global effort was needed to coordinate the establishment of intercontinental connections, and this gave birth to Global Network Architecture (GNA), later on merged with the Global Lambda Integrated Facility (GLIF) into Global Network Advancement Group (GNA-G).

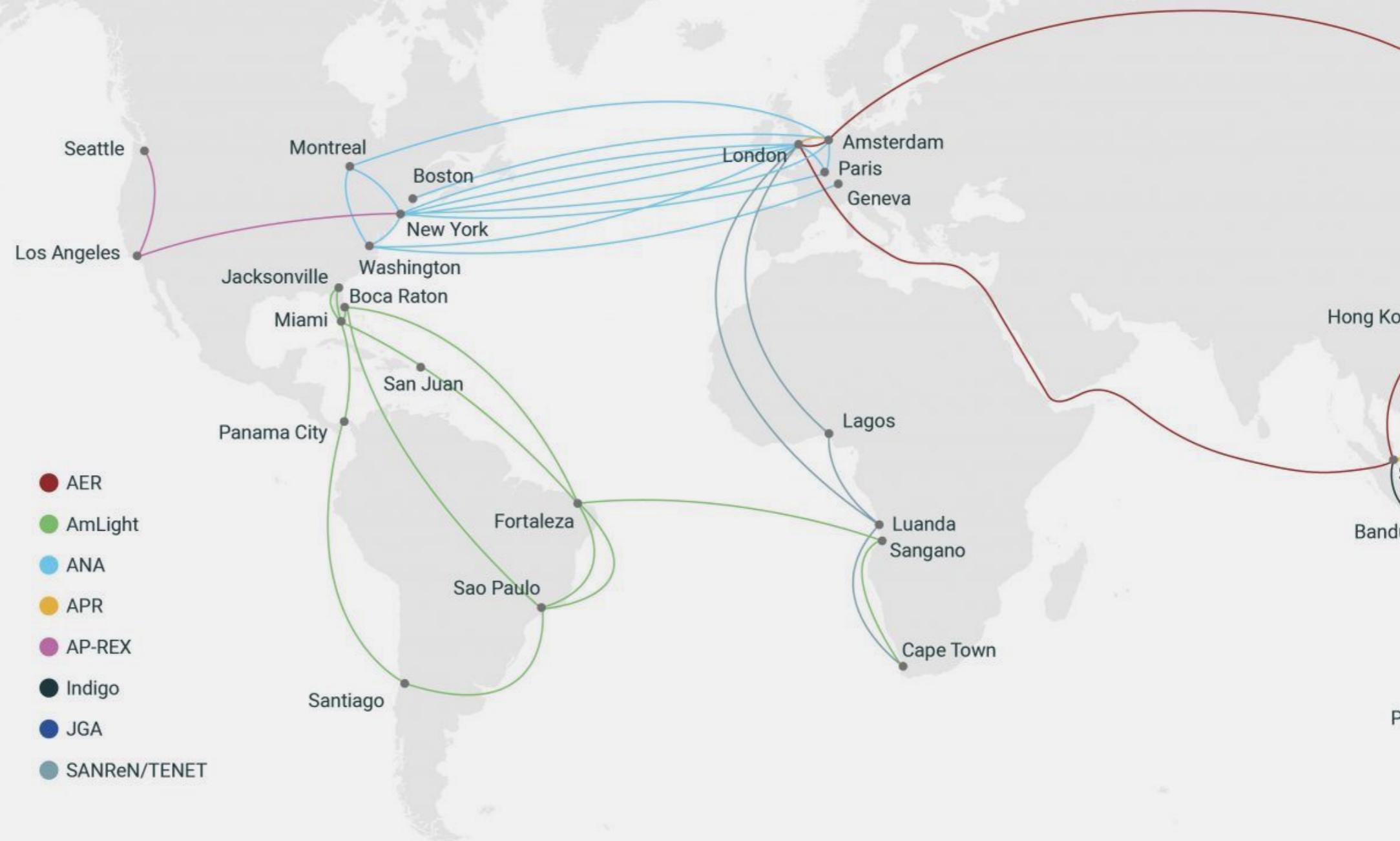


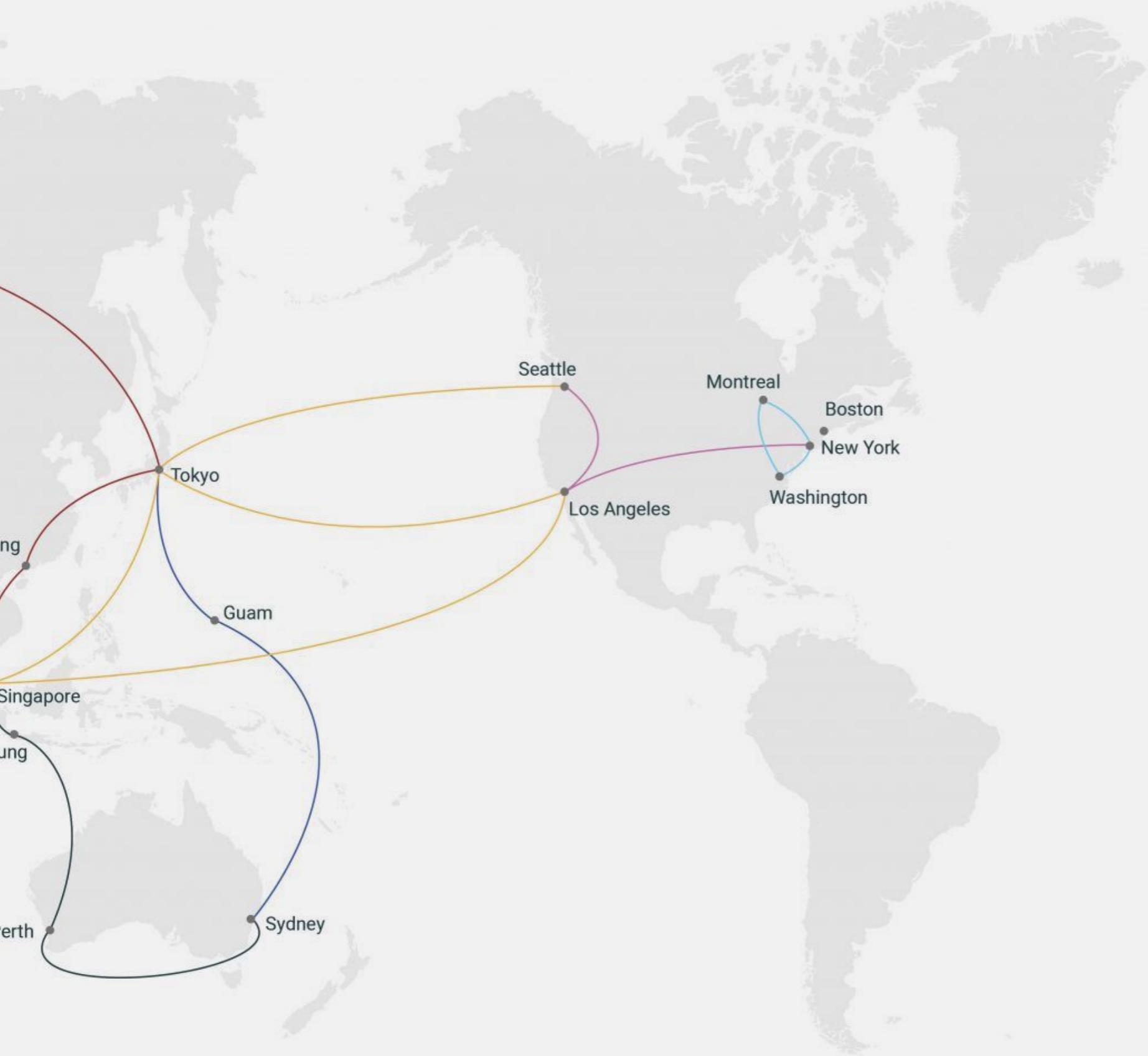
Around 2012, the time had come for the global R&E Network community to join forces and define a common global architecture for the future R&E network interconnect, a crucial aspect of the GREN.

By then, an innovative forefront of engineers in GLIF had successfully invented, tested, and produced numerous concepts for the R&E infrastructure to enable the transfer of heavy data loads produced by new science facilities like the Large Hadron Collider (LHC), which in this case led to the LHC Optical Private Network (LHCOPN).

These concepts formed a solid foundation for the global NREN community facing their next challenge. Modern science desperately needed the ever-increasing supply of fast and resilient network bandwidth, not just within a country or region, but all over the planet. Hence, the Global Network Architecture movement was established to coordinate and integrate all the different network solutions, to ensure a consistent standard for the existing and evolving GREN.







Global Research & Education Network (GREN)



“With the term GREN we can all talk about the exact same thing.”



“NORDUnet has a very critical role in the GREN.”

tap to see why



NORDUnet was one of the instigators and, still today, contributes to further enhancing the intercontinental infrastructure for Research and Education.

The major driver for this is that both science, research, and education, have become global endeavors, that require ubiquitous, fast, resilient, and cost-effective connectivity.





