Concepts and Architectures for the Next Generation Academic Networks

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GÉANT

RUCIO Community Workshop

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Oslo

Agenda

Introduction

GN4-3 Third phase of the GEANT2020 Framework Agreement

The Fibre Renewal Plan

Evolution - Opening up the optical transport layer

Architecture - Opening up the packet layer

The Conceptual Design of ESnet6

The NORDUnet Next Generation Network

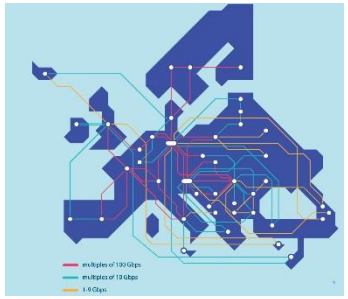
Summary

GÉANT Service Portfolio

GÉANT develops the specialist services members need to support researchers, educators and innovators – at national, European and international levels.

GÉANT's portfolio of advanced services covers:

Network centric services



Trust identity and security

eduroam

eduGAIN

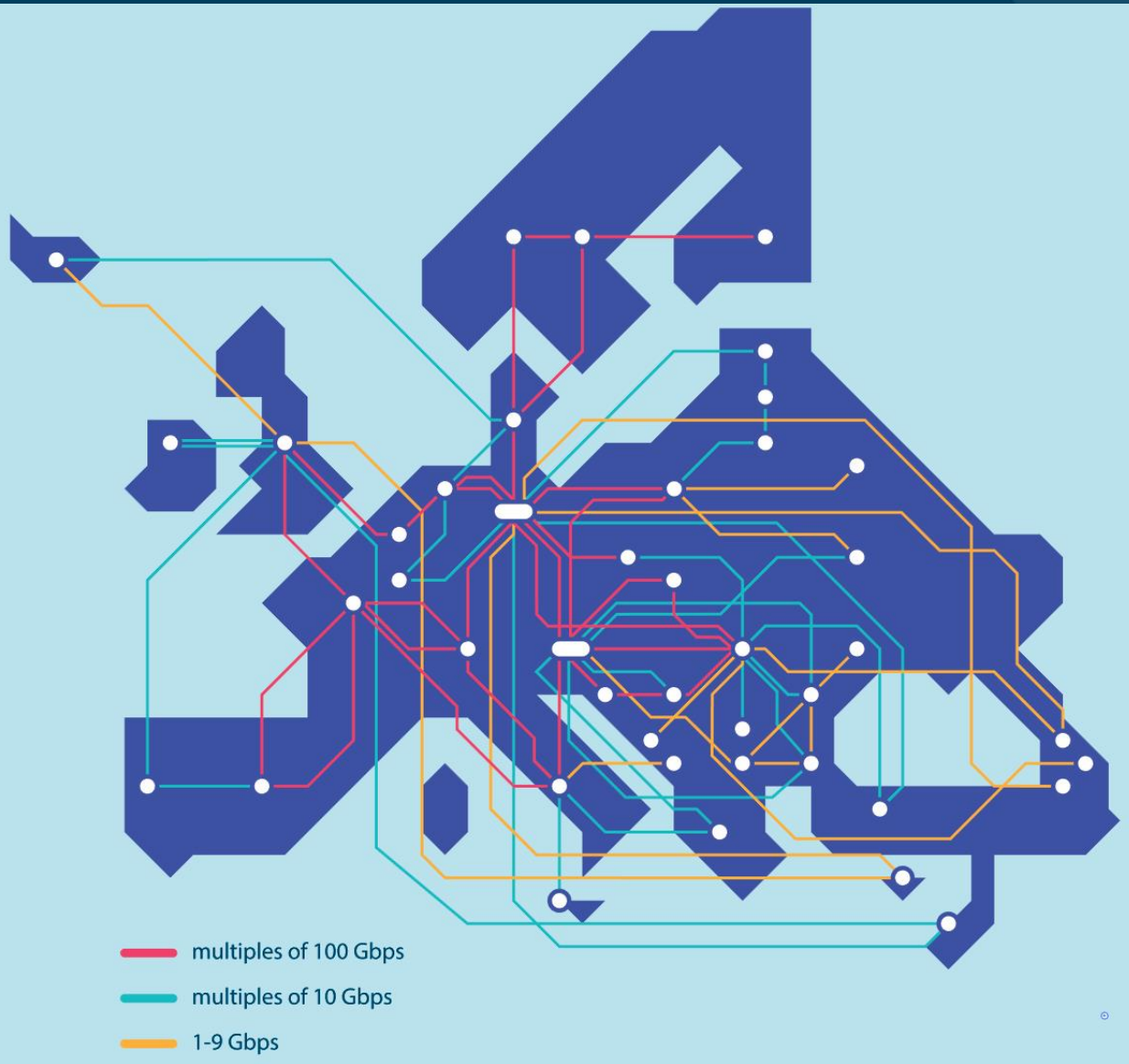
Storage and clouds

Real-time communications

Professional services

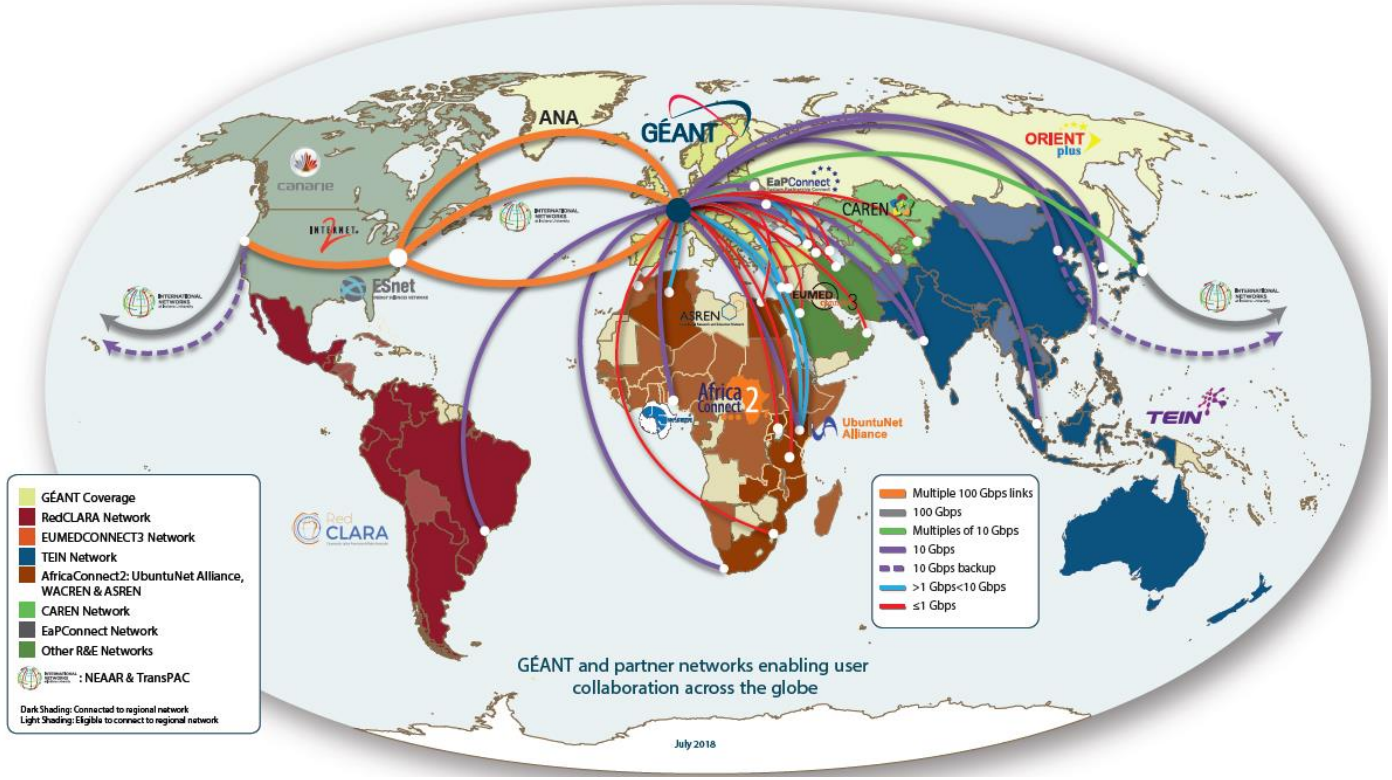
With thanks to:
Bridget Hannigan
Bram Peeters
Guy Roberts
Mian Usman
Tryfon Chiotis

