



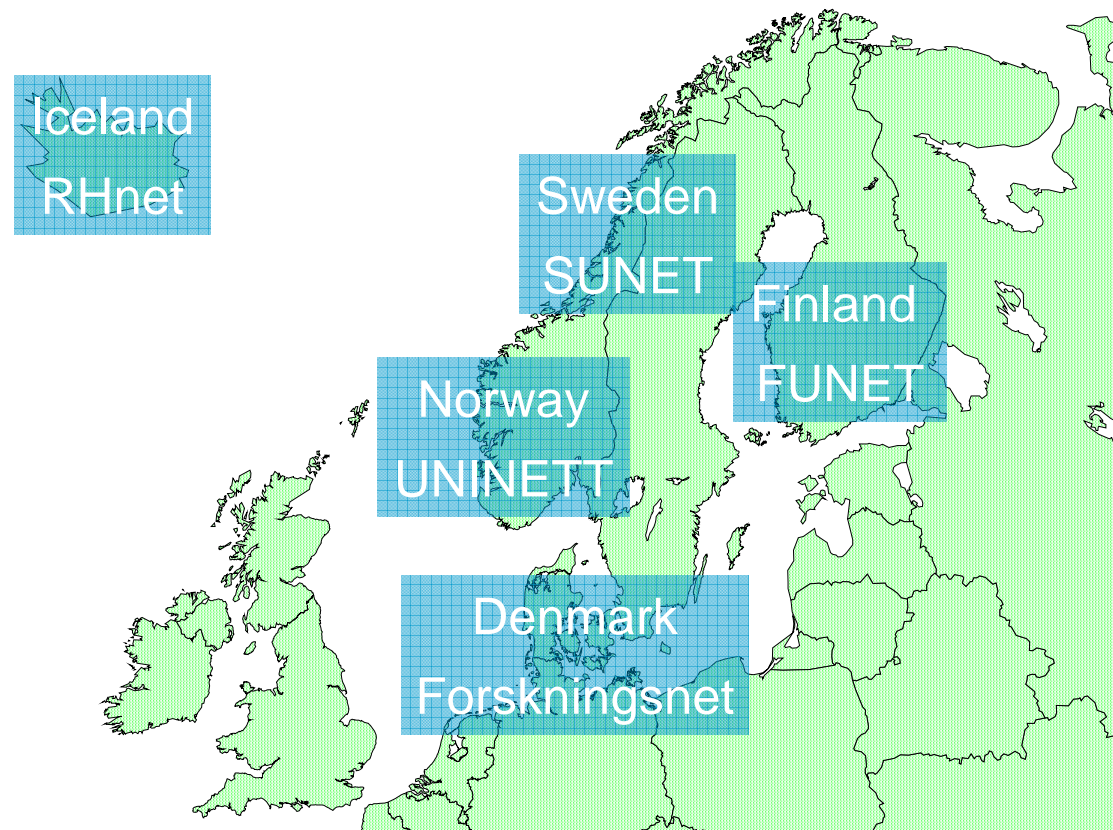
# NORDUnet

Nordic eInfrastructure for Research & Education

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## NORDUnet collaboration

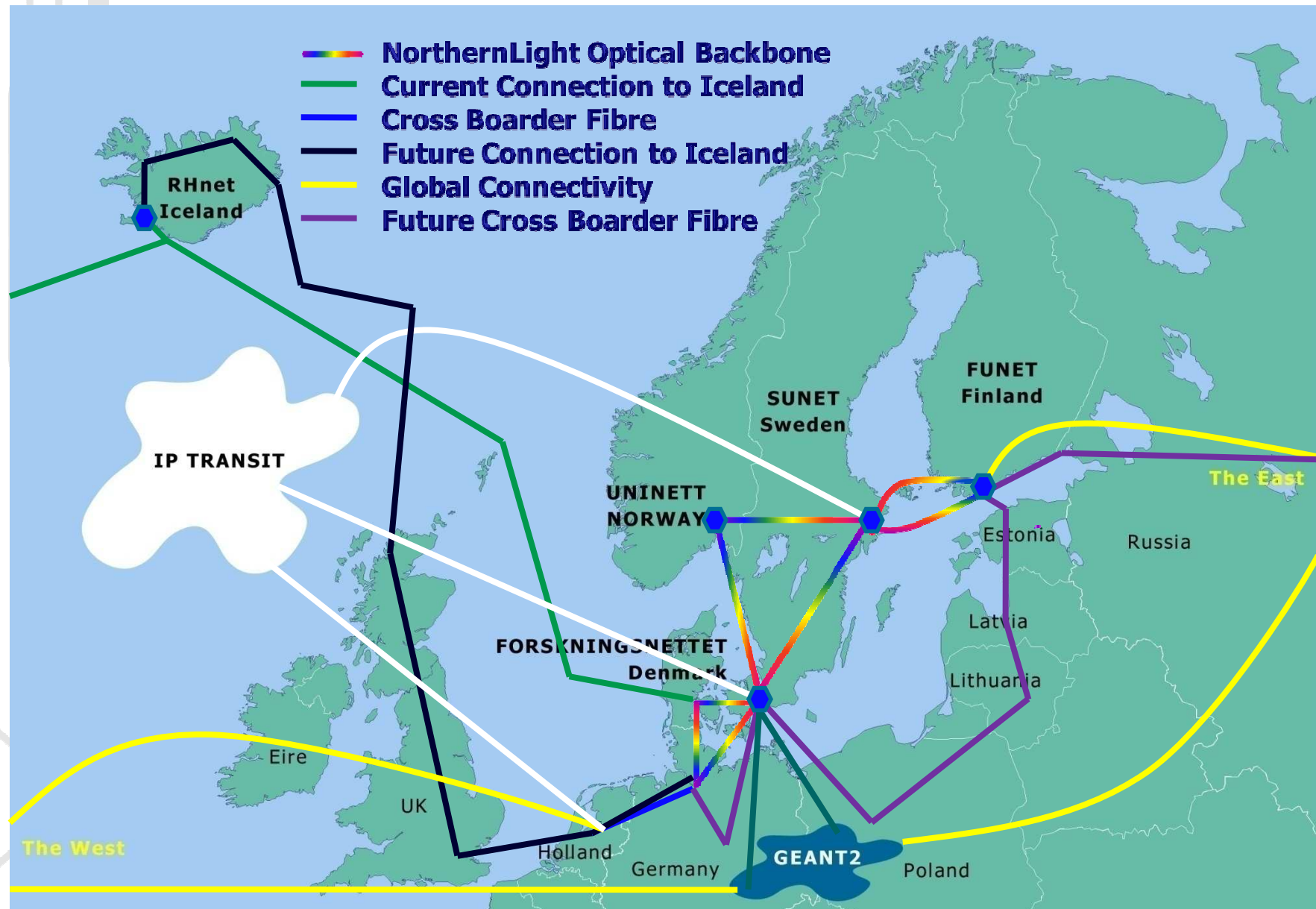


## NORDUnet

- 25 years of collaboration
  - NORDUnet originated in a joint network project
  - Doing together what we cannot do alone
  - Represent the Nordic countries internationally
  - 5 countries, one network, one voice
- 25 years of state-of-the-art networks
  - First European IP adopter
  - Strong international relations
  - 1 million users

## **NORDUnet mission – Enable It!**

- An ordinary ISP ... and then some
  - Services not yet commercially viable (or available)
  - e-Infrastructure: integration of capabilities
- Responsibility for the Future
  - 25 years ago, NORDUnet helped bring IP to Europe
  - NORDUnet helped Nordic countries secure a leading role in communications technology
  - Today, NORDUnet is helping advance Hybrid networking and grid infrastructures
- Building for science today what will be the standard offering tomorrow



## Organization

- Main office in Copenhagen
  - Management team
  - Administrative Staff
  - Close to Copenhagen Airport
- Technical Staff in Copenhagen and Stockholm
  - NOC, NMS, 1. level support in Stockholm
  - 2nd level support, engineering, design in Stockholm and Copenhagen
  - Use staff of Nordic NRENs for local maintenance and installation
- Staff: 35, including NDGF