GLOBAL CONNECTIVITY ANA, AER, & APR

THE ADVANCED NORTH ATLANTIC COLLABORATION (ANA)

Redundancy and 900 Gbit/s across an ocean

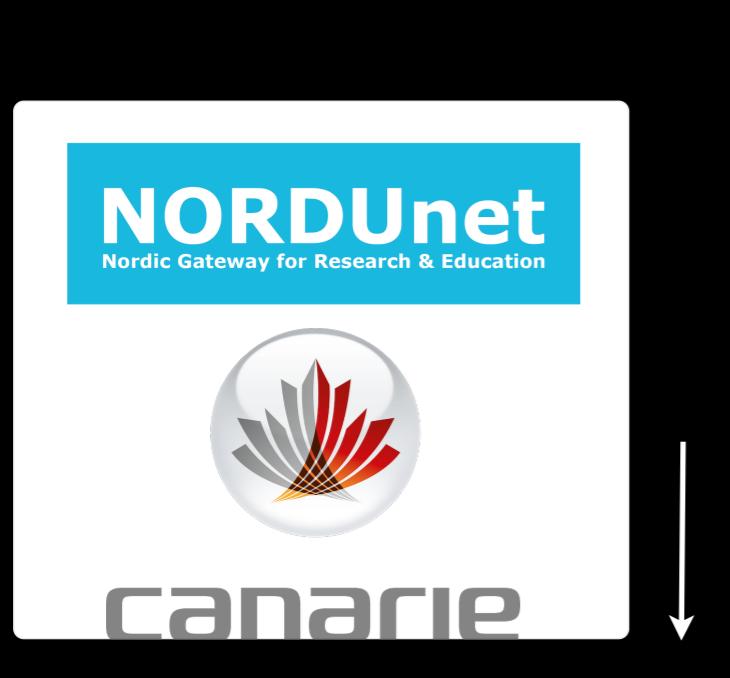
In 2012, Internet2, SURF, ESnet, and NORDUnet initiated a collaboration to secure bandwidth and redundancy across the North Atlantic Ocean.

The idea was to challenge the market, while aiming at taking intercontinental bandwidth a big step forward, in order to move from the actual situation with many 10 Gbit/s links towards a couple of 100 Gbit/s links, carefully acquired taking optimal price points and maximum resilience into consideration.

The initial single 100G link between Amsterdam and New York City developed into a brand-new way of collaborating among NRENs sharing the capacity.

CANARIE and GÉANT joined the collaboration, that has grown strong and now consists of six NRENs, with a steering group and associated working groups on operations, technology, cost sharing, and legal matters.

So, rather than each NREN owning a few links of their own, with little coordination, the NRENs together own a handful of well-architected, high-capacity links that connect to GXPs for easy sharing.

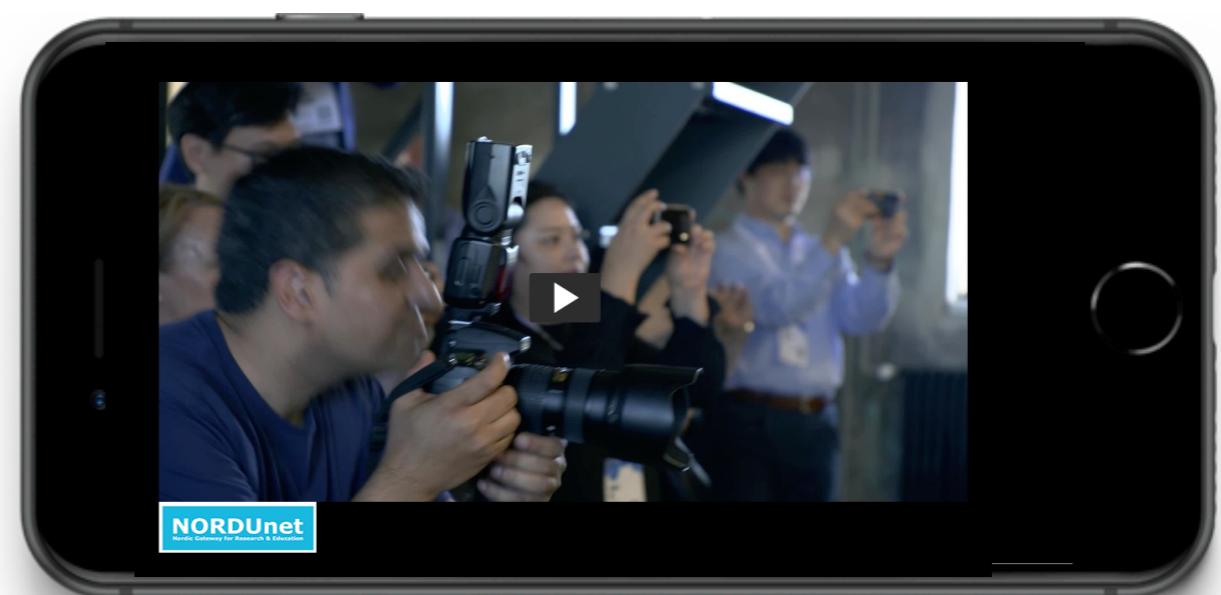




OTHER INTERCONTINENTAL COLLABORATIONS

ANA became a pathfinder for innovative NREN collaboration models, and similar initiatives have since developed:

1. The Asia Pacific Ring (APR) in 2017
2. Collaboration Asia Pacific Europe #1 (CAE-1) in 2019
3. The Asia Pacific Europe Ring (**AER**) in 2019
4. The 100G connection between Miami (Florida), Fortaleza (Brazil), Sangano (Angola), and Cape Town (South Africa), part of AmLight





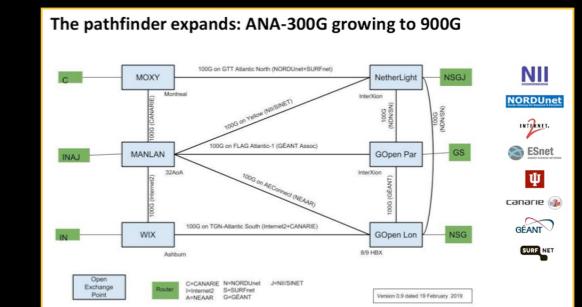
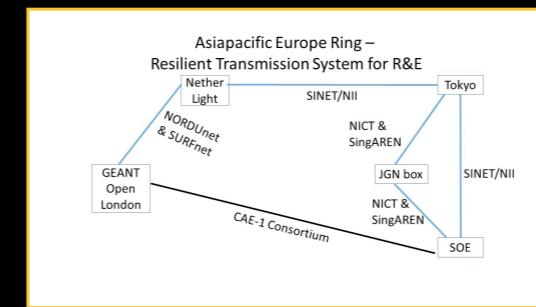
*this is something
to look at*

“So, prior to this system, every organization had their own links. They joined forces to gain much more capacity. By doing this together, they get more for less money.”

Alexander van den Hil
Product Manager
SURF

ANA AT 900 GBIT/S

Today, ANA runs at 900 Gbit/s, as a resilient system, with 100G links provided by NORDUnet, SURF, GÉANT, Internet2, CANARIE, ESnet, NII, and the NEAAR Project.



Network engineer's work documents

ANA NEXT STEPS

As contracts for some of the current ANA links are expiring towards the end of 2020, the time is right to relook at the existing ANA architecture

A series of next steps have now been defined, aiming at assessing solutions where collaborating NRENs on both sides of the North Atlantic Ocean can acquire long-term subsea cable resources, such as bandwidth and spectrum.

This phase brings technical challenges as well possible new models for funding and novel ways of collaborating.

This will allow the participating NRENs to own infrastructure between continents and across oceans, just like they do within countries, and on continents.

The NREN community has already seen several successful examples of this approach, for instance:

- Uninett's [subsea cable between two locations](#) on Svalbard
- FIU's AmLight projects between Miami and South America and Africa
- AARNet's Indigo cable system between Australia and Singapore
- REANNZ being an anchor tenant on Hawaiki, the subsea cable system between New Zealand and the US West Coast



IN THE FIELD STORIES

IN THE FIELD STORIES

A window to great achievements from the science, research and education world, enabled by R&E Networks

Amazing science, research, and education happens all around the world. Sometimes, results are well-known in their local environment; some are not known at all.

In 2015, AARNet came up with the idea to start a blog, highlighting the achievements on a global stage. This led to In The Field Stories, a collection of crisp and clear stories about these exciting results in (almost) all fields of science, research, and education, enabled by R&E Networks (almost) anywhere on the globe.

 **THE FIELD**

125 | 

NRENs as of
June 2020

in THE FIELD



IN THE FIELD STORIES

Since the launch in October 2015, In The Field Stories has published new articles on a weekly basis, except for the holiday seasons.

Statistics from October 2015 to October 2020

- 109,932 page views
- 305 stories published
- 103 NRENs across six continents
- 49,961 website users located in 205 countries





.in THE FIELD

In The Field Stories
is managed by:

AARNet
NORDUnet
IUCC



DISTANCE LEARNING

Long distance music teaching allows skilled musicians to be taught by the best.



5G

Rare opportunity to study real world 5G cellular mobile infrastructure.



