# NorthernLight
## A 3rd Generation Hybrid R&E Network

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**8th Annual Global LambdaGrid Workshop**

**Seattle, 2 October 2008**

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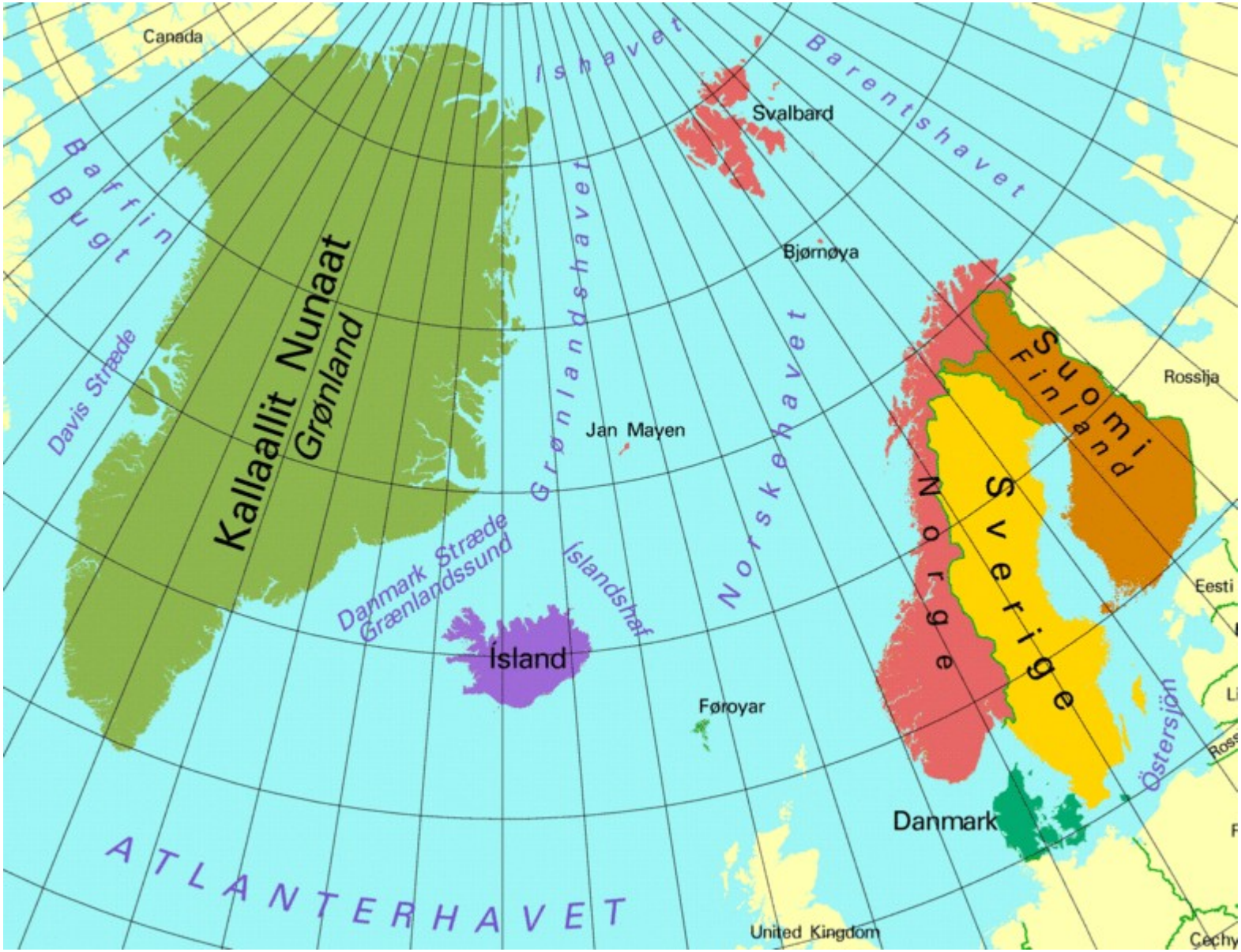
# The Nordic Countries



# The Nordic Countries

- Denmark, Norway, Sweden, Finland, Iceland.
  - 5 independent countries
  - 5 national R&E networks
  - Tradition of collaboration
- Large area, few people
  - 25 million citizens
  - 1,240,456 $km^2$ (3,406,542 $km^2$ w/Greenland)
  - Copenhagen – Svalbard: 2500 km
  - Copenhagen – Gibraltar: 2500 km

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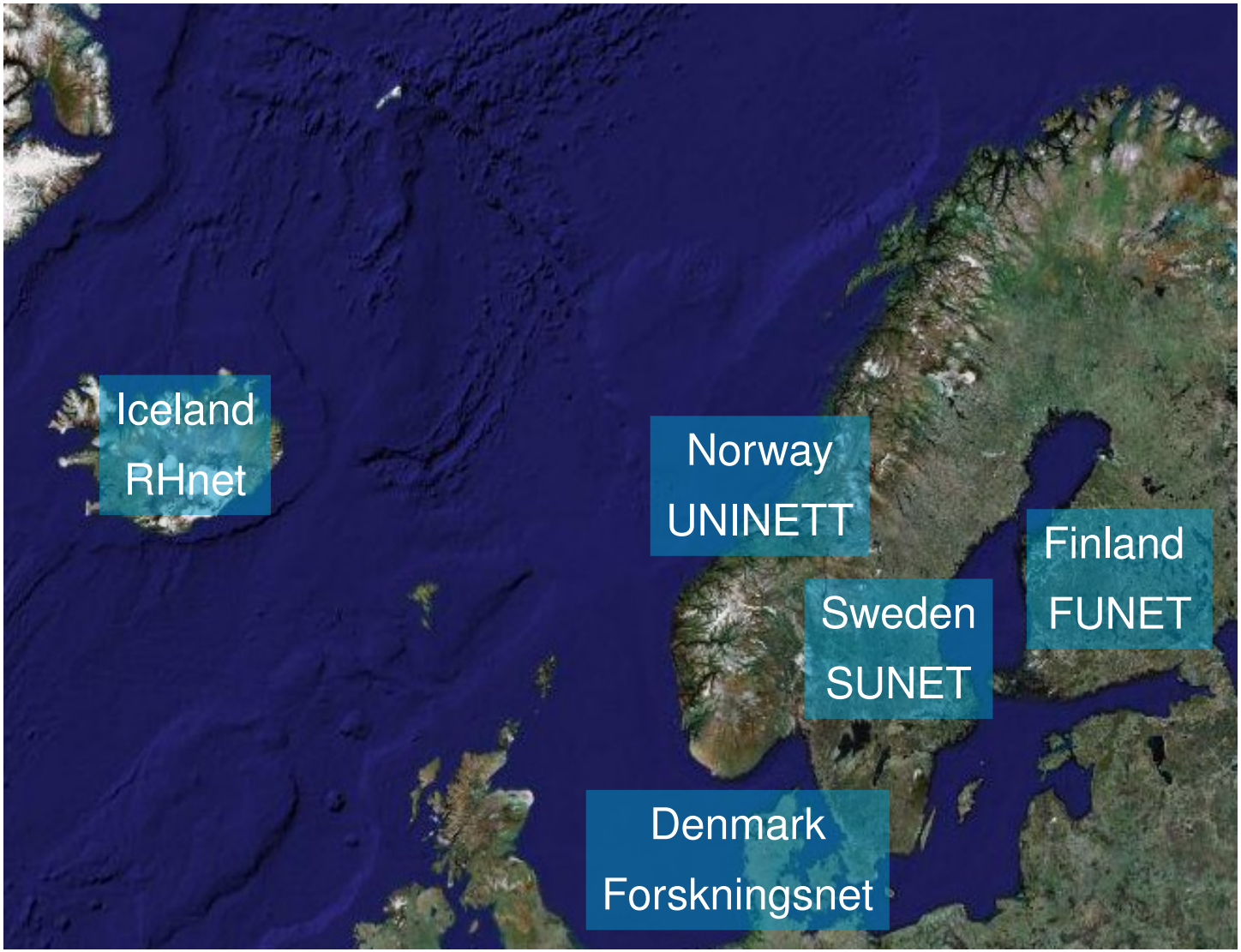
# NORDUnet collaboration



