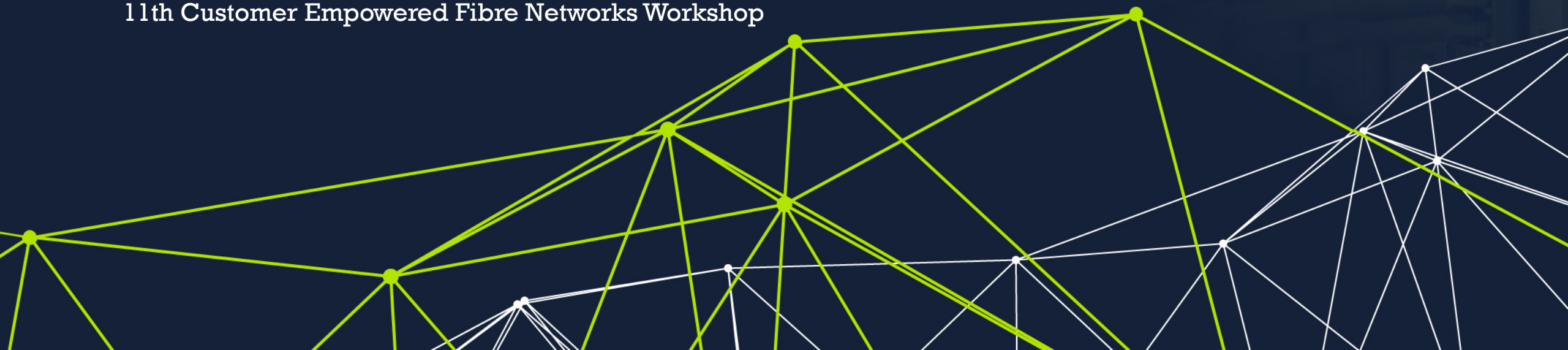


Data Center Interconnection over Spectrum Sharing

Matteo Colantonio

April 18th, 2023

11th Customer Empowered Fibre Networks Workshop



Outline

- Spectrum Connection Service
- CERN-CNAF DCI

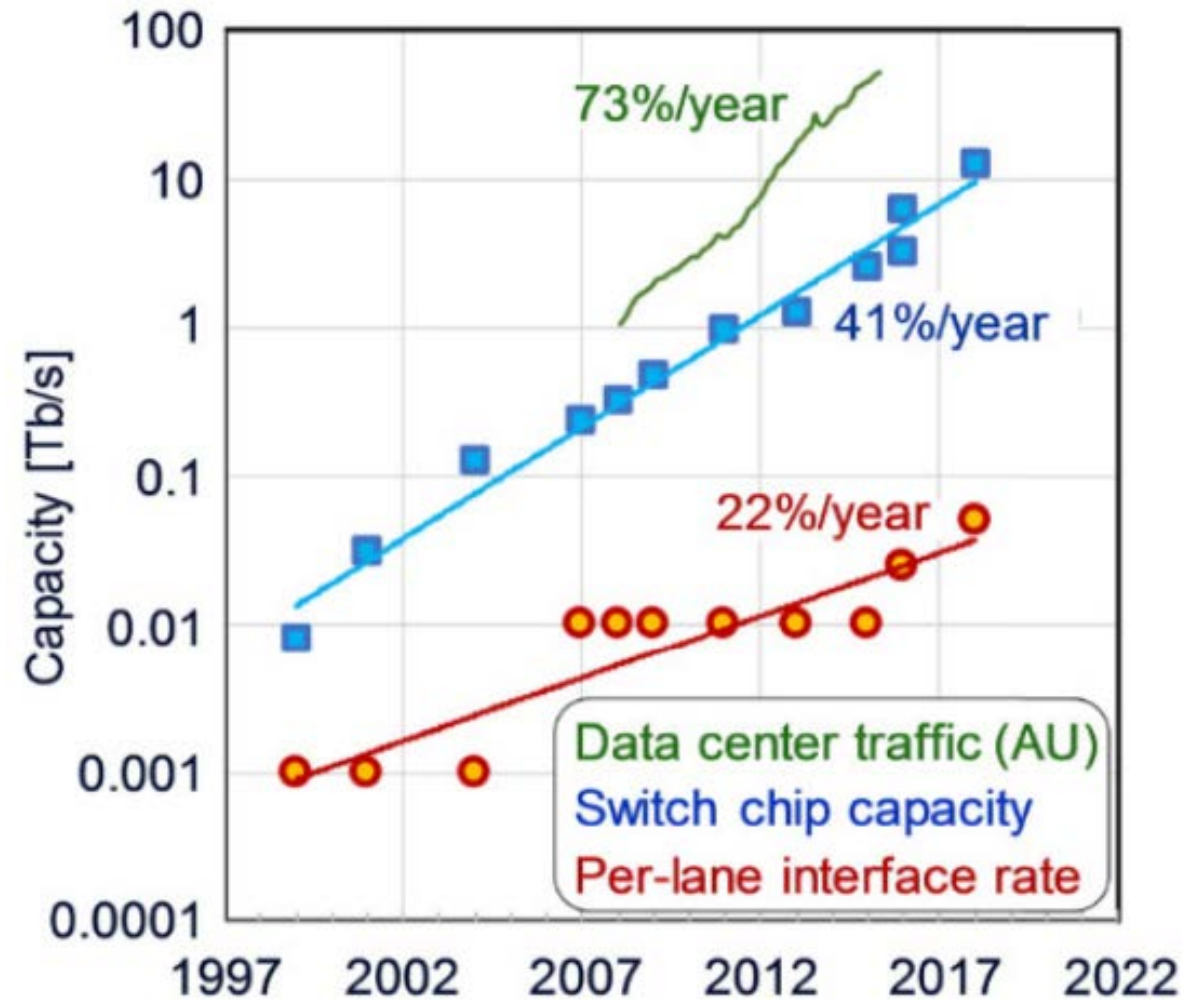
Motivation

“It is foreseeable on the 2030s timescale to connect most of the large HEP data centers with dedicated and private multi-Tb/s network links.”