MICROSCOPE LIVE IMAGES

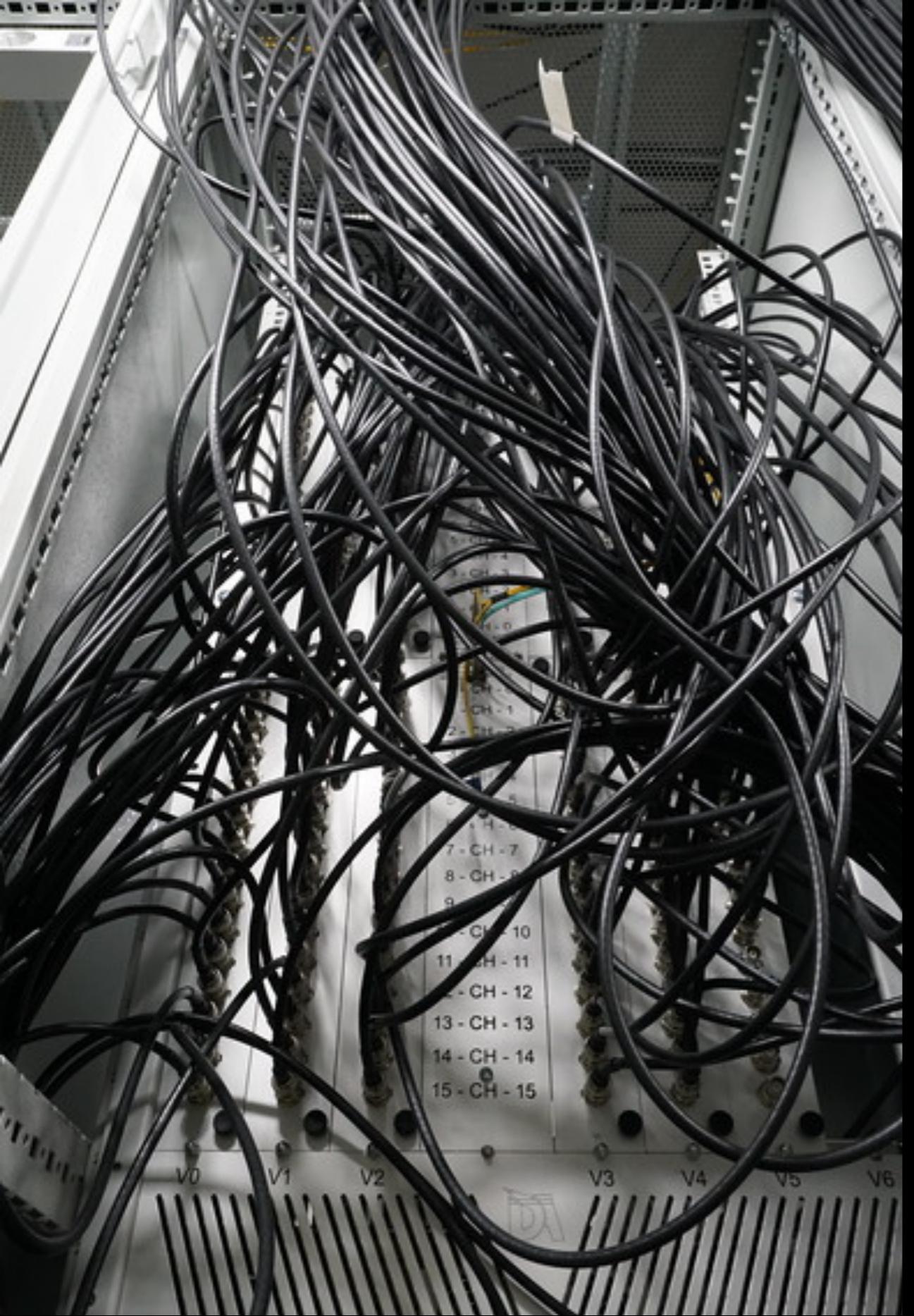
Live images from a 600 m long microscope.



"When somebody in an individual country is connecting to the R&E network, they are not just connecting to a local resource, or even a national one.

They're leveraging a **global resource, and more importantly: they are leveraging the **global community**."**

Howard Pfeffer
President and CEO, Internet2



EMERGING NRENs

THE IMPORTANCE OF WORKING WITH EMERGING NRENs

In many countries, all over the world, science and educational institutes are already well connected to the local R&E Network, like in the Nordic countries.

But there are still research facilities and educational institutes on many continents that suffer from more or less bad Internet connectivity.

This places a brilliant scientist or an excellent teacher on the back seat, and in a position where it might be hard to keep up with colleagues from better connected areas.

In many of these today underserved areas, there is an emerging NREN that has smart and enthusiastic people on board but a great need of state-of-the-art knowledge and experience.

The Nordic scientist, on the other hand, might have just as much need for easy access to a colleague or research institution, or maybe a scientific instrument, in a country with an emerging NREN.

Helping to establish a well-functioning fabric of R&E Networks in these countries is in our and everyone's interest.

For this reason, NORDUnet participates actively in selected programmes aimed at assisting emerging NRENs, all over the world.

R&E NETWORKS FOR A BETTER WORLD

My future wishes for the global NRENs
is to support the less developed countries.

NORDUnet
Nordic Gateway for Research & Education

tap to see why



NORDUNET'S OWN AND DIRECT ENGAGEMENT

2015

NORDUnet was one of the donors of an initial try-out at TNC15 in Porto, Portugal.

2016

NORDUnet launched the NORDUnet Emerging NREN Fellowship Programme and invited employees from Emerging NRENs to participate in the NORDUnet Conference 2016 in Helsinki, Finland and in a follow-up programme.

It allowed the participants to experience “life at NORDUnet”, by taking active part in meetings at NORDUnet’s Headquarters and at the NOC in Stockholm, Sweden.

We received a lot of positive feedback from these initiatives, which made us expand the activities and engage Emerging NRENs in the NORDUnet Technical Workshop as well.



2017 - Now

This programme was repeated in 2017, 2018, and 2019. We are planning to continue the Emerging NREN Programme, after the COVID-19 pandemic.

↗ *tap here*

fDLuDCf - AN ASI@CONNECT PROJECT

Intercontinental collaboration supporting the regional NREN community in Asia

In order to facilitate Distance Learning in Asian countries, the Bangladesh NREN, BdREN, initiated a new collaboration, which they successfully submitted to Asi@Connect. The name BdREN gave to the project is easy to remember: fDLuDCf. This stands for “facilitating Distance Learning using a Digital Conferencing facility. Indeed, the project did result in distant learning facilities in the region – and a lot more.

To begin with, BdREN partnered with NORDUnet, for expertise in running a multimedia conferencing environment. Next, BdREN involved NRENs from the APAN region, i.e. the Philippines, Sri Lanka, Thailand, Nepal, and Bhutan.

They jointly submitted the project proposal, which was accepted.

Bangladesh-BdREN



The funding allowed the collaboration to establish:

A Multimedia, Multi-country, Online Classroom

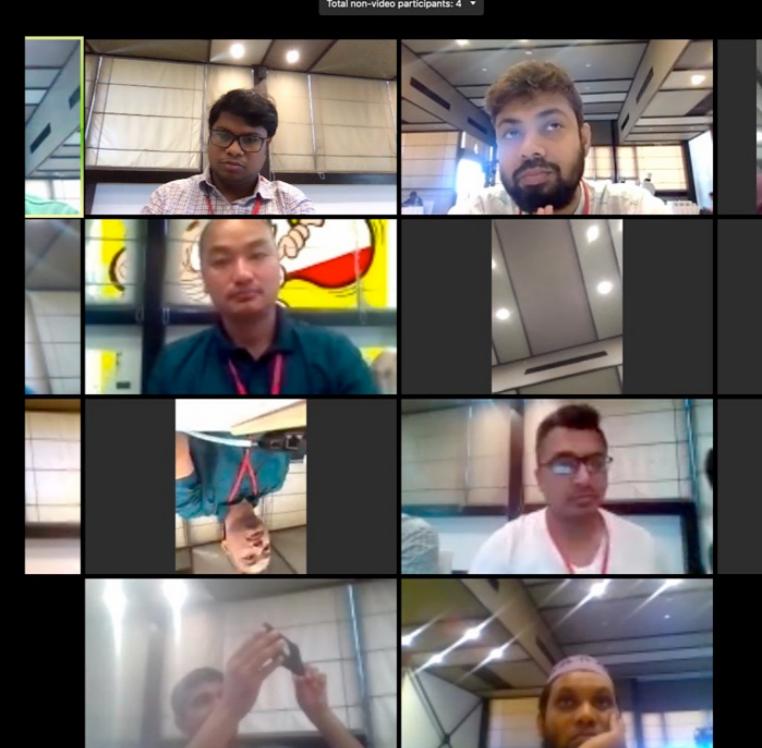
A Research Collaboration Platform



ZOOM IN A BOX

In order to achieve this, NORDUnet developed an appliance-based video conferencing platform “Zoom in a Box” that lead to an on-prem installation for video conferencing and support, hosted on the BdREN Cloud system.

This project proved successful and was awarded a 12 months extension to bring the results in the region even further.