European Network Connectivity



- **The GÉANT network interconnects Europe's NRENs over a 500Gb highly-resilient pan-European backbone.**
- **Two main networks**
  - Infinera based DWDM/OTN
  - Juniper based IP/MPLS
- **Wide range of Network services:**
  - GÉANT IP – 100Gbit/s or multiple 100Gbit/s.
  - GÉANT Point-to-Point Services – Dedicated connectivity up to 100Gbit/s .
  - GÉANT VPN – L3-VPN & MD-VPN for NRENs & institutions.
  - GÉANT Open – a protocol neutral efficient and flexible exchange.
  - Testbeds.
  - Performance monitoring – perfSONAR, eduPERT, GÉANT CERT.

Global Network Connectivity



- The GÉANT network interconnects research, education and innovation communities worldwide, with secure, high-capacity networks.
- North Atlantic – CANARIE, Esnet, Internet2
- Latin America – Red Clara
- Asia Pacific – TEIN, ORIENT plus
- Central Asia – CAREN
- Eastern Mediterranean - EUMEDCONNECT
- Africa – AfricaConnect2
- Eastern Partnership - EaPConnect

- Data transfer tests in 2017 between 10G servers in GÉANT and AARNET achieved 9.73 Gbps over 48 hours through R&E networks, whereas over commercial links this was only 1.77Gbps.
- Transfer tests between 100G servers in 2018 reached the TCP protocol limit for this RTT of 30 Gbit/s.

GN4-3 The Third phase of the GEANT2020 Framework Program Agreement

GÉANT
Networks • Services • People

GN4-1

May 2015 – April 2016

GN4-2

May 2016 – Dec 2018

GN4-3

Jan 2019 – Dec 2022

GN4-3N

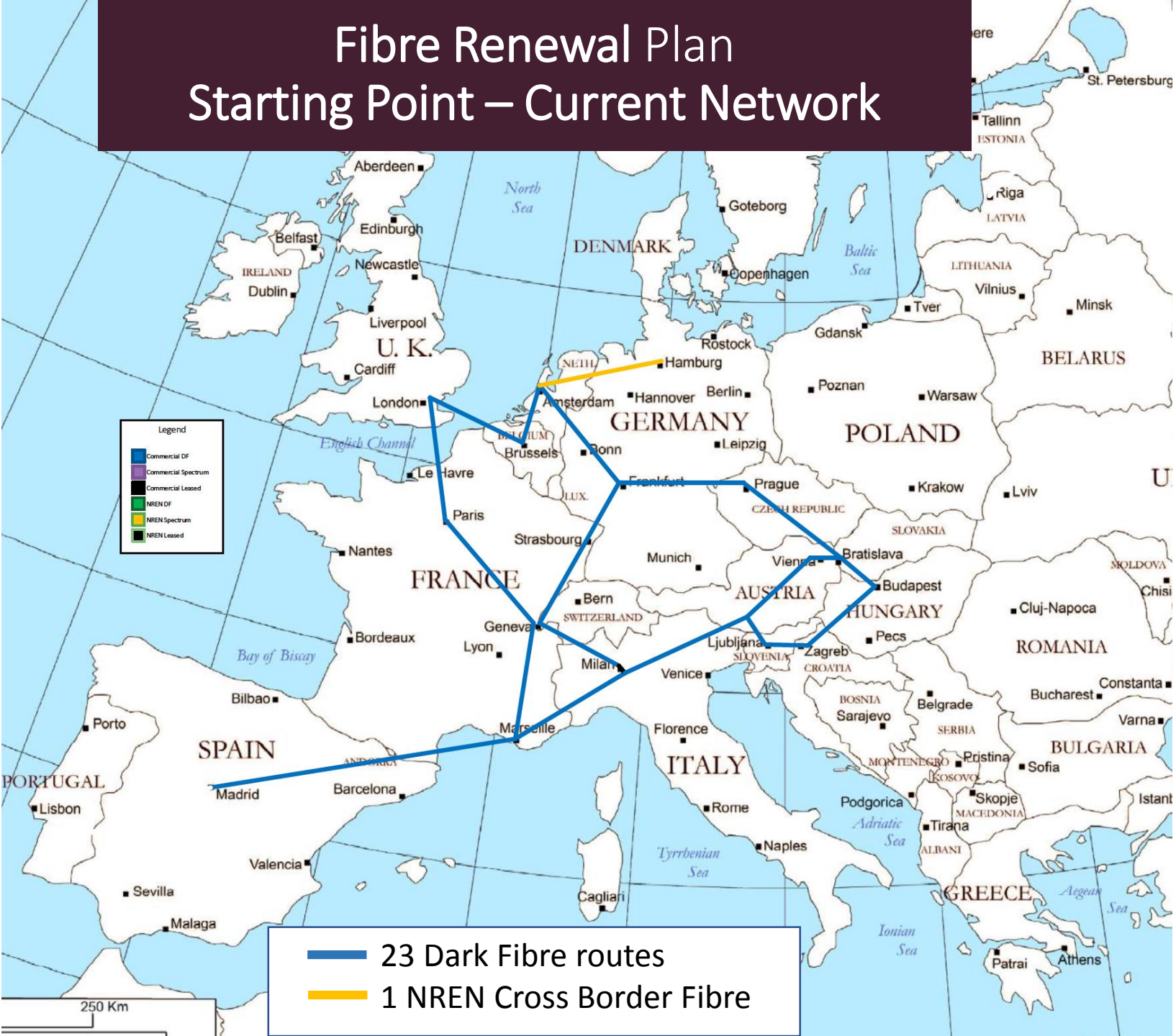
Jan 2019 – Dec 2022

Two Standard Grant Agreements

- GN4-3
  - Continuation of GN4-2
  - 77.5MEUR, 4 year duration until 2022
  - 10 activities ➔ 9 work packages
  - Work is grouped into 3 **Support**, 5 **Service DevOps** and 1 **Operations** WP

- GN4-3N
  - Improve the geographical coverage of the GÉANT backbone network using fibre optic technology, IRUs, CBF or spectrum sharing.
  - Purchasing of IRUs & associated equipment to expand the GEANT network
  - 50.5MEUR, 100% funding IRU & equipment, 4 year duration until 2022

Fibre Renewal Plan
Starting Point – Current Network



Current Fibre Network:

- **14 countries connected on fibre**
  - UK, BE, FR, CH, DE, AT, NL, HU, HR, IT, SI, SK, CZ, ES (spur)
- **Short term leases**
- **Agreements end 2020-21**
- **Other countries on leased lines**
  - Typical capacity multiple 10Gs

