



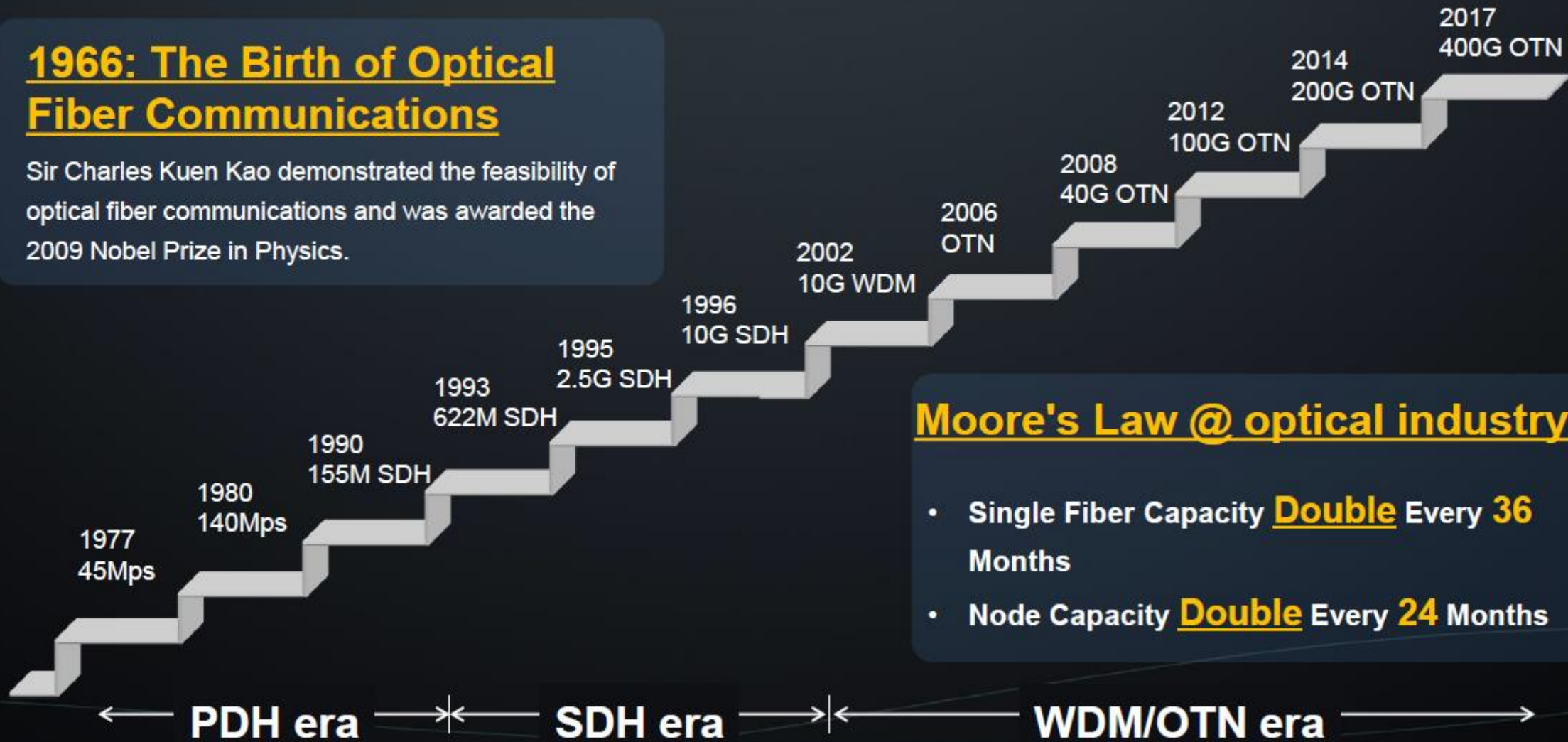
Technical Overview

Information Big Bang Stimulates Evolution of Optical Technologies

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1966: The Birth of Optical Fiber Communications

Sir Charles Kuen Kao demonstrated the feasibility of optical fiber communications and was awarded the 2009 Nobel Prize in Physics.



Moore's Law @ optical industry:

- Single Fiber Capacity **Double** Every **36** Months
- Node Capacity **Double** Every **24** Months

Moore's Law @ Single Fiber Capacity

• Single Fiber Capacity

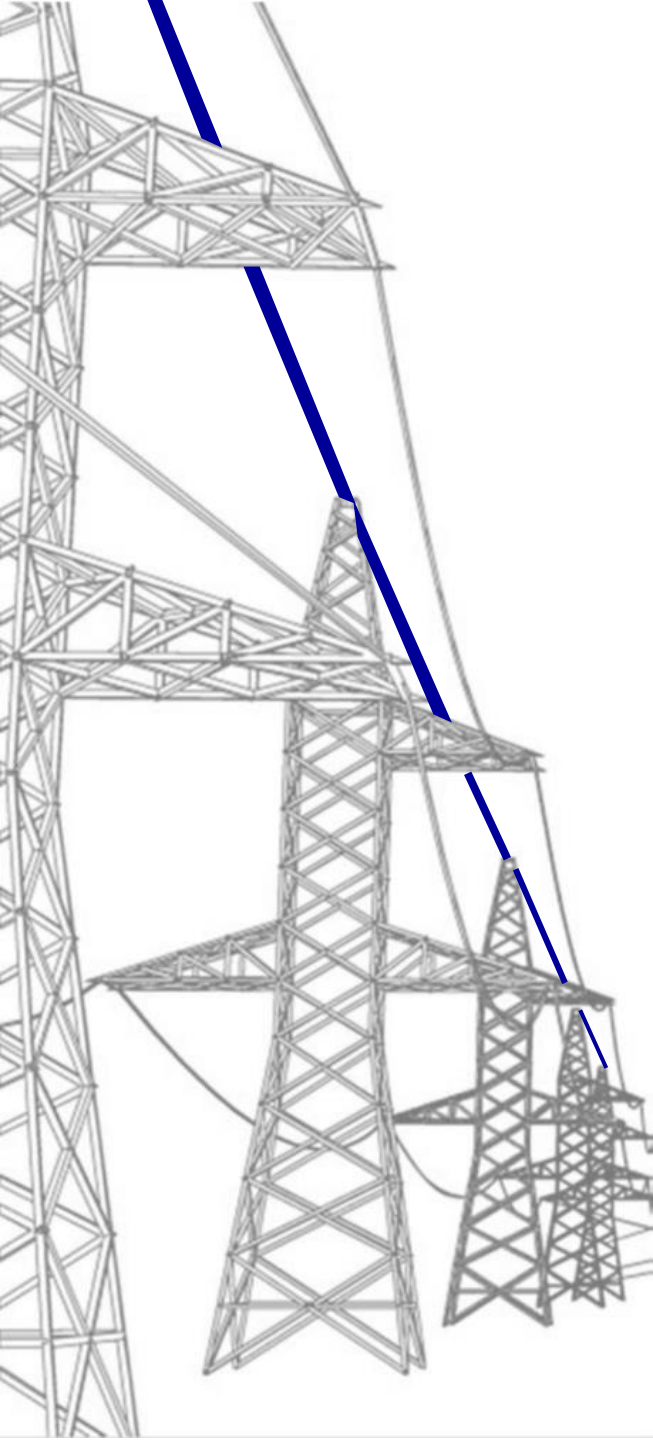
Single Fiber Capacity Double Every 36 Months



- **Node Capacity**

Node Capacity **Double** Every **24 Months**





Fiber Infrastructure in Telecommunications Network

1. Terrestrial Fibers
OPGW (Optical Ground Wire)
Grounding of the power transmission lines
Contains multiple optical fibers
1 x 12 G.655
3 x 12 G.652D
2. Submarine cables **interstitial** with power Lines (islands & Crete)
3. Leased Fiber pairs (IRU basis) in Metropolitan areas
4. Fiber Infrastructure in Metropolitan areas are under construction in Attica and soon in Thessaloniki & Patra.

