

# Fabio Cavaliere, Rapporteur Q6/15 | Ericsson, Sweden



Fabio Cavaliere is Expert in Photonic Systems and Technologies at Ericsson, and Rapporteur of ITU-T Question 6/15 (Characteristics of optical components, subsystems and systems for optical transport networks). Fabio is author of about 130 filed patent applications, more than 100 publications on optical networks, the book “Photonics applications for radio systems and Networks (Artech House, Boston, USA), and editor of the book “New Trends in Optical Networks” (Applied Sciences (ISSN 2076-3417). In 26 years of professional experience, his research activity encompassed radio access networks, fiber access, high speed optical transmission and integrated photonics. Fabio is in the technical program committees of international conferences on optical communications, guest editor of Applied Science’s Topical Collection on Optical Networks and of IEEE Communications Standards Magazine. He is in the Board of Stakeholders of Photonics 21 (the European technology platform on photonic technologies), in the Expert Advisory Board of NetworldEurope and in the Strategic Advisory Board of the European Quantum Flagship.



An aerial night photograph of Hong Kong, showing a dense cluster of illuminated skyscrapers and buildings along the waterfront. The city lights reflect on the water, and the overall scene is a vibrant display of urban architecture.

# ITU Workshop on “Evolution of Optical Networks for IMT2030 and Beyond”

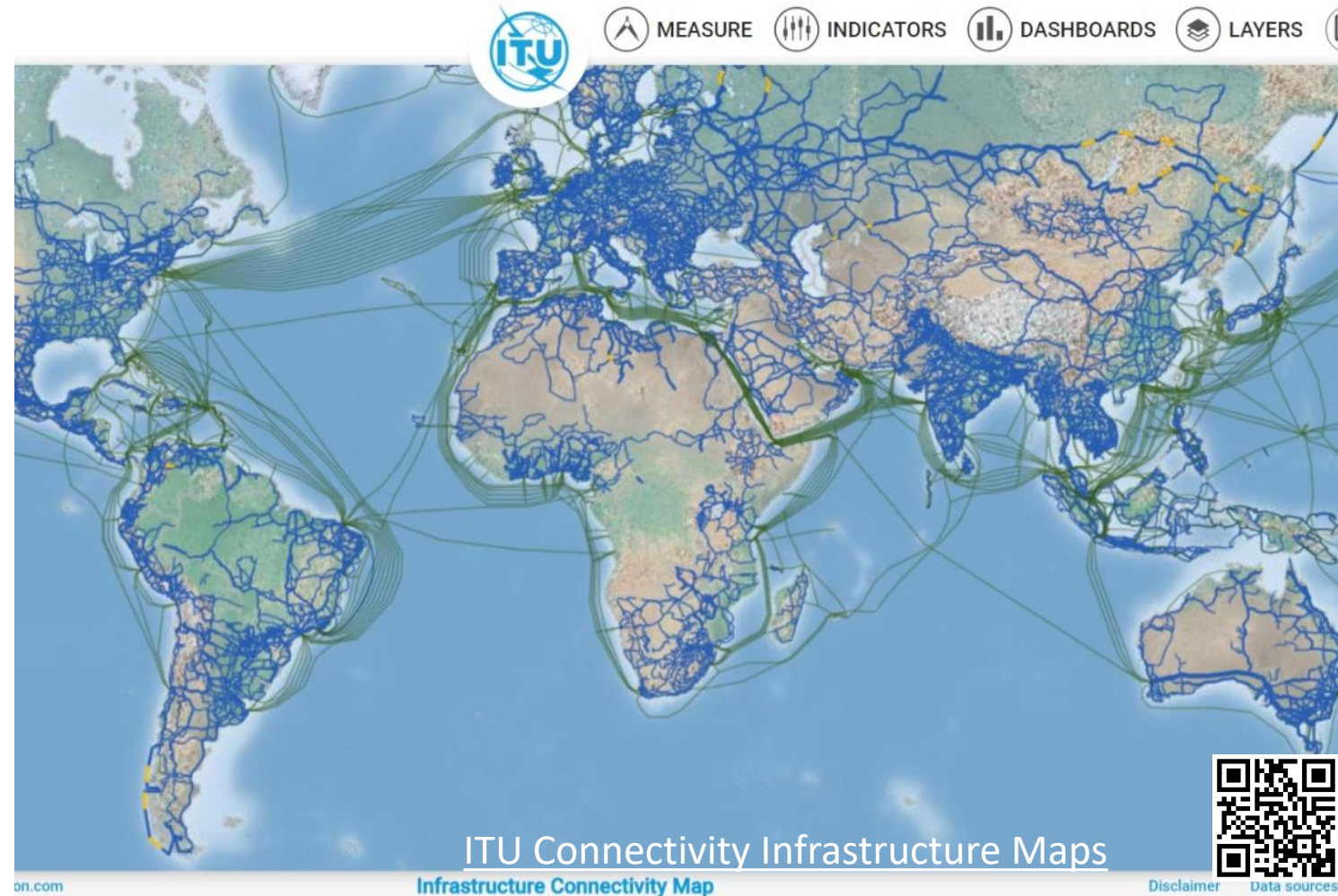
Charles K. Kao Auditorium, Hong Kong Science and Technology Park (HKSTP)  
– 20 November 2024, 15:00 - 18:00