# A Regional Network

- 25 years of collaboration
  - Doing together what we cannot do alone
  - Represent the Nordic countries internationally
  - 5 countries, one network, one voice
- Service the Nordic NRENs
  - Connectivity, cost efficiency
  - Project participation and coordination (GEANT, GLIF, GLORIAD, FEDERICA, ....)
  - International relations, international development efforts
  - eScience infrastructure services – networks for major projects and disciplines, grid computing, storage services

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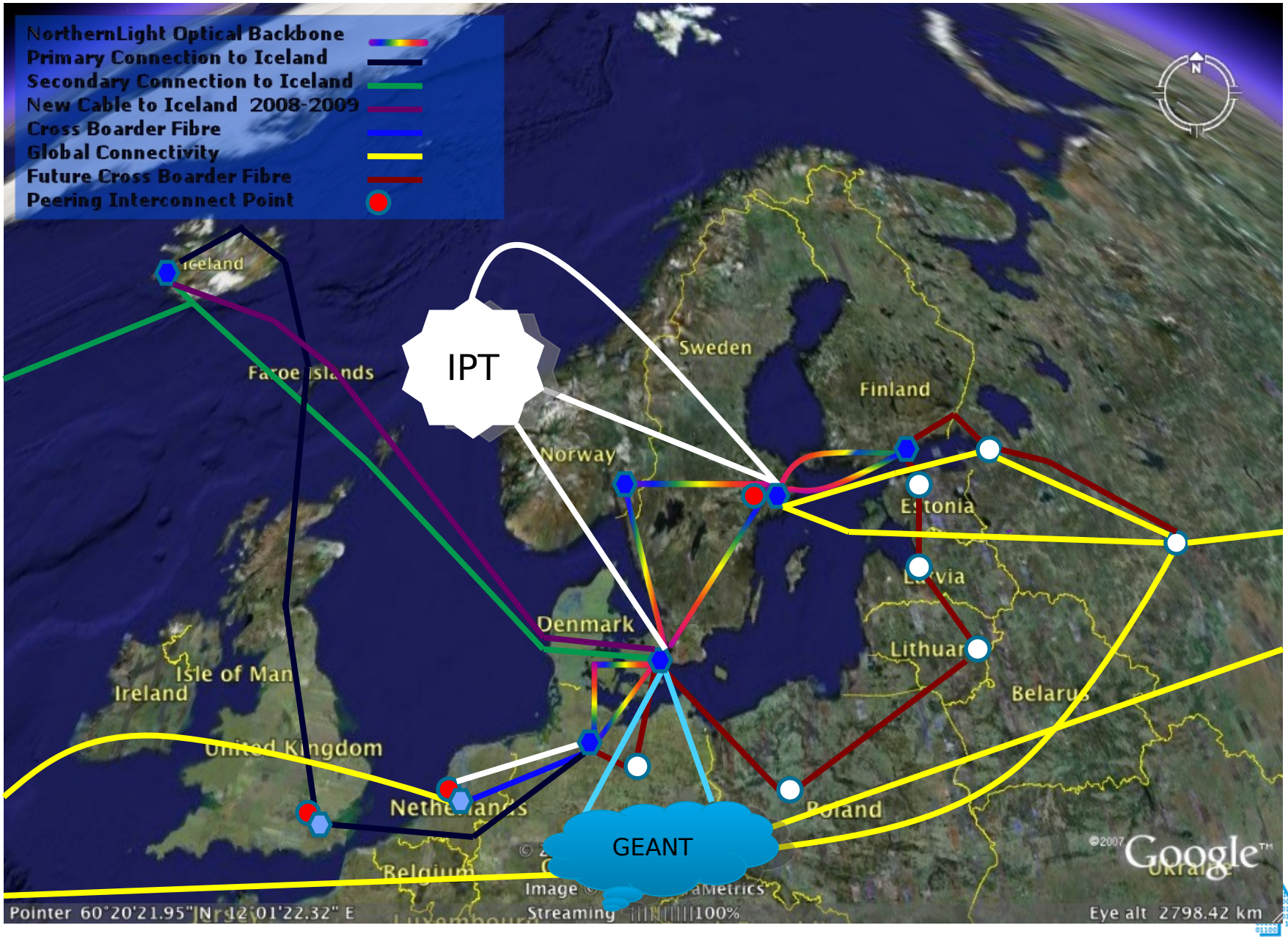
# The big picture



# 1st Generation "hybrid" (2003)

- Services
  - 10G / 2.5 G shared IP
  - 1G (subrate) Ethernet lightpath service
- Design
  - Based entirely on leased lines
  - Cisco ONS 15454 SONET lambda service platform, OC48 carrier
  - Lambda service platform and IP service platform separate infrastructures (w/ shared PoP's)
  - OC48 to Netherlight

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# 2003 Lambda Grid Workshop

# iGrid 2005 e-VLBI demo

# 2nd Generation Hybrid (2007)

- Services
  - 10G shared IP
  - 10G full wave service
  - Subrate 10G SONET / SDH / Ethernet
- Design
  - Based on dark on dark fibre
  - OC192 to NetherLight, MoscowLight
  - DWDM – wave blocker, 10 G waves
  - Deploys SONET / SDH / Ethernet switching capability, GMPLS control plane interface
  - IP service on top of DWDM service

# 3rd Generation Hybrid (2008)

- Services
  - 10G / 40G shared IP
  - 10G, 40G full wave service (100G coming)
  - Subrate 10G SONET / SDH / Ethernet
- Design ...as 2nd generation, but:
  - DWDM Wavelength Selector Switches
  - 96 channels, 10/40/100G waves
  - Mix of OC192 and Cross Broder Fiber for international links
  - towards TMPLS based control plane interface
  - towards non-blocking distributed switching capability

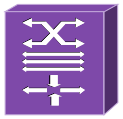
# Suppliers

- Dark Fibre
  - **Telenor**
    - Scandinavian Ring
    - Finland Link
  - **Global Crossing**
    - Southern Cross