One Optical Fiber Network in Greece managed by Grid T

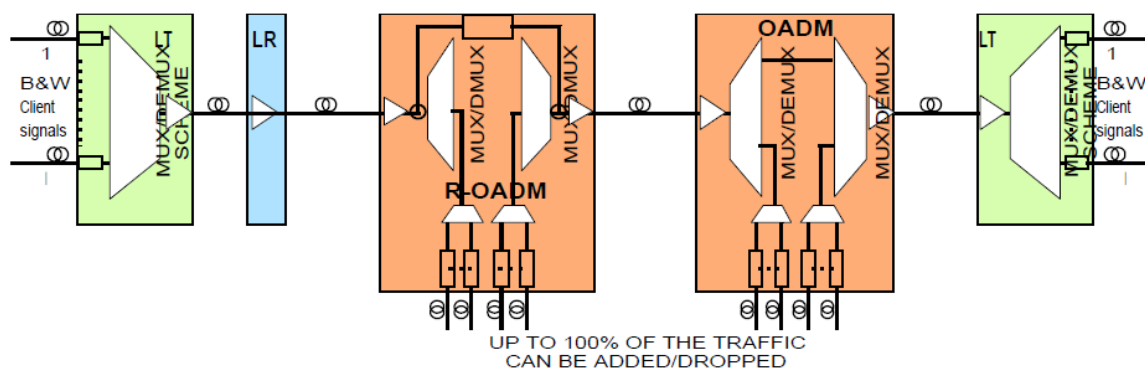
The map illustrates the One Optical Fiber Network in Greece, managed by Grid T. The network is represented by red lines connecting various cities and islands. Major cities labeled include Thessaloniki, Athens, and Heraklion. Islands shown include Kerkira, Patra, Korinthos, Megalopoli, Sparti, Kalamata, Chania, and Heraklion. The network extends to the northern border with North Macedonia and Bulgaria, and to the eastern coast near Orestiada. The map also shows neighboring countries: Albania, North Macedonia, Bulgaria, and Turkey.



DWDM technology developments.

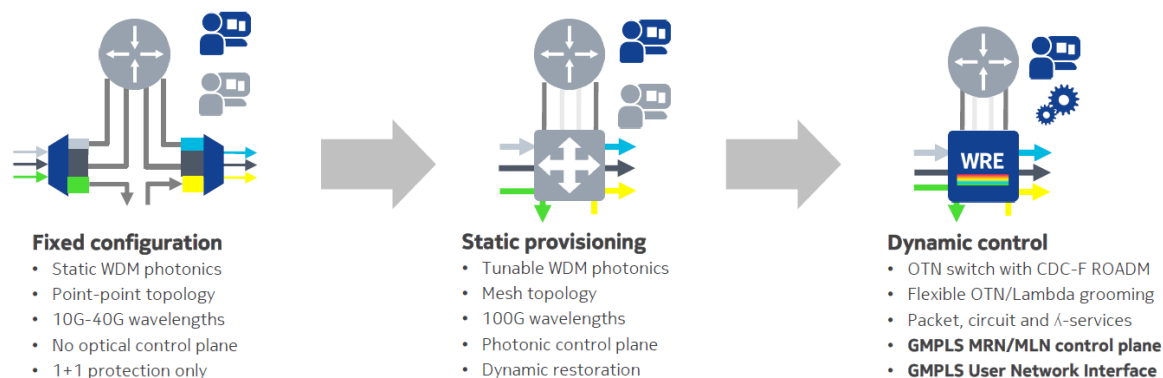
Legacy DWDM

- Fixed Grid – maximum 80 Wavelengths @50GHz spacing in C Band
- Amplitude modulation
- Typical 10GHz per wavelength
- Requiring Dispersion Compensation
- Fixed frequency WDM multiplexing