Campana, Simone, et al. "HEP computing collaborations for the challenges of the next decade." arXiv preprint arXiv:2203.07237 (14 Mar 2022).

“LHC requirements for Run4 (2029) [...] Larger Tier1s are supposed to get connected to CERN and to their Tier2s at 1 Tbps.”

Martelli Edoardo, "Networks for High Energy Physics: LHCOPN and LHCONE", AmRP Working Group Meeting (11 Oct 2022)



Peter J. Winzer, David T. Neilson, and Andrew R. Chraplyvy, "Fiber-optic transmission and networking: the previous 20 and the next 20 years [Invited]," Opt. Express 26, 24190-24239 (2018)

Back to...Circuit-based Networks

Optical circuits are simply **more efficient** than packet switching for high capacity and low latency applications when fiber spectrum is not scarce.

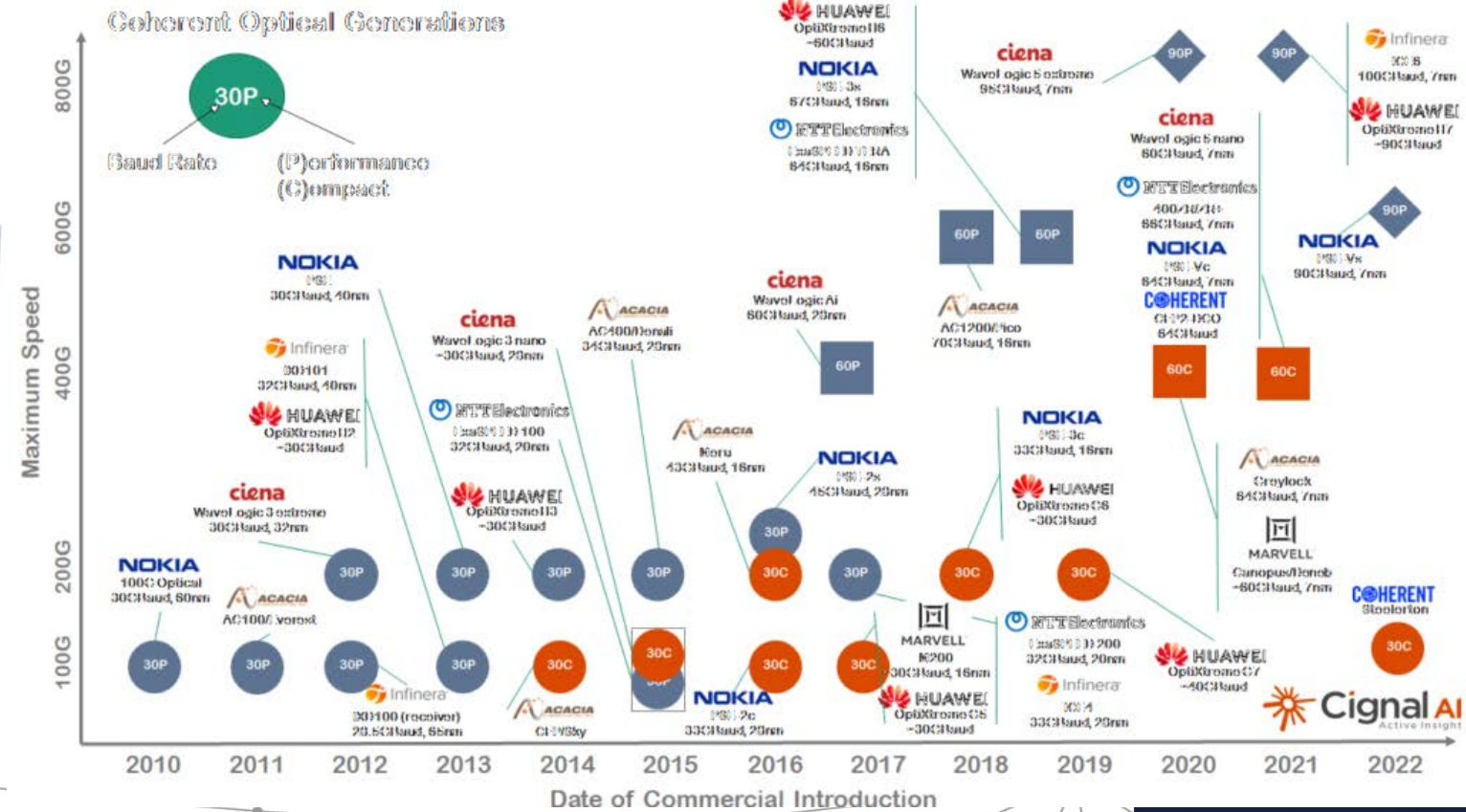
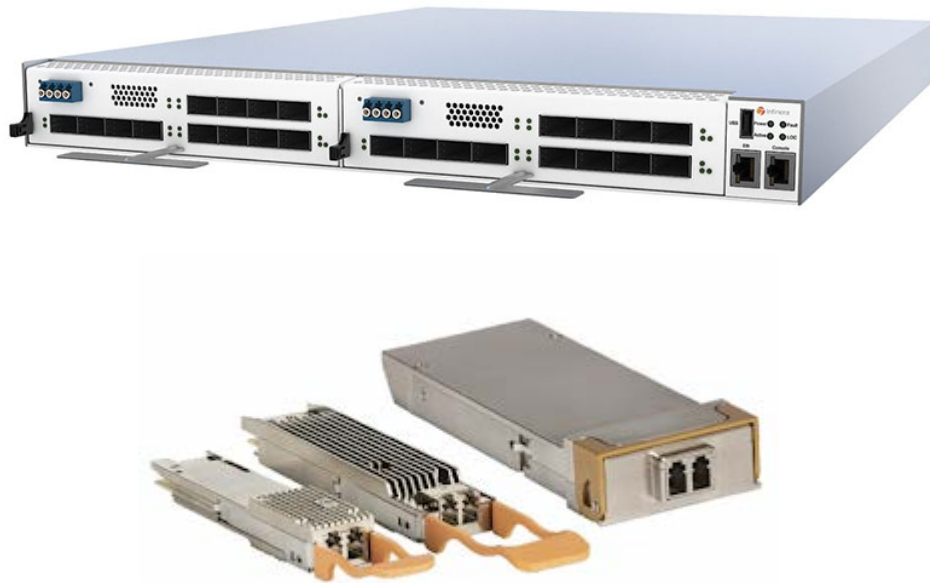
	Packet switching	Optical Circuit
Latency	Higher	Lower
Jitter	Higher	Lower
Capacity	Statistically muxed	Dedicated
Security	IP-address based	Almost for free
Scalability	Lower	Higher
Consumption	Higher	Lower
Provisioning	Days (if available)	Months