## Optical transport trends and impact on standards

Fabio Cavaliere  
Ericsson

# The importance of optical infrastructures

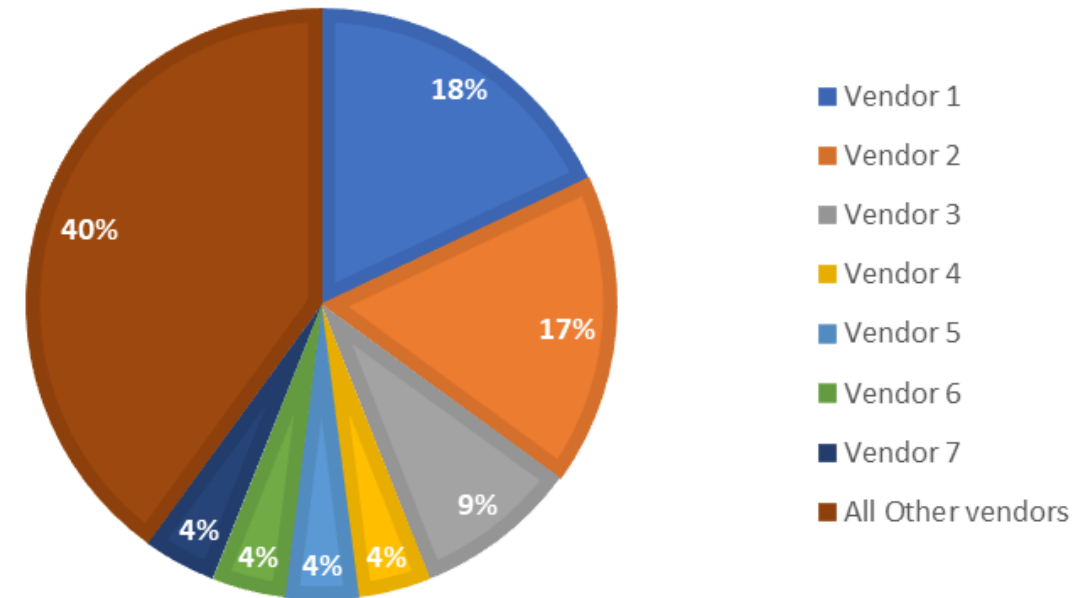
- Optical fiber networks are deployed in telecommunication systems worldwide, generating a healthy market
- They are continuously being pushed by new bandwidth-demanding services, including 5G/6G and high-speed Internet access.



# The optical infrastructure market

- Revenue of the optical networks market in 4Q23 (excluding access and routers): \$16.5bn (+1.4% compared to 4Q22)
- 14th consecutive quarter where it exceeded \$16bn
- What about the future?
  - Headwinds: uncertain macroeconomics and geopolitics; operators struggles with inventory optimization and high cost of capital
  - Tailwinds: AI roll-outs, xPU and optics expansion in data centers
- The optical components market (\$13bn in 1Q24) remains healthy but fragmented
  - Competition fosters innovation but also poses profitability challenges
- Standards, like the ones developed by ITU-T, are essential, to secure multi-vendor interoperable products, produceable in high volumes

