
Introduction to Optical Networks – Physical Layer

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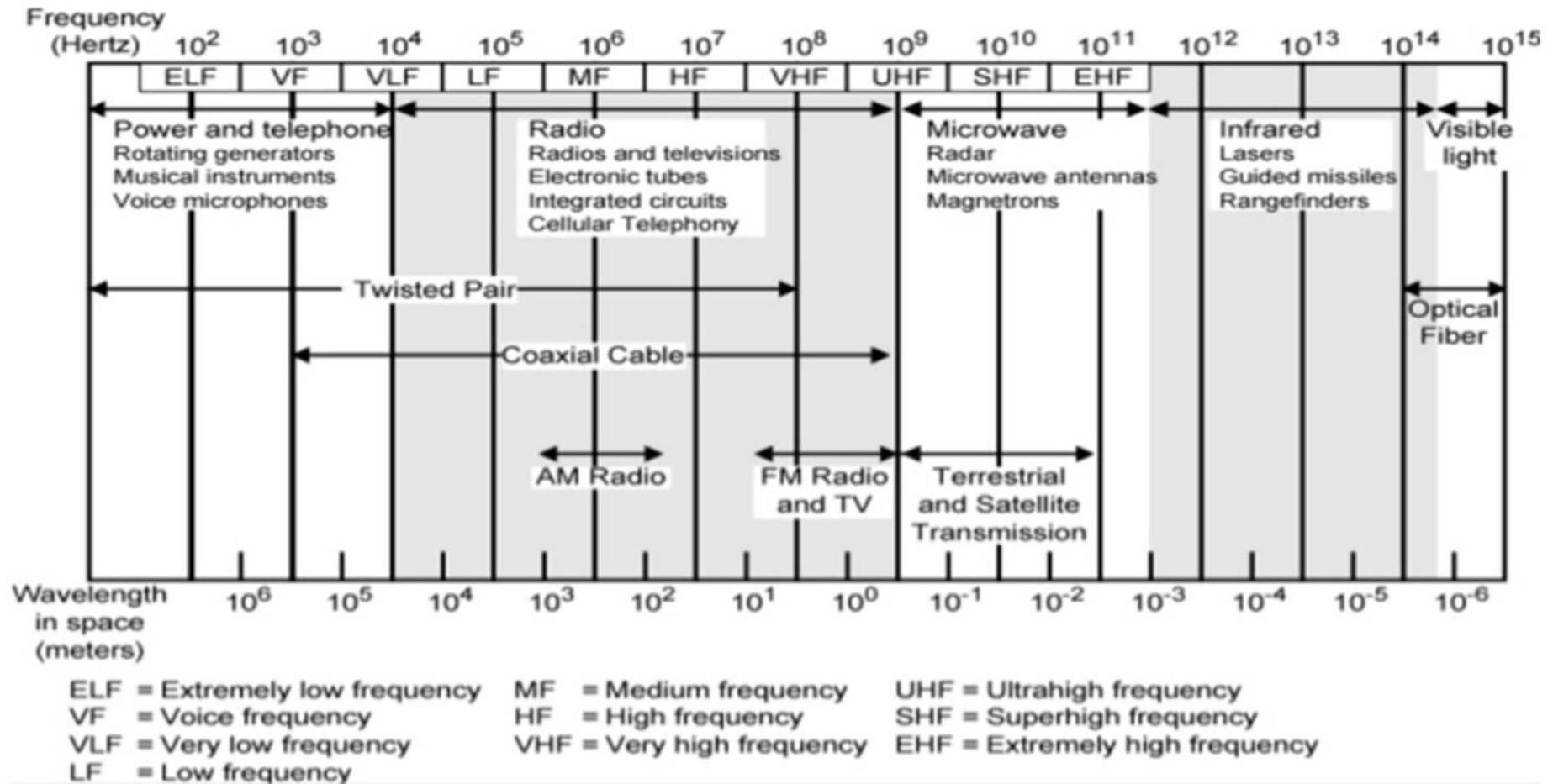
Optical communications: Why?