Enabling Technology

Disaggregated optical network:

- Open Optical Line System (~10y life span)
- Coherent optical interfaces (~3y life span)
 - Transponders boxes
 - Pluggable transceivers



Spectrum Sharing

Many NRENs are already using alien wavelength circuits.
GARR has done it since 2017.

ALIEN WAVELENGTH TECHNIQUE TO ENHANCE GARR OPTICAL NETWORK

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<https://doi.org/10.48550/arXiv.1805.05811>

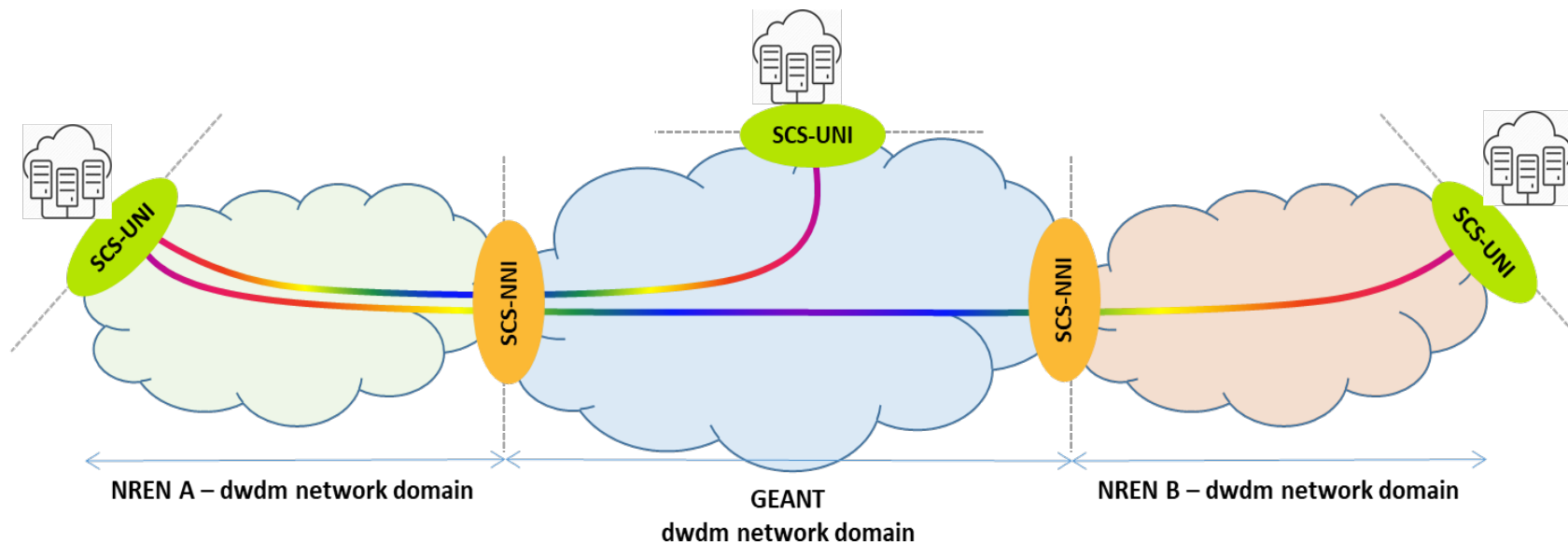


A multi-domain service model has been defined by WP7-T2 of GN4-3 with the name of **Spectrum Connection Service (SCS)**.