ZOOM IN ASIA

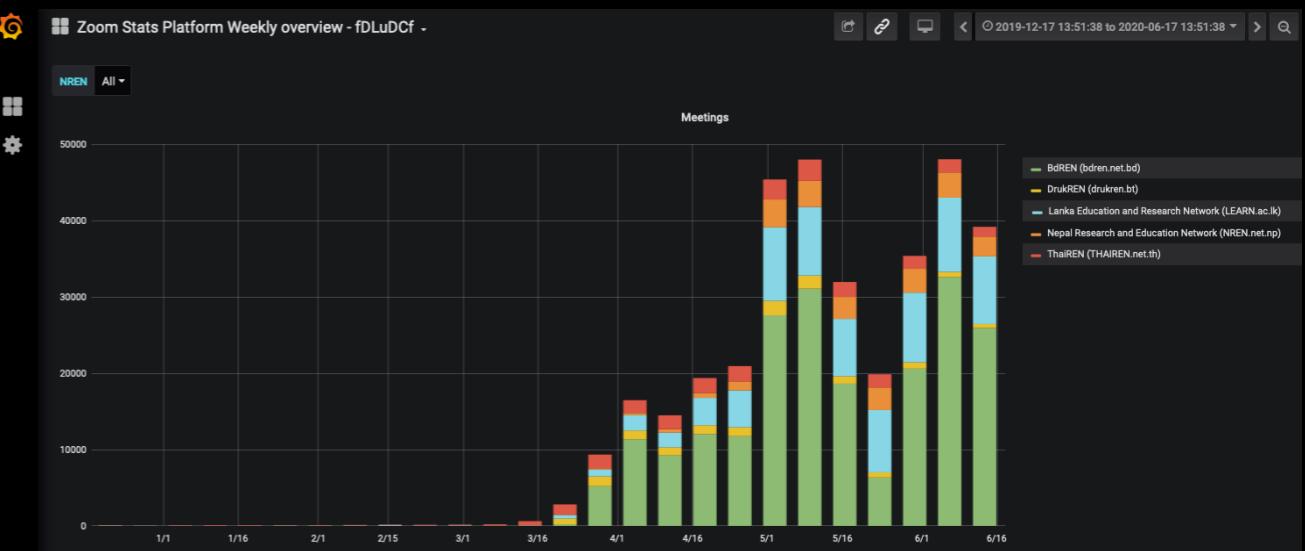
BdREN's initiative with Asi@Connect led to:

- Technical knowledge exchange
- Dissemination of knowledge through distance learning and education
- Technology Transfer
- Reduction of the Digital Divide
- Foundation of a community to regularly meet

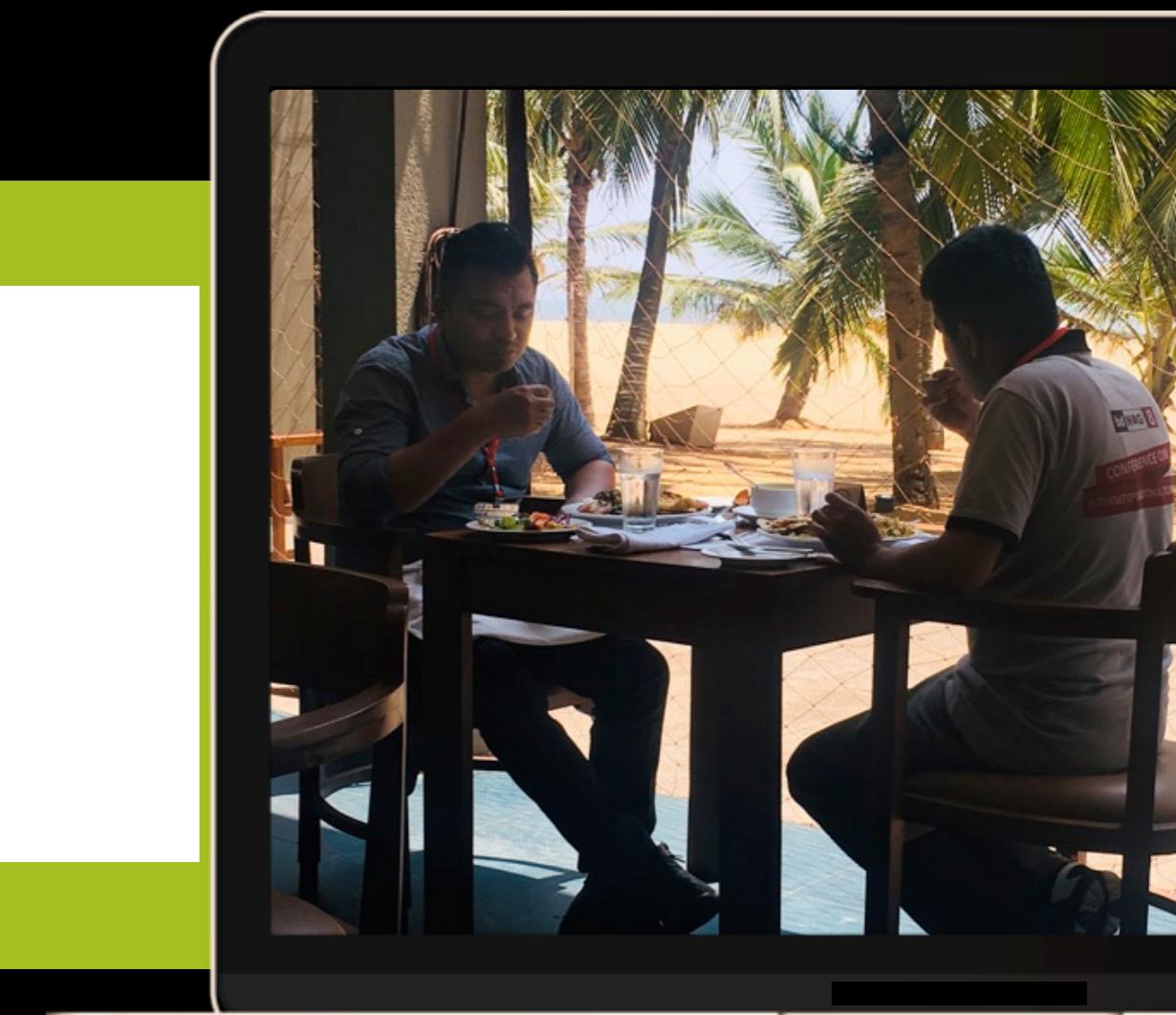
The Asi@Connect Programme is executed by TEIN*CC and funded by the European Commission.

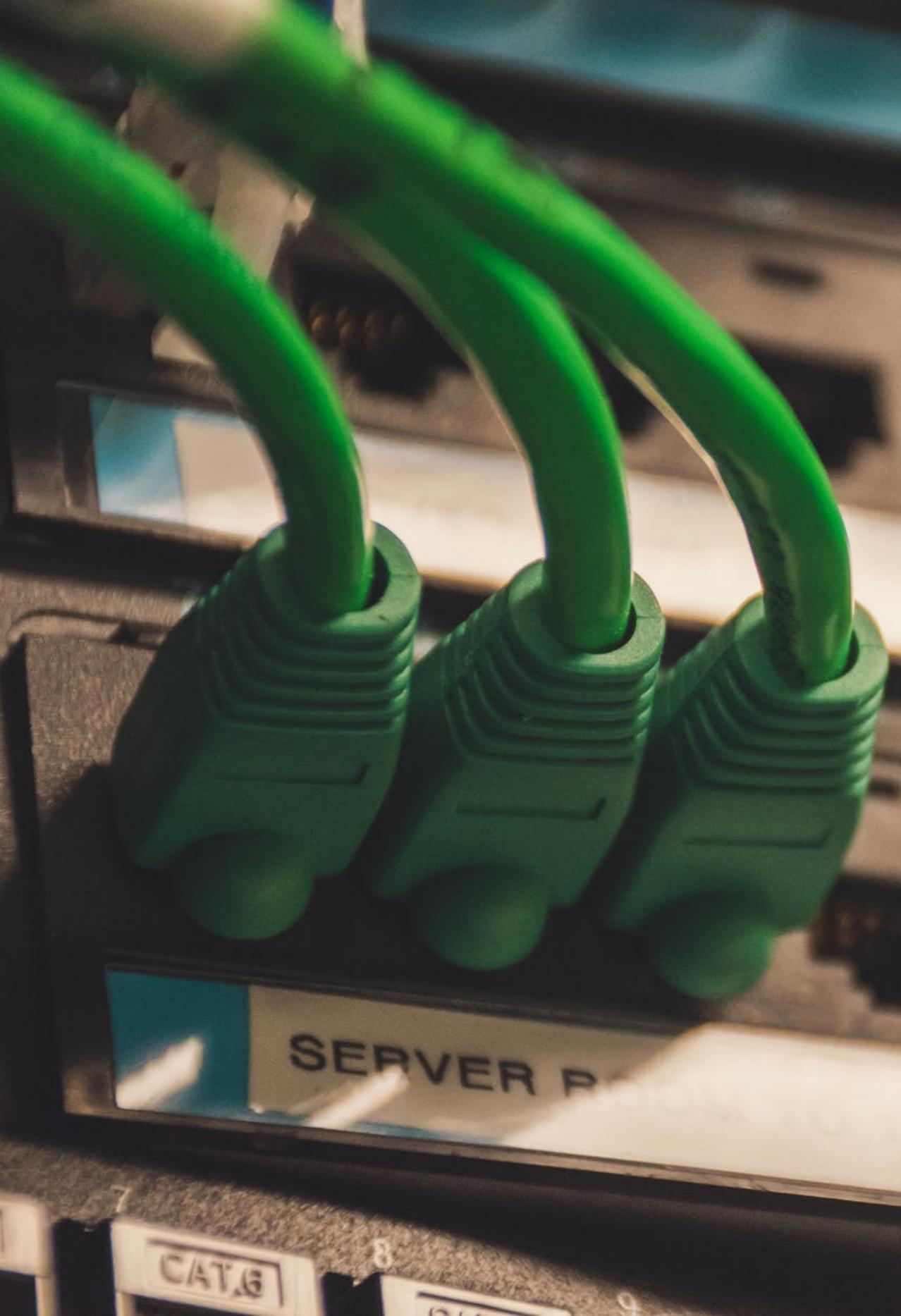
Learn more:

- [TEIN*CC](#)
- [Asi@Connect](#)
- [Distance Learning using Conferencing](#)



swipe left





COLLABORATION
AARnet



COLLABORATION ON SERVICES ACROSS THE GLOBE

NORDUnet and AARNet (the Australian NREN) have agreed to jointly operate a number of services, and the long-distance collaboration has many advantages.

The idea of a collaboration between two NRENs from each end of the world took shape when both parties realized that their operations of media services was performed more or less alike.