Dark Fiber G.652

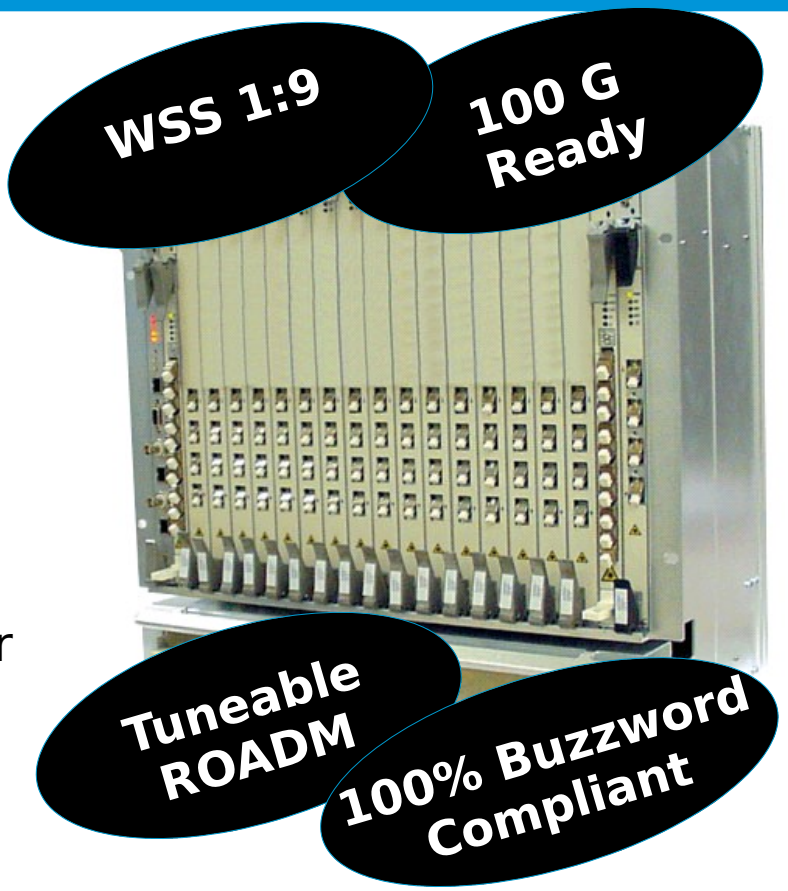
Dark Fiber G.655 TrueWave RS

- Equipment
  - **Alcatel-Lucent**
    - 1626 Light Manager
      - ULH DWDM
    - 1850 Transport Service Switch
      - SDH/Sonet/Ethernet
      - CWDM and SH DWDM
  - **Juniper**
    - T640



# ALU 1626 Light Manager

- Wavelength Selector Switches
  - LH/ULH up to 96 channels
  - Add/Drop 72 channels
- Automatic system alignment
- Enhanced functionality
  - Tuneable filters
  - 50 GHz filters
- Long Haul:
  - Fully Tuneable ROADM
- Fully C band tuneable interfaces over any interface
  - 10 G Universal Transponder
    - STM-64
    - 10GE WAN & LAN
  - 40G transponder
    - PSBT (50 GHz - SH)
    - qDPSK (50 GHz – LH/ULH)
- Embedded Optical Protection
- Raman Amplification




- 
- Same modules for OADM and ILA
  - Shelf
  - Amplifier

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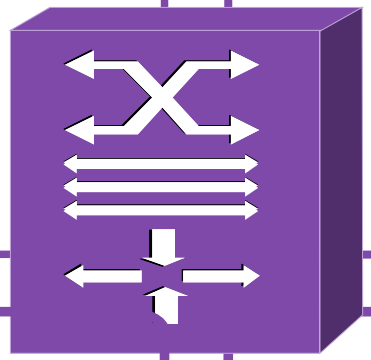
# ALU 1850 TSS-320

## SDH/SONET

- STM-1, 4, 16 & 64
- Cross-Connection
- Termination
- ETH Mapping over SDH
- Complete Scope of SDH/SONET Features

## Ethernet

- 10GE LAN/WAN - Optical
- GE - Optical
- 10/100/1000 - Electrical
- ETH Traffic Classification
- Complete Scope of Ethernet Features