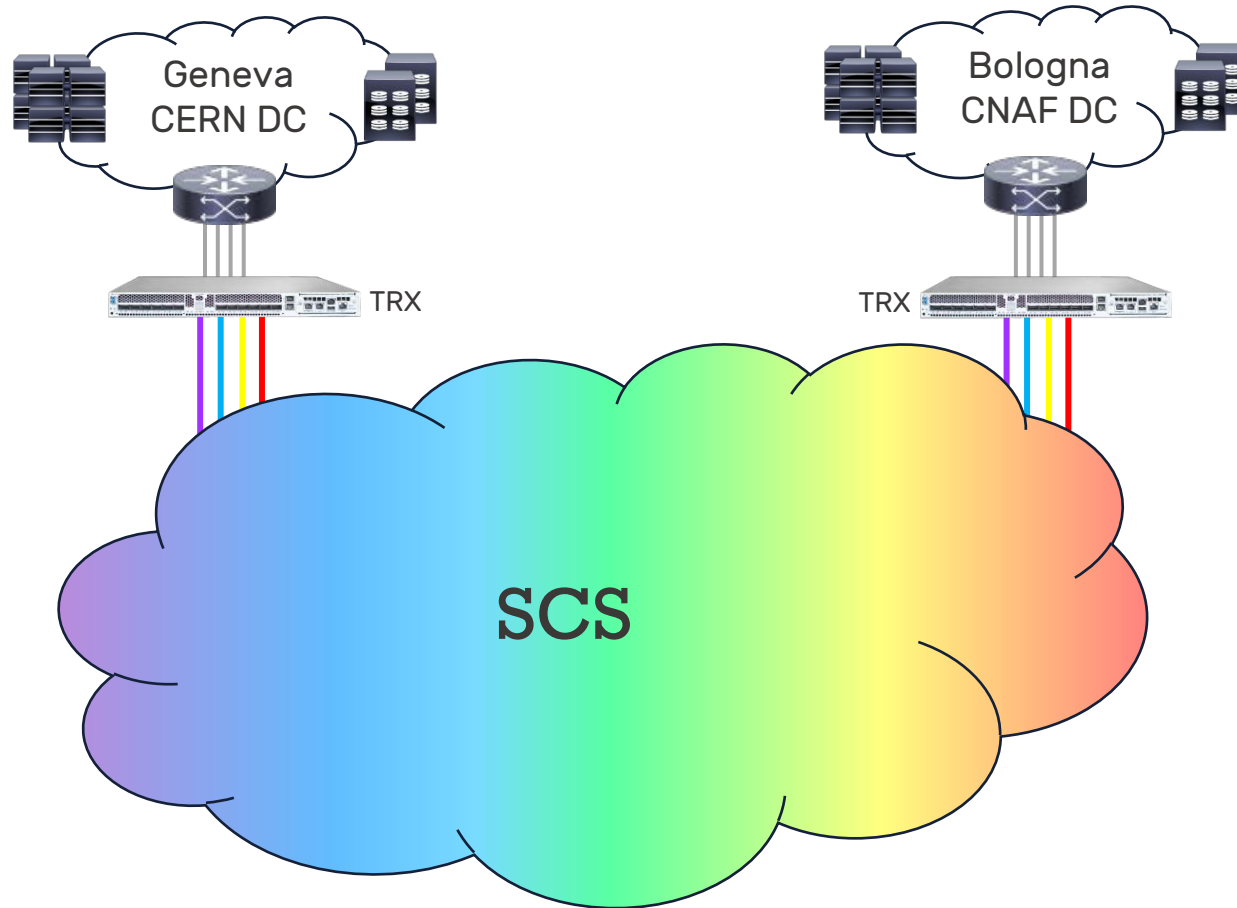
Spectrum Connection Service

- **Users** own the coherent transponder or transceiver
- **Providers** own and operate their OLS
- User-to-Network Interface (**UNI**) defines the boundaries between users and providers (e.g. a LC port on a patch panel).
- Network-to-Network Interface (**NNI**) defines the demarcation point between providers (e.g. a patch cord between ROADMs).