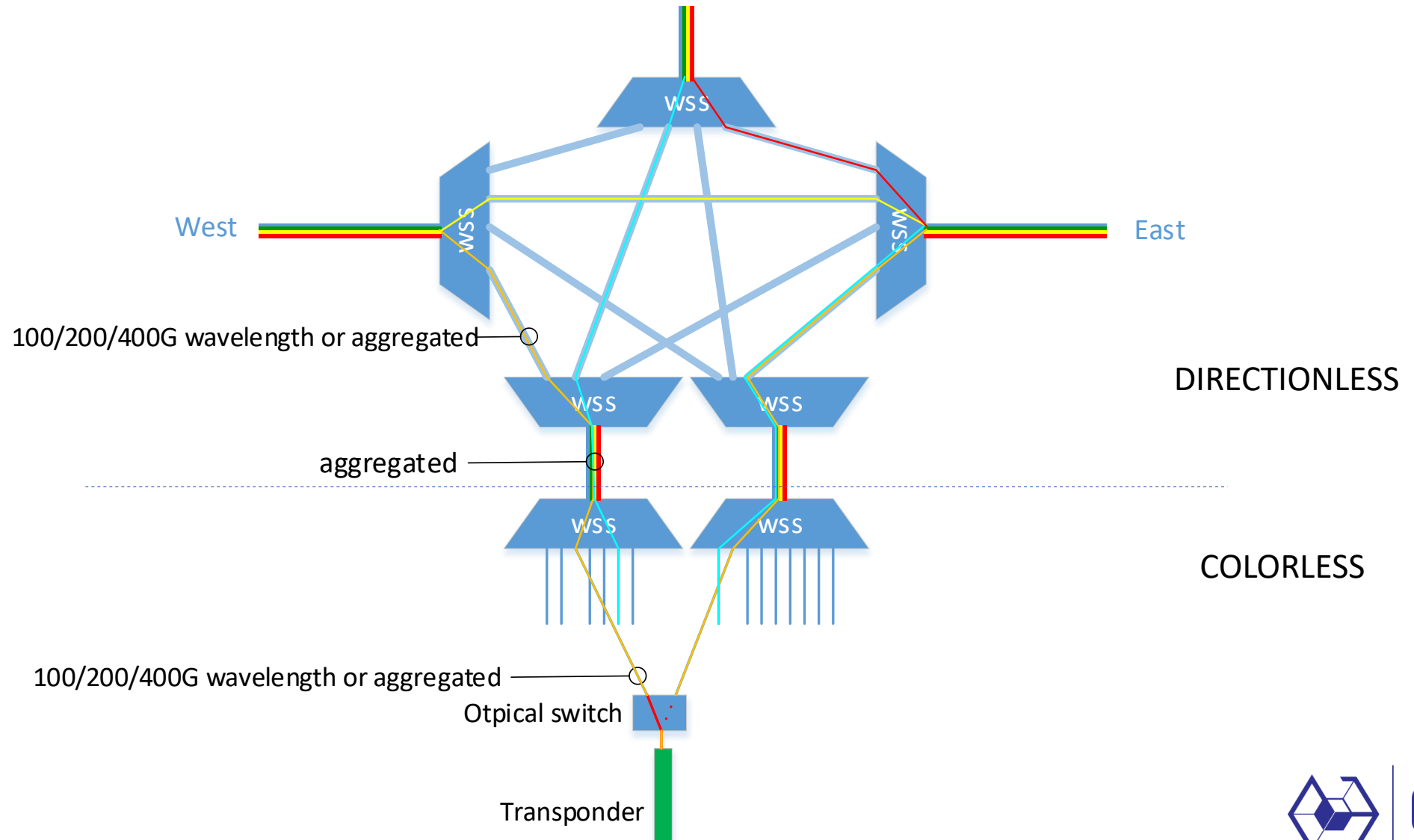


Next Generation DWDM

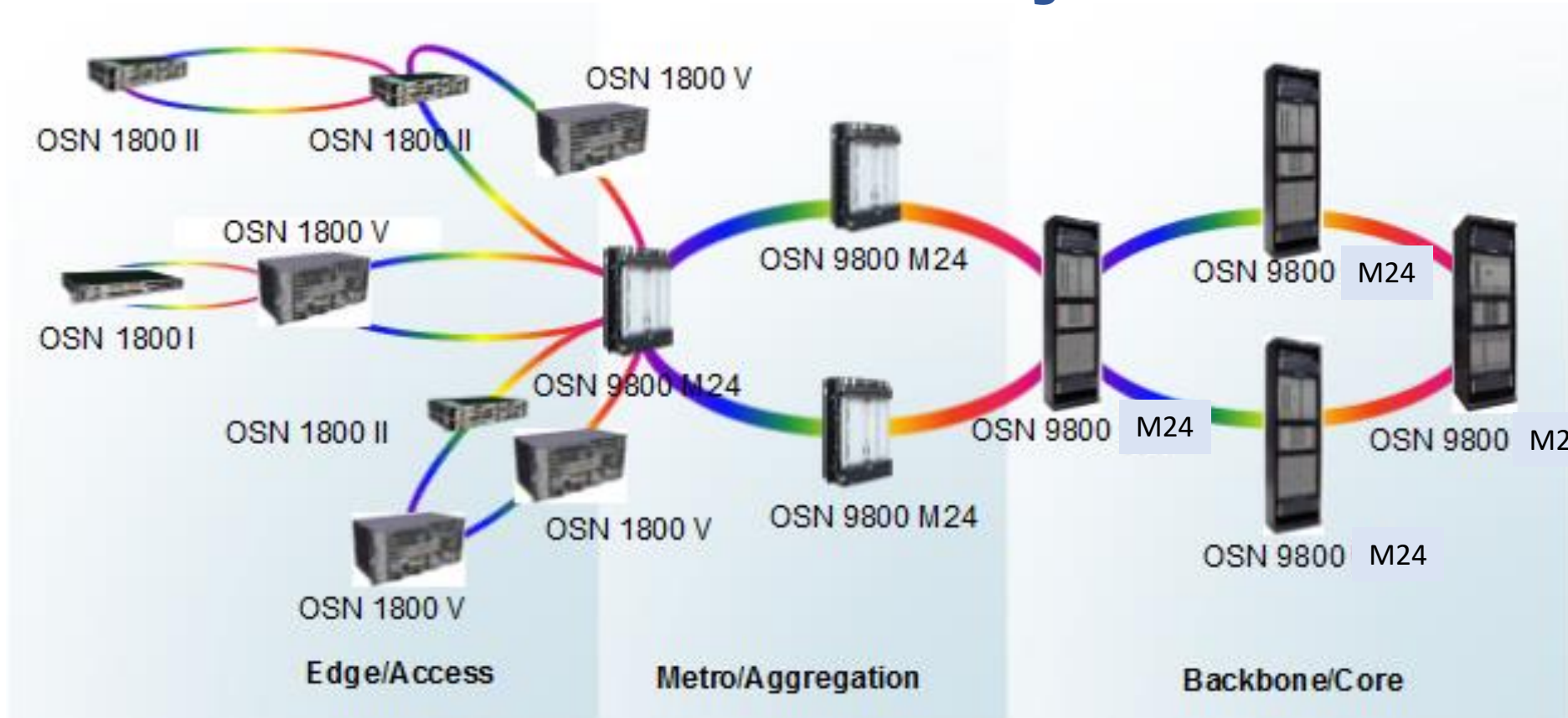
- FlexGrid, frequency and channel width programmable wavelength by WSS cards in C+L bands
- Phase-amplitude modulation techniques (QPSK, 16 QAM, 64 QAM etc).
- Transmission rates higher than 400G per wavelength available
- Coherent detection does not require dispersion compensation
- Colorless WDM multiplexing using programmable filters/WSS (LCoS - wavelength-selective switch)



WSS node structure



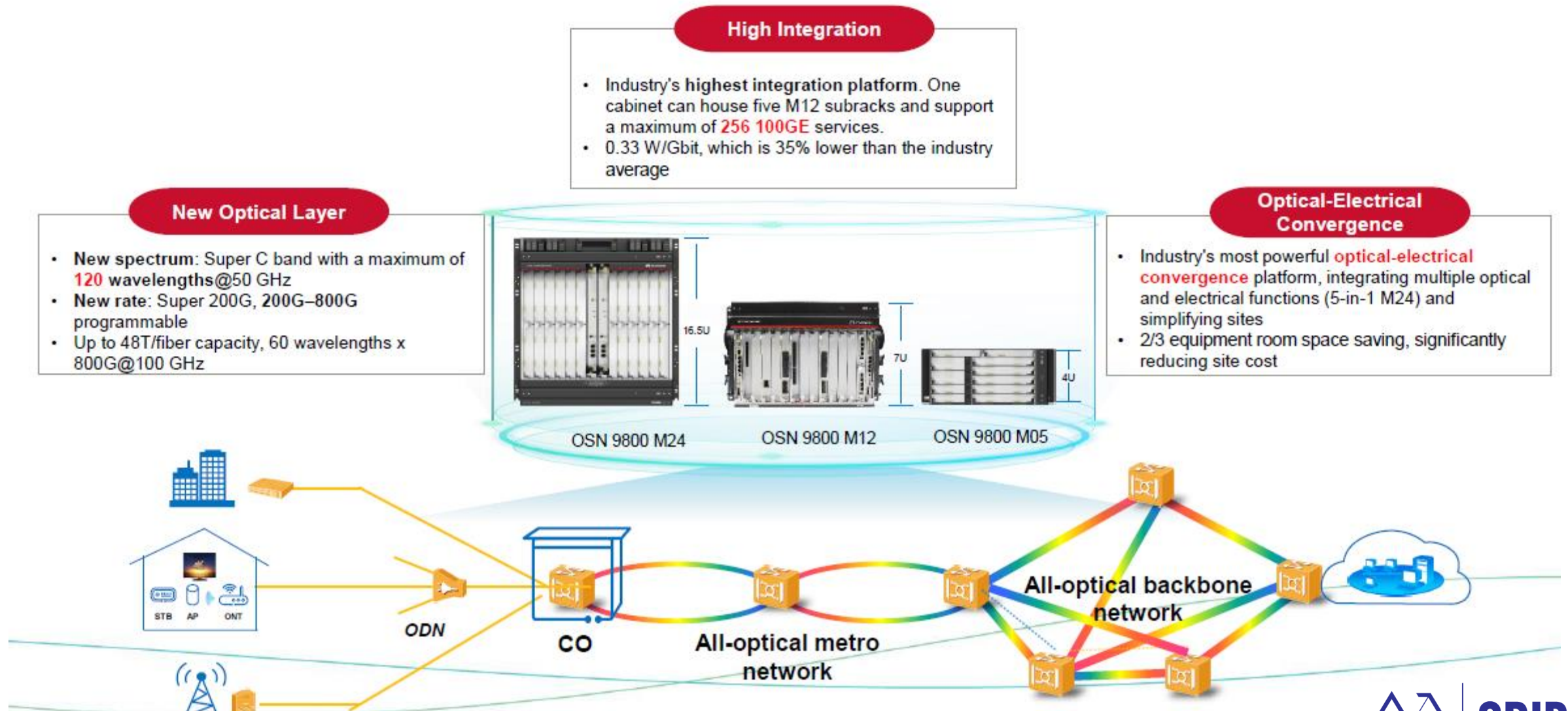
Position of the GRID Telecom DWDM equipment in the network hierarchy