5 Regional study groups:

- **GÉANT – NREN collaboration on the new ecosystem.**
- **Renew/replace existing fibre infrastructure & extend the fibre reach across other regions**
- **Agree requirements & topology**
- **Make use of NREN resources where possible.**

Straw Man approved at GÉANT General Assembly June 2018

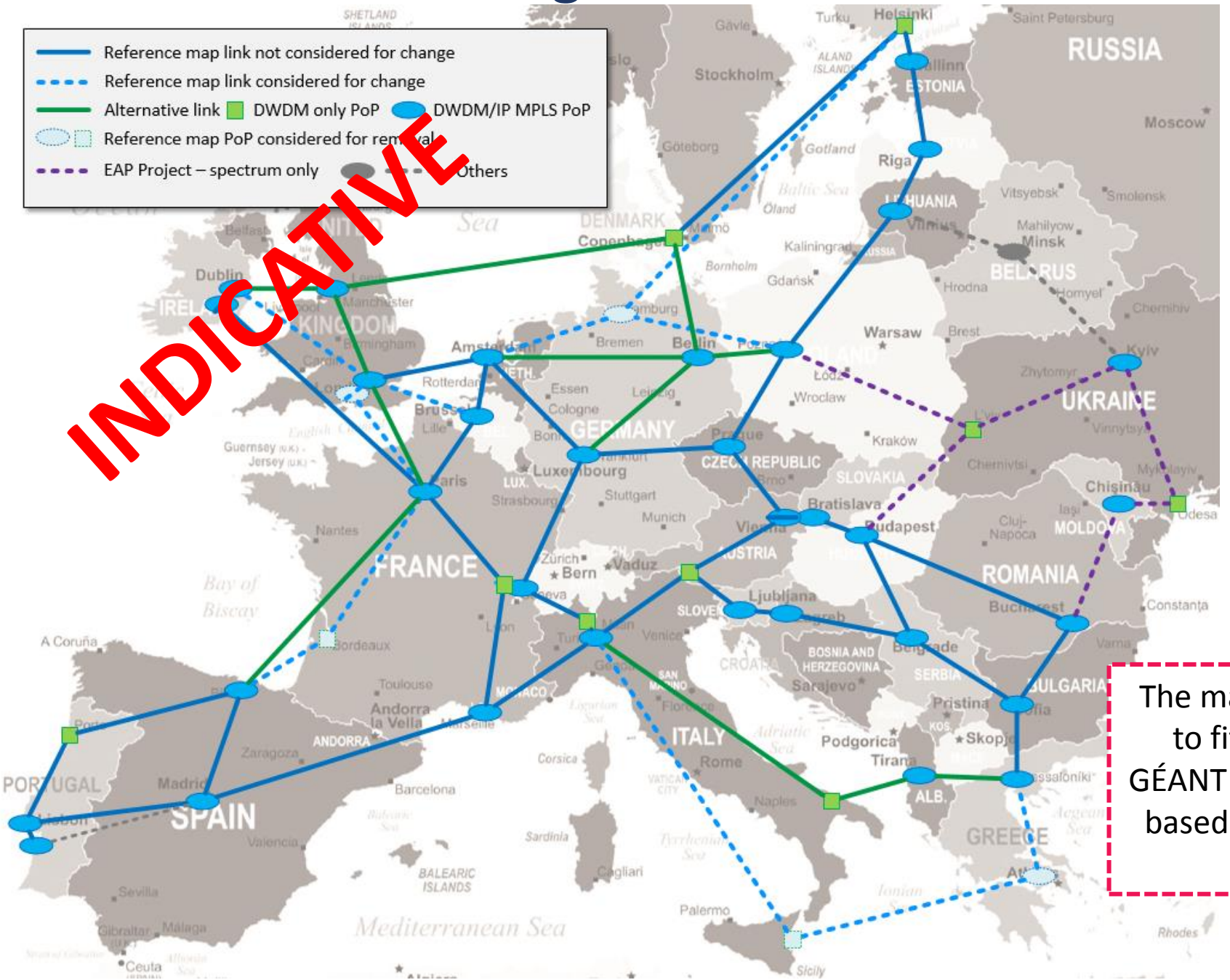
- **REPLACEMENT NETWORK proposal**
- De-risked: Included links that can be built with sufficient certainty
- Based on regional studies
- **Investment required: 48 M€**

Result: On fibre: 24 countries:
UK, **IE, PT**, ES, FR, BE, NL, DE, **EE, LV, LT, PL**, AT, CZ, SK, CH, HU, IT, SI, HR, **RO, BG, GR, RS**

CYNet, IUCC, MARNET, MREN, RASH, RESTENA, ULAKBIM:

- standard leased capacity (minimally 10GE, might be 100GE)
- or additional DF/spectrum projects as part of regional improvement / extensions

GN4-3N: View Including some of Eastern Partnership



Other locations not on footprint

Location	Example Lease	Spectrum/Fibre
Israel	2x 100G	YES
Cyprus	2x x10G	YES
Malta	1x x10G	YES
Turkey	2x 100G	YES
Luxemburg	2x 100G	YES
Montenegro	2x x10G	NO
Macedonia	2x x10G	NO

The map is showing some options on how to fit EAP connectivity with the wider GÉANT connectivity plans. Links selection is based on real infrastructure, but used for illustrative purpose only.

Network Evolution
Opening up the Optical Transport Layer

Vendor Proprietary Network Controller

- Proprietary and Closed APIs
- Vendor-Specific data model

Vertically integrated single vendor solution

Disaggregate: Open Optical Line System

Multi-vendor Open Network Controller/Orchestrator

- Open and Standard APIs
- Open data model

NMS

NMS

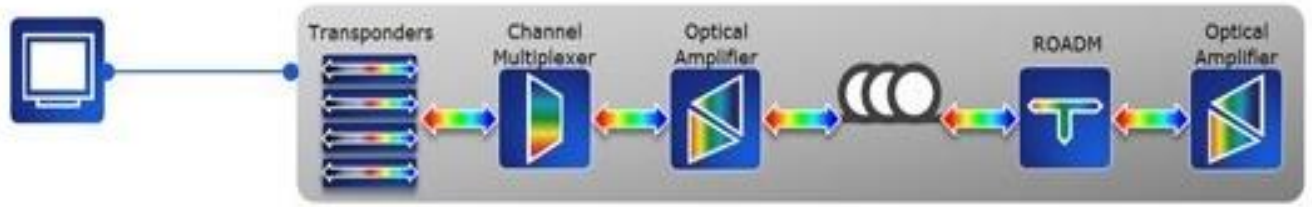
Multi-vendor, disaggregated solution

DCIs

Open Optical Line SYSTEM

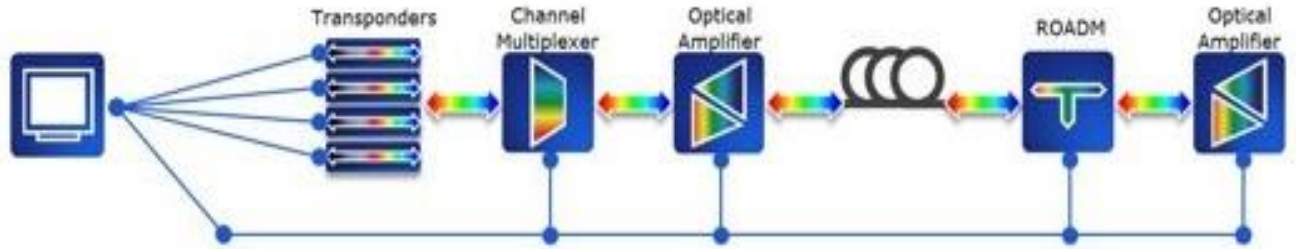
Open Line Systems

- No Disaggregation: Entire transport network acts as one element



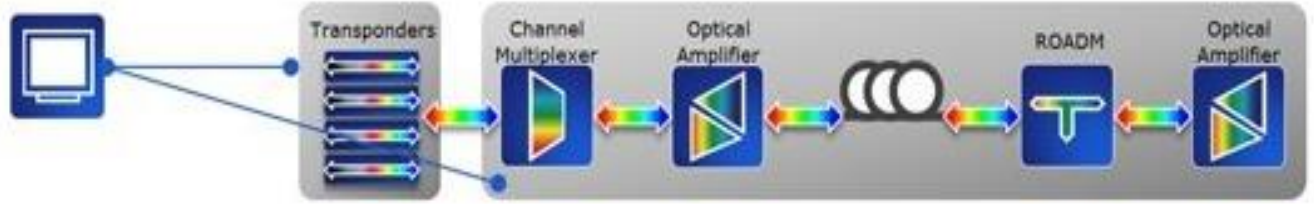
Current traditional closed interop 1 vendor model