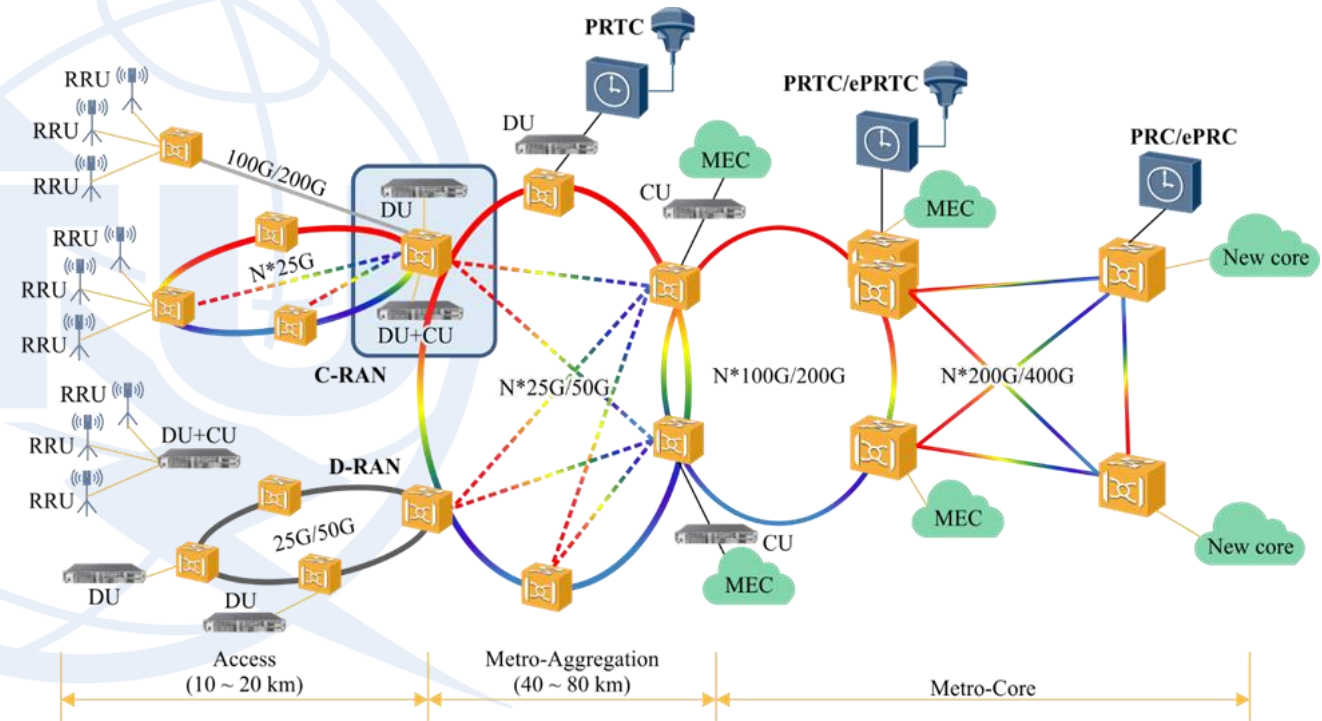
OPTICAL COMPONENTS MARKET SHARE



# How the RAN evolution affects optical transport networks

- 5G RAN, and even more 6G, leads to the new requirements in optical transport networks
  - Short distances, as in access networks
  - High capacity and multiple topologies, as in WANs
  - Self-configurability and automation
  - Low latency transmission and switching.
- What does it imply for optical systems?
  - High product volumes, as in datacom
  - Low target cost is low, as in access
  - Demanding features as in WAN
- These new developments lead to business opportunity appealing but also to risks
- Standardization is the key to mitigate these risks