HUAWEI M SERIES (OSN 9800 FAMILY)

10

Huawei **M** Series: The **Next-Generation** All-Optical Transmission Platform



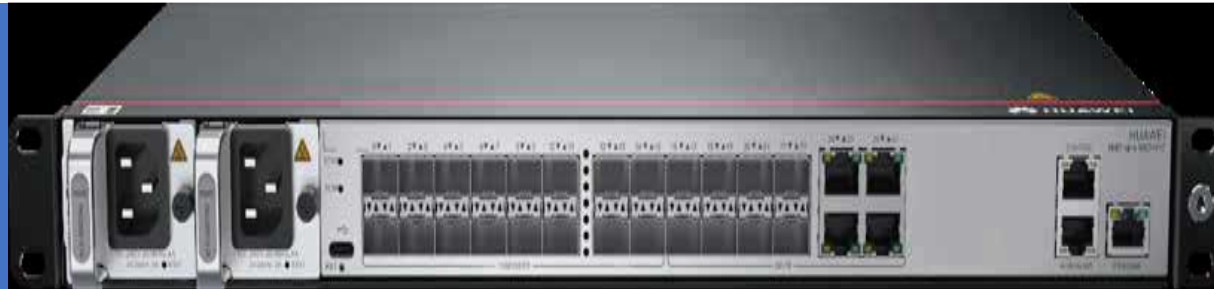
HUAWEI (OSN 1800 FAMILY)

11

1800 II Pro (Appearance)



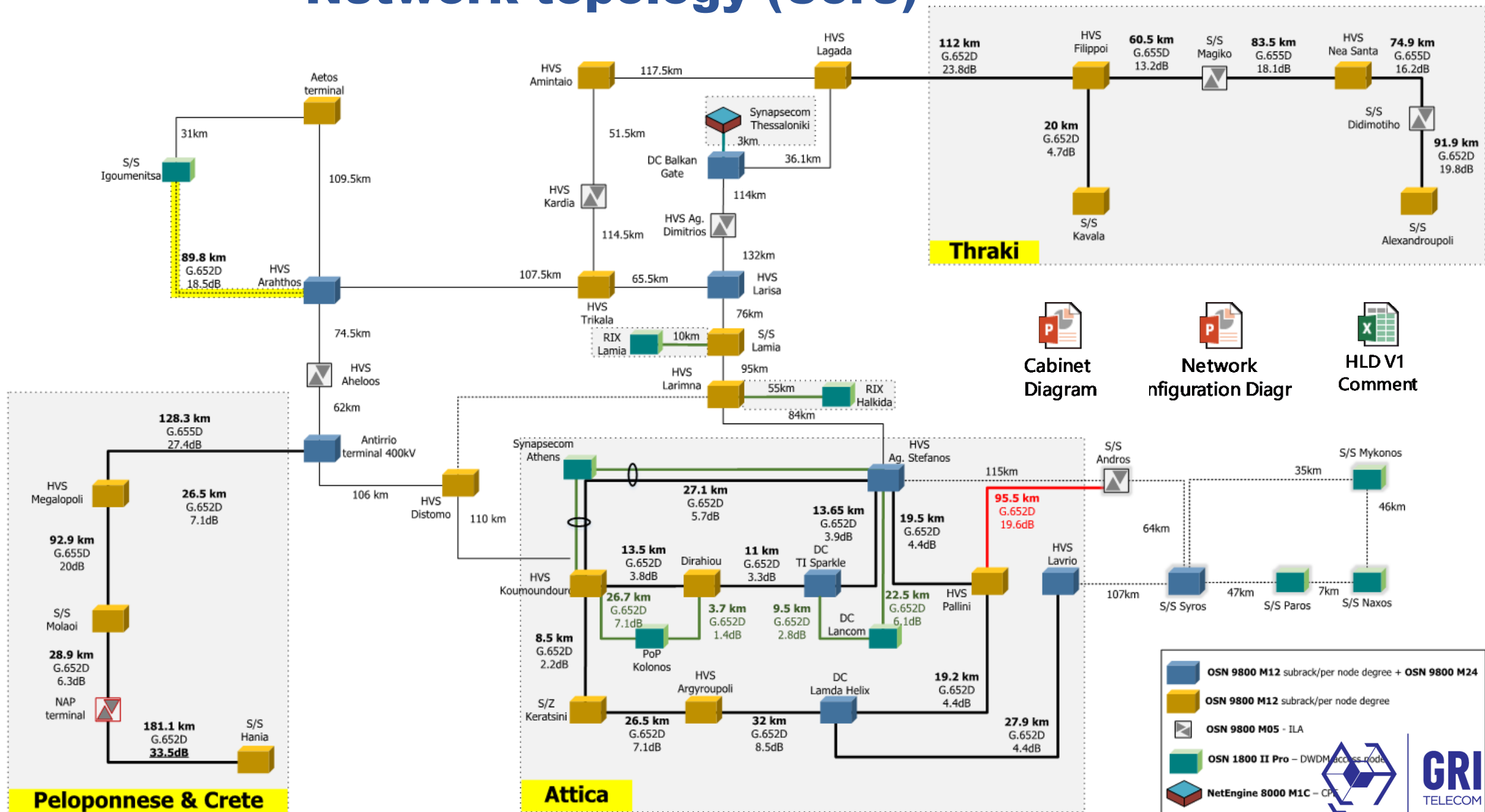
NetEngine 8000 M1C



Technical Features

- Directionless and Colorless Network
- Dispersionless Network with Coherent Detection
- Flexigrid with λ rate > 100 Gb/s
- Protection schemes in Optical / Electrical Domain
- Any to any λ connection (up to 200 Gb/s rate) including protection path without 3R
- ASON enabled protection in Optical Domain when a third or more Optical routes are available
- Dynamic allocation of bandwidth / programmable Modulation Formats (QPSK, 16 QAM etc.)
- Flexible OTN Multiplexing-Grooming and Consolidation
- Real time monitoring of the Network (Physical Layer & Network Elements)

