400G Ethernet in the field: towards game-changing technologies

Thomas Delaby – Network engineer

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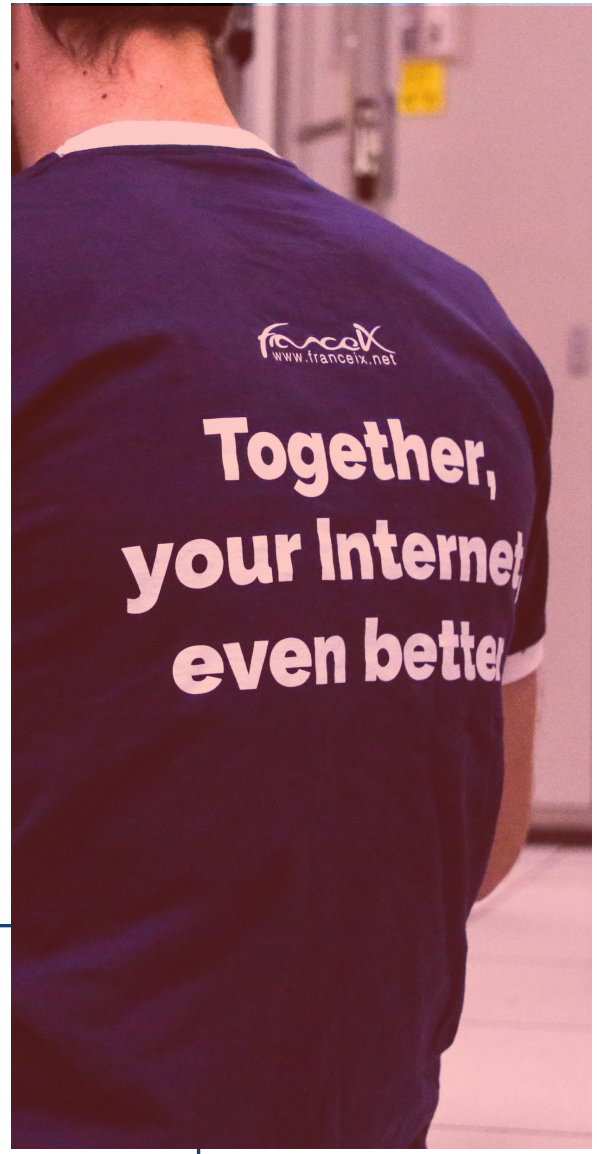
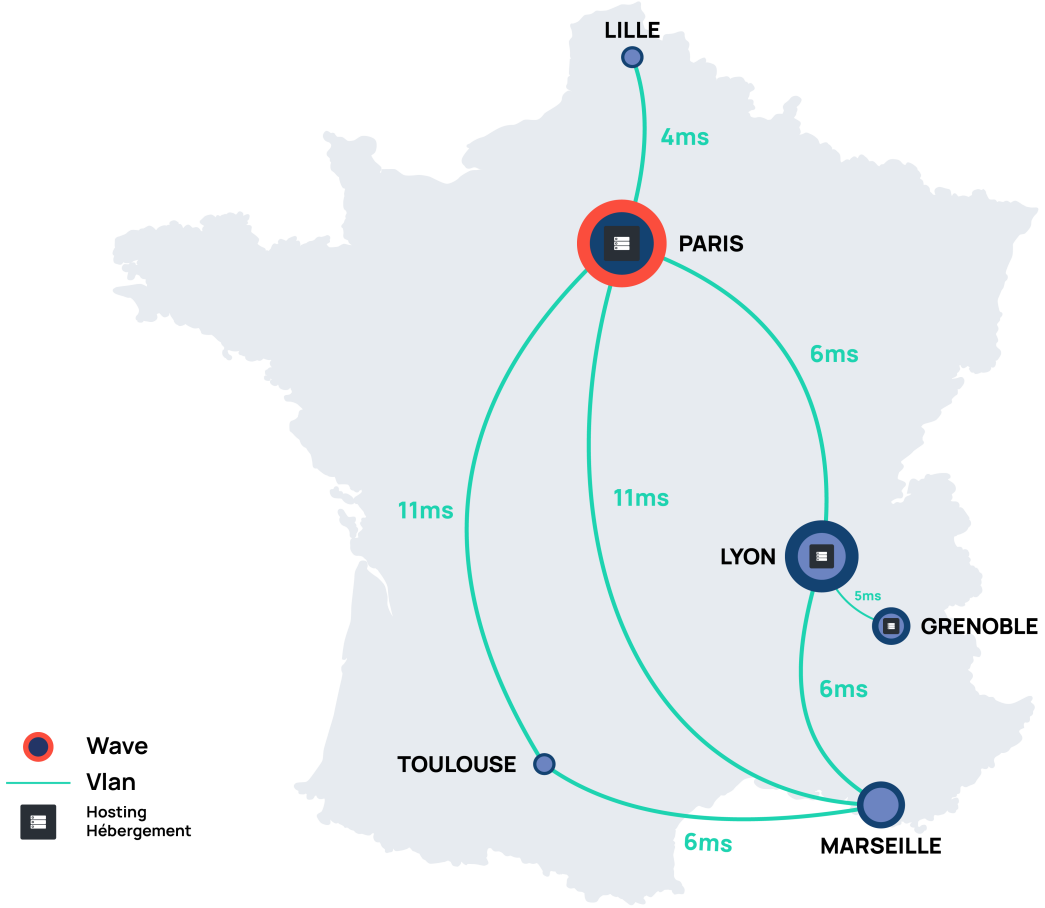
www.franceix.net