- Fully Disaggregated: Everything is a separate network element



Long-term vision. But needs open standards and the management is under development

- Partially: Transponding is one element, OOLS is second.

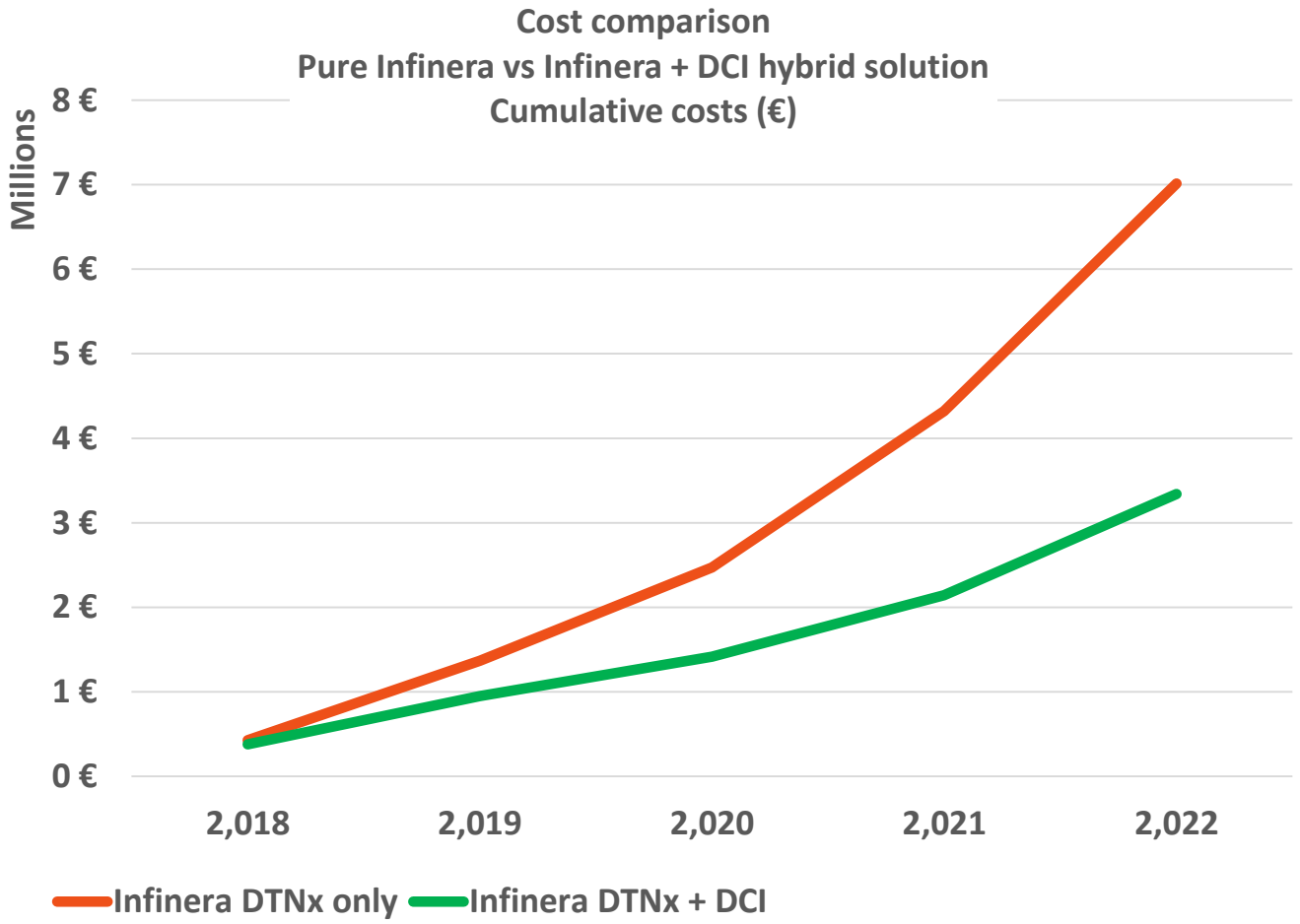


Medium term solution.
Optical edge open access, any transponder / optics in router.
Single management plane for OLS.

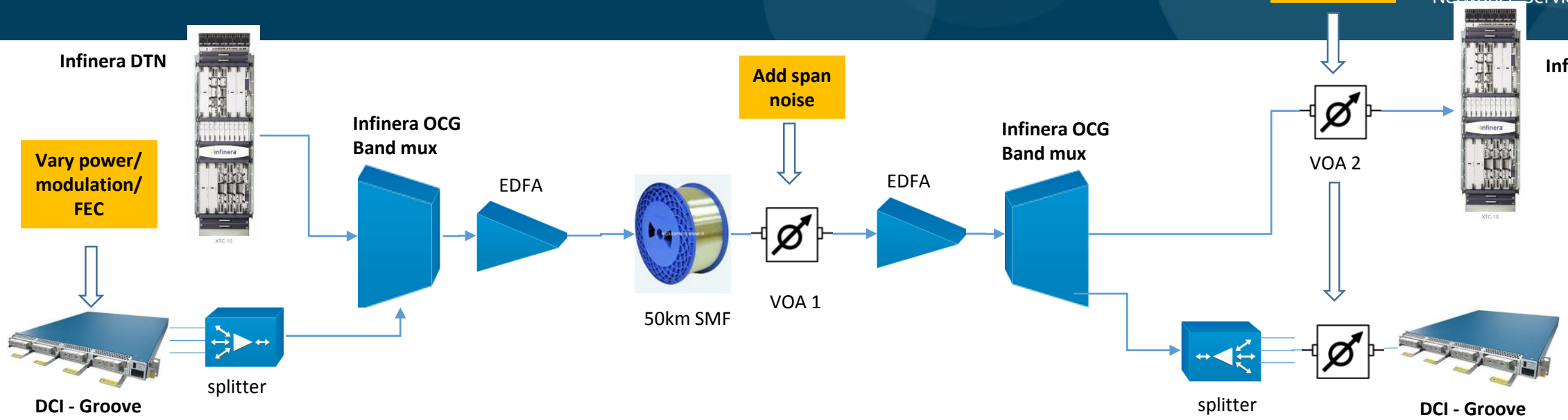
Powerful planning tools - understand impact