On top of this, the basic ideas and conditions for services overlapped, so why not get the most out of this? It took only few meetings to agree on the terms, and a Memorandum of

ADVANTAGES OF JOINING EFFORTS ON SERVICES

A. Product operations and development:

With similar user needs and an almost identical technical setup, we have worthwhile opportunities to exchange knowledge and benefit from each other's efforts.

B. Common tactics:

Defining tactics together for dealing with new and existing technologies and products puts us in a better position for successfully implementing some of them.

C. Different time zones:

If a problem on one of the joint services turns up in the Nordics at night, the Australian support desk is on duty, ready to deal with it - and vice versa.

For now, the intention is to collaborate on Zoom, Panopto, eduroam, Support desk, Network value added services, DDoS mitigation, network data analytics, and AARNet's storage service CloudStor.

STATEMENTS FROM THE TWO PARTIES

What's in it for you?

Erik Kikkenborg, NORDUnet

“Resources are sometimes scarce for all of us, but not necessarily at the same time. The idea is, that the work and development done by us as partners, is going to benefit us both. So, whenever NORDUnet has come up with a solution to a common challenge, AARNet is welcome to implement the same. Next time, it will be the other way around, and NORDUnet will benefit from AARNet’s initiatives.”

How does it work?

David Wilde, AARNet

“We found that our approach to delivering services was pretty much alike, and we were looking for synergies. For instance, we had just developed a connector for recorded Zoom meetings to be stored automatically in our storage environment, CloudStor. NORDUnet wished to do the same, and since it was already fully implemented here, all they needed was to join us. Nice and easy.”

How is this practically possible?

David Wilde, AARNet

“For something like this to work, you need to know each other well. We have worked side by side for many years, in various global working groups. It’s clear, that we have a lot in common. To start with, we have more or less the same technical solutions. But there is more. On the interpersonal level, we communicate easily, and we laugh of the same jokes – most of the time, anyway. The concept is based on a high level of trust.”

Do you see more of this on the agenda for the future?

Erik Kikkenborg, NORDUnet

“NRENs from around the world are, in terms of service delivery, more alike than you would expect at first sight. I think there is a tremendous opportunity among the NRENs to share knowledge, skills, and competences, for the benefit of all. I definitely expect more such collaborations in the Global R&E Network community!”



David Wilde
AARNet



Erik Kikkenborg
NORDUnet

AUTOMATION OF LIGHTPATHS

NETWORK SERVICE INTERFACE (NSI)

Follow the path of light and automate relevant procedures

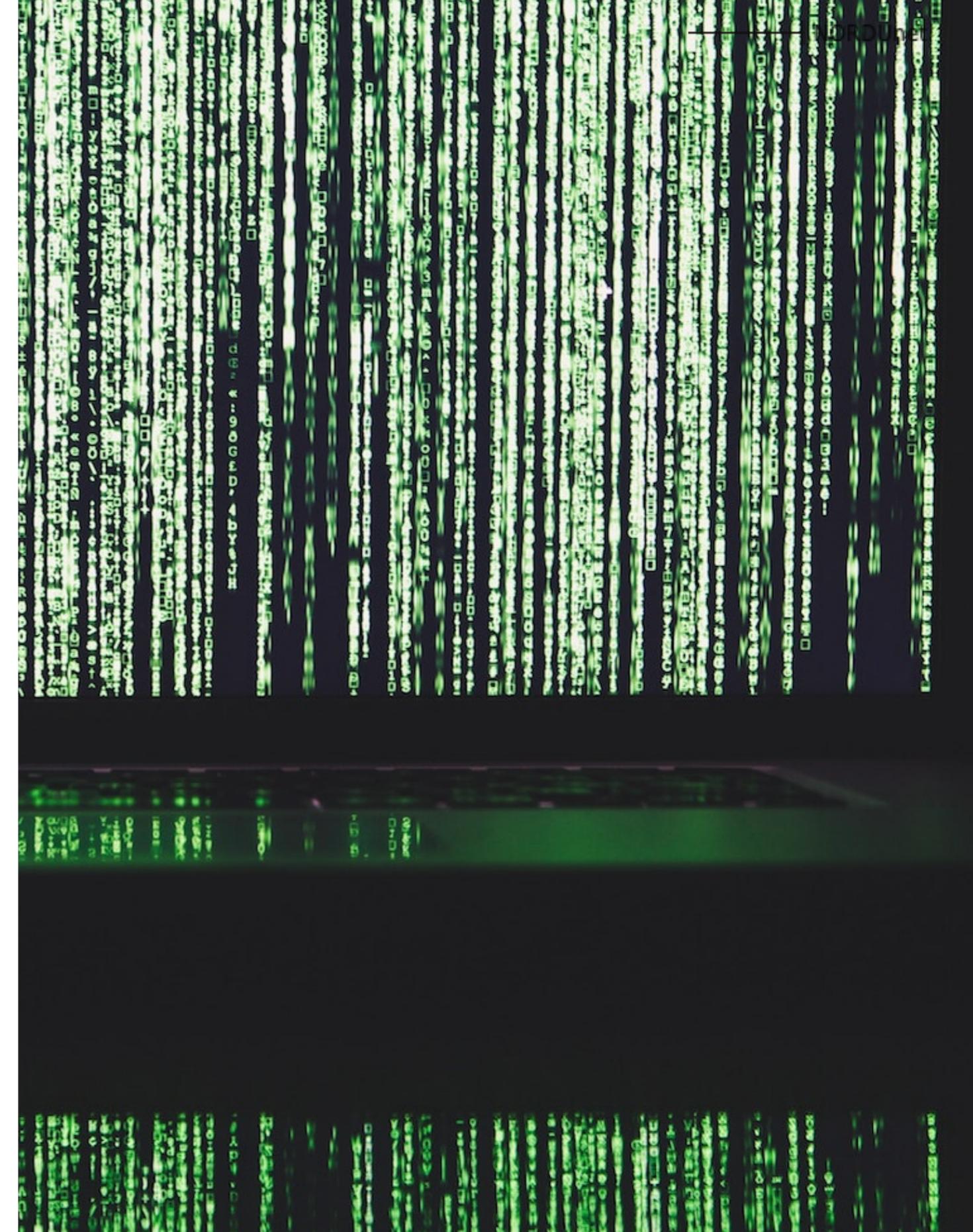
The ideal network solution for a big data scientist is to have access to a network, where data can flow without restrictions, cost effectively.

In 2001, this was one of the aims for GLIF (Global Lambda Integrated Facility), when this community of network specialists from R&E Networks and universities invented the so-called lightpath concept.

The concept worked as designed, however manually preparing each lightpath for data transfer was laborious and time consuming, and soon emerged a desire to automate these procedures.



Global Lambda Integrated Facility





Early implementations of NSI have been, among others:

- NORDUnet's [OpenNSA](#)
- [ESnet's OSCARS](#)
- GÉANT's [AutoBAHN](#)

Facilitating extensive testing in a safe environment, a large effort based on NSI is GTS ([GÉANT's Testbeds Service](#)), that provides testbed facilities to some European NRENs and their users.

The future of NSI is unsure.

NSI AND OpenNSA

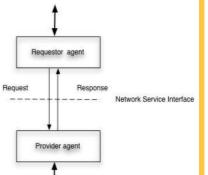
In Open Grid Forum (OGF), around 2008, an international group of NREN network engineers, including from NORDUnet, and network researchers from universities started to work on how to automate the setup, modification, and tear down of lightpaths. They needed to actively design an interface standard upon which everyone could agree. A vast collaborative achievement it was, and it bore fruit in September 2011, when the first successful demonstration of the open protocol Network Service Interface (NSI) took place at the GLIF meeting in Rio de Janeiro, Brazil.

NSI enables a user to build, modify, and tear down one or more circuits with guaranteed bandwidth and isolation from other network flows, wherever there is NSI capable infrastructure. To make actual use of an NSI capable infrastructure, you obviously need software to drive the network elements.

NORDUnet developed and still maintains software called Open Network Services Agent ([OpenNSA](#)) that is an implementation of NSI. OpenNSA is in use in many NRENs and GXP (R&E open exchange points) all over the world.

In the GLIF context, AutoGOLE was an initiative that started in 2010, with the aim to bring NSAs to the GXP. AutoGOLE today is a working group inside the [GNA-G](#).

- NSI is defined as the interface between a NS requestor agent and a NS provider Agent to request a transport connection.
- Requestor might be
 - Host, middleware, network provider
- NS agent/Resource might be
 - Home net
 - Campus net
 - National infrastructure provider
 - Communication link provider



© 2008 Open Grid Forum

TERENA IxD Workshop - 2009

www.ogf.org

11



SCIENCE DMZ & DTNs



SCIENCE DMZ & DTNs

Today staggering amounts of data flow between researchers all over the globe, and much more traffic is predicted in the future.

In the Nordics, [EISCAT 3D](#), ESS, and LUMI are examples of installations which are currently under construction.

These new science facilities will add significantly to the data load on the global R&E network, when they are fully up and running.

This poses a challenge, because a common network setup with firewalls is not fit for data amounts of this magnitude.

A data transfer on the R&E network, using the normal path with firewalls at the end sites, is great when data, e.g. from websites and e-mails, is transferred.