Agenda

- Who are we?
- What technologies for metro-distance backbone?
- Why are we changing?
- How to use 400G-ZR?
- More 400G ethernet
- Conclusion



FranceIX platforms & interconnections



POPs Paris :
DATA 4
Equinix PA6 Condorcet
Equinix-Telecity PA7 Courbevoie
Interxion PAR1
Interxion PAR2
Interxion PAR5
Telehouse 2 - Léon Frot
Telehouse 2 - Voltaire
Telehouse 3
Scaleway Datacenter DC2
Scaleway Datacenter DC3

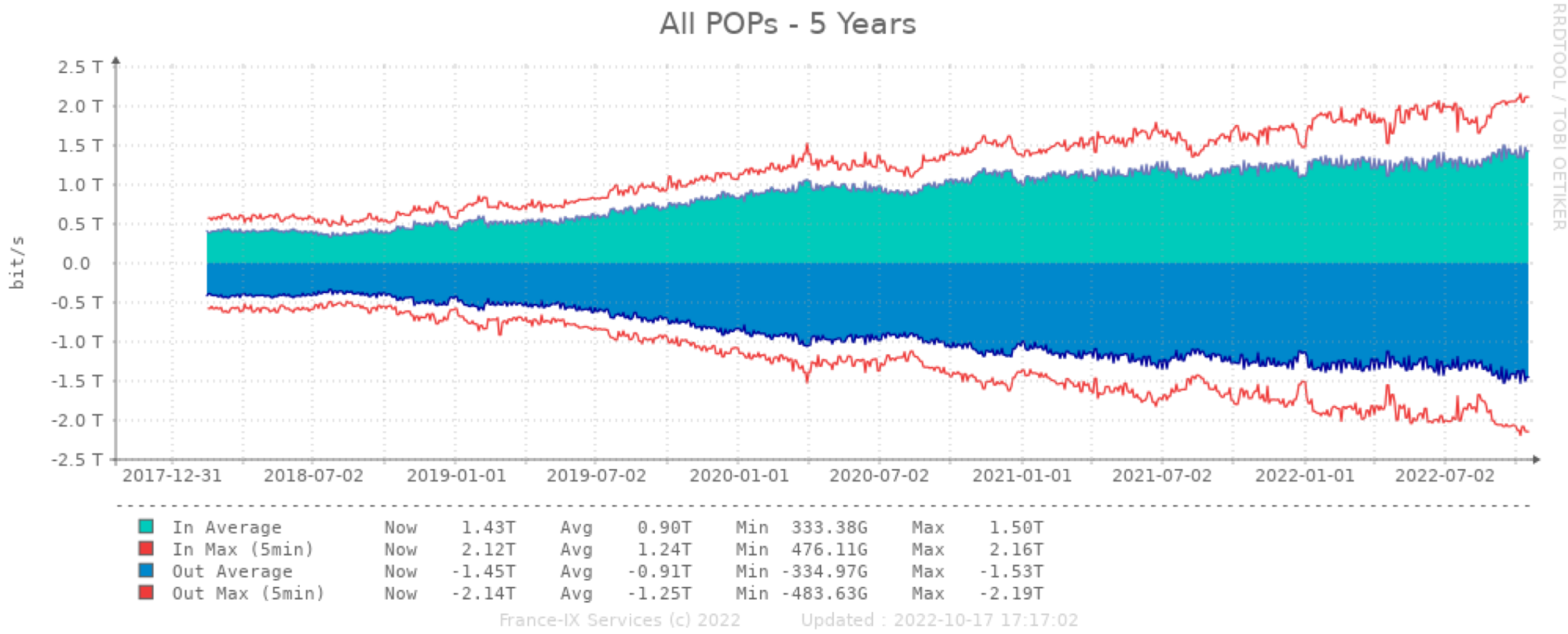
POPs Lyon :
DCforDATA
IN2P3
hostTELyon
Netcenter SFR
ROCK

POPs Grenoble :
Cogent Grenoble
Eolas Grenoble

POPs Marseille :
Interxion MRS1
Interxion MRS2
Jaguar Network MRS01
Telehouse Marseille