Optical fiber advantages

- Huge bandwidth
- Long range transmission (optical amplifiers)
- Strength
- Use flexibility (transparency)
- Low noise
- Low cost
- Interference immunity

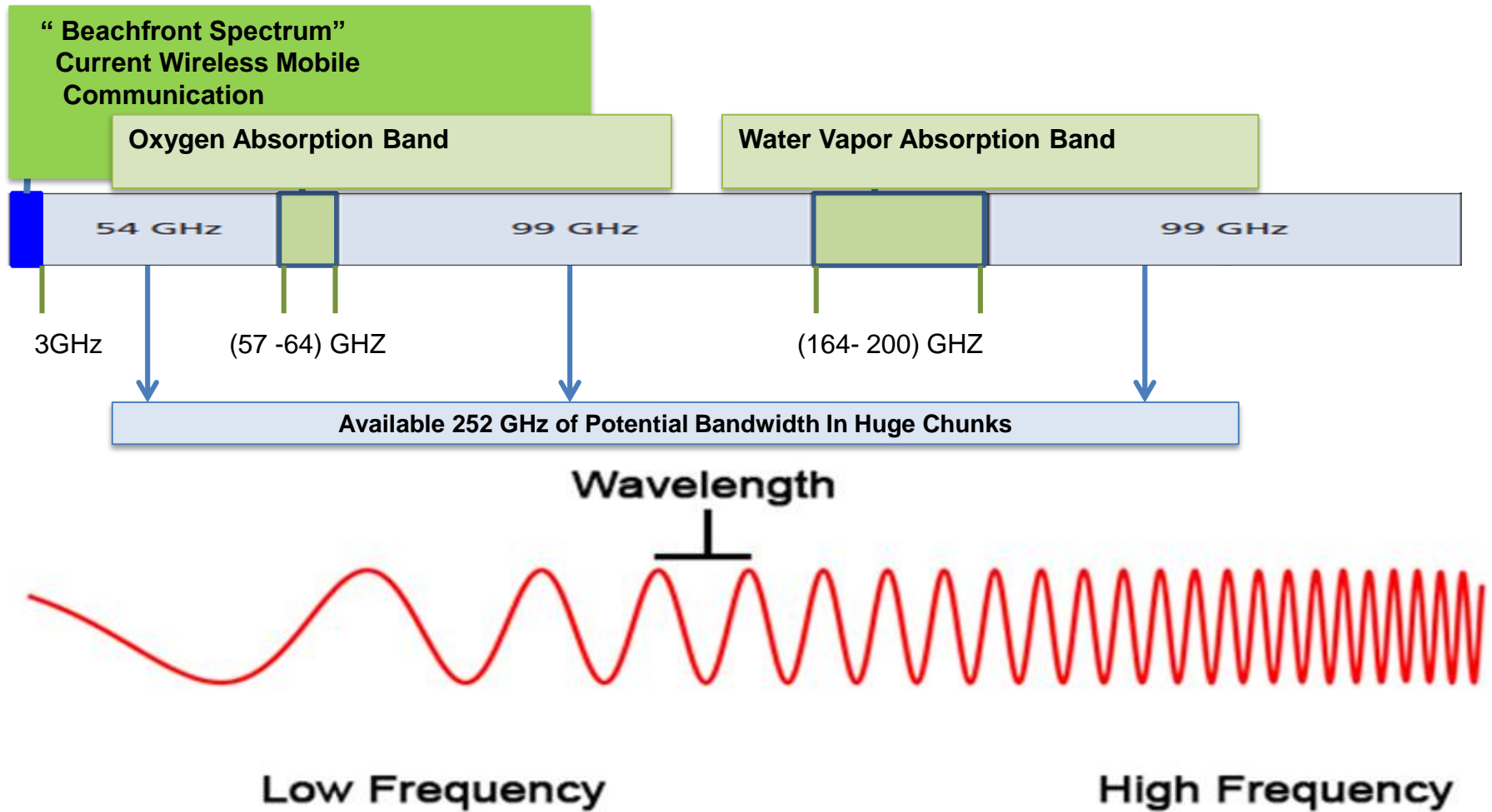
Spectrum of transmission media

Electromagnetic Spectrum



$$\lambda = v/f, \quad v = C = 3 * 10^8 m/s$$

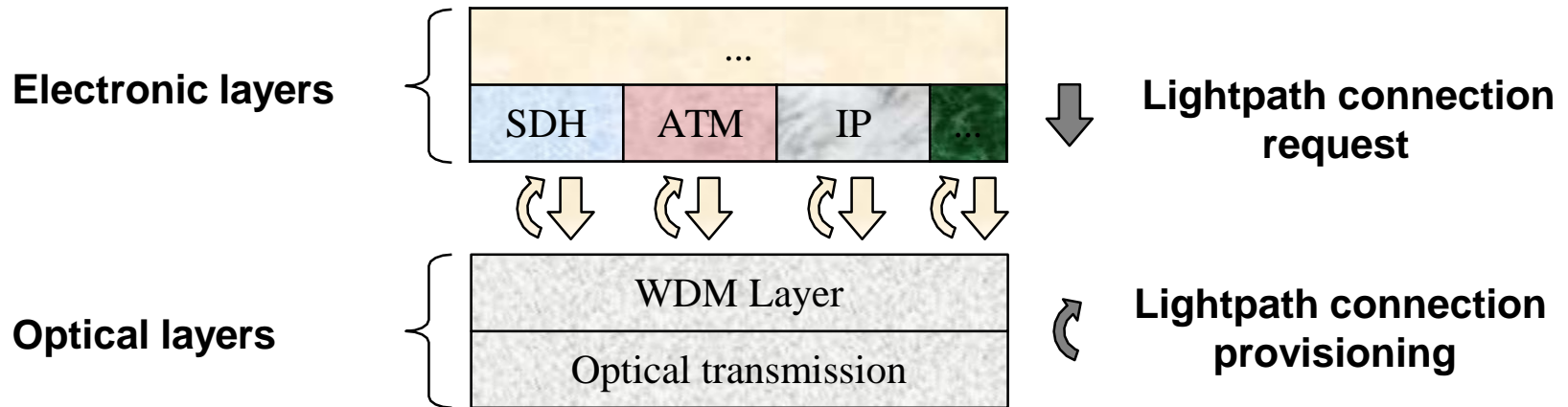