## CWDM

- Terminal, Hub, OADM Ring
- Stacked C-WDM Rings

## MSPP

- CLI, SNMP and TL1
- 2008 GMPLS feature set

**1850 TSS-320**

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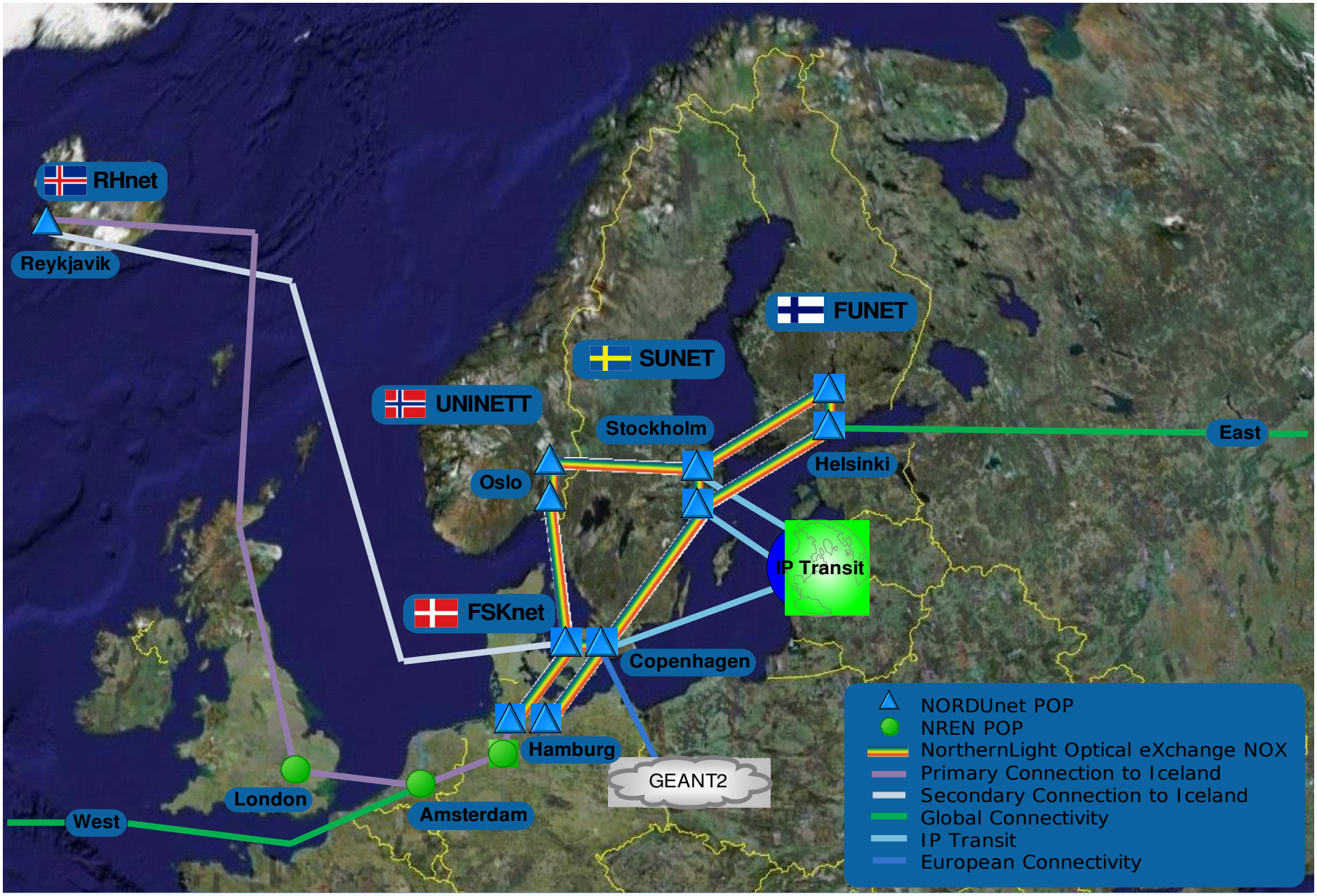
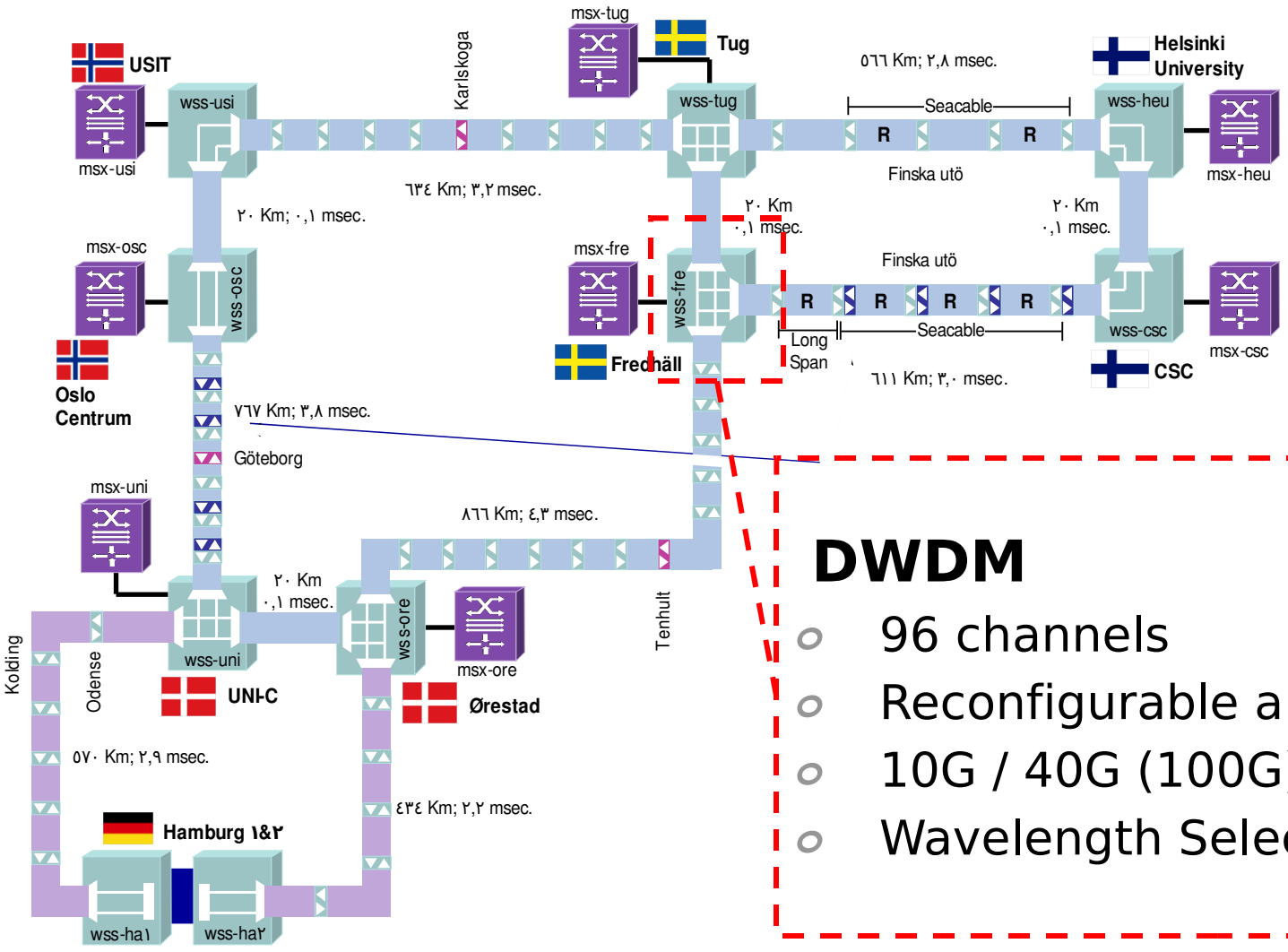
# NorthernLight 2008



# Optical Network




## DWDM

- 96 channels
- Reconfigurable and tunable
- 10G / 40G (100G) waves
- Wavelength Selector Switch

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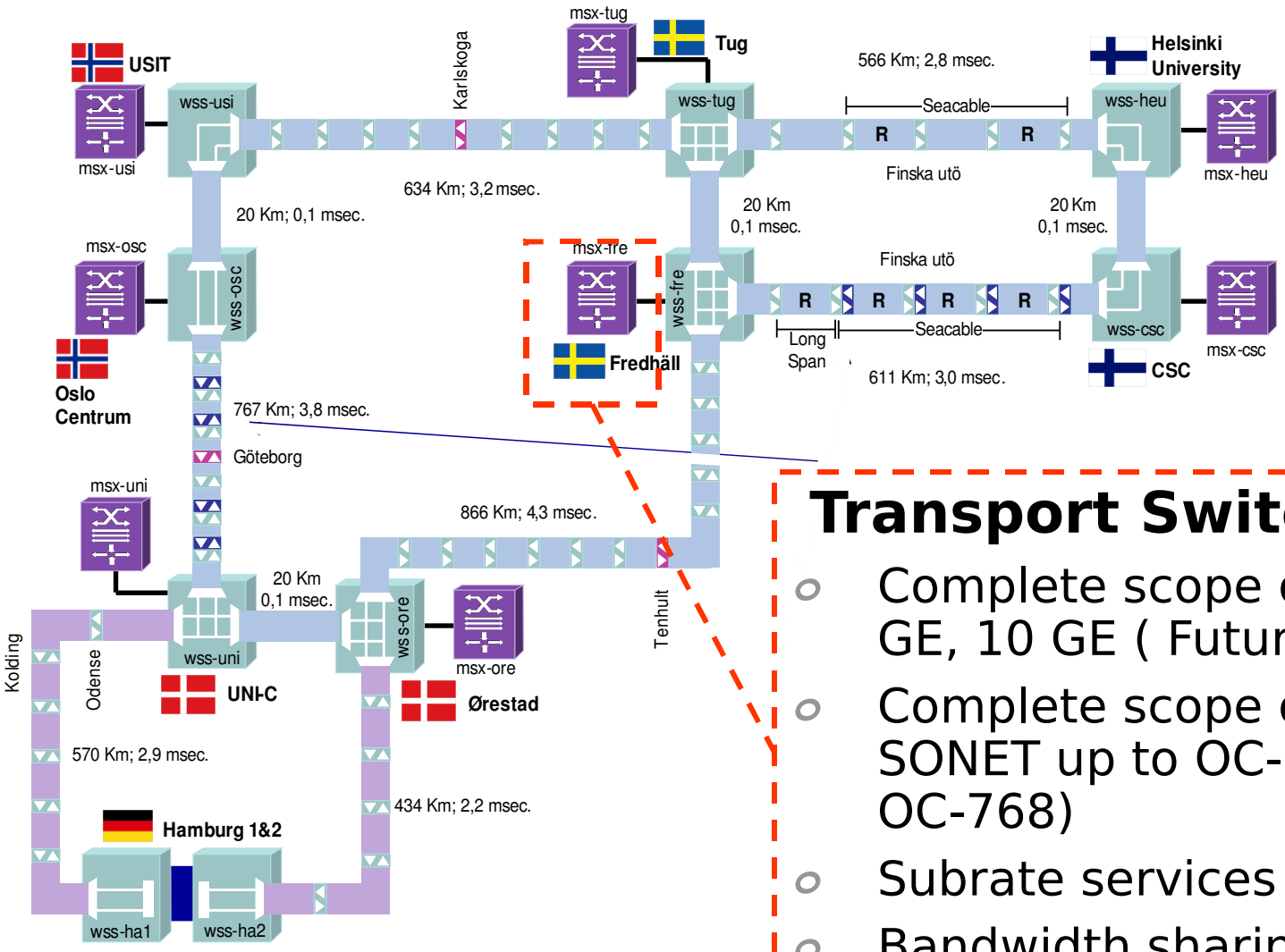
# Distributed Switch Fabric