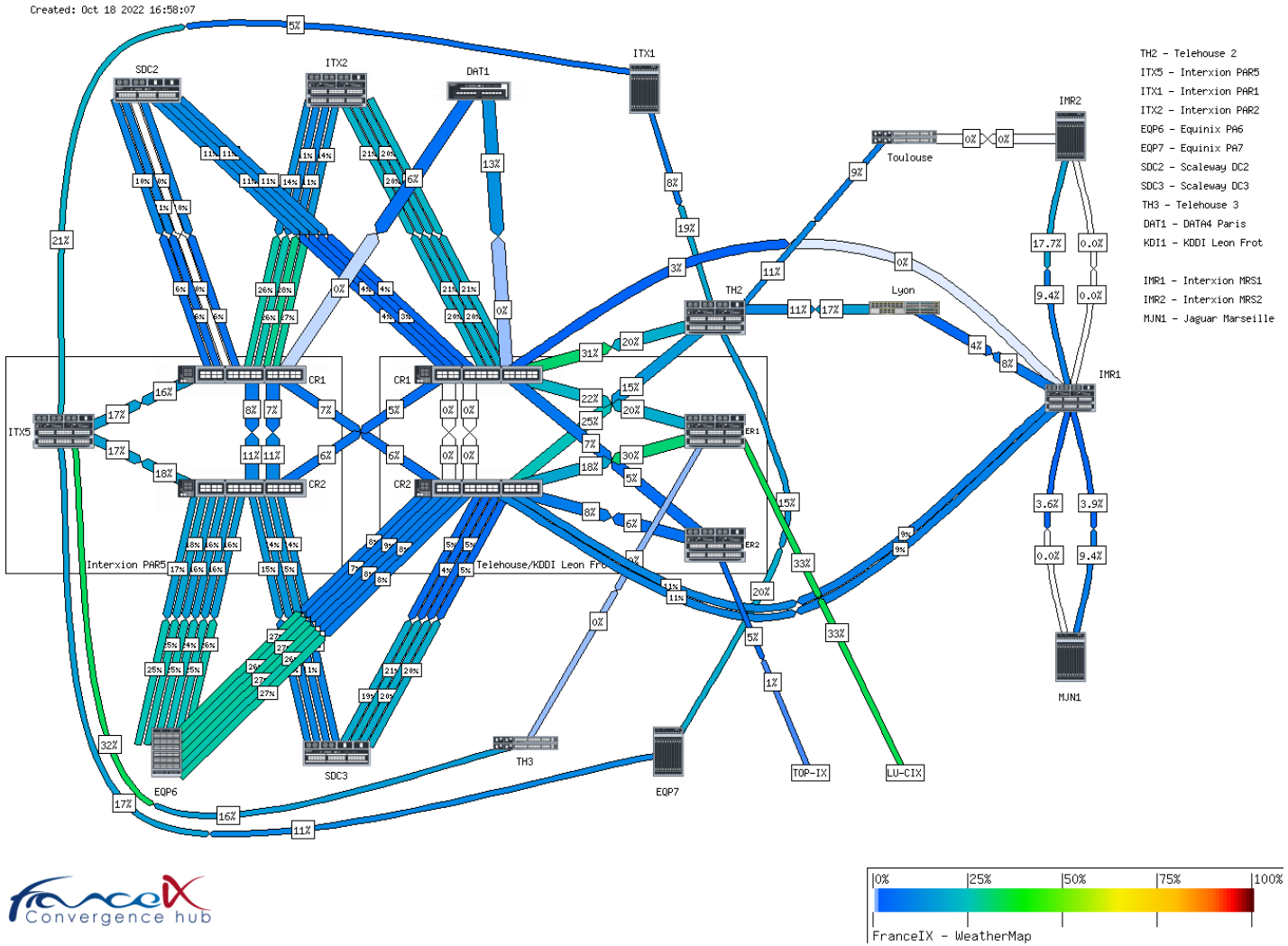
* map shows service catalog, not actual infrastructure

Steadily growing!