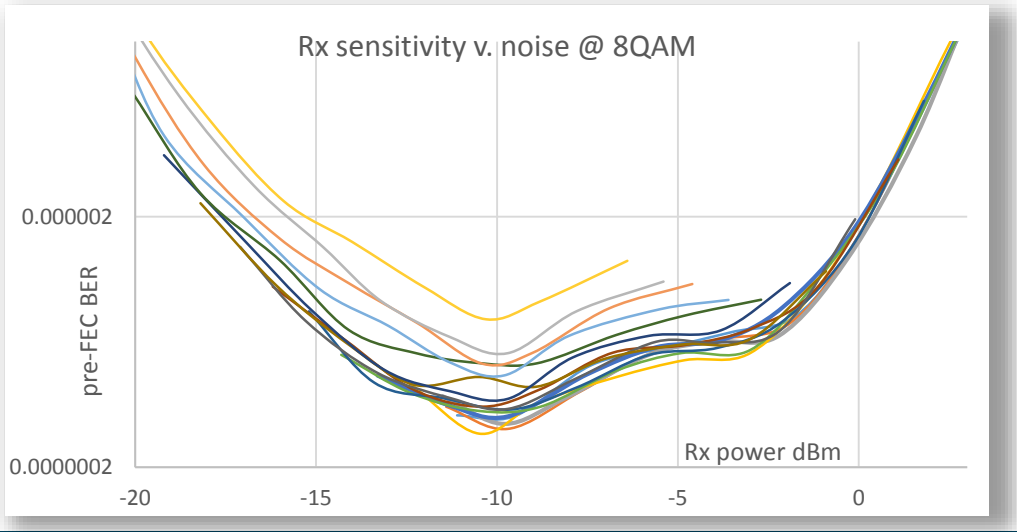
Guide introduction of new technology

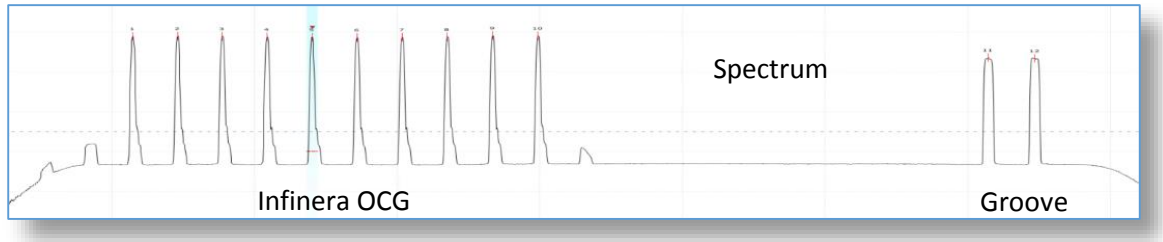
- Supporting growth on current Infinera DTNx leads to very high costs, and is not effective
  - Major changes expected on Network in next few years – DTNx components may be obsolete
  - Requirement-to-Technology mapping not optimal for DTNx – 70% of capacity does not use (expensive) OTN switching capabilities
- Modelling used to understand **how** and **where** DCIs should be used to integrate the Infinera system to offset short term issues and optimize investment



Network Engineering Lab Automation: Testing Infinera Groove G30 Optical Layer and Alien Waves







- Scripting allows to set/read all parameters
- Dozens of optical settings for new transponders
- **Automation allows hundreds of tests to be run overnight**

Planning and deployment of DCIs

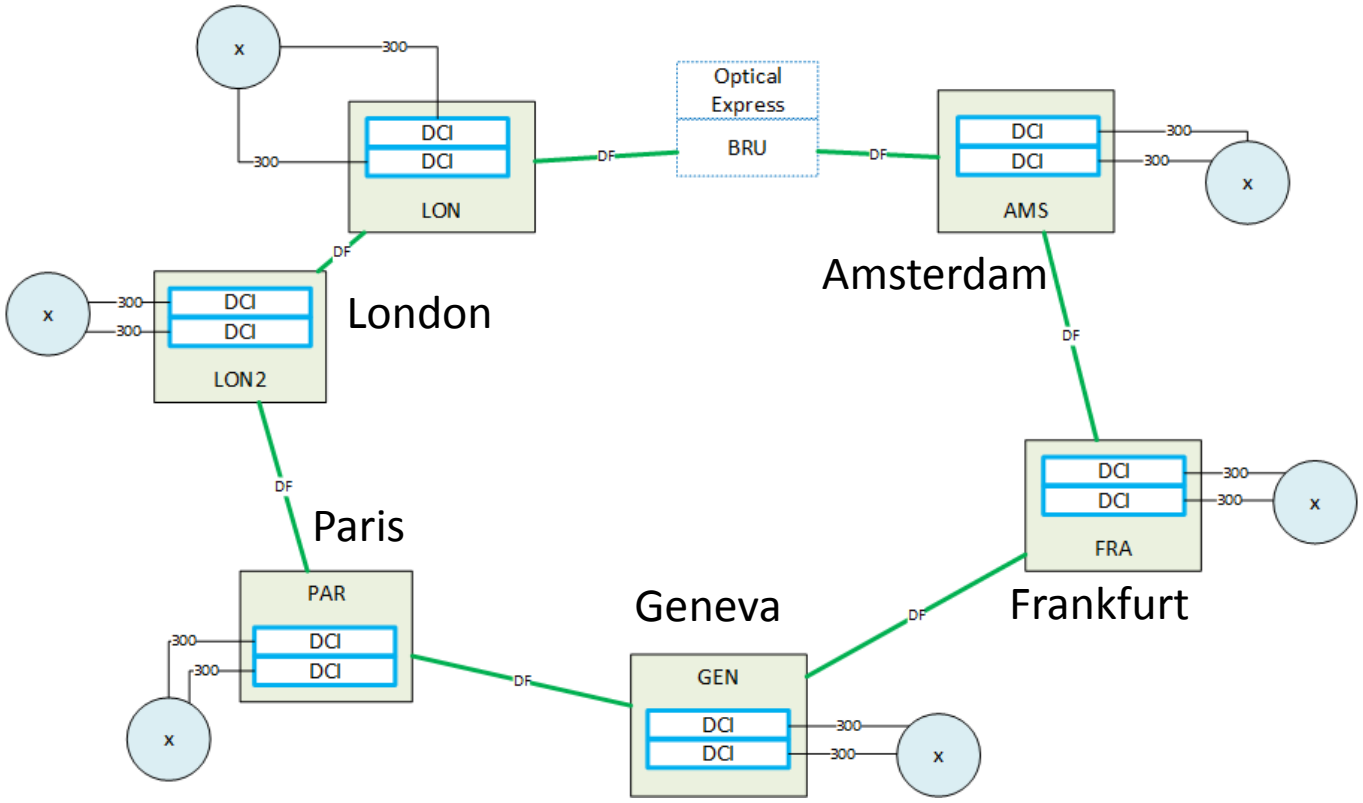
Plan for deployment completed during 2018 - based on modelling and analysis

2 phases:

- **Phase 1** (2018-2019) – Western ring IP trunks move to DCI and upgrade to 300G
- **Phase 2** (2020) – Milan - Marseille – Geneva IP trunks move to DCI

First 300G link live in GÉANT from December 2018 (Lon1-Lon2)

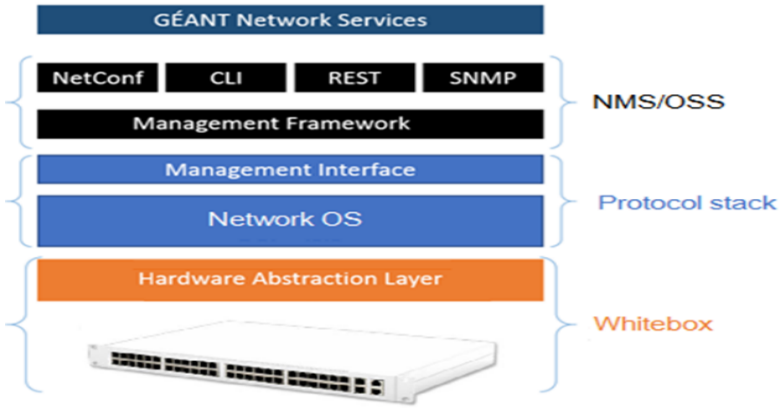
Phase 1 overview



Network Evolution
Opening up the packet layer

Options:
cost effective solution

Disaggregated



Current vendor

Alternate aggregated

The IP/MPLS layer – OPEX optimisation / MX204

- Maintenance cost could be optimised for small PoPs in GÉANT
- MX204 tested for operational deployment and procured
  - Low cost of change, as no integration work is required, no forklift migration.
  - Fewer new skills to learn for the Ops and NOC teams
  - Both software and hardware support provided by a single vendor.