Example of mobile transport network topology, from ITU-T Recommendation G.8300



G.8300(20)\_F9-1

# Key enabling technologies and Q6 standards

High transmission speed

G.698.2  
G.959.1  
G.695

Integrated communication and sensing

G.dfos  
G.697  
New TR

Network automation

G.698.4

Flexibility at low latency

G.671  
G.672

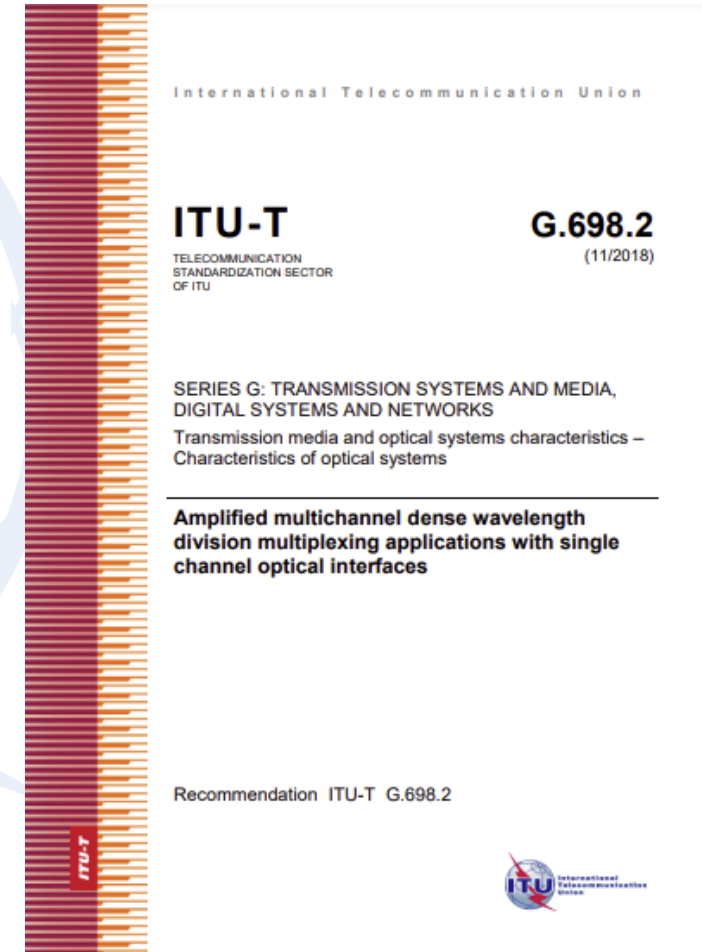
Long distance

G.661

# Enabling high transmission speed at lower cost

## Transmitter Quality Metrics (TQM) for coherent transmitters

- Rec. ITU-T G.698.2 defines Error Vector Magnitude (EVM) as TQM for 100G DP-QPSK
- Works are on-going about a TQM for DP-16QAM (used at 400G and 800G)
- EVM is already used as TQM for 400G ([OIF 400ZR IA](#)) but has some issues:
  - Reference receiver not sufficiently defined
  - EVM evaluation depends on finely tuned parameters that require to maintain a script as an Annex of the Rec.
  - The script should be embedded in a test equipment
- This leads to effort (=cost) vendors are not willing to pay
- Problem: define a TQM simpler than EVM based on a realistic reference Rx that would not oblige vendors to buy expensive instrumentation from a single vendor
- ETCC os being developed as a new simpler metric in liaison with IEEE 802.3



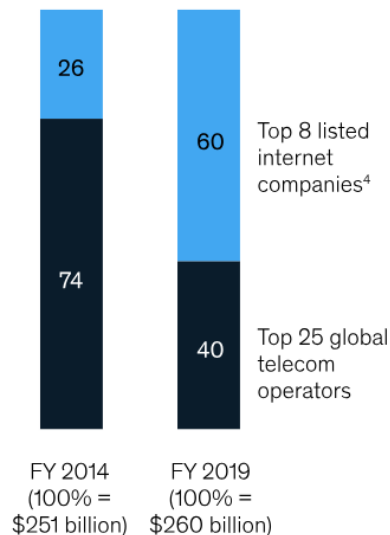
# Enabling low latency and flexibility

- Most operators are struggling with the TCO of their networks
- Skipping aggregation stages (whenever possible) would reduce number and size of network sites and relevant TCO sources (real estate, security personnel, energy bill, equipment maintenance, ...)
- Bypassing unnecessary processing stages requires programmable optical switching means (e.g. ROADMs) to continue to ensure a certain degree of flexibility and low latency
- Can ROADMs be made cheap enough to be used in the metro-access and aggregation segments?

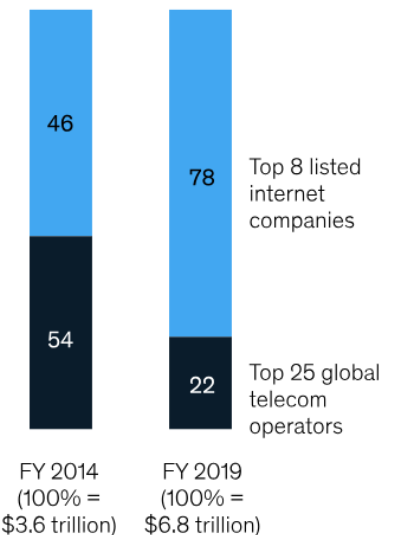
ROIC<sup>1</sup> to WACC<sup>2</sup> spread for top 25 global telecom operators,<sup>3</sup> %



Share of profit by company type, %



Share of market cap by company type, %



<sup>1</sup>Return on invested capital, including goodwill.

<sup>2</sup>Weighted average cost of capital.

<sup>3</sup>Top 25 global operators by revenue, excluding private companies.

<sup>4</sup>Top 8 internet companies by revenue, excluding private companies.