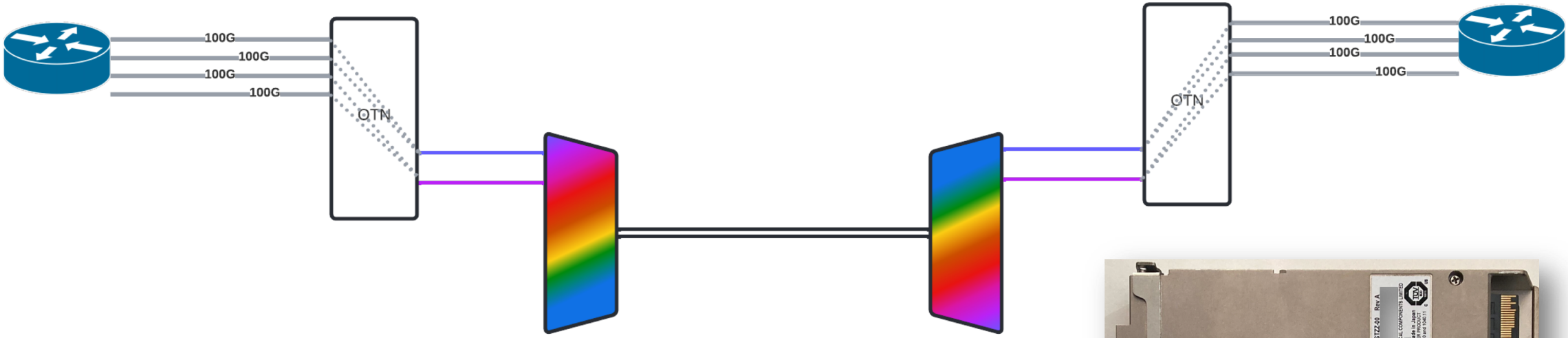


Focus on MPLS backbone

- Mainly **dark fibers** lit by FranceIX
- Historically **n*10G to n*100G** capacities provided by muxponders or DWDM optics
- Highest capacity links up to 600G inter-PoPs
- Need for a cost-effective and performant optical transport solution