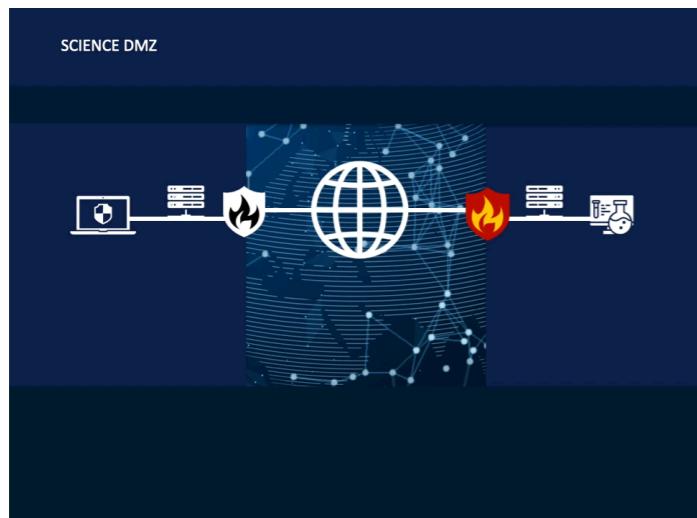
When it comes to research data in high quantities, we are in a different category:

- This is data from a well-known source, transmitted to a well-known destination, and if the involved parties trust each other – why not avoid the firewall, for just this traffic?
- This is possible today, and NRENs, among them NORDUnet, provide the knowledge and services needed: The answer lies in the establishment of a “DeMilitarized Zone for Science”, better known as the “Science DMZ”.

With a Science DMZ in place, scientists can agree to transfer research data between the dedicated source and the dedicated destination, with no firewall in the path. A Science DMZ greatly enhances the transfer speed, resulting in a significantly shorter transfer time.

SCIENCE DMZ

Science DMZ – Performance for big data transfers



*tap
have to
see how*

Regular data transfer

Big data from scientific instruments can be sent over the Internet, from one campus network to the other, but it can take ages, because a firewall at the receiving end is set up to inspect every single data packet. As a result, the firewall slows down the data flow or, when overloaded, rejects to admit some of the data.

Transfer with Science DMZ

When two researchers, trusting each other, transfer big data to each other, they can use the concept of a “DeMilitarized Zone” for Science, better known as the Science DMZ. With a Science DMZ, the research data flows freely on a secure connection between the data stores of the two research institutions, without the limitations of firewalls. All other data flows, e-mail for instance, is sent on the regular path, passing through the usual firewalls.





CEO FORUM

THE GLOBAL R&E NETWORK CEO FORUM

What is it?

A group of CEOs from just short of twenty willing and able R&E Networks from all around the world that meet roughly twice a year, with some video-calls in between the face-to-face meetings.

When did it start?

The CEO Forum was founded in September 2012, with NORDUnet as a founding member.

What is the aim?

The aim of the members of the CEO Forum is to kick-off initiatives that further develop the Global R&E Network, for the benefit of Research & Education, for all NRENs to participate in.

Show me examples!

GNA-G

section highlights the
Global Network
Advancement Group



In The Field Stories

A blog with amazing stories from research & education achievements from around the world enabled by NRENs





WISHES FOR THE FUTURE



“I wish that we embrace the mutual dependency, our international diversity, and the need for democracy.”

Jim Ghadbane
President and CEO
CANARIE



“Continue what we have established, improve what is weak, and complement what is missing.”

Christian Grimm
CEO
DFN



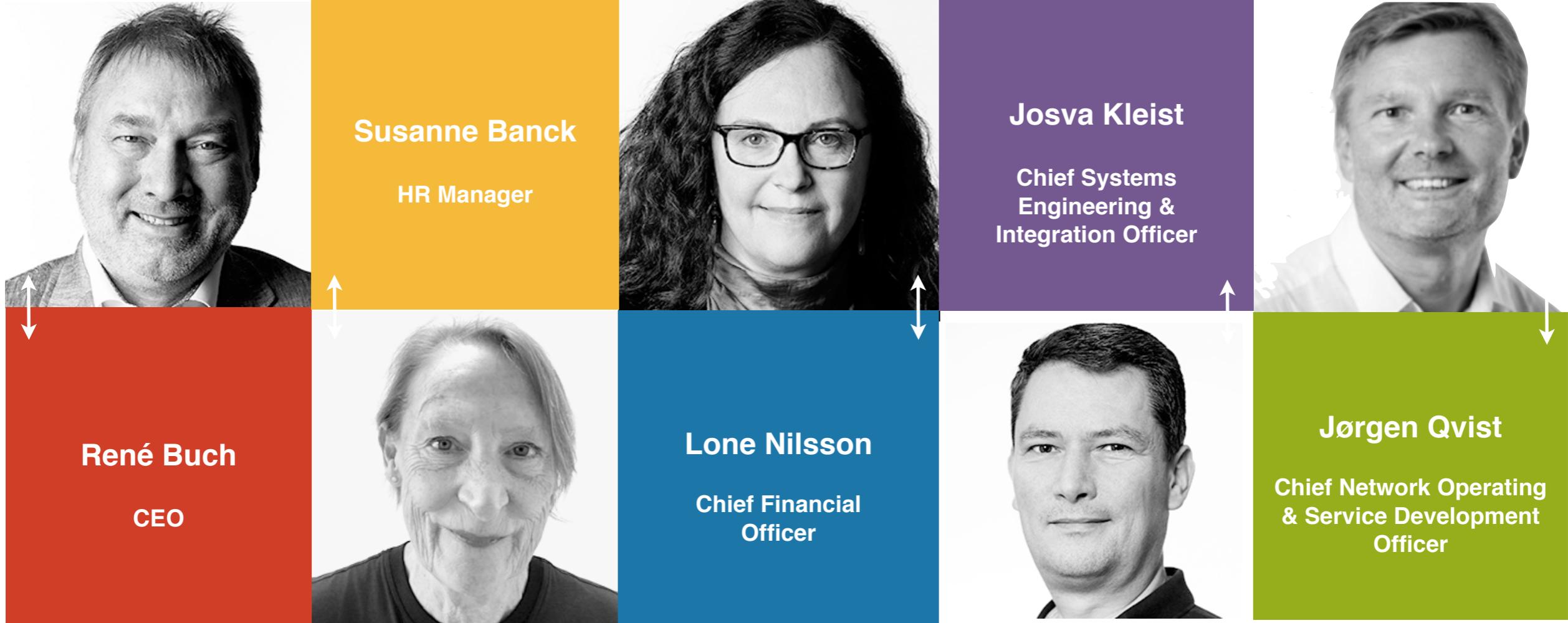
7

RESOURCES



ABOUT NORDUNET

NORDUNET MANAGEMENT TEAM



*tap to learn more
about our team*



ABOUT NORDUNET

- Started as the NORDUNET Programme in 1980
- Established as a private company under Danish law in 1994
- Number of employees (summer 2020):
 - 24 permanent employees
 - 3 consultants
 - 2 student helpers
- Annual turnover (2019): 19 MEUR



CONTACT

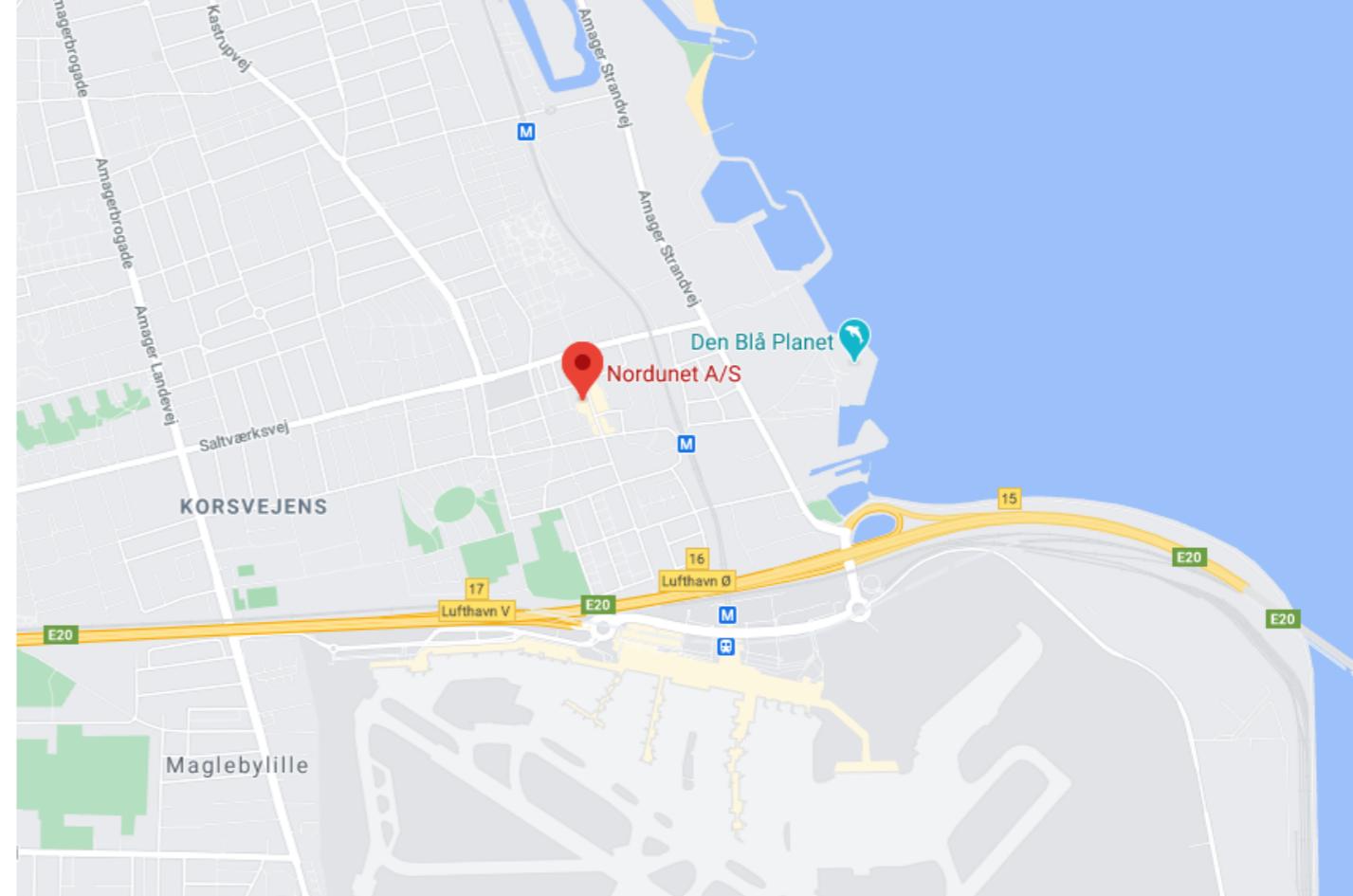
You are always welcome to contact us

Please do not hesitate to contact us at NORDUnet with questions about the Nordic R&E collaboration, our services, conferences and workshops, or, of course, this publication:

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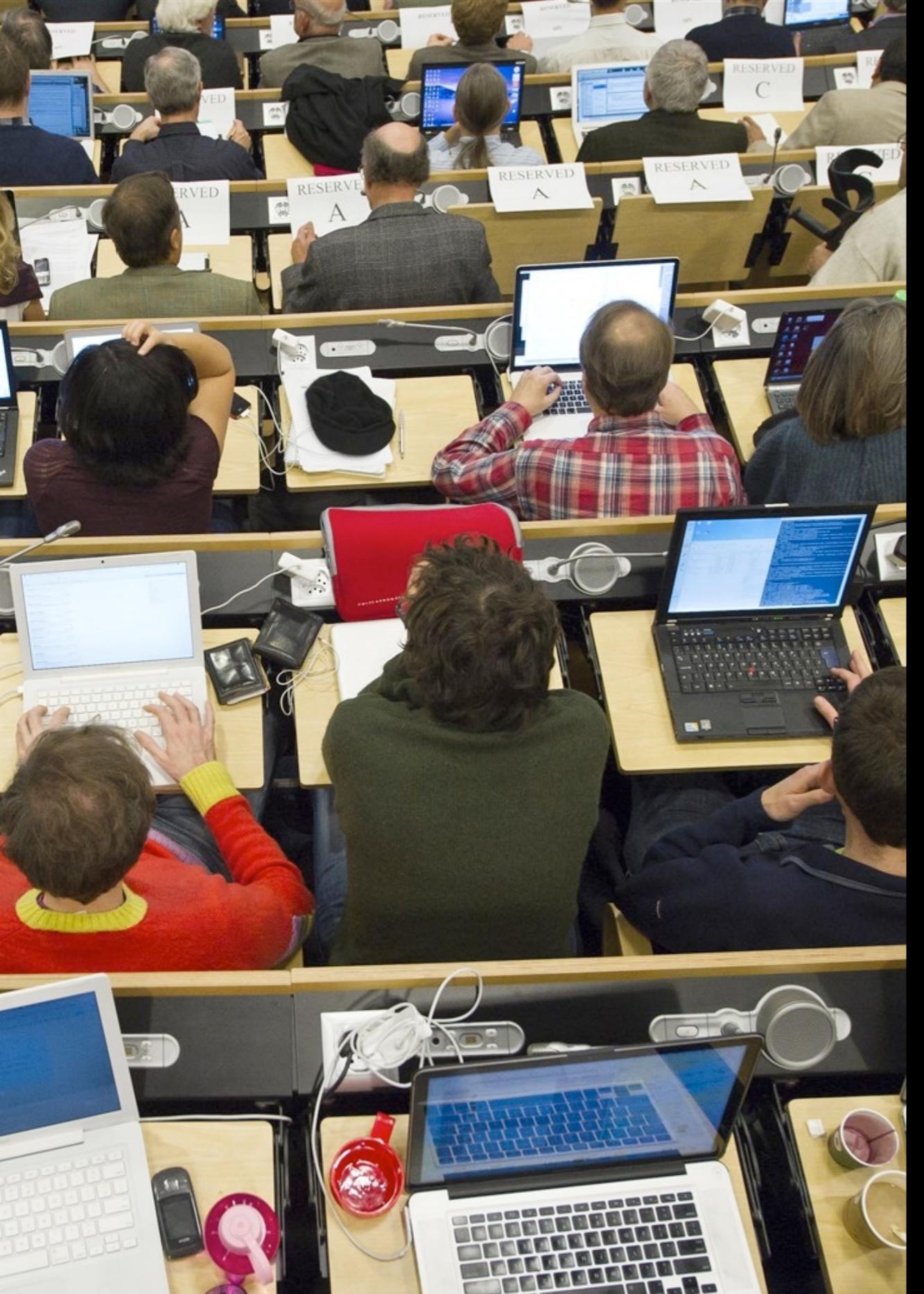
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HOW THIS BOOK WAS MADE



THANK YOU

Many people have been involved in this production. We are very grateful as without you we couldn't have delivered this book. Thanks a lot!

Who made it happen?

Our founders, the governments of the Nordic countries, form the basis of our activities.

**We count ourselves fortunate that
they had the foresight, back in
1980, to start NORDUnet.**

A special thank goes to the Nordic NREN CEOs and NORDUnet Board Members throughout the years. Their dedication and will to collaborate have been and still are crucial to NORDUnet's mission.

And, of course, a large number of skilled and dedicated employees at NORDUnet and the Nordic NRENs deserve warmhearted acknowledgements.

They form the backbone of our activities. Many have been with us for a decade or (much) longer, continuously serving the community with energy and passion.

PRODUCTION TEAM

Erik-Jan Bos, NORDUnet – Editor in Chief

Erik-Jan Bos graduated from Delft University of Technology in 1987, as an electrical engineer, with a focus on architectures of computers and data networks. After 23 years at SURF, he started to work for NORDUnet as Policy & Strategy Officer, on international projects, to ensure the Nordics have the best possible R&E connectivity at affordable prices. Erik-Jan's interest is furthering R&E networking to advance science, research, and education, as he truly believes that knowledge empowers and education is key. Both elements are paramount to solve humanity's biggest challenges.



Karoline Lawætz, ScienceCPH – Project Manager & Content Creator

Karoline Lawætz has a MSc. in natural science from the University of Copenhagen with a postgraduate qualification in communication from the Danish School of Media and Journalism. Since 2004 she has run the bureau ScienceCPH specialized in communication of science and technology. If the topic is well explained, most people understand and appreciate the complexity of the scientific and technical worlds. This is Karoline's specialty.



Bee Kapitan, Interactive Bee Media – Creative Director & Producer

Bee Kapitan is a multi-award-winning designer who focuses on tech innovation, digital communications, and UX/UI design. She is an alumna of the British Columbia Institute of Technology, Simon Fraser University, and a member of the Interaction Design Foundation. With 25 years of hands-on tech design experience, Bee helps organizations and entrepreneurs build or audit their branding to market powerful visuals that convey trust, leadership, and value to their niche audience. Bee specializes in project management and coaching others to create interactive digital storytelling through ebooks and evolving tech solutions.





DEFINITIONS & ABBREVIATIONS

Definitions of abbreviations and NREN names found in this book

AER	Asia Pacific Europe Ring
AI	Artificial Intelligence
ANA	Advanced North Atlantic Collaboration
APAN	Asia Pacific Advanced Network
APR	Asia Pacific Ring
Asi@Connect	4th phase of EU funding for TEIN
AutoGOLE	Automation of GXP
BGP	Border Gateway Protocol
CAE-1	Collaboration Asia Pacific Europe #1
CDN	Content Distribution Network
CISO	Chief Information Security Officer
CSC	IT Center for Science in Finland
DDoS	Distributed Denial of Service
DTN	Data Transfer Node
EC	European Commission
eduGAIN	Global R&E Inter federation of Identity Providers
eduROAM	Global R&E Secure Roaming service

DEFINITIONS & ABBREVIATIONS

eduVPN	Global R&E Secure Access service	GPPC	GÉANT Programme Planning Committee
EISCAT	European Incoherent Scatter	GREN	Global Research and Education Network
EOSC	European Open Science Cloud	GTS	GÉANT Testbeds Service
EOSC-Nordic	Coordination of EOSC within the Nordic and Baltic countries	GVM	Generalized Virtualization Model
ESS	European Spallation Source	GXP	Global (R&E) Exchange Point
EuroHPC	European project on High Performance Computing	HPC	High Performance Computing
fDLuDCf	facilitating Distance Learning using Digital Conferencing facility	ICT	Information and Communication Technology
FIU	Florida International University	ITFS	In The Field Stories
FP	Framework Project	IXP	Internet Exchange Point
GÉANT	Pan-European R&E Networking organization or project	LEOSat	Low Earth Orbiting Satellites
GLIF	Global Lambda Integrated Facility	LHC	Large Hadron Collider
GNA	Global Network Architecture	LHCOPN	Large Hydron Collider - Optical Private Network
GNA-G	Global Network Advancement Group	LMS	Learning Management System
GNx	GÉANT project version x	LSST	Legacy Survey of Space and Time mission of the Vera C. Rubin Observatory
		LUMI	The EuroHPC supercomputer in Kajaani, Finland