Effects of mmWaves



✓ High frequency => More data

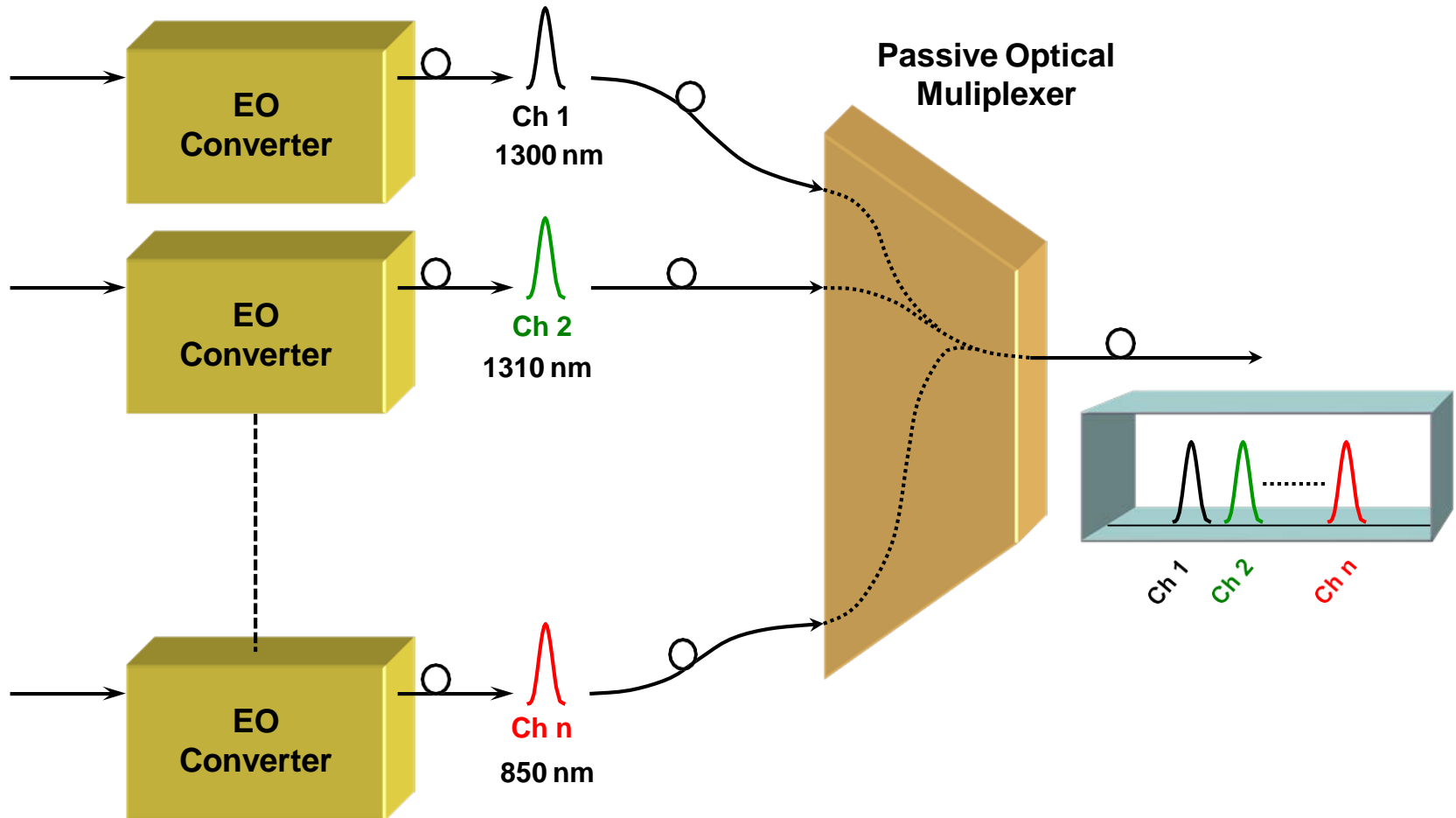
WDM optical networks

- **WDM = Wavelength Division Multiplexing** (wavelength = channel)
- **WDM layer basic functions**
 - Offers optical circuit (LIGHTPATH) for electronic layers
 - Common transport platform for a multiple protocol in L2 and L3