Network topology (Core)



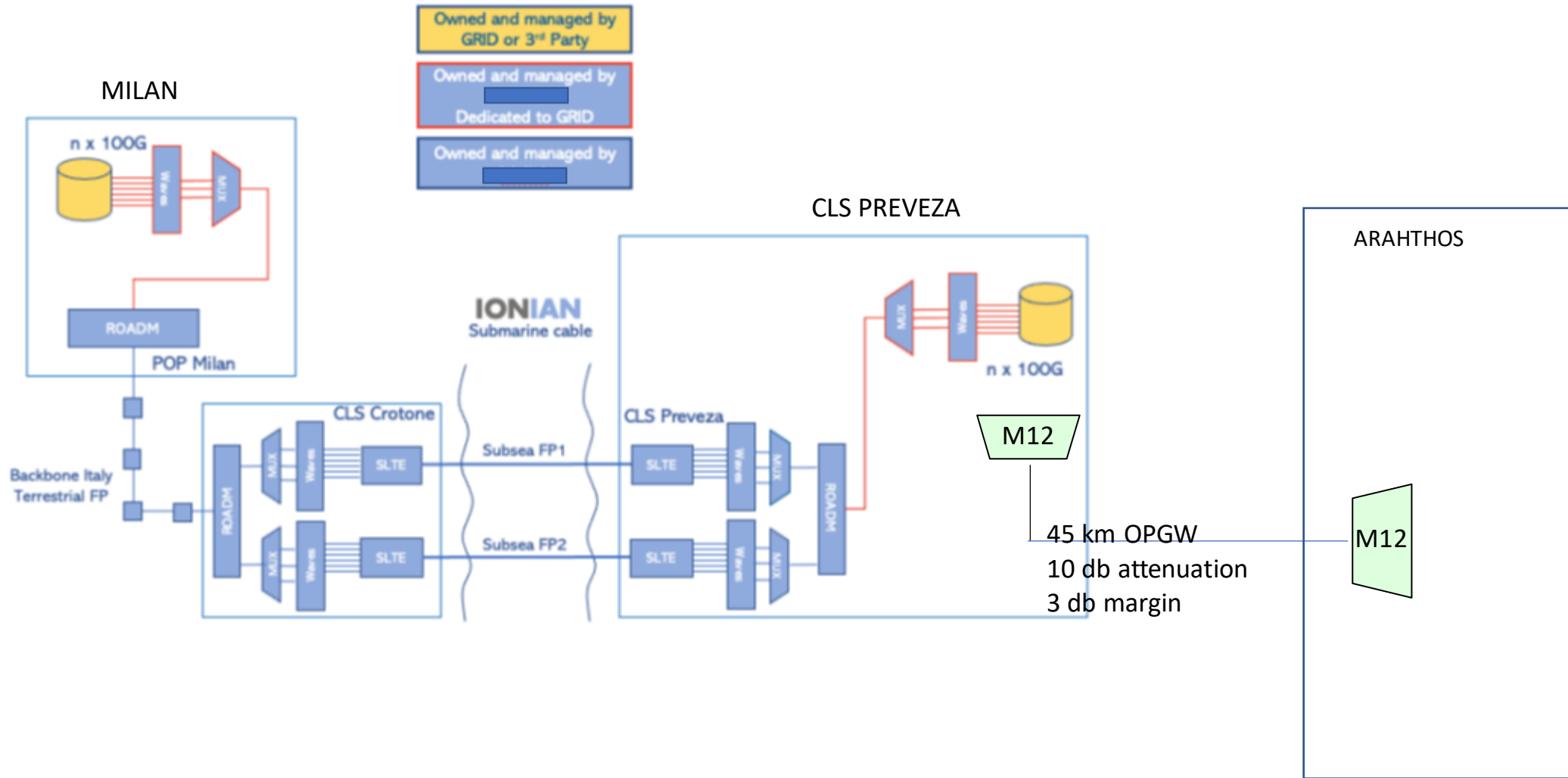
Network topology (International)



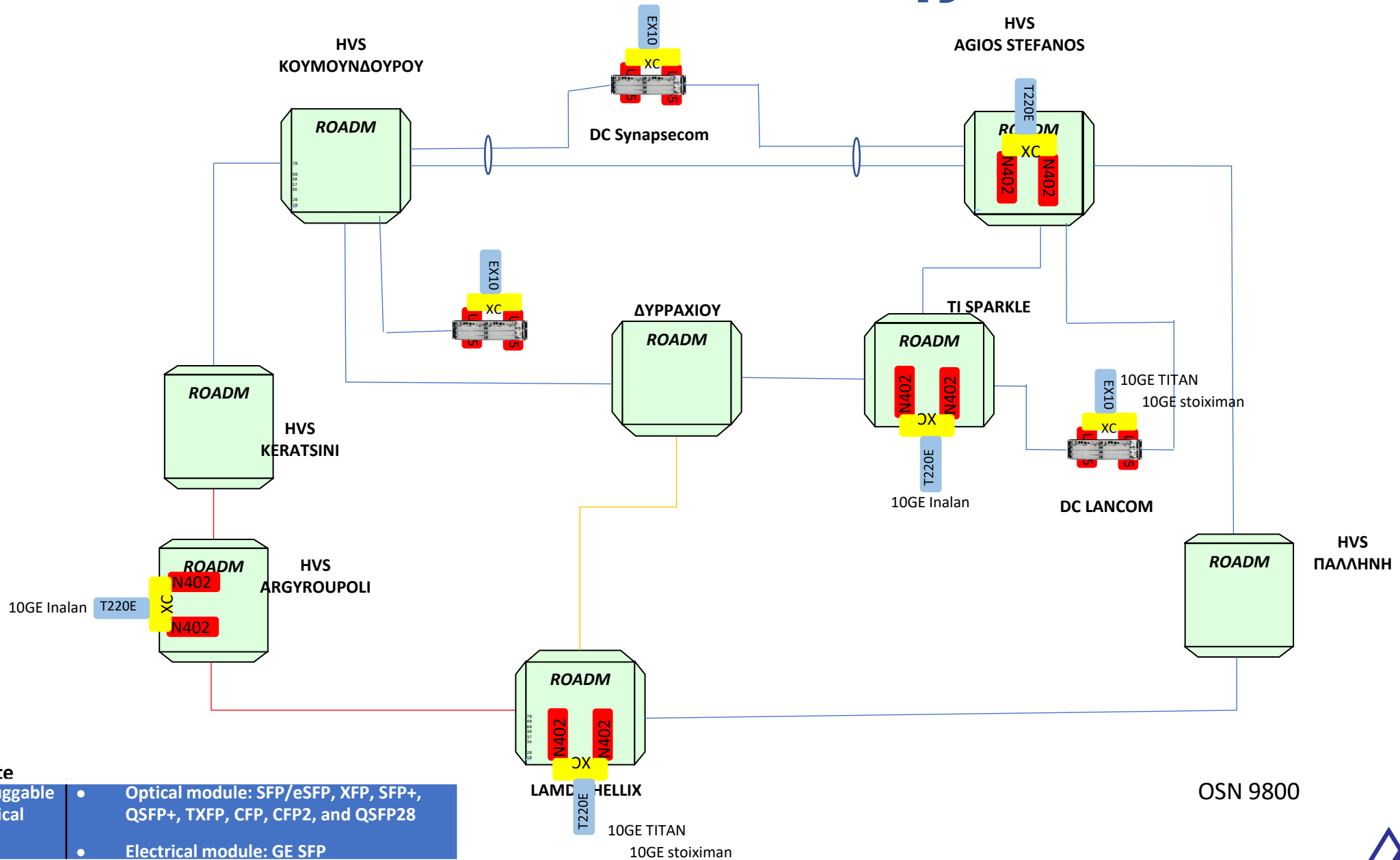
Network topology (International)