## Governance

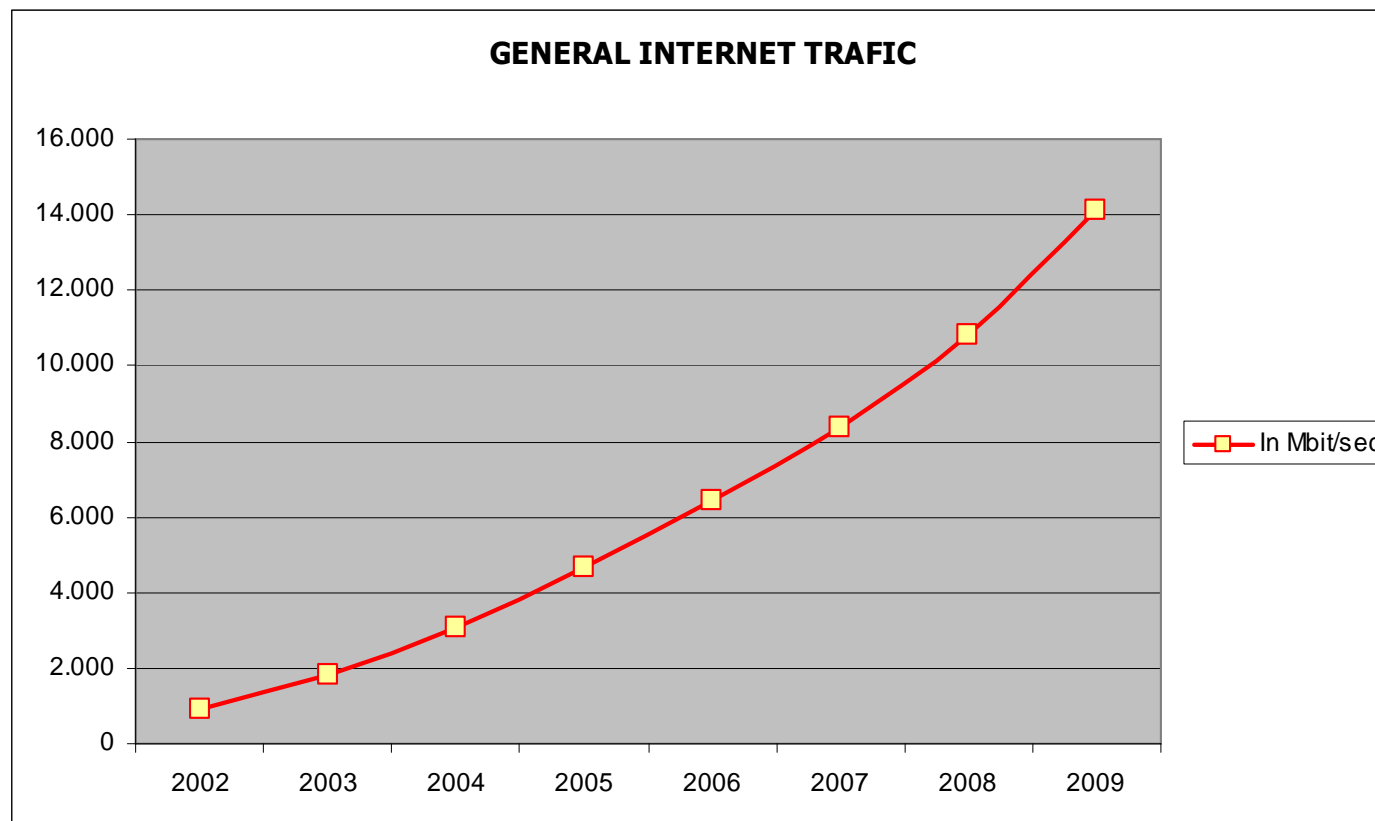
- Danish limited company
- Shareholders are Nordic state institutions
  - DK - Ministry of Science
  - FI - Ministry of Education
  - IS - University of Iceland
  - NO - UNINETT
  - SE - National Agency for Higher Education
- Board members represent the Nordic national research and education networks
- Financed by the Nordic national networks with GNP based cost sharing

## NORDUnet NUNOC

- A Nordic 24x7 Operations Center for Research and Education
- Functions
  - Phone and mail handling 24 x 7
  - trouble ticketing, case handling
  - Monitoring, Measurement
  - Trouble-shooting, escalation
- Customers
  - NORDUnet
  - SUNET
  - NDGF
  - ....



## Traffic Projections



## Drivers for Hybrid Networking

A: Lightweight. Mail, browsing. One-to-Many.