## Transport Switching

- Complete scope of Ethernet 1 GE, 10 GE ( Future 40 & 100G )
- Complete scope of SDH / SONET up to OC-192 (future OC-768)
- Subrate services
- Bandwidth sharing, dynamic capacity allocation

# Additional Connections

- Short term
  - 10G Copenhagen - Reykjavik
  - 10G Amsterdam – New York City
  - 10G Copenhagen – London (using GEANT)
  - 2.5G Reykjavik – London
  - Switching platform in London, Reykjavik (?)
  - Additional IP, optical exchange points
- Longer term
  - Additional European CBF projects
    - Norway – Northern Russia, Finland – Russia CBF
    - Baltic States
    - Poland
  - ... more

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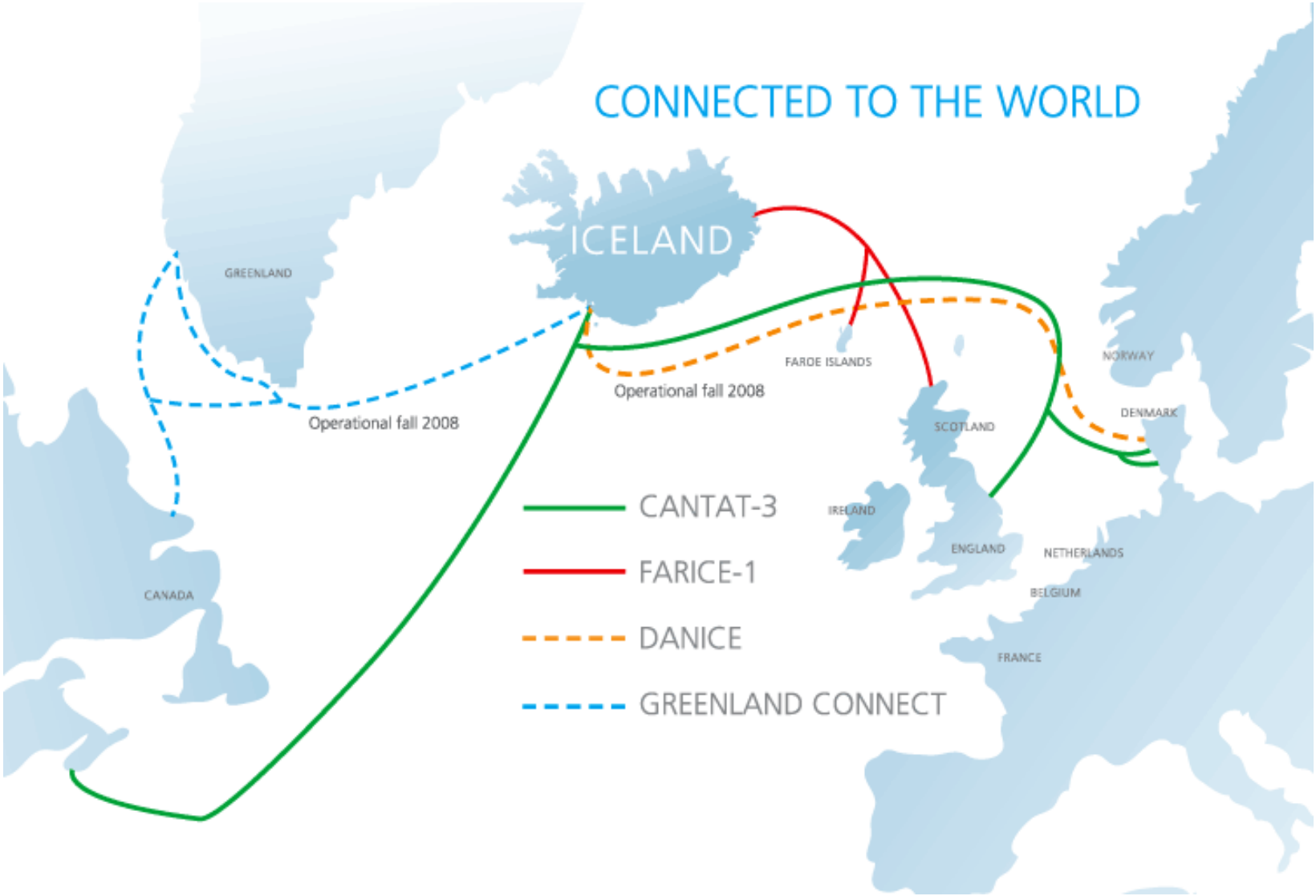
# North-Atlantic Connectivity



# A Distributed GOLE

- Goal
  - A distributed, open optical exchange
  - Redundant nodes in Copenhagen, Helsinki, Oslo, & Stockholm
  - Connect Anywhere, switch anywhere
- Challenge
  - Achieve a non-blocking, distributed switching capability
- Status
  - Distributed switching capability
  - Experimenting with (reasonably) transparent shaping / profiling / buffering