MX 204

4x QSFP – 1x100G or 4x10G

8x SFP – 1G or 10G

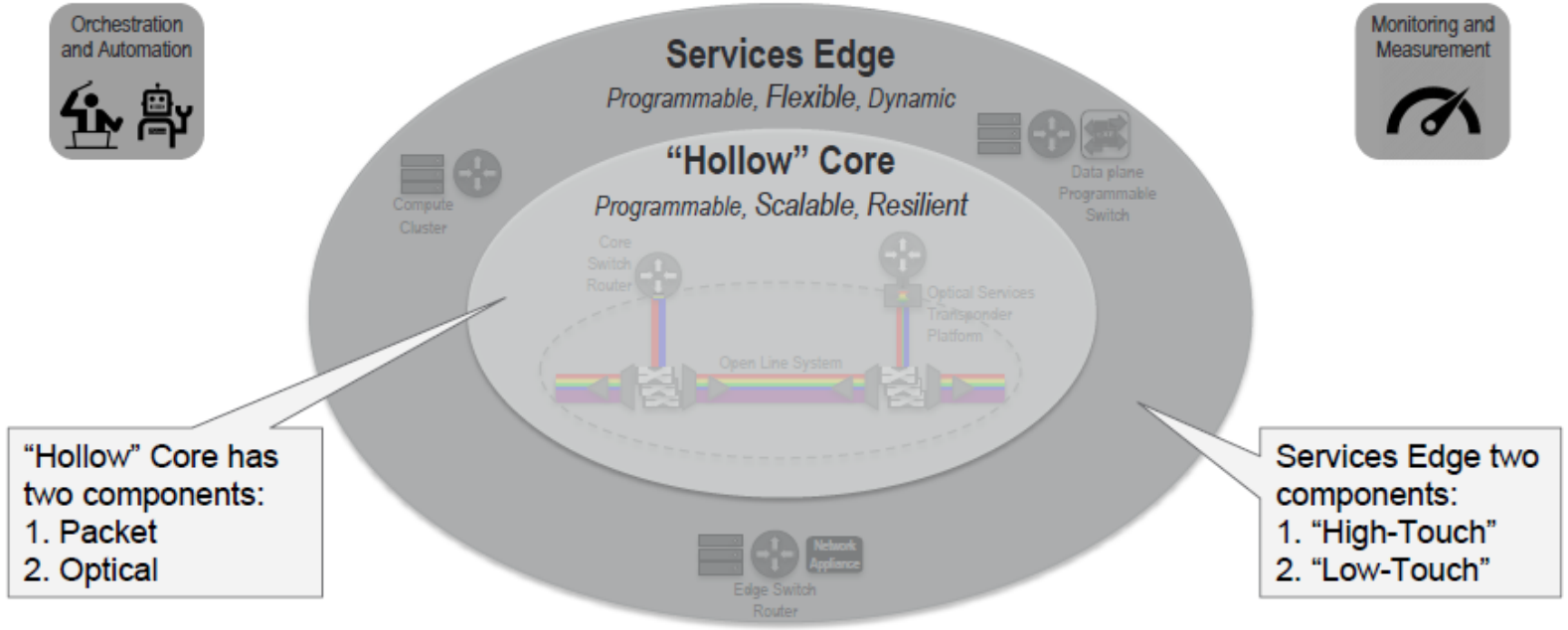
400G total switching capacity
Enhanced QoS
PTP support
Dual PSU
Single routing engine

80% OPEX reduction

70% less power

Deployment plan:
Q2 - 2019

The ESnet6 Conceptual Design



"Hollow" Core

- ***Programmable*** – Software driven APIs to allocate core bandwidth as needed, and monitor status and performance.
- ***Scalable*** – Increased capacity scale and flexibility by leveraging latest technology (e.g. FlexGrid spectral partitioning, tunable wave modulation).
- ***Resilient*** – Protection and restoration functions using next generation Traffic Engineering (TE) protocols (e.g. Segment Routing (SR)).

Services Edge

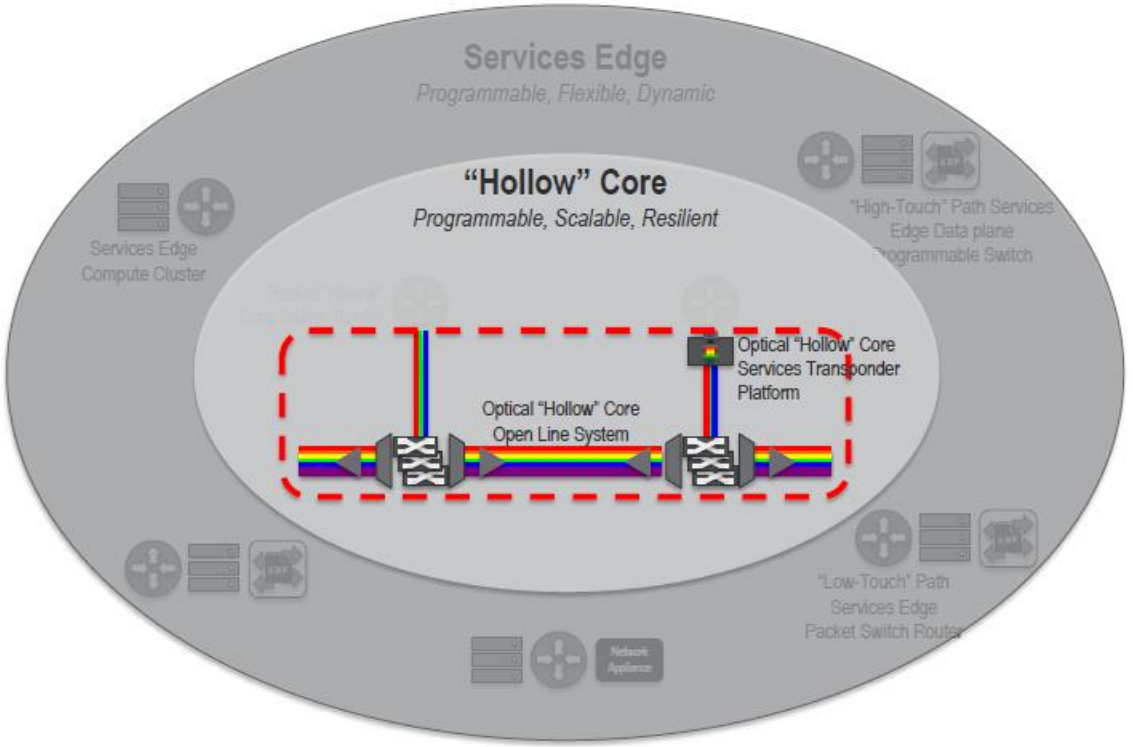
- ***Programmable*** – Software driven APIs to manage edge router/switch and retrieve telemetry information.
- ***Flexible*** - Data plane programmable switches (e.g. FPGA, NPU) in conjunction with compute resources to prototype new services (driven by Software Defined Networks (SDN))
- ***Dynamic*** – Dynamic instantiation of services using SDN paradigms (e.g. Network Function Virtualization (NFV, Virtual Network Functions (VNF), service chaining).