B: Business, Streaming, VPN. Many-to-Many

C: e-Science. Few-to-Few

Total traffic:  $C \gg B \gg A$

U  
S  
E  
R  
S

A

B

C

BANDWIDTH

Graph inspired by Cees de Laat

## The Drivers

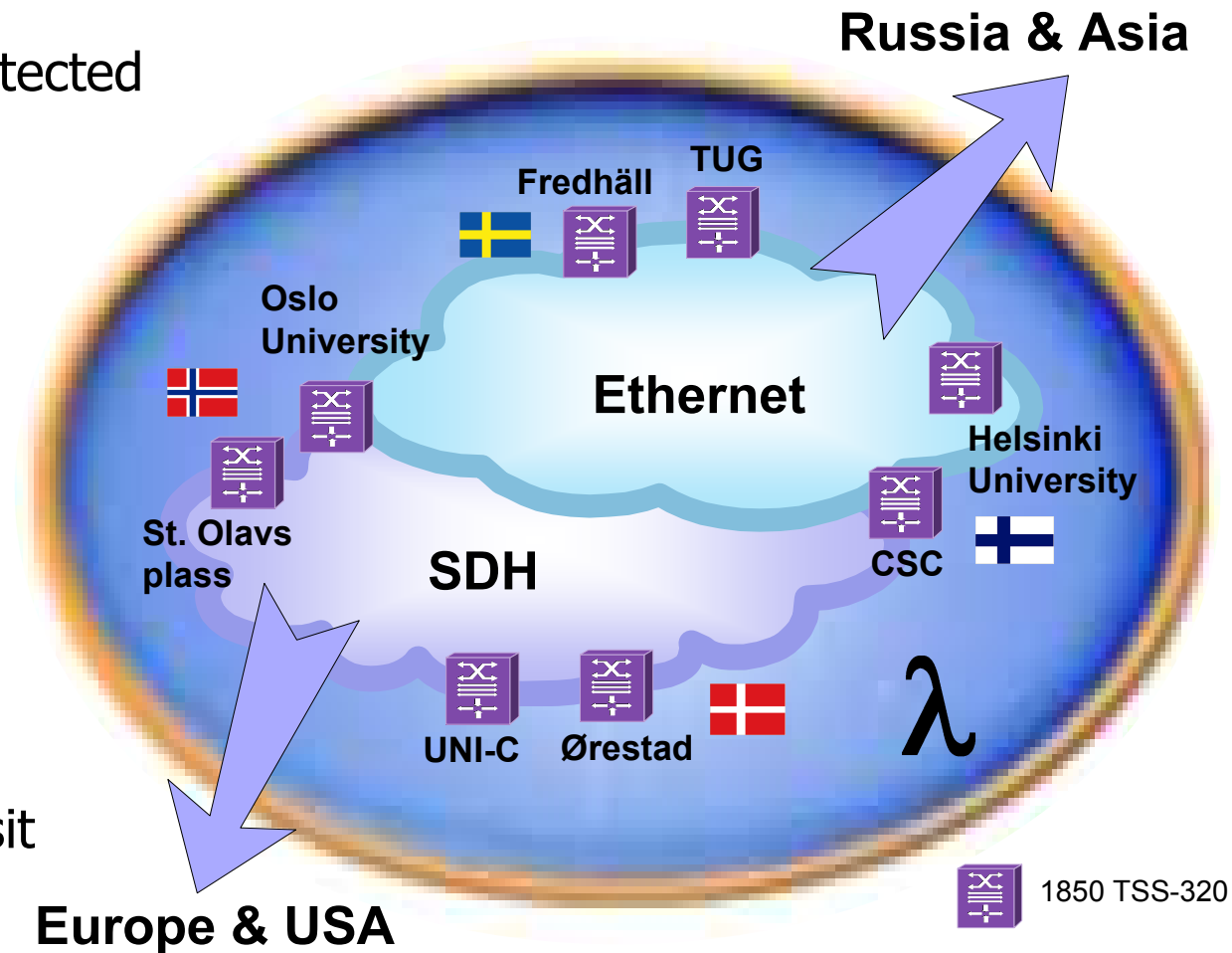
- Cost-control for network services
- Growth in shared IP service
- New types of users
  - eScience projects
  - Virtual Organisations
  - Large-scale international resource sharing
  - Testbeds
- Hybrid and lambda networking
- International network collaboration