Now and then, OTN muxponders



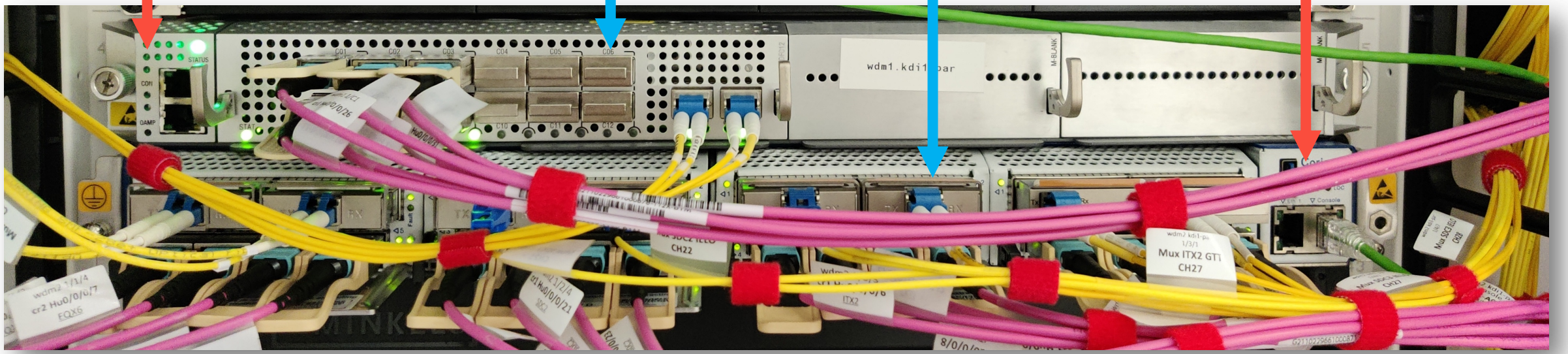
Muxponders in their natural environment

Nokia 1830 PSI-M

Coriant Groove G30

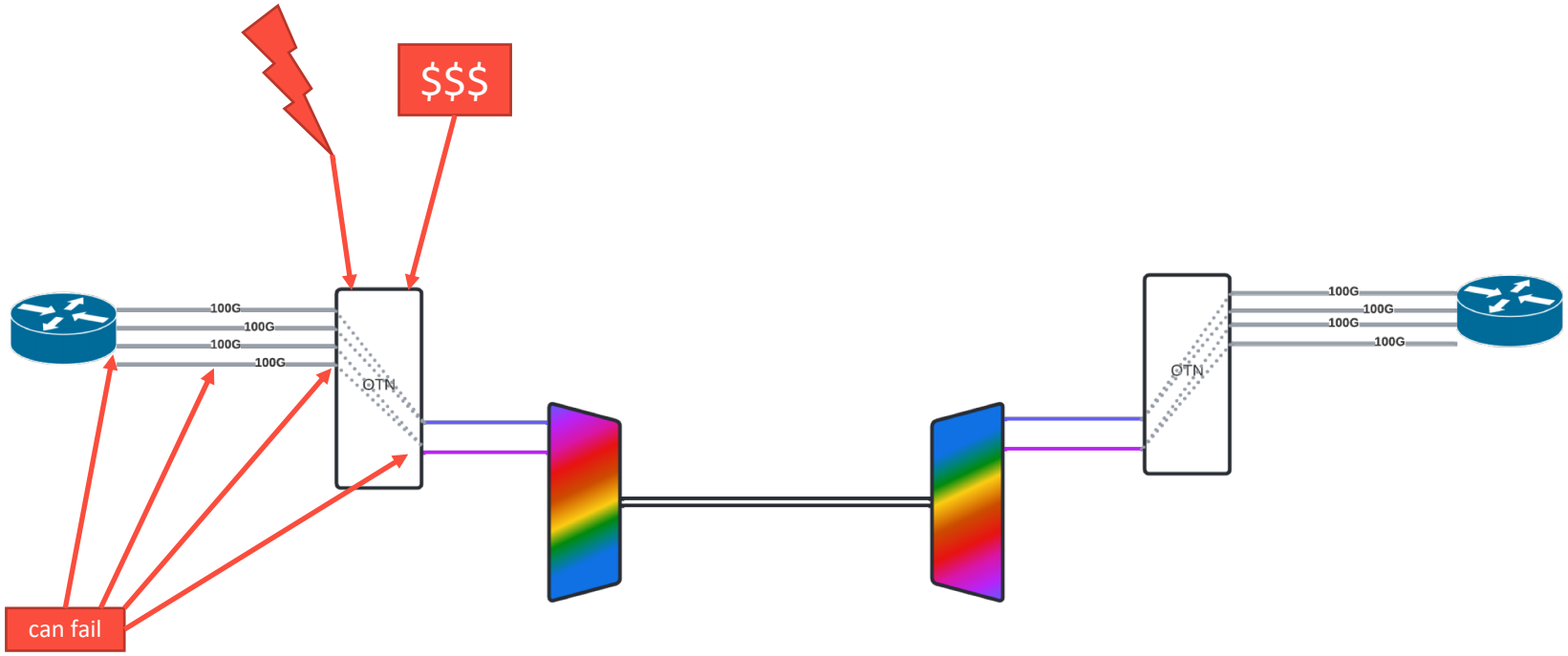
DFC12 – 12*100G clients & 2*600G lines

CHM1 – 4*100G clients & 2*200G CFP2 lines

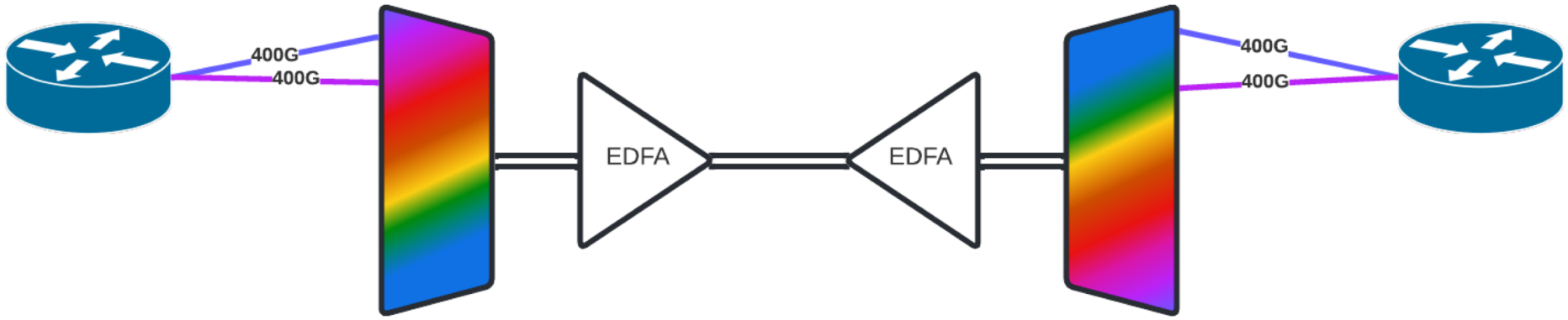


So why are we stopping muxponders?

- Cost
- Power consumption
- Complexity
- Multiple points of failure
- Cabling nightmare
- IP hardware is 400G-ready



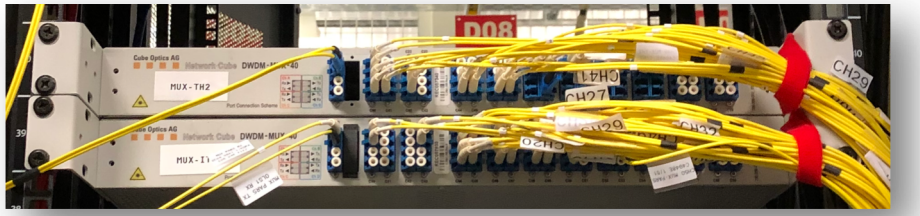
400G in the backbone – 400G-ZR model



- Cost: **-43%** for the first 400G w/ booster only, up to **-53%** at 1,2T
- Power consumption:
  - Coriant: 2*685W for 1,6Tbps = 1,14W/Gbps
  - 400G-ZR: 15W/module, 30W/EDFA, total 180W for 1,6Tbps = 0,11WGbps **(90% decrease)**
- Complexity: less active components
- ~~Multiple points of failure~~
- Cabling nightmare ended with standard LC/LC single-mode cables
- IP hardware is 400G-ready – and happy to operate at those speeds