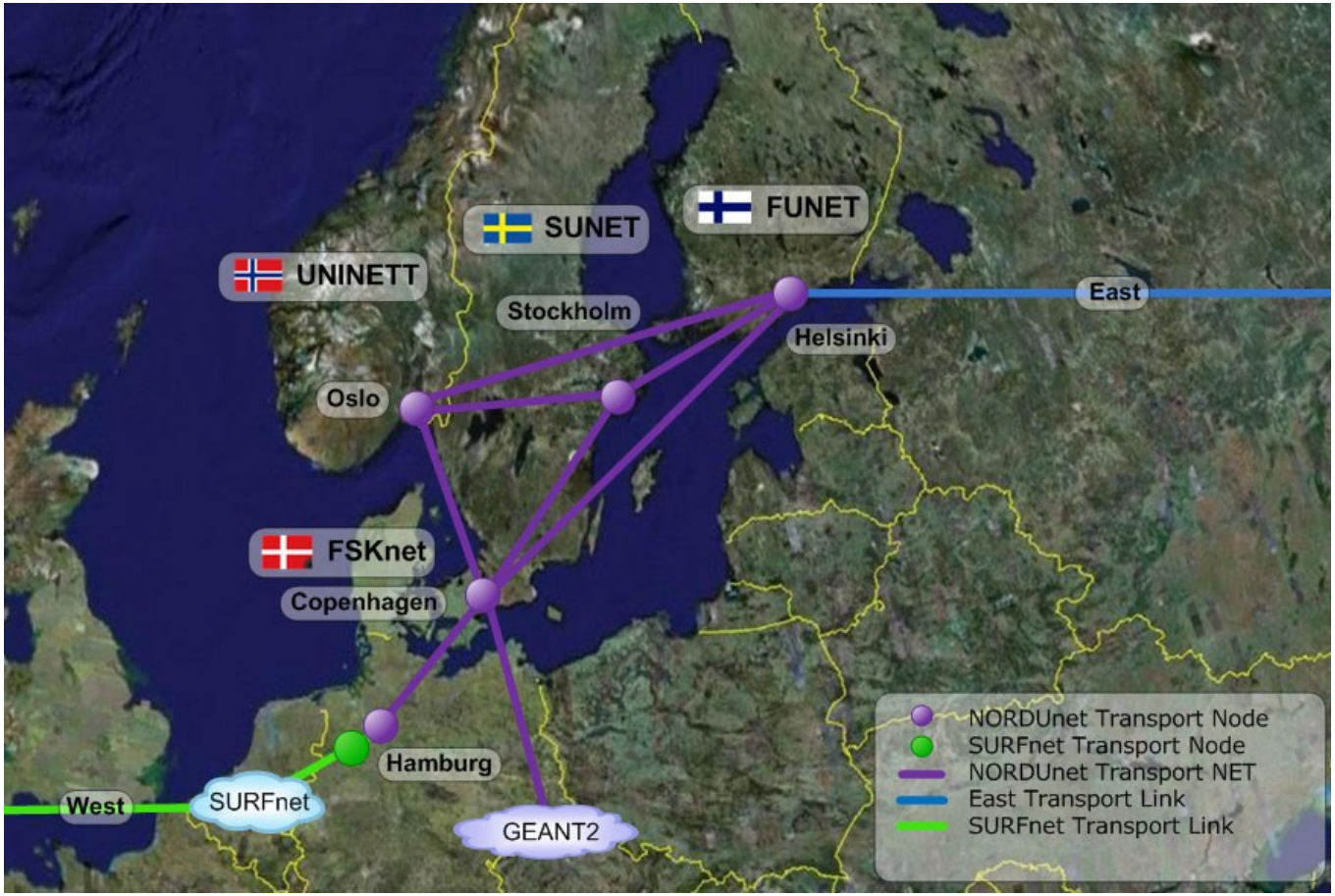
# NORDUnet Optical Exchange

## Interfaces type

- STM-4
- STM-16
- STM-64
- STM-256
- GE
- 10 GE
- OTU2
- OTU3

## Services

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



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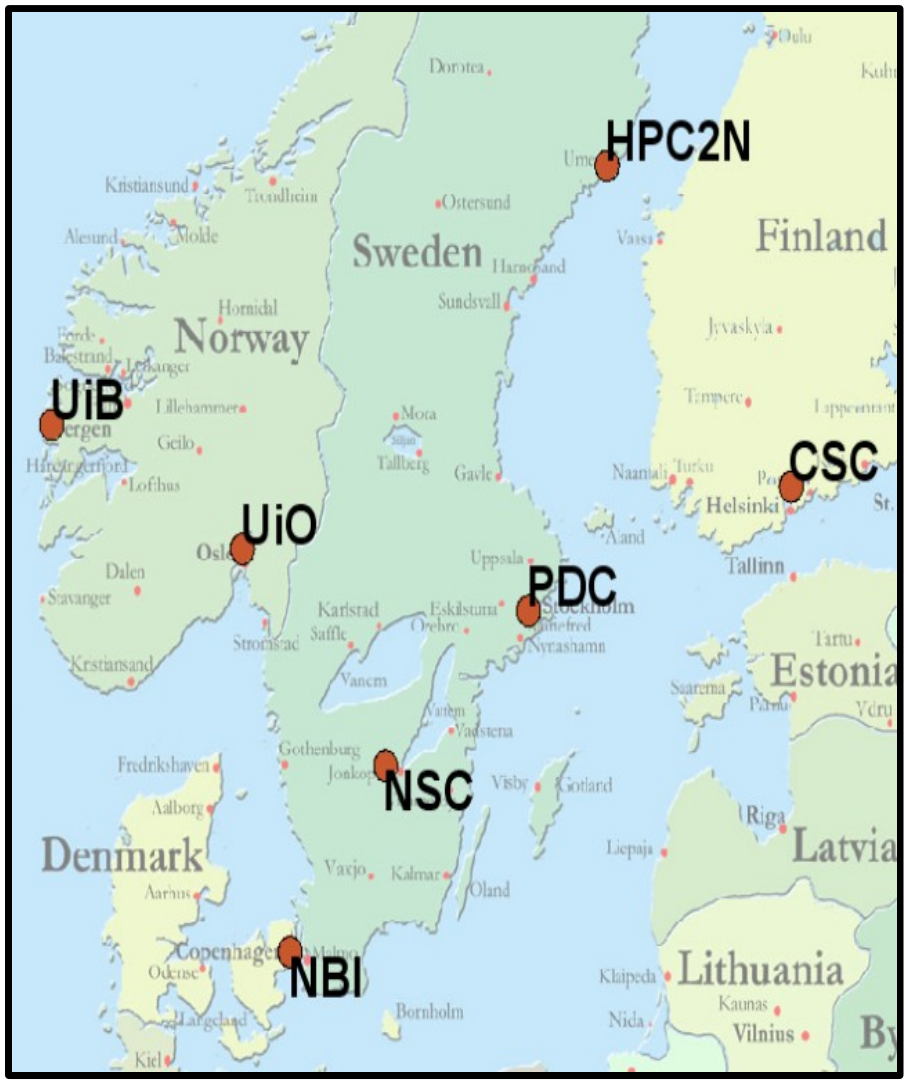
# Nordic NREN Optical Networks

- Sweden: SUNET
  - Dark Fibre & DWDM acquired
  - Ligthpath service in operation
  - Ciena
- Denmark: Forskningsnet
  - Dark Fibre & DWDM acquired
  - Lightpath Service being deployed
  - AlcatelLucent
- Norway: UNINETT
  - Dark Fibre & DWDM acquired
  - Ligthpath service in operation
  - Siemens
- Finland: FUNET
  - Dark Fibre & DWDM acquired
  - Lightpath service being deployed
  - NokiaSiemens Networks
- Iceland: RHnet
  - Dark fibre network in Reykjavik area

# NDGF Tier-1 for WLCG

- A virtual HPC centre, made of resources from major Nordic HPC sites
- Resources (Storage and Computing) are scattered
- 10G Private Network + 10G connections to LHCOPN (CERN, Amsterdam, Ljubljana)