## Services

- Protected & Unprotected
- Over-subscribed
- VLAN
- P2P
- P2M

## Applications

- Shared IP
- Lambda Services
- OPNs
- International Transit



## The Requirements

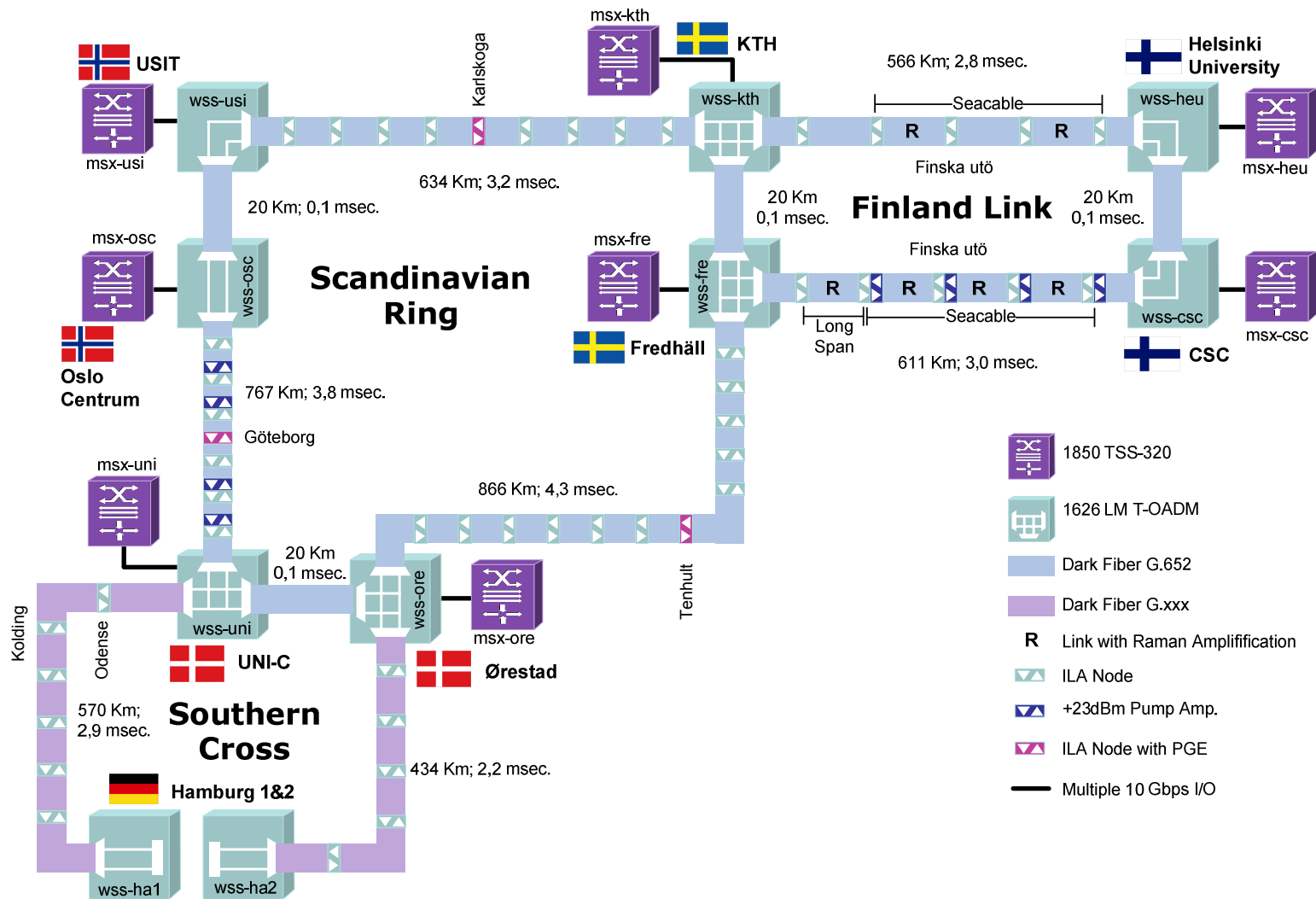
- Dark fiber
  - No leased circuits
  - Coverage: Oslo, Copenhagen, Helsinki, Stockholm, Hamburg
  - Resilience
- Multi-Service
  - IP – with router aggregation
  - Lambda Switching
  - 1 GE, 10 GE, 40 GE circuits
  - SDH/SONET, Ethernet
- An Open Optical Exchange

- Fibre distances
  - NORDUnet 4200+ Km (Completed)
  - SUNET 7300+ Km (Operated by NORDUnet)
  - FUNET 4300+ KM (Tendering)
  - Forskningsnett 1500+ KM (Tendering)
  - UNINETT 7000+ KM (In Progress)
  - Rhnet Planned 2,5 Gbit/s Lambda connection
- Sites:
  - NORDUnet 60+
  - SUNET 80+
  - FUNET 60+
  - Forskningsnett 20+
  - UNINETT 80+
  - Rhnet Planned 2,5 Gbit/s Lambda connection