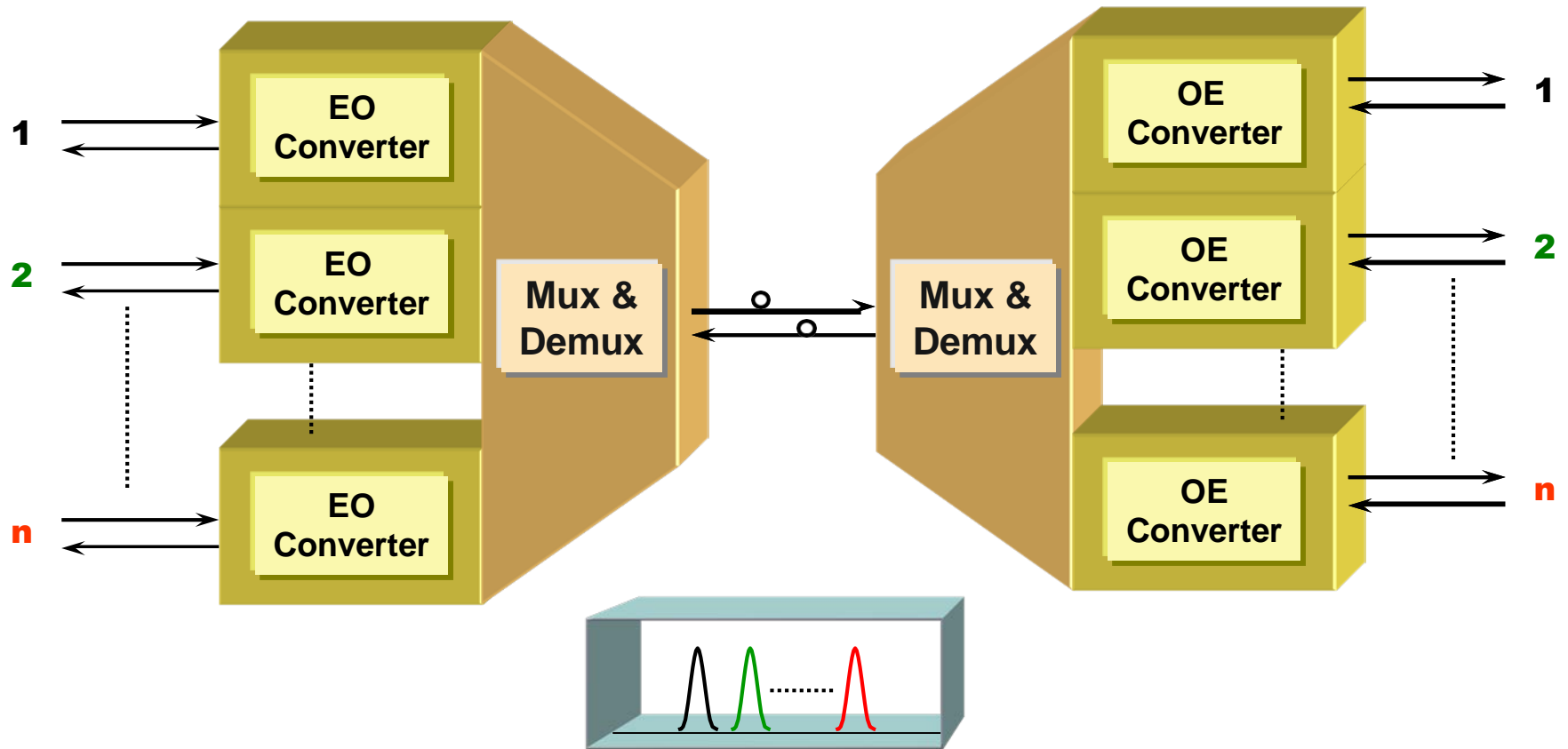
- **WDM layer fundamentals**
 - **Wavelength Division Multiplexing:** data carried on different channels (i.e., different wavelengths) on the same fiber
 - **Switching:** WDM systems switch optical flows in the space (fiber) and wavelength domains

What's a WDM System?