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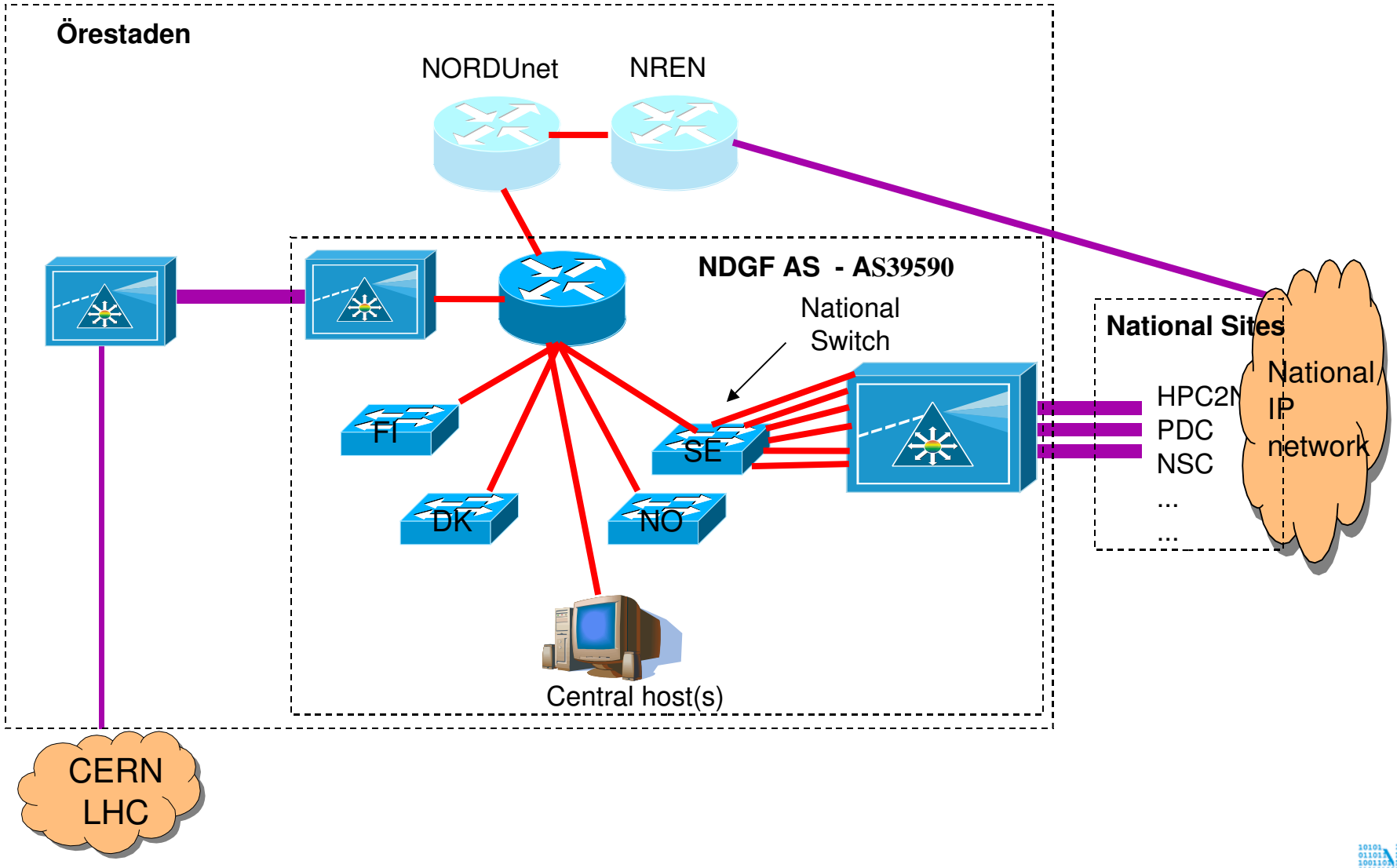
# NDGF Tier-1 Network



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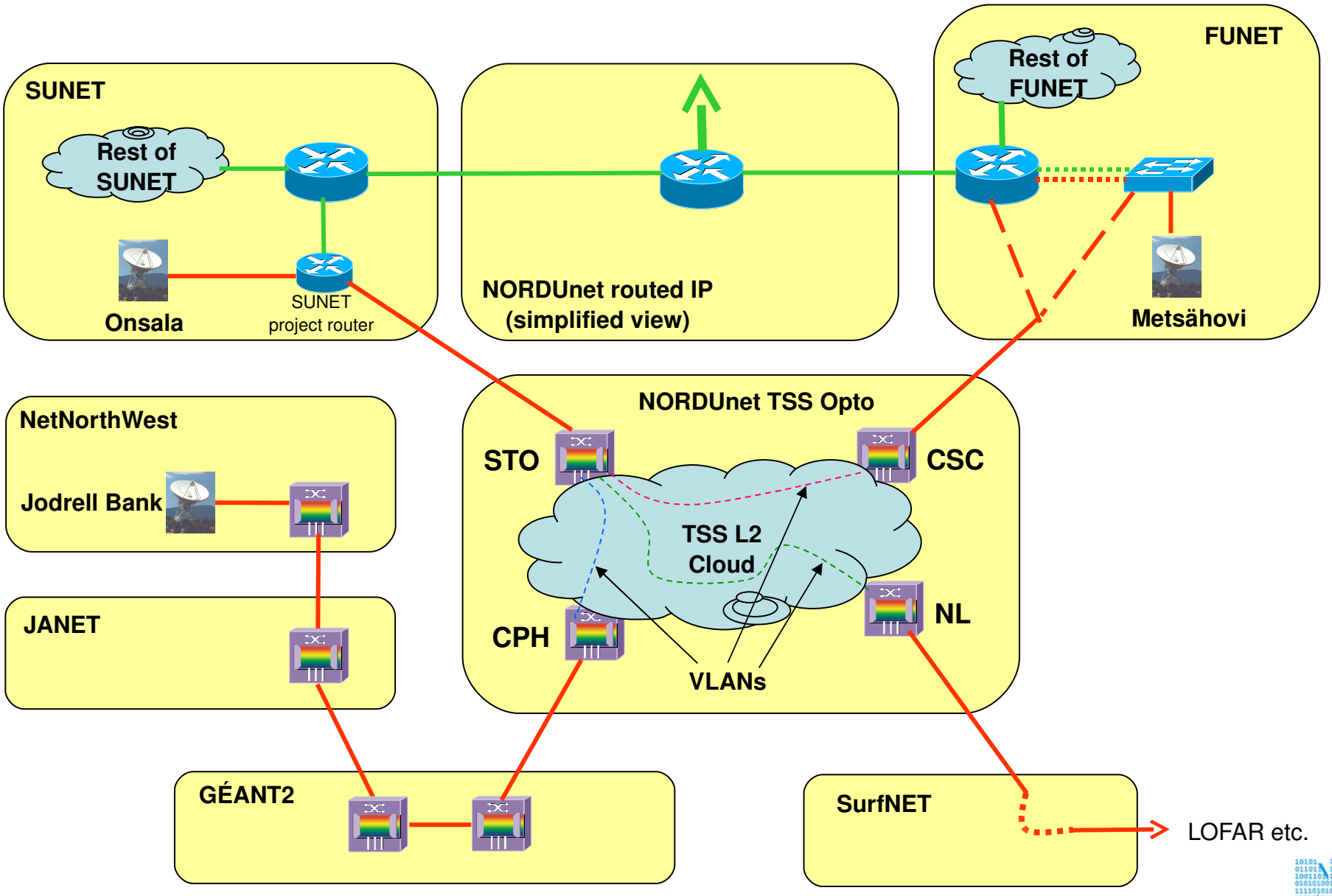
# Nordic Astronomy OPN