End-to-End Capacity Reserve + On-demand activation:

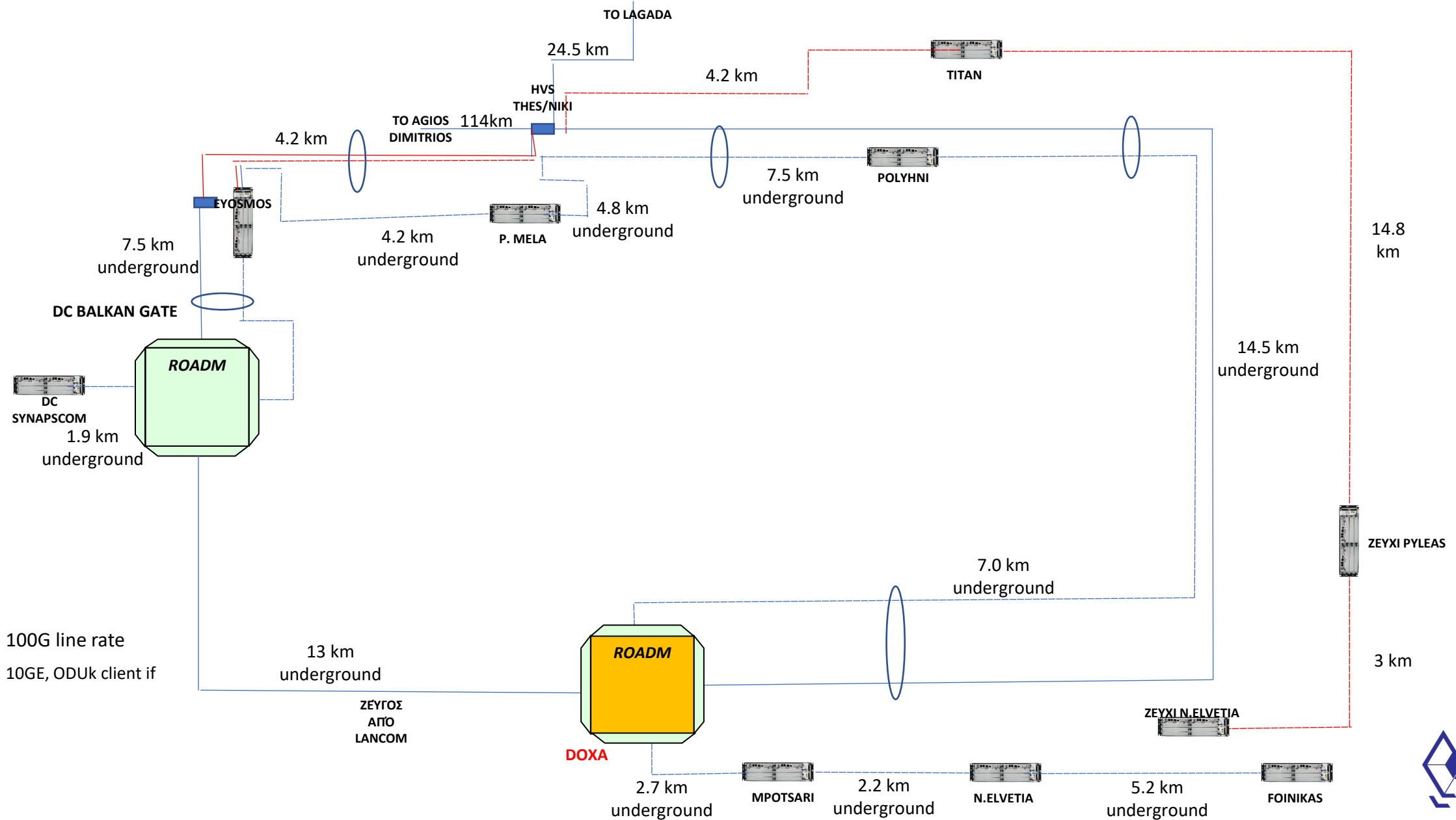
- End-to-End Preveza-Milan segment capacity reserve 1.2Tbps
- [Redacted] will activate capacity on-demand [1x100G per request]



Metro Core Αττικής



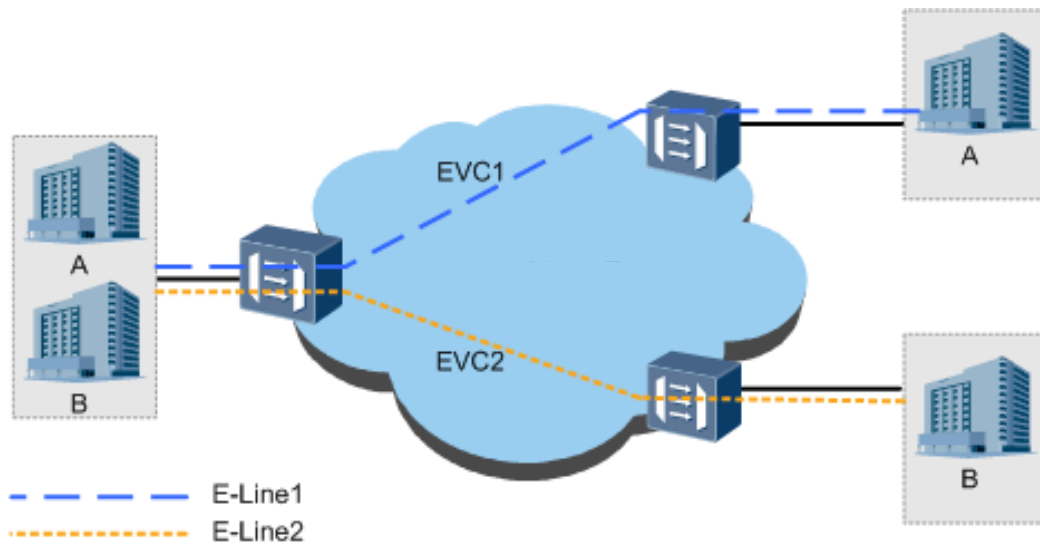
Metro Core Θεσ/νίκης (under planning)