SCS Pilot: CERN – CNAF DCI

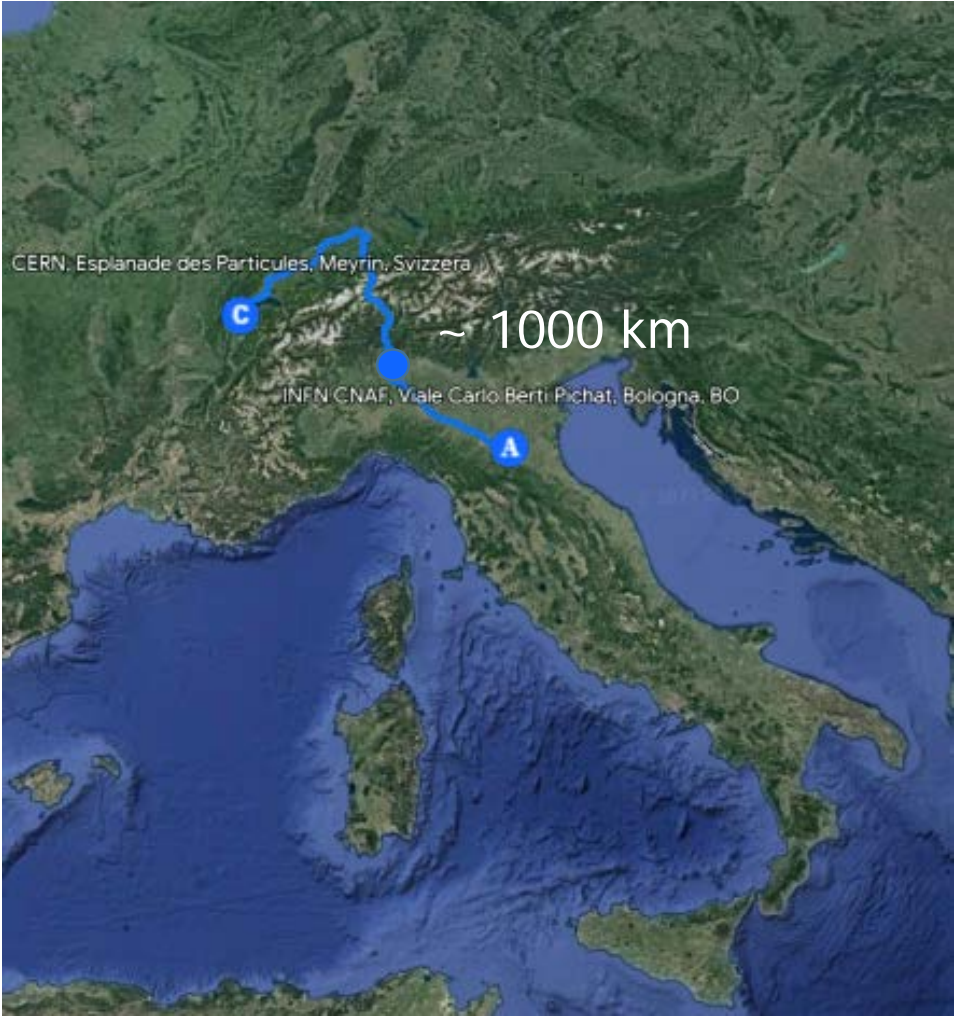
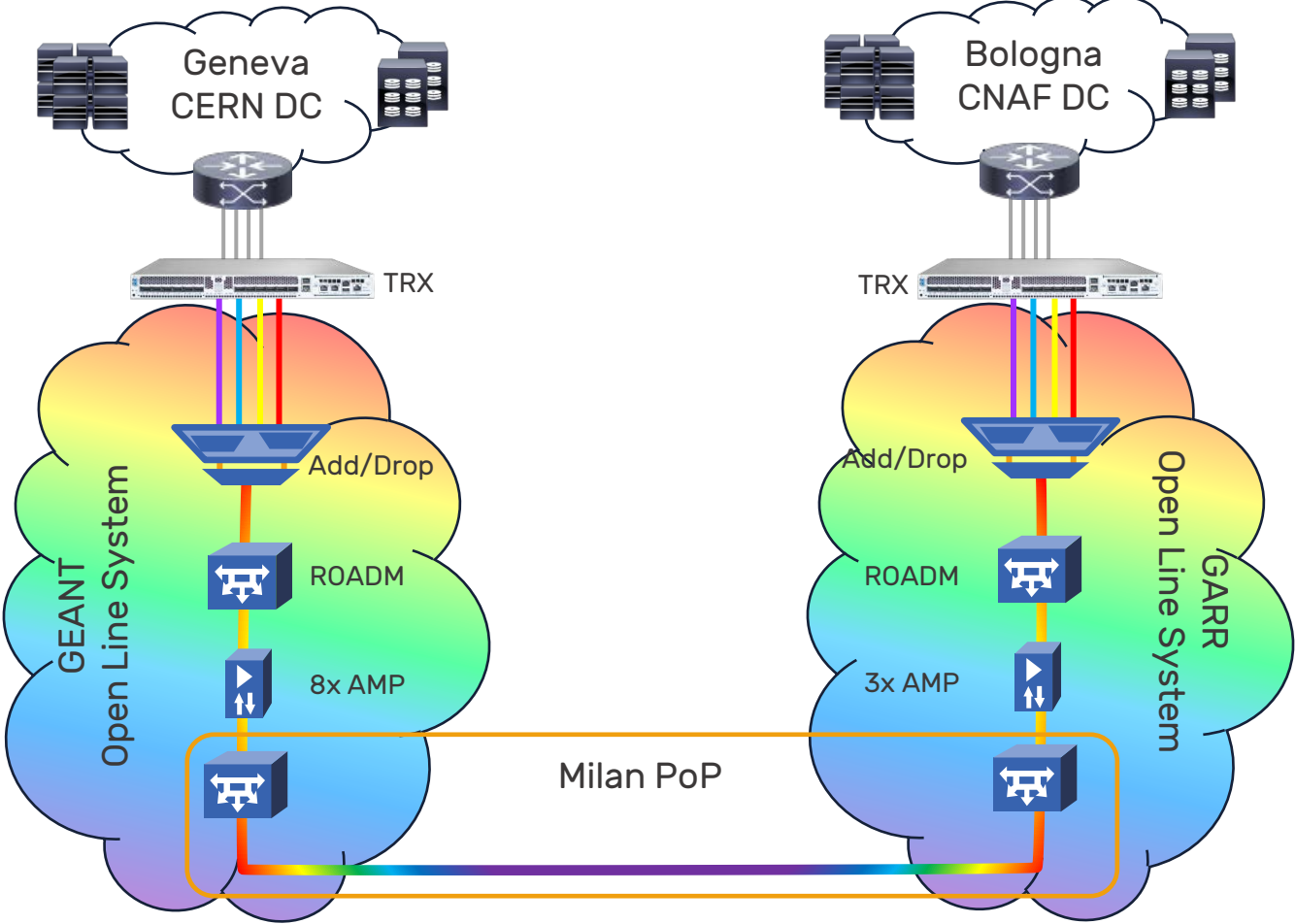