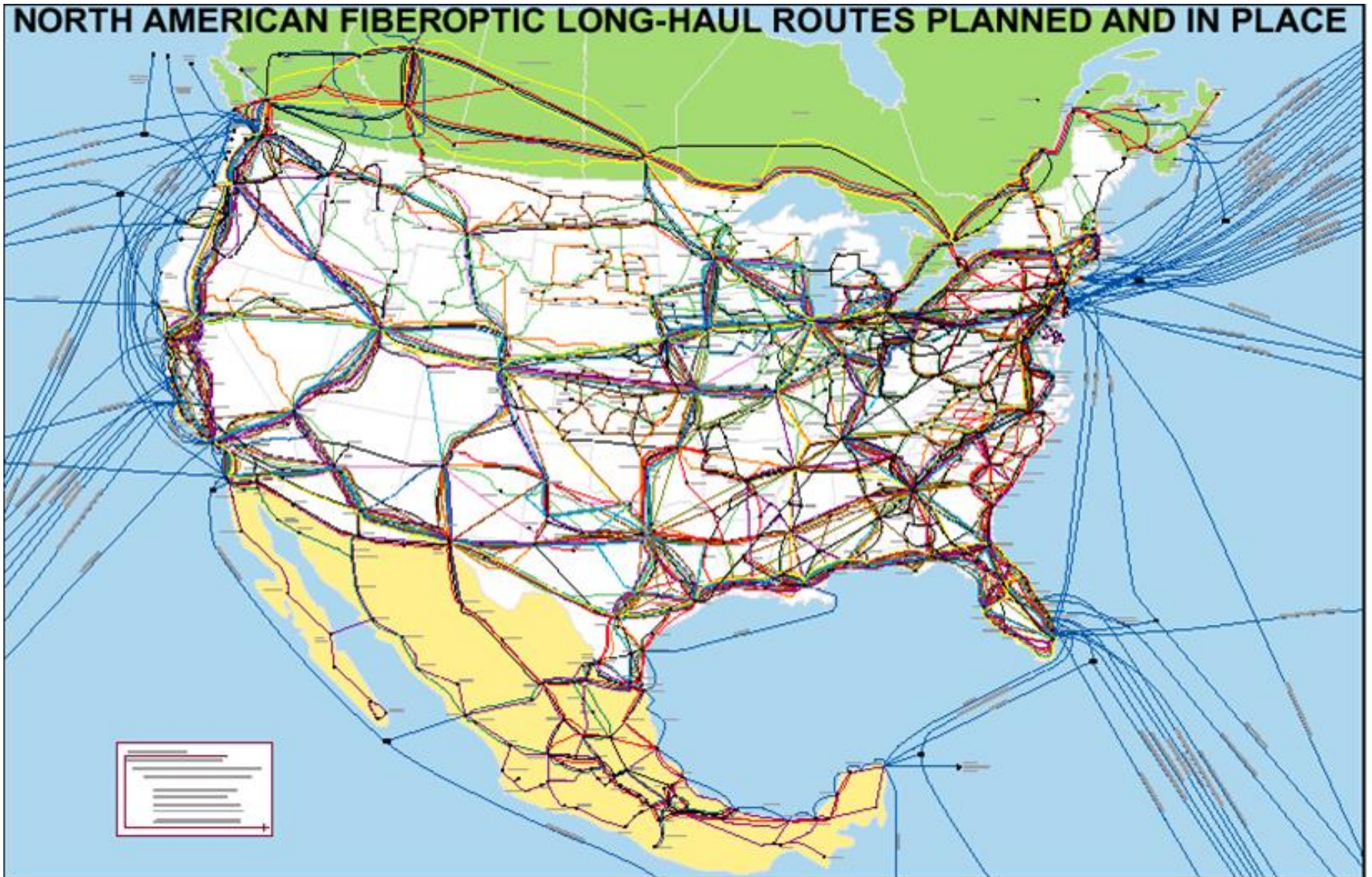


EO – Electrical to Optical

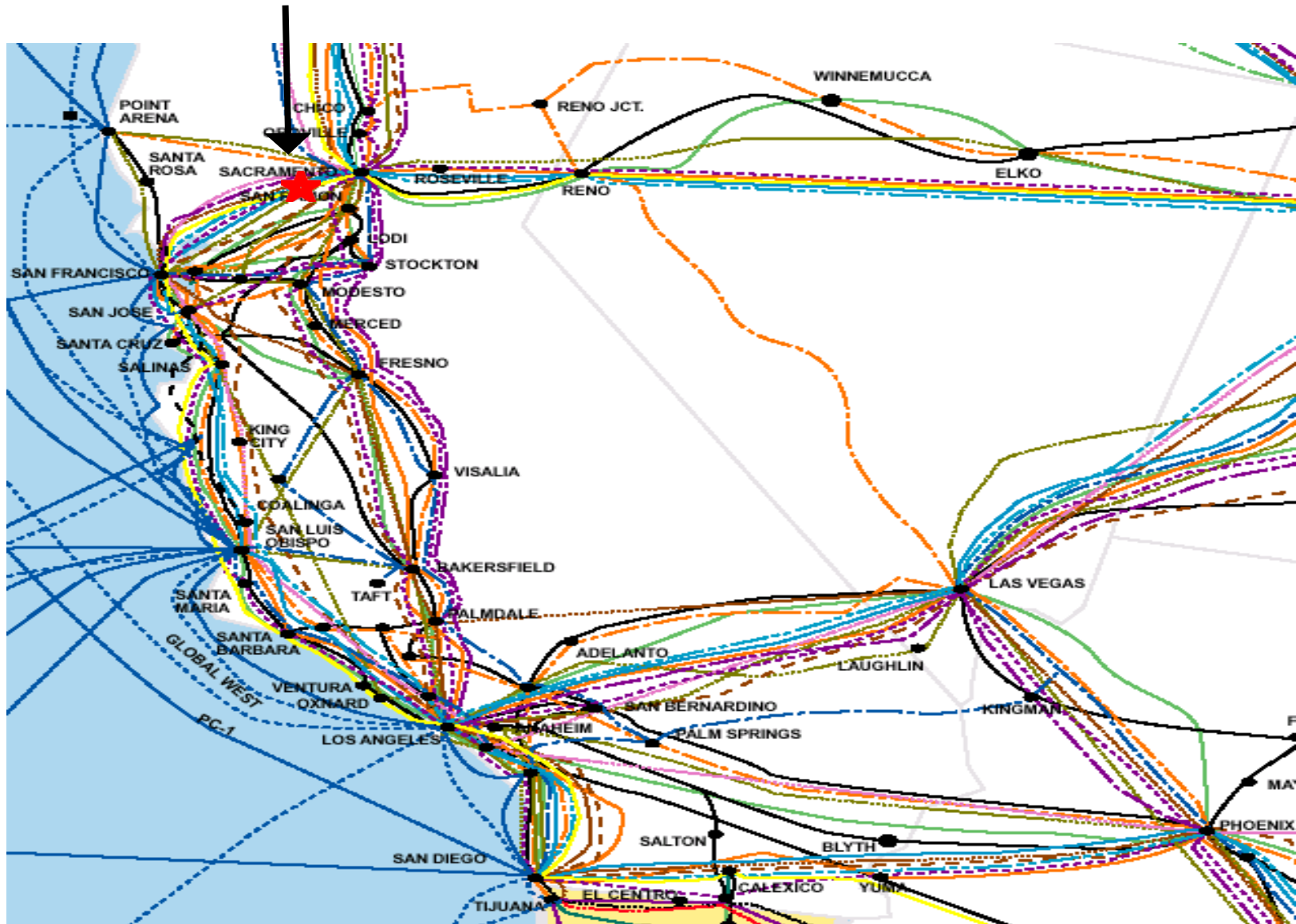
WDM System Function



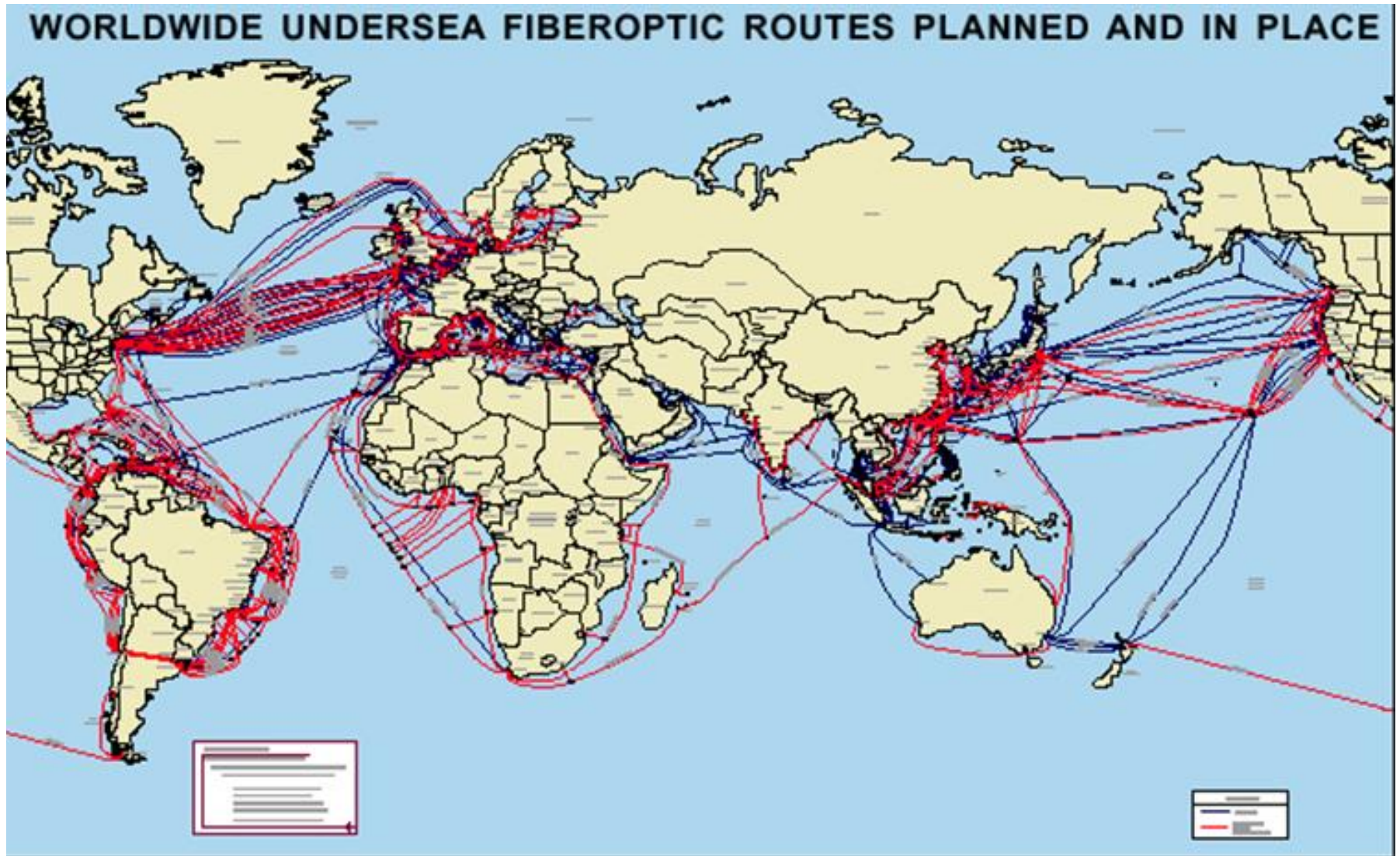
North American Fiber Routes



California Fiber Routes



Global (Undersea) Fiber Routes