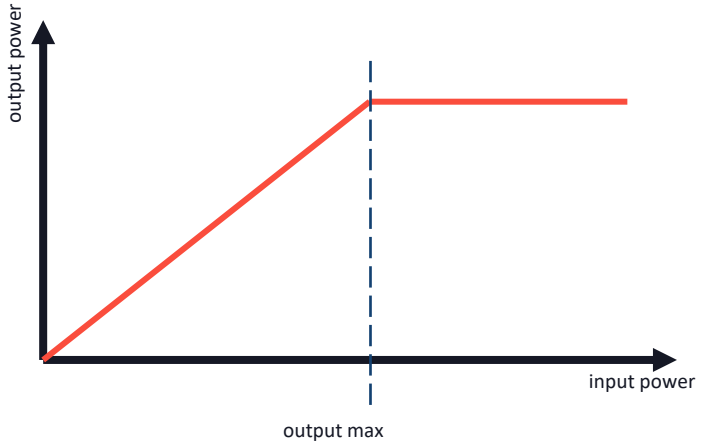
400G-ZR, building blocks

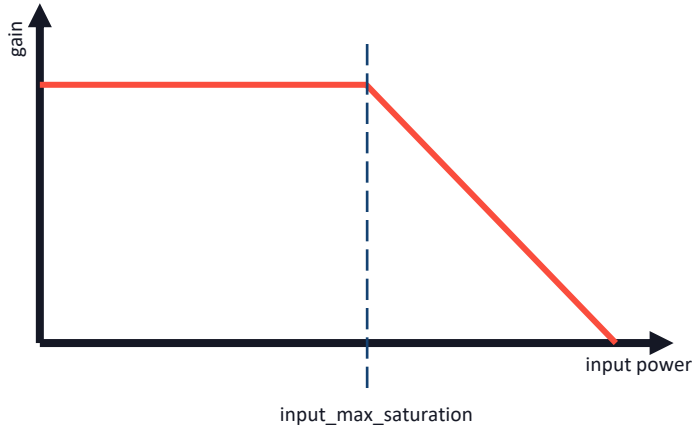
- ZR optics:
  - Competition is around the corner
  - Compatibility broadens
  - TX -8dBm, RX ~-21dBm depending on OSNR – amplification required
- EDFA amplifier:
  - Some homework to do!
  - Gain? Saturated output power? Channel equalization?
- Regular DWDM mux…
  - Better check your mux's specs
  - Channel passband ~75GHz required

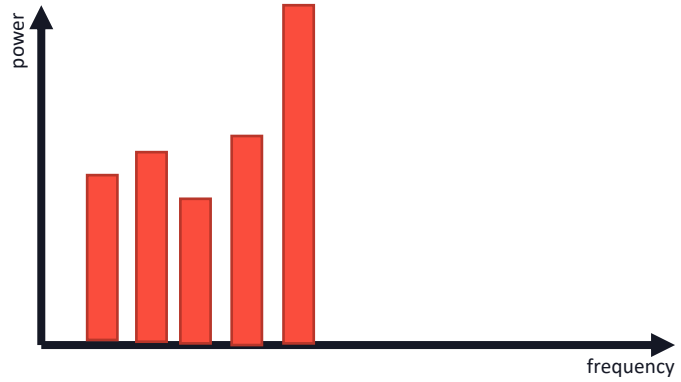


EDFA 101, learnt by experience

- Most EDFAs have settable gain:
  - +0 to +30dB depending on application and model
  - gain is almost the same on all channels
- But they can’t melt your fiber:
  - Total combined power usually limited around +20dBm