CERN – CNAF Data Center Interconnection



1.6 Tbps

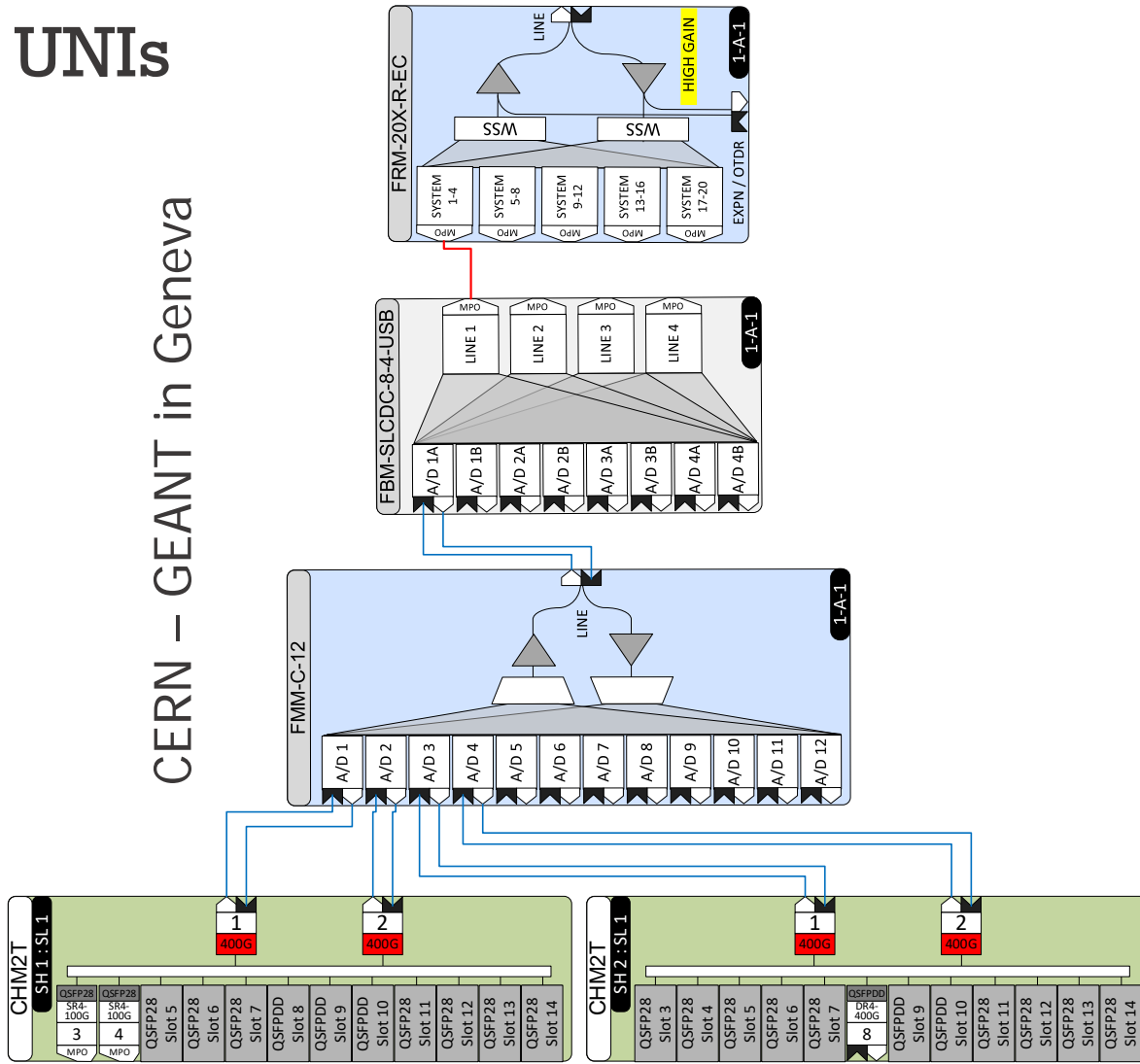
- 4 carriers
- DP-16QAM
- 27% SD-FEC
- 69 Gbaud