Source: Analysys Mason; Omdia; Corporate Performance Analytics by McKinsey

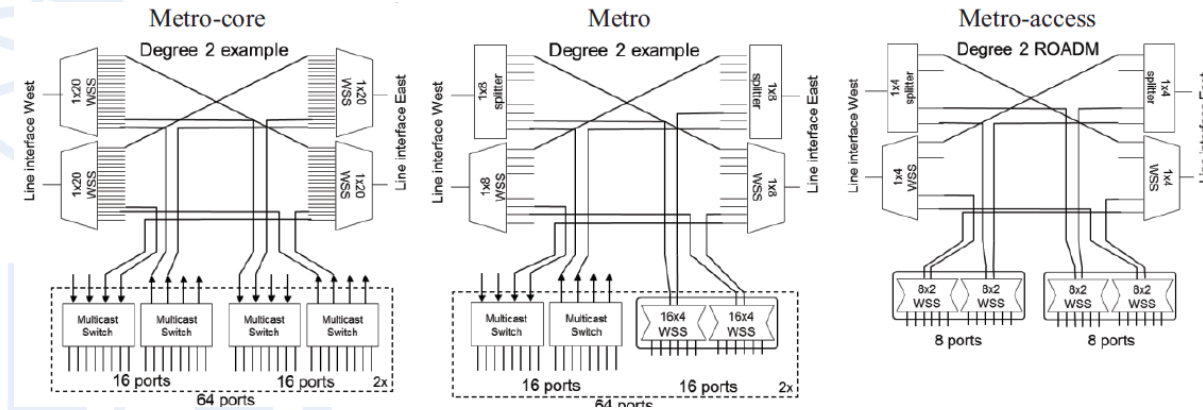
McKinsey  
& Company

A blueprint for telecom's critical reinvention  
April 28, 2021 | [Article](#)

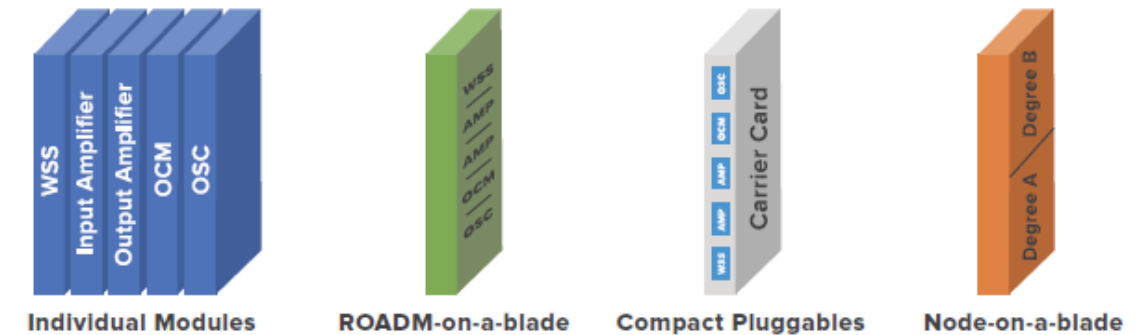


# ROADM technology evolution

- Since their introduction in the 2000s, ROADMs evolved in different directions: increase of port counts, support of flexigrid, more flexible add/drop and reduction in footprint
- A single LCoS array can be partitioned to deliver multiple WSSs in a single unit. Twin and quad WSSs are today on the market.
- Optical amplifiers are today available in a pluggable form factor (e.g., XFP or QSFP-DD)
- The components required for one or more ROADM degrees can be integrated in a single, possibly pluggable, module.
- Integrated photonics offer further opportunities for footprint and cost reduction
- But this is not trivial (next slide)



M. Schiano, A. Percelsi and M. Quagliotti, "Flexible node architectures for metro networks," 2015 Optical Fiber Communications Conference and Exhibition (OFC), Los Angeles, CA, USA, 2015, pp. 1-3, doi: 10.1364/OFC.2015.W3J.4.



Source: Infinera White Paper "The Seven Vectors of ROADM Evolution"

# HW disaggregation vs integration

- Photonic Systems on chips
  - Very cost effective
  - Ultra-compact footprint
  - Optimized designs
  - Proprietary design and processes
  - Lack of PDK and standards
  - Requires high volumes to fly
- Disaggregated HW
  - Standard interfaces
  - Multi-vendor interoperable
  - Easy to manage
  - Performance trade-offs
  - Possible footprint issues
  - More expensive
- Digitized integrated photonics designs, based on standard PDKs, interfaces and fabrication processes (including packaging). Call for a standard?



# Conclusions

- Optical infrastructures are vital for our society and economy
- 5G and 6G are leading to new developments = opportunities & risks
- Standardization is the key for operators and industry to mitigate these risks
- ITU-T (and Q6 😊) are at the forefront of this evolution, developing standards for key enabling technologies
- This is a difficult but exciting task, which require tradeoffs
  - Multi-vendor interoperability vs. cost (example: 800G TQM)
  - Integration vs disaggregation (example: ROADMs)



**Thank you !**