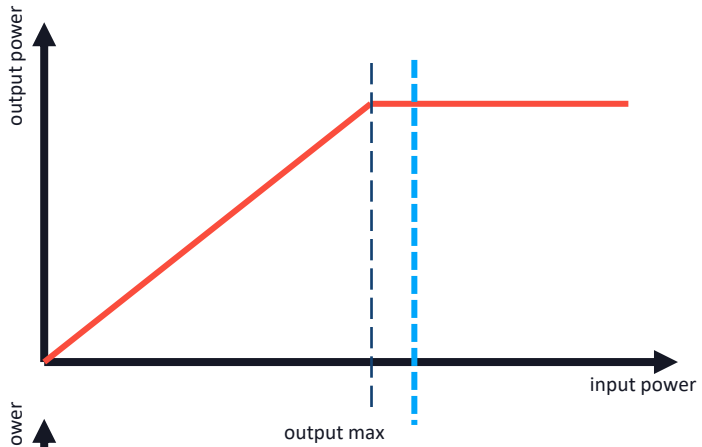


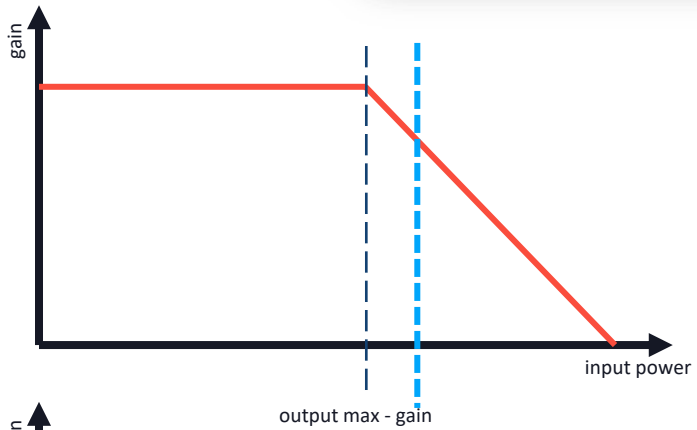


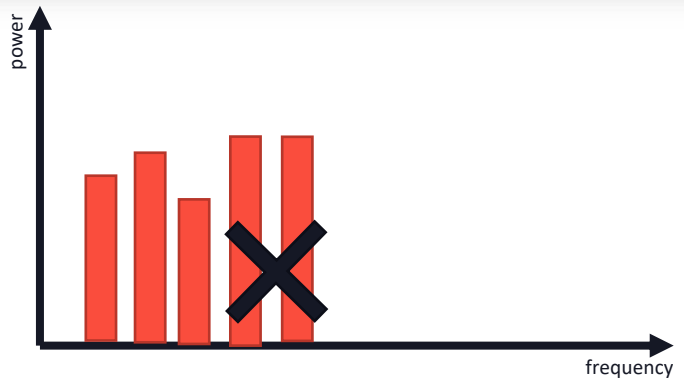


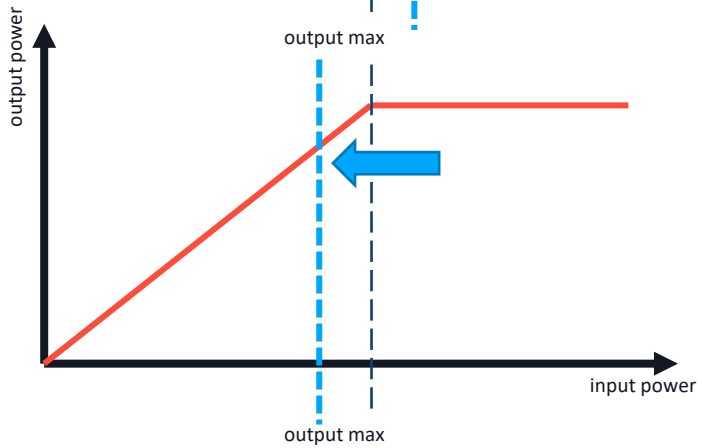
EDFA 101 (cont'd)

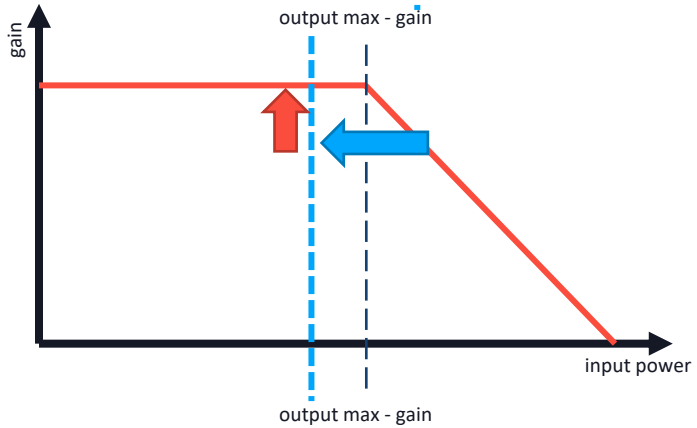
- Saturated EDFA is dangerous when channels drop!