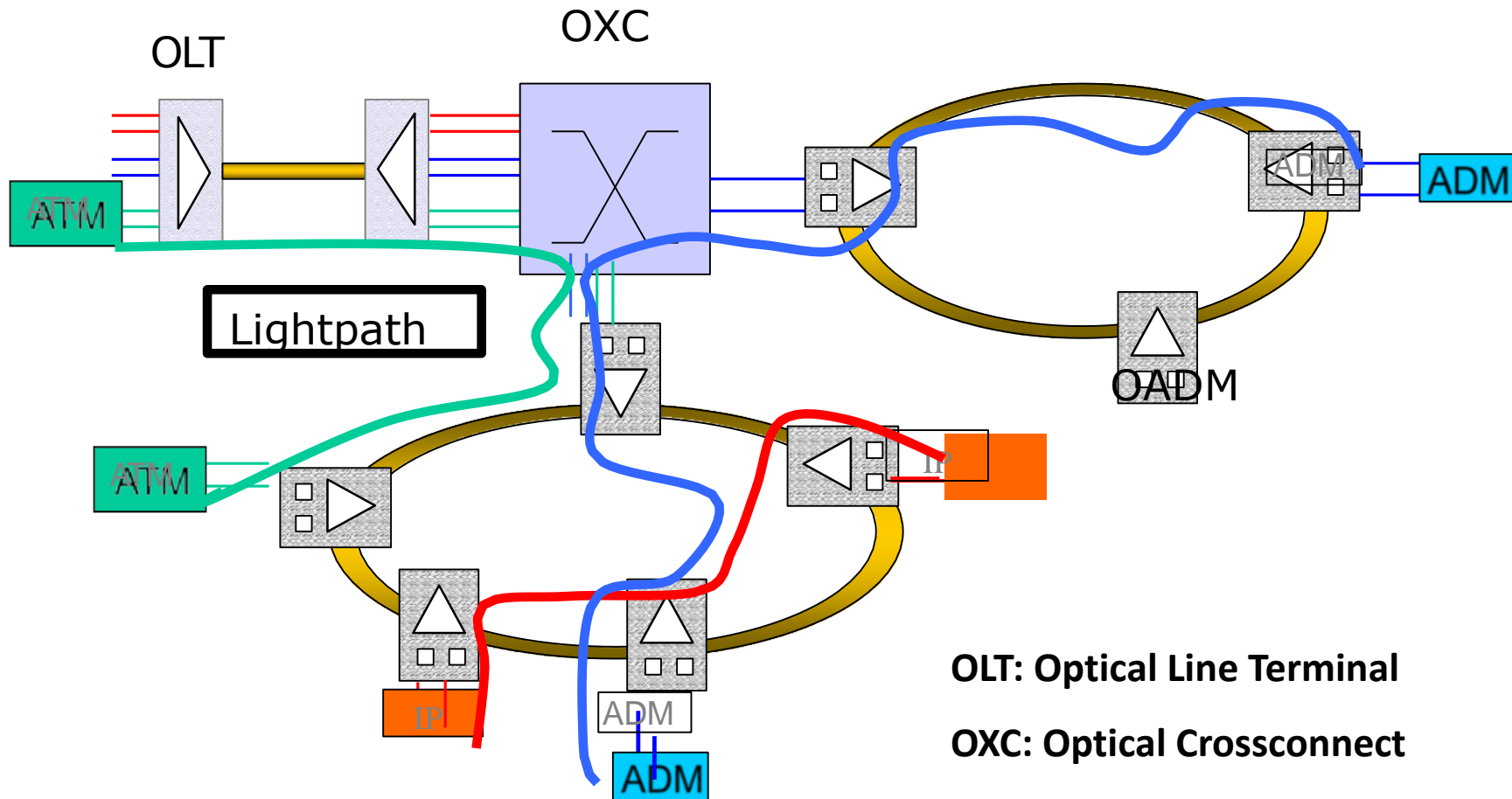


Optical Networks: Summary

- It is **NOT NECESSARILY** all optical
- **Characteristics of an optical network**
 - **Transmission:** optical
 - **Switching:** could be optical, could be electronic, could be hybrid could be circuit, could be packet, could be burst