ESnet

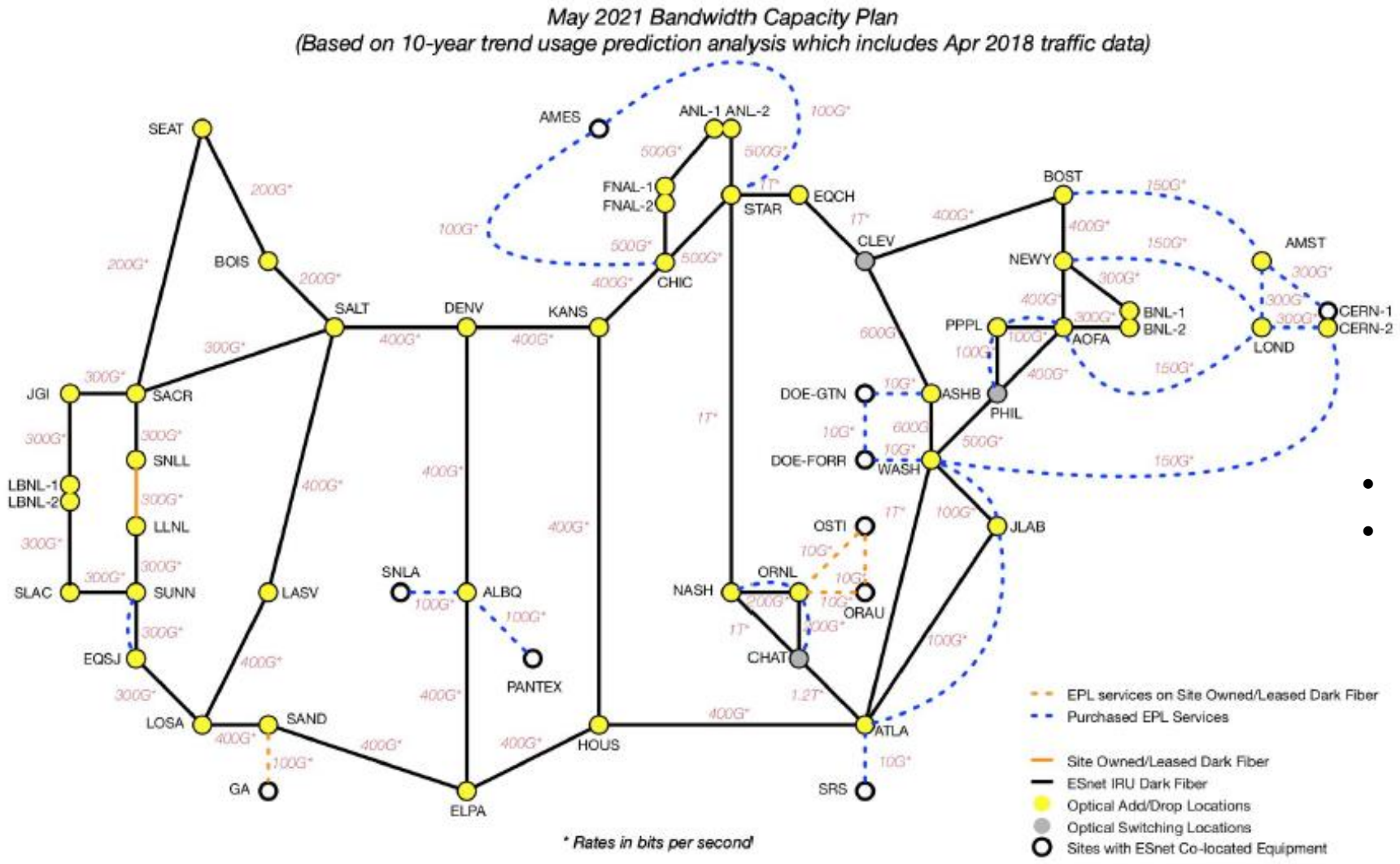
With thanks to Chin Guok

ESnet6 Optical “Hollow” Core

- Provided raw capacity to meet ESnet6 project day-1 deployment needs and incremental growth over the ESnet6 network lifespan.
- Support reliable connections over a wide geographic area in the most scalable, flexible, and cost-effective way possible.
- **Leverage an Open Line System model** to support integration of foreign (3rd party) transponders (transmitters/receivers) and enable multi-vendor ecosystem to eliminate vendor lock-in.
- Select higher-order modulation rates to maximize aggregate spectral efficiency over varying distances
(e.g. 400Gbps for 500km, 200Gbps for 2000km).



ESnet6 Proposed Footprint



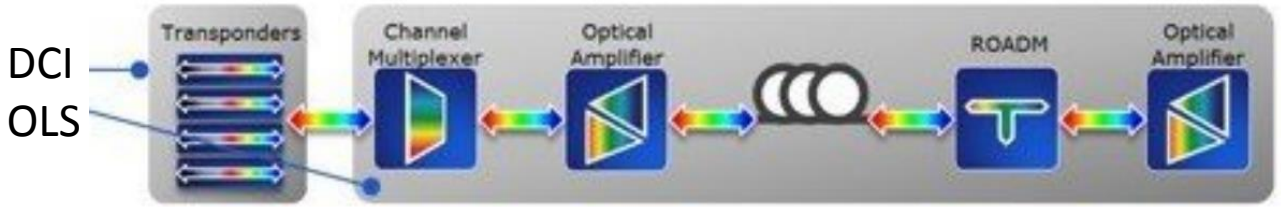
- Adding more fibre
- Increasing Bandwidth

Current NORDUnet topology

With thanks to
Jørgen Qvist

Technology for NORDUnet Nextgen

- 100G coherent
- Open Line System (OLS)
- Partial disaggregation with OLS from the same provider
- Control / management simplified
- Use of Data Centre Interconnect (DCI) Transponders