CERN – CNAF Data Center Interconnection

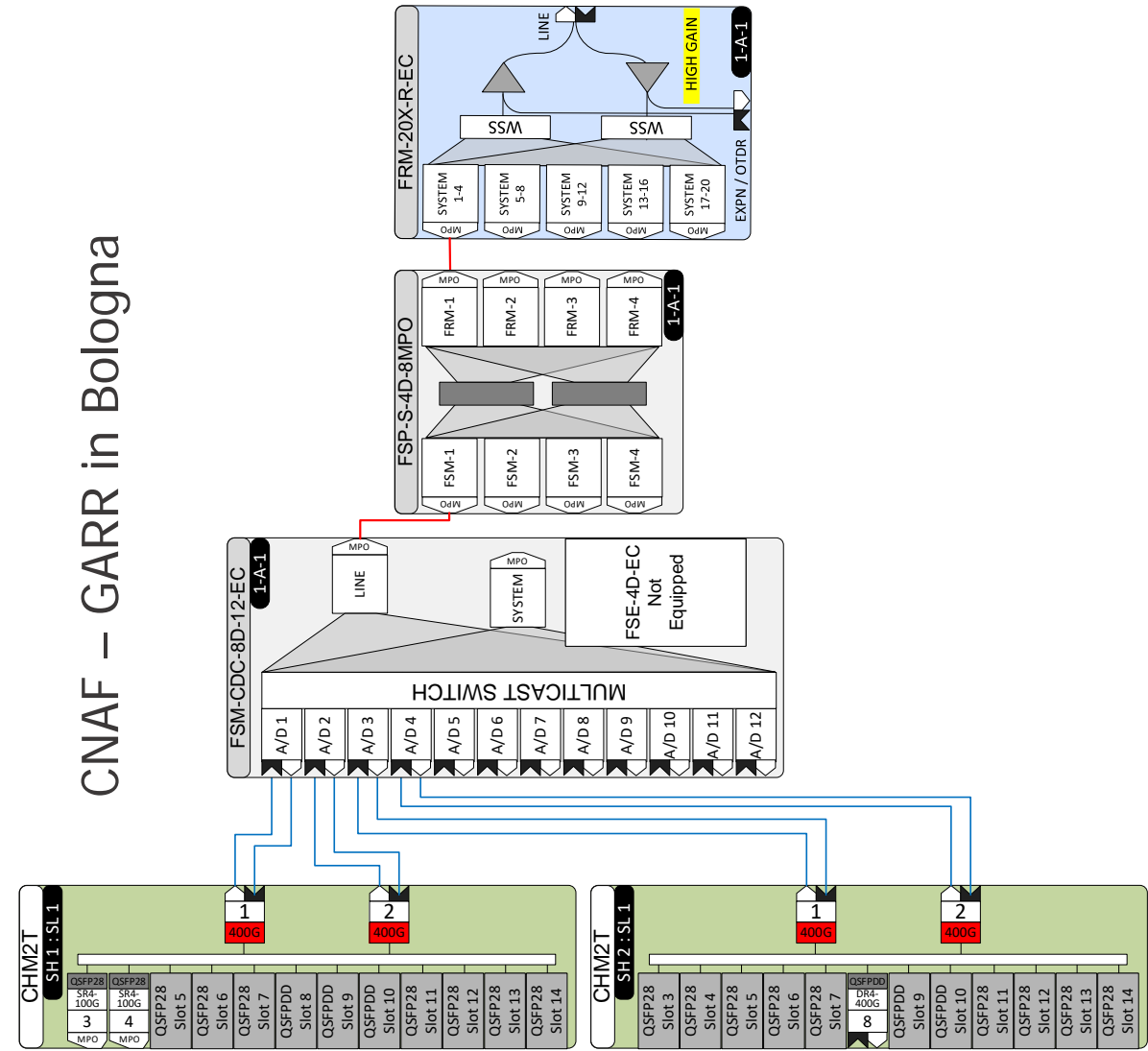


UNIs

CERN – GEANT in Geneva



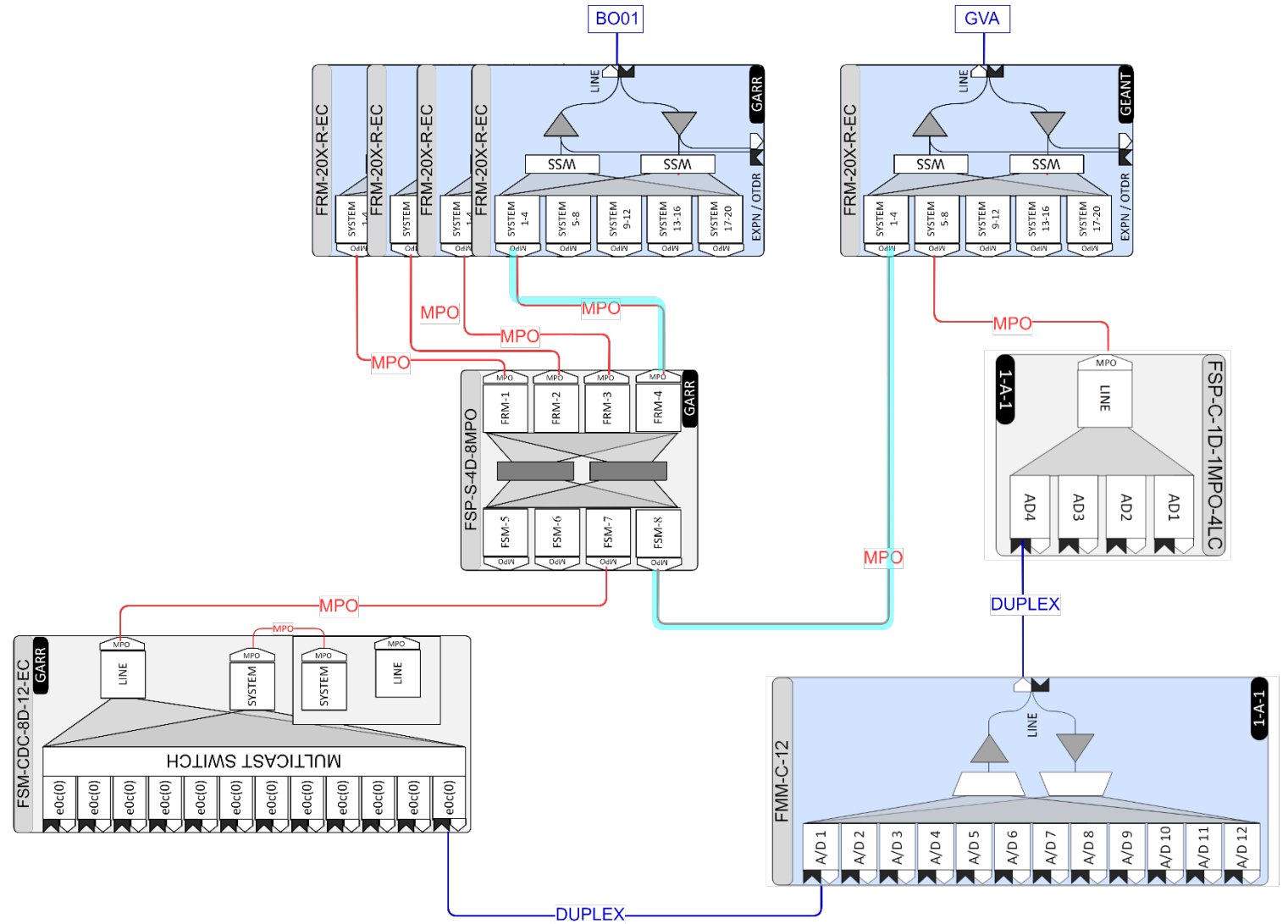
CNAF – GARR in Bologna



Interconnection **privacy** and optical **shielding**: dedicated add/drop modules or shared add/drop without power splitters/combiners

NNI

- Route and Select ROADMs
 - Privacy
 - Spectrum Policing
 - Spectrum Shielding
- Two NNIs
 - Directly using WSS ports
 - No additional noise
 - Limited losses
 - Through A/D modules (MCS, amplified splitter/combiner)