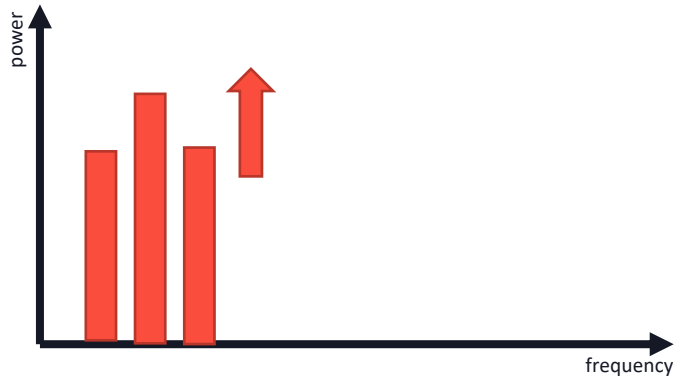












400G-ZR real-world deployment

- In Paris metro area between Interxion PAR5 and Data4 Paris-Saclay
- About 60km of dark fiber
- OSNR is 36.4dB
- Tx pwer and channel number are tunable from CLI
- Rx power irrelevant here

```
================================================================================
QSFP-DD Connector
================================================================================
Description        : QSFP-DD Connector
Interface          : 1/2/c1
FP Number          : 1                           MAC Chip Number  : 1
Licensed           : Yes
Admin State        : up
Oper State         : up
IfIndex            : [redacted]
Last State Change  : 03/10/2022 16:09:12
Last Cleared Time  : N/A                         DDM Events       : Enabled
Breakout           : c1-400g
RS-FEC Config Mode : None

Transceiver Data

Transceiver Status : operational
Transceiver Type   : QSFP-DD
Model Number       : [redacted]
TX Laser Wavelength: 1545.321 nm                 Present Channel  : 40
TX Laser Frequency : 194.000 THz                 Configured Chann*: 40
Laser Tunability   : fully-tunable               50GHz Ch Min/Max : 135/605
                                                 100GHz Ch Min/Max: 13/61
RxDTV Adjust       : Disabled                    DAC Percent      : 50.00 %
Diag Capable       : yes
Number of Lanes    : 1
Connector Code     : LC                          Vendor OUI       : [redacted]
Manufacture date   : 2022/01/10                  Media            : Ethernet
Serial Number      : [redacted]
Part Number        : [redacted]
Optical Compliance : 400G-ZR-Amp 400G-ZR-Unamp
Link Length support: Unknown

================================================================================
Transceiver Digital Diagnostic Monitoring (DDM)
================================================================================
                                Value High Alarm  High Warn   Low Warn  Low Alarm
--------------------------------------------------------------------------------
Temperature (C)                +53.0     +80.0      +75.0      +15.0      -5.0
Supply Voltage (V)              3.21      3.46       3.43       3.17       3.13
================================================================================

================================================================================
Transceiver Lane Digital Diagnostic Monitoring (DDM)
================================================================================
                                     High Alarm   High Warn    Low Warn   Low Alarm
--------------------------------------------------------------------------------
Lane Tx Output Power (dBm)             0.00       -2.00       -13.00      -14.00
Lane Rx Optical Pwr (avg dBm)          2.00        0.00       -21.02      -23.01

--------------------------------------------------------------------------------
Lane ID Temp(C)/Alm       Tx Bias(mA)/Alm   Tx Pwr(dBm)/Alm   Rx Pwr(dBm)/Alm
--------------------------------------------------------------------------------
    1             -                 -             -8.47             -7.98
================================================================================

================================================================================
Coherent Optical Module
================================================================================
Cfg Tx Target Power:  -8.00 dBm              Present Rx Channel : 40
Cfg Rx LOS Thresh  : -23.00 dBm              Cfg Rx Channel     : 40 (auto)

Disp Control Mode  : automatic               Sweep Start Disp   : -25500 ps/nm
Cfg Dispersion     :      0 ps/nm            Sweep End Disp     :   2000 ps/nm
CPR Window Size    : 32 symbols              Rx LOS Reaction    : squelch
Compatibility      : longHaul

Cfg Alarms         : modflt mod netrx nettx hosttx
Alarm Status       :
Defect Points      :

Rx Q Margin        :    1.7 dB               Chromatic Disp     :   1019 ps/nm
SNR/OSNR X Polar   :   16.8 dB / 36.4 dB     Diff Group Delay   :      2 ps
SNR/OSNR Y Polar   :   16.8 dB / 36.4 dB     Pre-FEC BER        : 2.500E-03

Module State       : ready
Tx Turn-Up States  : init laserTurnUp laserReadyOff laserReady
                     modulatorConverge outputPowerAdjust
Rx Turn-Up States  : init laserReady waitForInput adcSignal opticalLock
                     demodLock
================================================================================
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* indicates that the corresponding row element may have been truncated.
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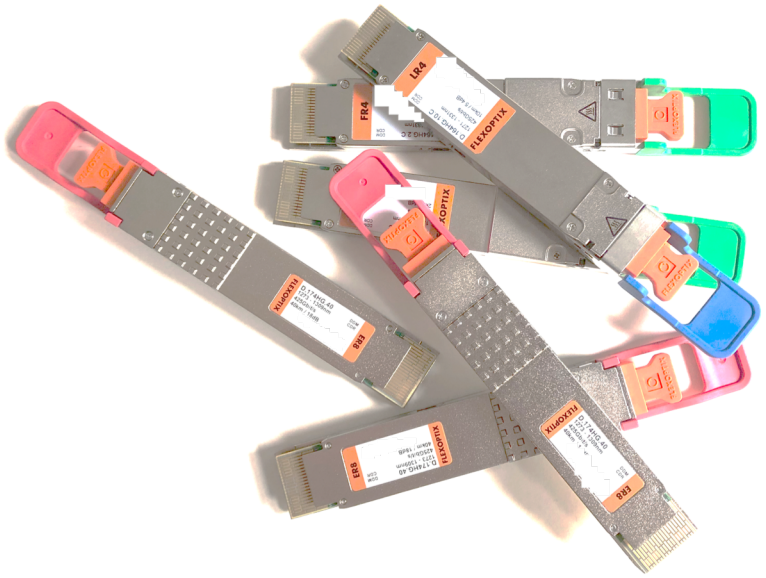
400G-ZR and its friends

- 400G-ER8: 40km, 1310nm, price tag -75% compared to muxponder
- 400G-LR4: up to 10km, 1310, price tag -90%



Conclusions

- 400G is more than ready for production
- Your backbone loves it:
  - Cheap
  - Consumes less power
  - Reduces complexity
- Lowers significantly the bar for high-capacities in the backbone: where another technology was relevant, 400G is better now
- High capacities are also generally cheaper

Together, your internet even better

W W W . F R A N C E I X . N E T

Thomas Delaby – Network Engineer

tdelaby@franceix.net
Corporate twitter : @ixpfranceix
Technical twitter : @as51706, @as42064