## NORDUnet Network Features

- Three resilient rings
  - Stockholm-Helsinki, Copenhagen-Oslo-Stockholm, Copenhagen-Hamburg
- DWDM Equipment
  - Up to 88 channels
  - Fully Reconfigurable, tuneable OADM
  - 10 Gbps, prepared for 40 Gbps
  - (88 \* 40 Gbps = 3.5 Tbps)
- Transport Switching Equipment
  - SDH / SONET up to OC-192, prepared for OC-768
  - Ethernet 1 GE, 10 GE
  - Bandwidth sharing, dynamic use of capacity

## The Core Network





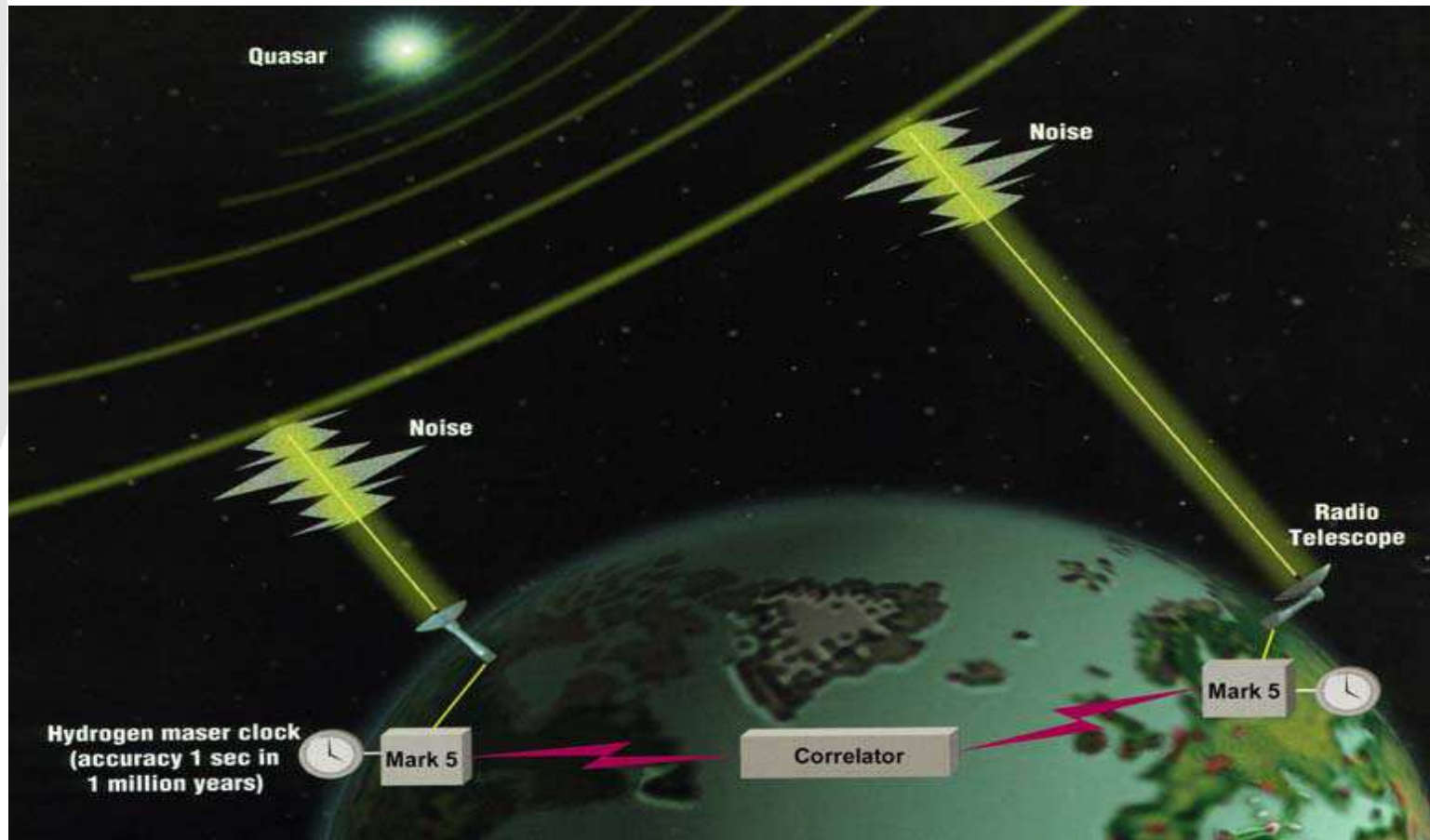
## The network is...