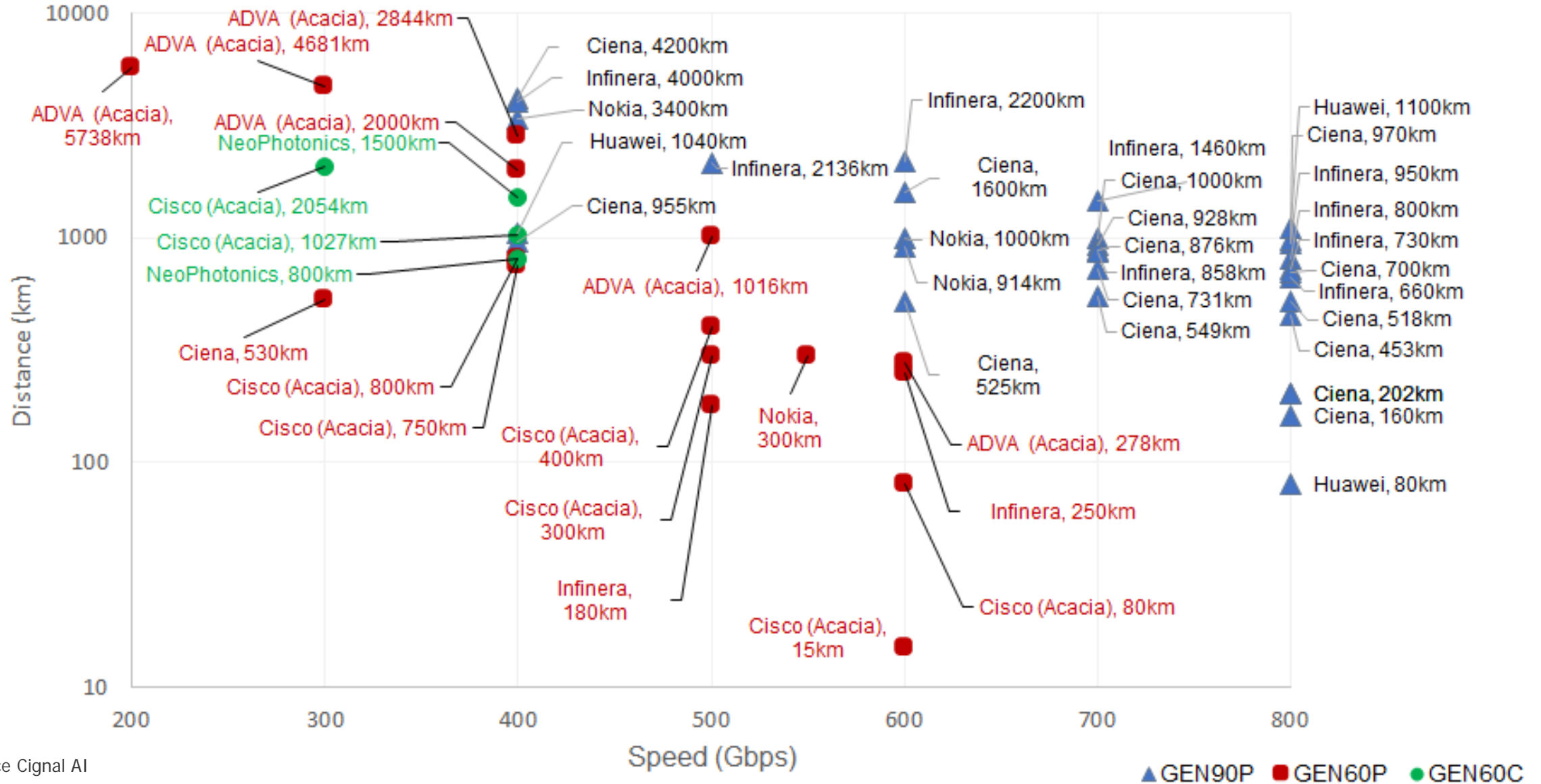


FRM = 1x20 twin WSS w/ amps
 FSP-S = shuffles MPO

FSM = Multicast Switch
 FMM = 1:12 w/amps

FSP-C = adapter MPO-LC

Transponders



Source Signal AI

Operations

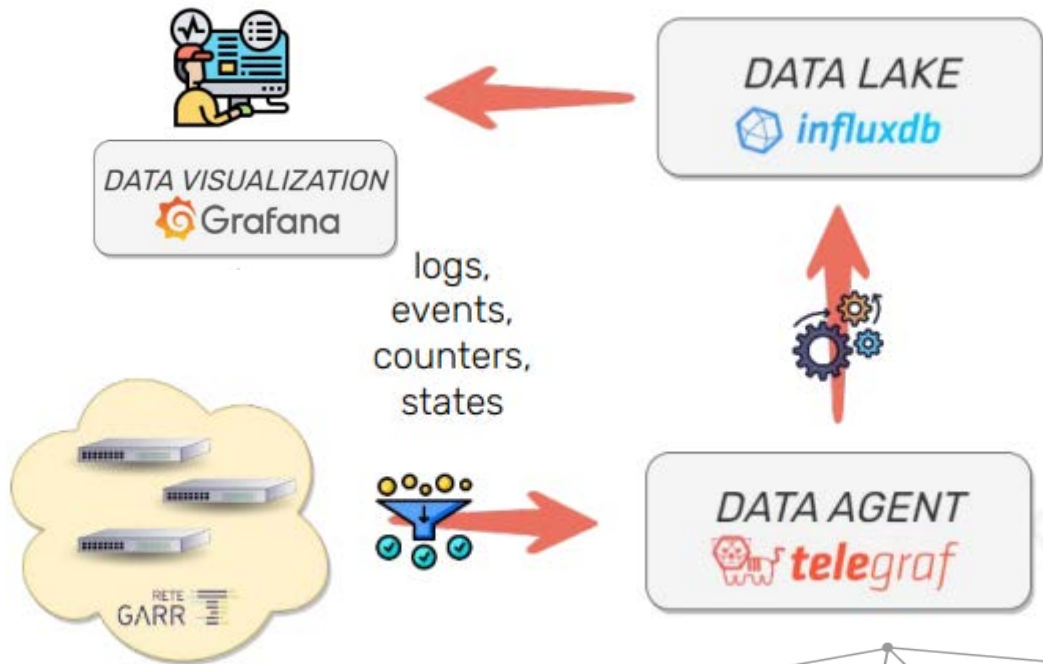
Each provider configures and manages a chunk of the user-to-user lightpath.

Spectrum utilization should be known because

400GHz ≠ 4x100GHz for SCS

Thresholds can be applied to optical power.

Share spectrum...and also telemetry data!



The screenshot displays a network management interface with two panels. The top panel, titled 'Service Summary', shows a lightpath between source node 'flex.mi01' (1-A-1-S8-11) and destination node 'flex.bo01' (5-A-3-T7-1). The path includes intermediate nodes '1-A-1-L1' and '1-A-1-L1'. The bottom panel, titled 'Optical Circuit Properties', shows details for circuit ID 'och093_bo01-mi01_scs-cnaf-cern'. It includes fields for Label ('cnaf-cern'), Tag, Admin State ('Unlocked'), and Alarm Reporting ('Enabled'). The 'Settings' section contains fields for Profile ID, Profile Sch Number, Super Channel ('NONE'), Carrier List [THz,GHz] ('(191.5125,87.5)'), Passband List [THz,THz] ('(191.4625,191.5625)'), System Carrier List [THz,GHz] ('(191.5125,87.5)'), and System Passband List [THz,THz] ('(191.4625,191.5625').

Next Steps

- Testing CNAF – CERN DCI
 - Line operating modes
 - NNI using a/d modules
 - Threshold profiles
- Telemetry and event
- Best practice
- Multi-domain simulation tool