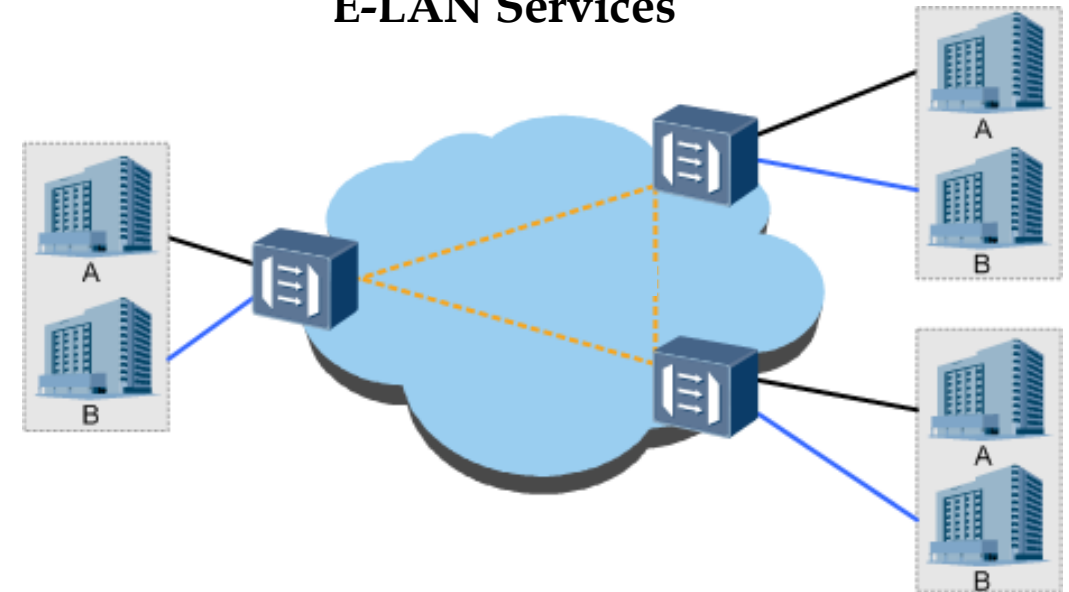
Supported Services Types

- OTUk, FEe/o, GEe/o, 10 GE LAN, 10 GE WAN, 100 GE, SAN (FCx00), SD/HDSDI, ESCON, FICON
- Ethernet Services Model (MEF)

E-Line Services



E-LAN Services



Survivability

Latency

Availability

Path protection on the optical layer

Path protection may be implemented

- On the upper layer (i.e.IP layer)
 - Simplified optical layer
 - More than 50% increase on capacity requirements for more than 2 optical paths protection
 - Protection switching time not guaranteed
 - Higher link utilization when protection is applied
 - Complex traffic engineering on L3
- On the optical layer
 - Complex optical layer with GMPLS L0 / Optical ASON
 - Minimum capacity requirements on the optical layer while utilizing all available optical paths
 - Fast protection time (sub 50ms) as long as resources are available
 - Link utilization does not change when protection is applied
 - Traffic profile not affected on L3 even after multiple optical link failures
 - Compatibility issues may arise between different IP – Optical vendors (proper setting of BFD)

THANK YOU

Back up slides

Leading Optics

6.25GHz Flexible Roadm Boards,
high density 9/20 degree Roadm board

TN03DW5MD9



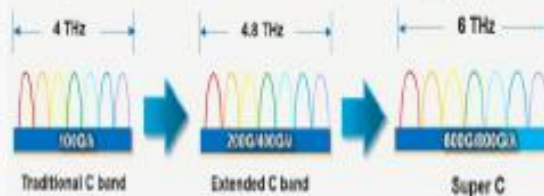
9-port selective switching
multiplexer/demultiplexer
board
(C96, 6.25 GHz Slice)

TN03DW5S20



20-port selective switching
multiplexer/demultiplexer
board
(C96, 6.25 GHz Slice)

Expanding New Spectrum, Improving
System Capacity, C80->C96->C120
Wave, 9800M series all support



Pluggable EDFA, support C96,C120

Pluggable EDFA



Flexible OTN

Powerful Platform: 5 in 1 Optical-
electrical convergence equipment, 10T
OTN switching capacity, no slot
restrains.



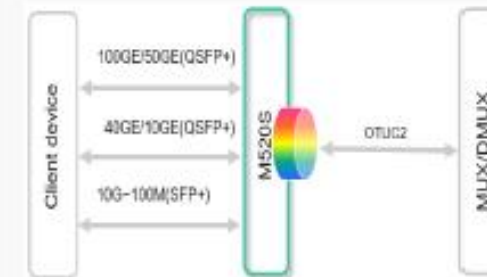
Unified switching: Unified Bearing of
All-Granularity Multi-Service Access,
Hard Pipe, and Low Latency

Unified service bearing interface and pipe resource allocation

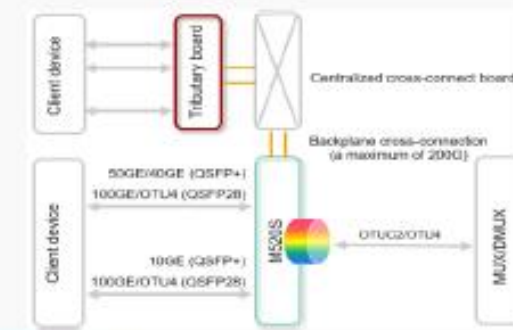


Flexible Ponder

100G~100M: Enabling Flexible
Access of Small- and Large-
Granularity Services



Backplane Cross-Connect
Supported by Ponder: Improving
Line-Side Resource Utilization



ASON 2.0

Elastic large network, reducing TCO by 10%



3000+ electrical-layer NIEs, 1000+ optical-layer NIEs, ROADM+OLA unlimited

Fast self-healing and more stable network



Optical-layer ASON restoration time: **< 10s**
Electrical-layer ASON restoration time: **< 200 ms**
IP+optical synergy, reducing IP network flapping

High intelligence and reliability, eliminating service interruptions



Ultra-High Bandwidth

Continuously improved single-fiber capacity



100G/200G/400G/800G



Mini MSA
200G-800G

High performance scenario:
200G PDM-QPSK (5000 km)
800G PDM-64QAM (45T/fiber)

Transmission distance
increased by 20%
Channel matching shaping

Traditional C band → Extended C band → Super C band



All Pluggable Module

Line-Side Optical Module: Small Size, Pluggable, and Low Power Consumption



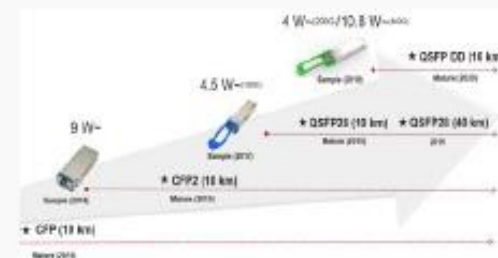
CFP/CFP2 module
100G/200G@50 GHz



High integration scenario:
200G PDM-e16QAM (3000 km) **Unique in the industry**

Halved power consumption (compared with MSA)
15 nm → 7 nm FinFET
Continuous algorithm optimization