- A network for all of the R&E community
  - The many with ordinary traffic patterns
  - The advanced users with large amounts of traffic
  - The few with extreme requirements
- A network for international collaboration
  - For both science and networking
  - Europe and beyond
  - Dynamic network build-out
  - Transit services
- A network for growth
- A network for the future

## **e-Infrastructure - Beyond Transport**

- It's more than just a Network
- It's enabling global collaboration
- It's facilitating use of remote instruments
- It's facilitating sharing of data
- It's joint capabilities for storing and processing
- It's all the resources for global e-Science

## Example: e-VLBI



**Very-Long Baseline Interferometry**

## e-Science

- e-Science is by nature collaborative
- e-Science is by nature international, often global
- Well-defined groups or projects
  - Specific to one science area
  - Small(ish) number of users
  - Shared resources
- Communication is mostly internal to the group or project

## e-Science Requirements

- Sharing Scientific Instruments
  - Radio-telescopes, CERN, microscopes, ...
  - Sharing Research Infrastructure
- Sharing Large Datasets
  - Genome Databases, ...
- Sharing Compute Resources
  - Large-scale computation, Simulations, Visualization, ...
- International project management

## Infrastructure for e-Science

- The new e-infrastructure should offer:
  - Transport
  - Computing Resources
  - Storage
  - Databases
  - Authentication, Authorization, Accounting
  - Dynamic resource allocation
  - User control
- A Collection of Capabilities

## Grids and Hybrid Networks

- Facilitating e-Science collaboration
  - Hybrid Networks allows distribution and sharing of resources – local & global
  - Grid allows researchers to take full advantage of advanced networks and integration of capabilities
- Complimentary views
  - Computing as just another element in the Hybrid Network
  - Transport as just another grid resource
  - From both points of view, Grid and Networks belong together

## Nordic e-Science Infrastructure

- Enable new ways of doing science
- A Hybrid Network
  - IP for the masses + OPNs for e-Science
  - Ability to build new networks on demand
- A Joint Nordic production Grid facility
  - Leveraging national grid resources
  - A Common Nordic Grid policy framework
  - Joint Nordic planning and coordination
  - Shared Nordic storage facility
- Co-ordinate & host major e-Science projects



## **One Grid & Network Organization**

- Fits NORDUnet mission – be an enabler
  - One view of resources
  - Project management for e-Science projects
  - Enable Nordic collaboration and sharing
- Interfacing & collaboration
  - One entry point for users
  - One interface toward the global community
- Create collaboration - Enable e-Science

## Nordic Data Grid Facility

- A Collaborative Grid Production Facility
  - Facilitate joint use of national computing resources
  - Coordinate deployment of facilities and middleware
  - Support middleware development
- Support Science Projects and applications
  - Adapt and support e-Science applications
  - Do project management for e-Science
  - Deploy project-specific shared resources
- Do for Nordic Grid Computing what NORDUnet has done for Networking

## NORDUnet Network Evolution

- Regional Dark-fiber Hybrid network
  - Support future capacity growth
  - Enable optical private networks
  - Take advantage of fiber window-of-opportunity
- Cross-Border Fiber development
  - Position Nordic region in global research networks
  - Facilitate regional and global networks
  - Have the facilities to support international initiatives
  - Cost reduction in peering and IP Transit
- Be a driver in network evolution

## Supernetworking

- 1986-2000 : Supercomputing
  - was the driver for many areas of science
  - made new applications and approaches possible
  - The Internet was built to support supercomputing
- 2000- : Supernetworking
  - is a driver for many areas of science
  - makes new applications and approaches possible
  - computing resources is a service in the network
- This requires
  - ownership of lower layers of infrastructure
  - dynamic networks and user control

## Summary

- Nordic infrastructure for Science
  - A Hybrid Network
  - A joint production grid facility
  - Shared middleware efforts
  - Project support infrastructure
- Built on tradition for regional collaboration
  - Doing together what we cannot do alone
  - Regional networks as foundation for global networks
- Computing as a capability in the network, or, the network as an element of the grid

Thank You!  
Questions?

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