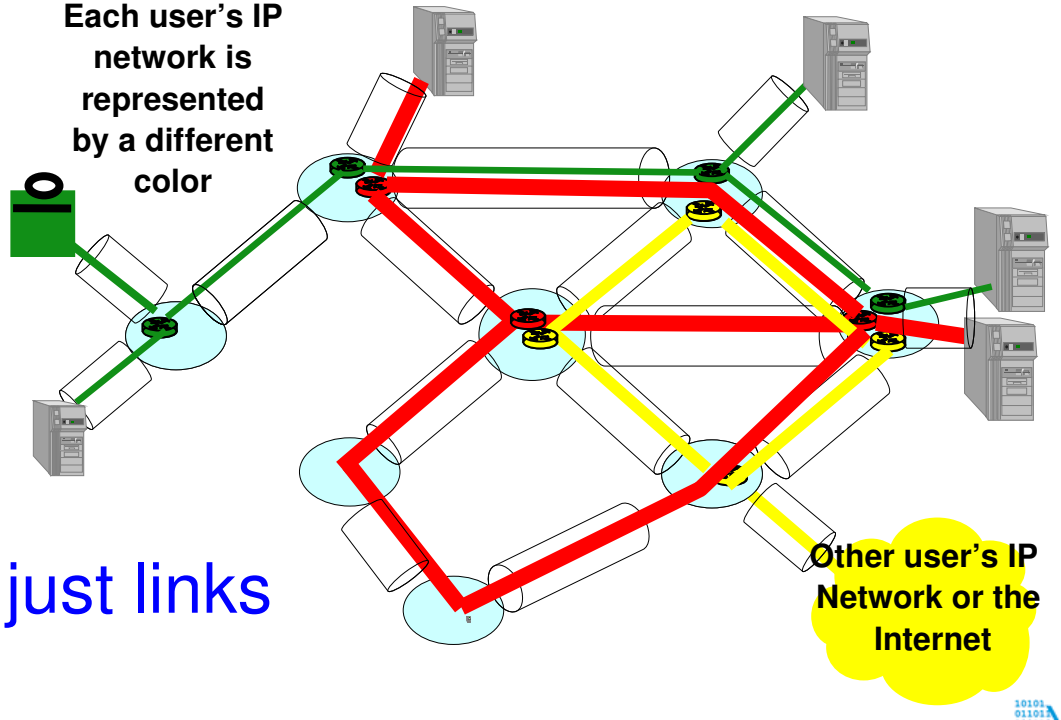


# Some Next Steps

- Dynamic Circuit Networking
  - Nordic DCN solution – NORDUnet and Nordic NRENs Interoperable with major DCN approaches
  - NORDUnet will participate strongly in GN3, including further AutoBAHN development
  - Participate in interoperability trials
- (Network) Virtualization
  - FEDERICA: European testbed for network and service virtualization
  - MANTICORE: Logical IP networks
- Transmission
  - Cross-border alien waves, multi-domain WSS
  - 40G, 100G trials

# MANTICORE

- Logical IP Networks, using IaaS
- Virtual community networks at L3, across multiple physical network domains
- Similar to IaaS at L1 / L2
- Many applications including lightpath last mile
- Provide user with routed network, not just links



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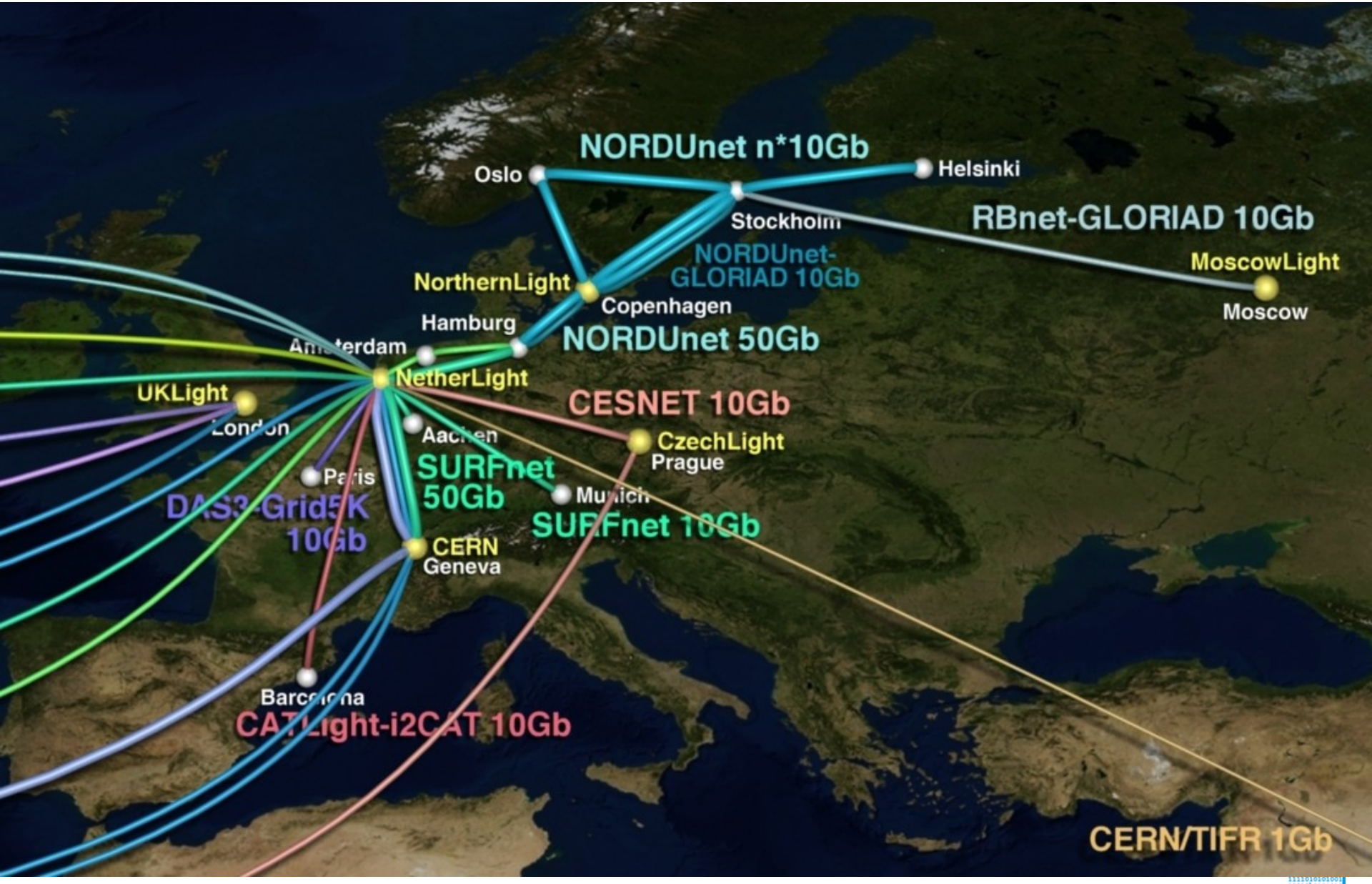
# With a little help from our friends...



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# Questions?

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