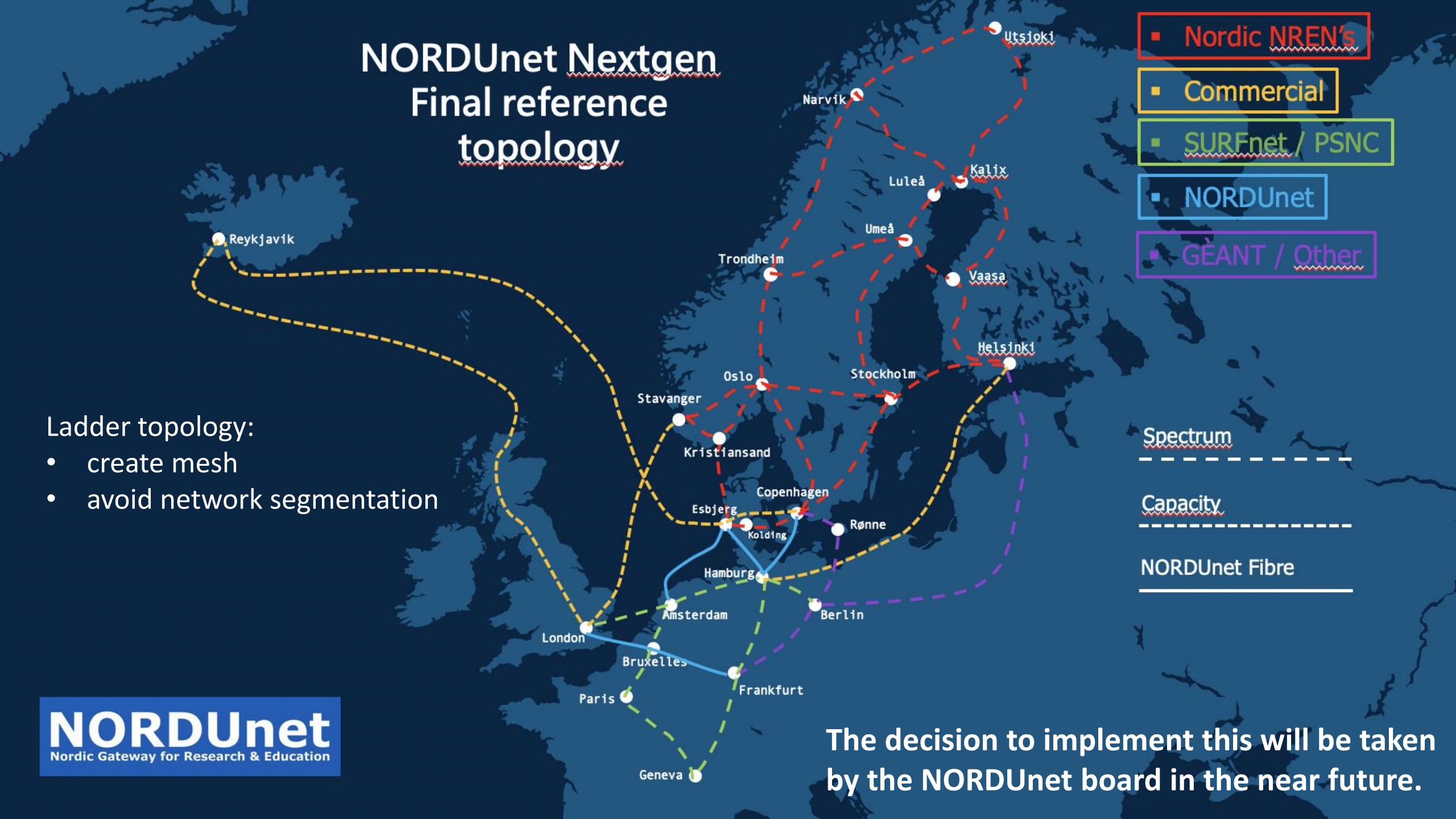


Nextgen Infrastructure

- A lot of experience in running alien waves with SURFnet and PSNC.
  - Collaborations using shared infrastructure
  - Experience with operations of shared infrastructure
- Network working group of Nordic NREN CTO’s and senior techs to agree a Common set of objectives, Cost model and Topology.

- Nordic NREN’s will provide NORDUnet with the required spectrum in their respective networks
- NORDUnet will cover the cost of getting access to the spectrum (incremental cost)
- Reuse of existing Ciena OLS platform to lower the initial investment.

NORDUnet Nextgen Final reference topology



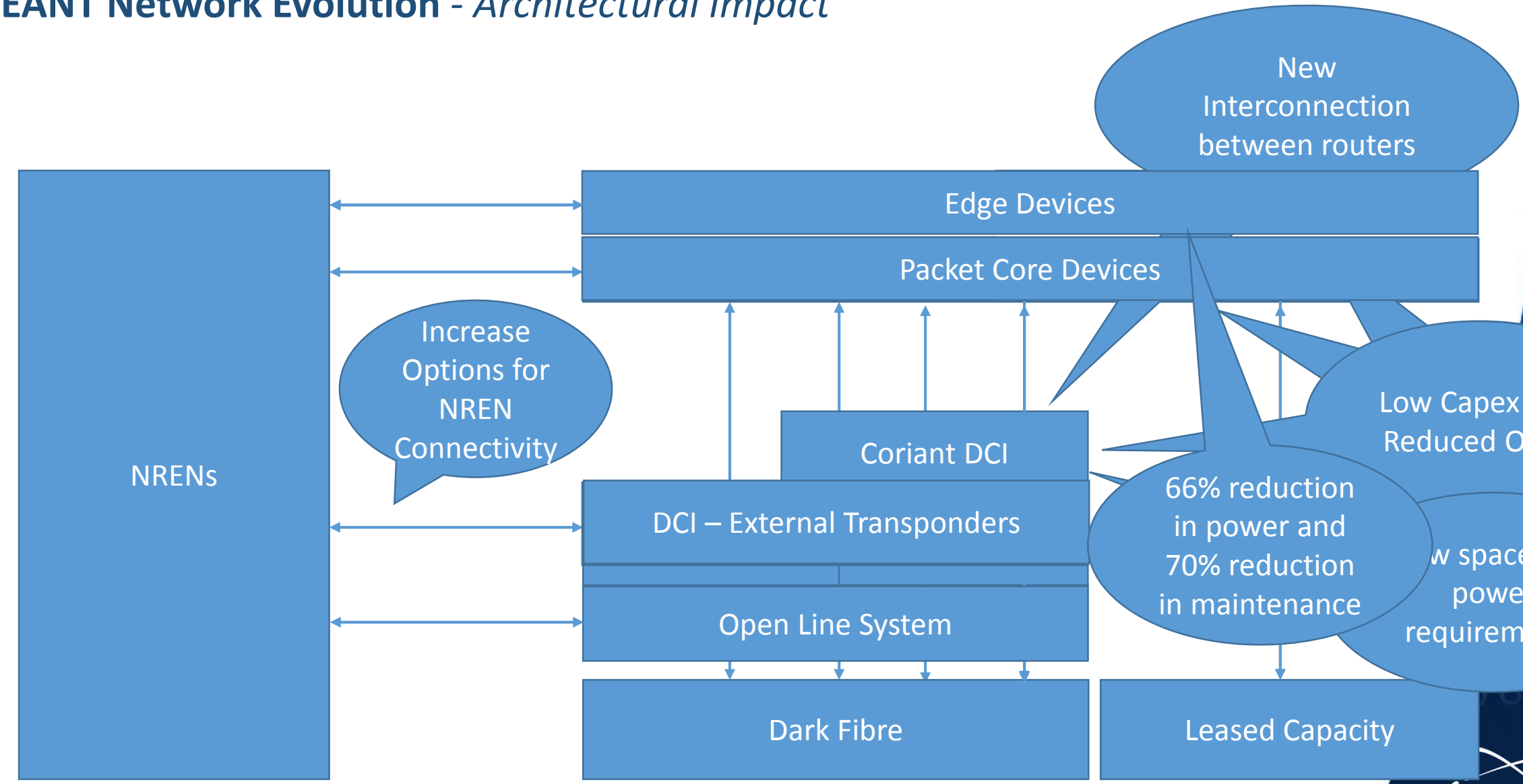
Ladder topology:

- create mesh
- avoid network segmentation

NORDUnet
Nordic Gateway for Research & Education

The decision to implement this will be taken by the NORDUnet board in the near future.

GÉANT Network Evolution - *Architectural Impact*



Summary

- The fibre infrastructure is being renewed or replaced and coverage extended across Europe.
- Making use of shared NREN resources where possible.
- Adopt partially disaggregated Open Optical Line System provides flexibility and lower costs.
- Introduction of Data Centre Interconnect transponders to better track technology, provide more options to connect NRENs, and lower the cost.
- OPEX optimisation of the IP/MPLS layer by opening up the packet layer.

- Virtualization - as a way to separate traffic and create virtual private networks
- Automation - Automation at all layers of the network (SDN / NFV), speed up provisioning and increase security.

Thank you

Any questions?

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