Client-Side Optical Module: High Rate and Density, Halving Power Consumption

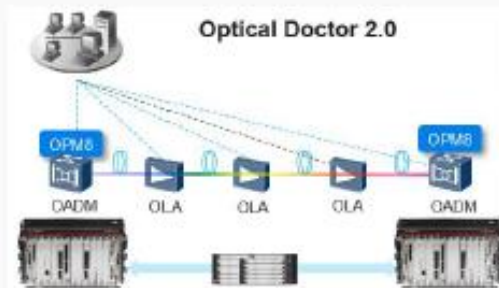


Real-time Monitoring

Fibre Doctor: Real-time monitoring of fiber status, with the monitoring precision comparable to that of high-end instruments



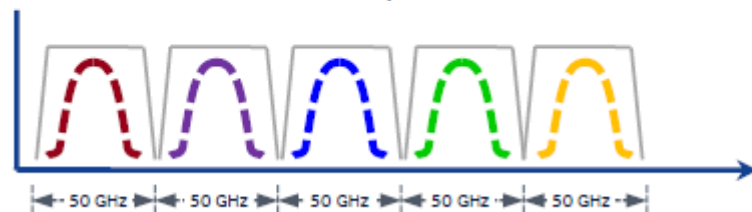
Optical Doctor: Real-time network quality monitoring, pre-warning and optimization of link deterioration



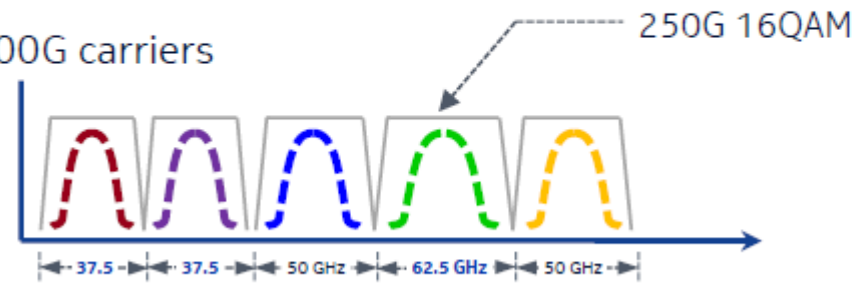
Flexible Grid

- Flexible Grid vs Std 50GHz Grid
 - Existing WDM networks based on standard, ITU 50 GHz Grid
 - All channels the same
 - Flexible Grid enables flexible channel sizes & center frequency
 - Better match between channel size & data rate / modulation
 - Enables up to 30% additional capacity on smaller (metro) networks
 - 120 channels in C-Band
 - Using 37.5 GHz spacing for 100G QPSK signals
 - Enables “Super Channels” of nx100G or nx200G carriers

Modulation	Rate	Spectrum	C-Band (Tb)
BPSK	50G	50 GHz	4.8
QPSK	100G	37.5 GHz	12.8
QPSK	100G	50 GHz	9.6
SP-QPSK	100G	62.5 GHz	7.6
8QAM	200G	62.5 GHz	15.2
16QAM	200G	50 GHz	19.2
16QAM	250G	62.5 GHz	19
64QAM	400G	62.5GHz	30.4



Fixed 50 GHz Grid



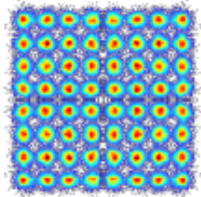
Flexible Grid

Probabilistic Shaping

- Operate optical systems close to the Shannon limit
- Enable highest flexibility in data rate
- Based on rectangular QAM formats
- Employ **non-uniform** distribution of symbols
- Emulation of Gaussian shape

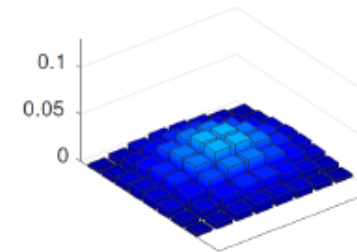
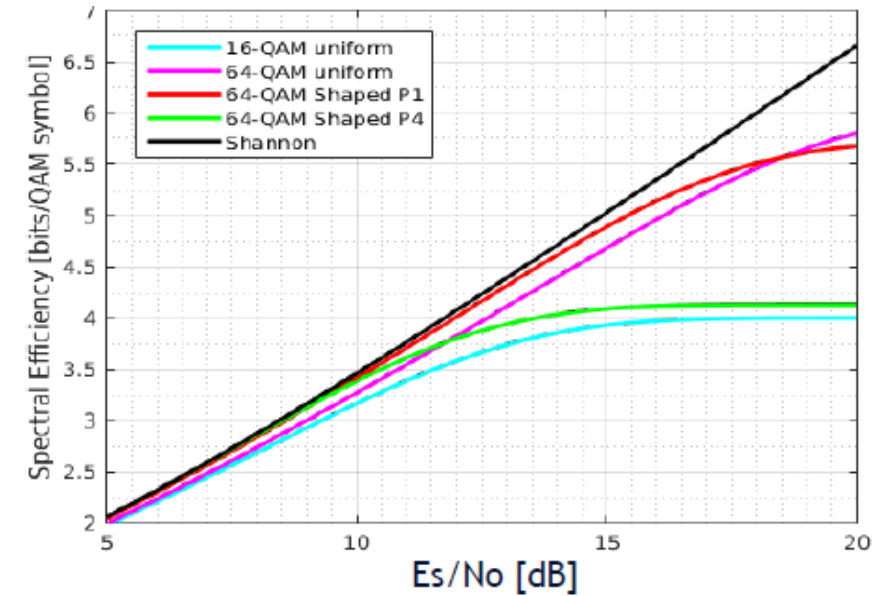
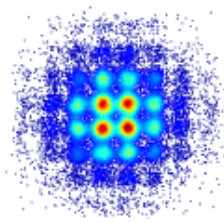
Traditional QAM

Fixed Probability Distribution

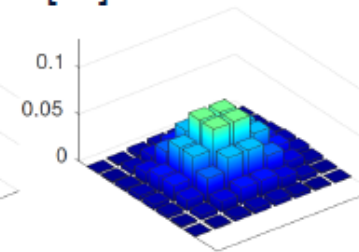


Probabilistically Shaped QAM

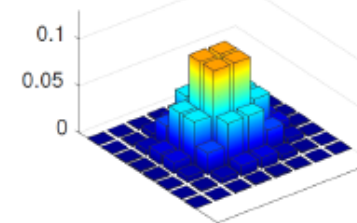
Any Probability Distribution



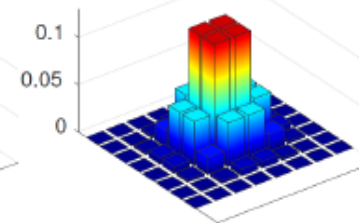
(a) $H(P_1) = 5.73$ bits



(b) $H(P_2) = 5.23$ bits



(c) $H(P_3) = 4.60$ bits



(d) $H(P_4) = 4.13$ bits



Shaping - Infinitely variable rate / reach tradeoff

Changing rate without changing modulation – **simplified programmability**

Capacity