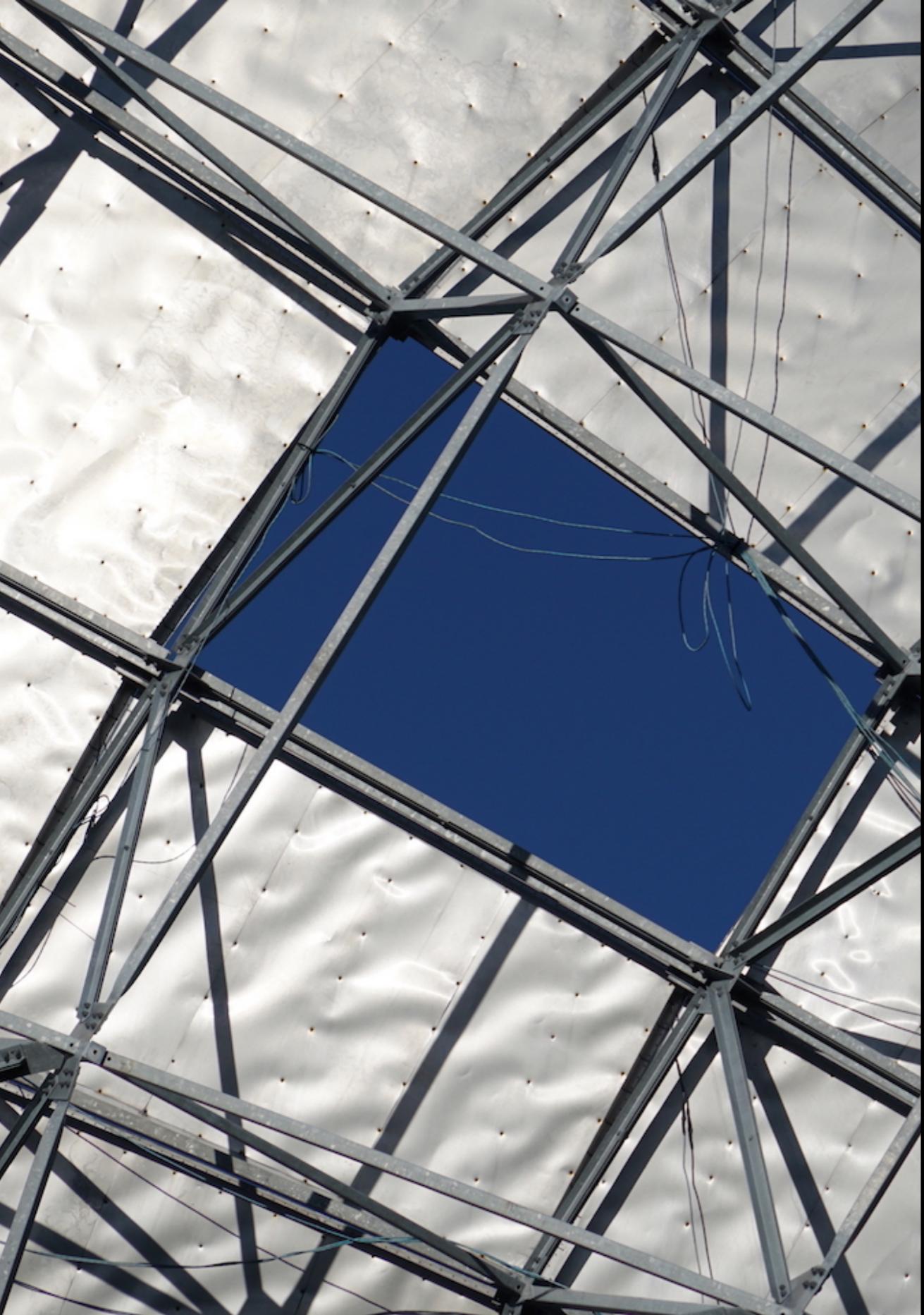
DEFINITIONS & ABBREVIATIONS

MANRS	Mutually Agreed Norms for Routing Security	R&E	Research and Education
MD-VPN	Multi-Domain Virtual Private Network	RARE	Réseaux Associés pour la Recherche Européenne
MOOC	Massive Open Online Course	RREN	Regional Research and Education Network
NGI	Next Generation Internet	SAML2	Security Assertion Markup Language (version 2)
NIAC	Network Infrastructure Advisory Committee of GÉANT	Science DMZ	Science DeMilitarized Zone
NOC	Network Operations Center	SPOC	Single Point of Contact
NREN	National Research and Education Network	TEIN	Trans-Eurasia Information Network
NSA	Network Service Agent	TEIN*CC	Trans-Eurasia Information Network Cooperation Center
NSF	National Science Foundation of the USA	TERENA	Trans-European Research & Education Networking Association
NSI	Network Service Interface	TNC	GÉANT's Annual European Networking Conference
OGF	Open Grid Forum	Up2U	Innovative Up to University ecosystem
OpenNSA	Open Source implementation of NSI by NORDUnet	VLBI	Very Long Base Interferometry
OSCARS	On-Demand Secure Circuits and Advance Reservation System	VPN	Virtual Private Network
PC	Programme Committee		
PNI	Private Network Interconnect		



DEFINITIONS & ABBREVIATIONS

NREN Name	Country (Region)
AARNet	Australia
BdREN	Bangladesh
CANARIE	Canada
DeiC	Denmark
ESnet	USA
Funet	Finland
GÉANT	Europe
Internet2	USA
IUCC	Israel
Jisc	United Kingdom
NORDUnet	European Nordics
PSNC	Poland
REANNZ	New Zealand
RHnet	Iceland
SUNET	Sweden
SURF	The Netherlands
Uninett	Norway



CREDITS & MEDIA INDEX

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In The Field Stories

Page: 165

GÉANT

Page: 129

GNA

Pages: 152-153

Anna Gościnna-Poulsen

Pages: 75, 76

Network Diagrams

Guide to Iceland

Pages: 28, 143, 155

Guide to Iceland provides an unparalleled variety of travel services in Iceland. It is the most popular website and travel brand about Iceland, offering comprehensive travel information in 14 languages.

Harri Kuusisto (CSC)

Page: 147

Video kindly made and provided by Harri Kuusisto (CSC)

LUMI

Page: 179

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Page: 86

Netnod Internet Exchange i Sverige AB

SARAO

Page: 154

Credit: South African Radio Astronomy Observatory (SARAO)

Khulu: An image of one of the 64 MeerKAT radio telescopes of the South African Radio Astronomy Observatory (SARAO) in the Karoo region in South Africa.

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Page: 56

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Page 140 Petr Kratochvil

Page 142 Petr Kratochvil

Page 163 Petr Kratochvil

Page 192 Circe Denyer

Giphy

Page 73 Xponential Design

Page 114 Mathematica

Page 139 ExddKdNixp

Page 142 Xponential Design

Page 174 YW5i0QaCH3qw

Pexels

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Page 20 Rudolf Kirchner

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Page 46 Ruvim Miksanskiy

Page 66 CCO

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Page 69 Till Rottmann

Page 87 Satnesh D

Page 93 Olenka Sergienko

Pexels

Page 98 Pressmaster

Page 100 Pressmaster

Page 103 Harsch Shivam

Page 104 CCO

Page 113 CCO

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Page 120 #WOCinTech

Page 121 Edward Jenner

Page 122 LA Libertad

Page 124 CCO

Page 124 Donald Tong

Page 128 Tomáš Malík

Page 134 Fauxels

Page 139 Stefan Stefancik

Page 141 #WOCinTech

Page 165 CCO

Page 168 CCO

Page 169 Swinon

Page 169 CCO

Page 169 Tomáš Malík

Page 173 Brett Sayles

Page 175 CCO

Page 177 Markus Spike

Page 180 Chokniti Khongchum

Pixabay

Page 26 Karsten Bergmann

Page 71 David Mark

Page 74 Bluesnap

Page 116 Broesis

PNGTree

Page 82 Tt7

Page 147 Tt7

Stocksnap

Page viii Dion Taverier

Page 176 Travel Photographer

UnSplash

Page v Annie Spratt

Page xi Fabian Moller

Page 19 Donald Giannatti

Page 26 Razvan Mirel

Page 26 Sam Poullain

Page 26 Charley Litchfield

Page 26 Chris Lawton

Page 27 Tapio Haaja

Page 27 Saikrishna Saketh

Page 28 Jeff Sheldon

Page 28 Jonatan Pie

Page 29 Drahomir Posteby

Page 29 Lukas

Page 29 Daniel Welsh

Page 29 Peter Ivey Hansen

Page 29 Alexandr Bormotin

Page 30 Simon Williams

Page 30 Christoffer Engstrom

Page 30 Darya Tryfanava

Page 30 Margalit Toyber

Page 30 Febiyan

Page 31 Jon Fobrant

Page 32 Serpil

Page 33 Adrien Olichon

Page 38 Krzysztof Kowalik

Page 42 Tommi Selander

Page 44 Nils Schirmer

Page 51 Akira Hojo

Page 59 Matheo Jbt

Page 70 Benjamin Davies

Page 72 Torbjorn Sandbakk

Page 78 Anders Jilden

UnSplash

Page 80 Knut Troim
Page 89 Markus Spiske
Page 92 Kasper Rasmussen
Page 97 Jaanus Jagomagi
Page 99 Joakim Honkasalo
Page 102 M. Schmidt Rasmussen
Page 106 Akira Hojo
Page 107 Pierre Chatel
Page 109 Clark VanDerBeken
Page 114 Tim VanDerKuip
Page 125 Matt Morelli
Page 126 Ava Coploff
Page 136 Mathias Arlund
Page 145 Mark S
Page 149 Jacob Christiansen
Page 156 Pierre Chatel Innocenti
Page 157 Mikita Karasiou
Page 160 Michael Odelberth
Page 160 Pascal Mauerhofer
Page 162 Jakub Chlouba
Page 178 Ari He
Page 183 Hakon Sataoen
Page 185 Florencia Viadana
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