- **Most Used Approach Today**
 - Electronic and optical circuit switching
- **Example Utility for IP Networking**
 - Connect any two IP routers (geographically far apart) with a direct (“virtual”) bandwidth pipe... of whatever capacity (1G, 10G, 100G)
 - Increase (or decrease or delete) the capacity on demand
 - Dynamically control the “topology” connecting the IP routers

WDM Network

An example of optical circuits



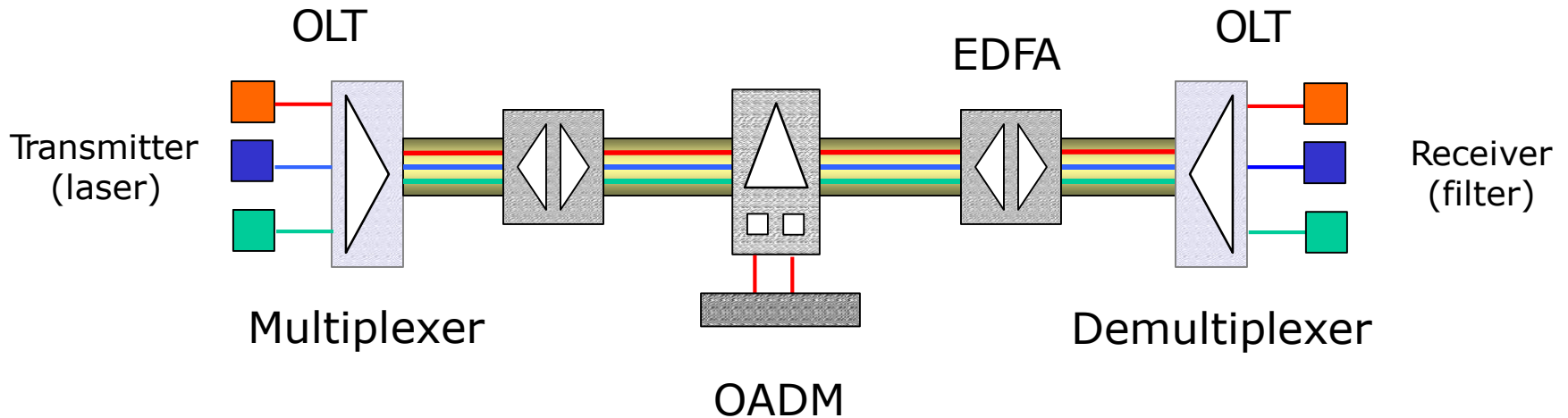
OLT: Optical Line Terminal

OXC: Optical Crossconnect

OADM: Optical ADM

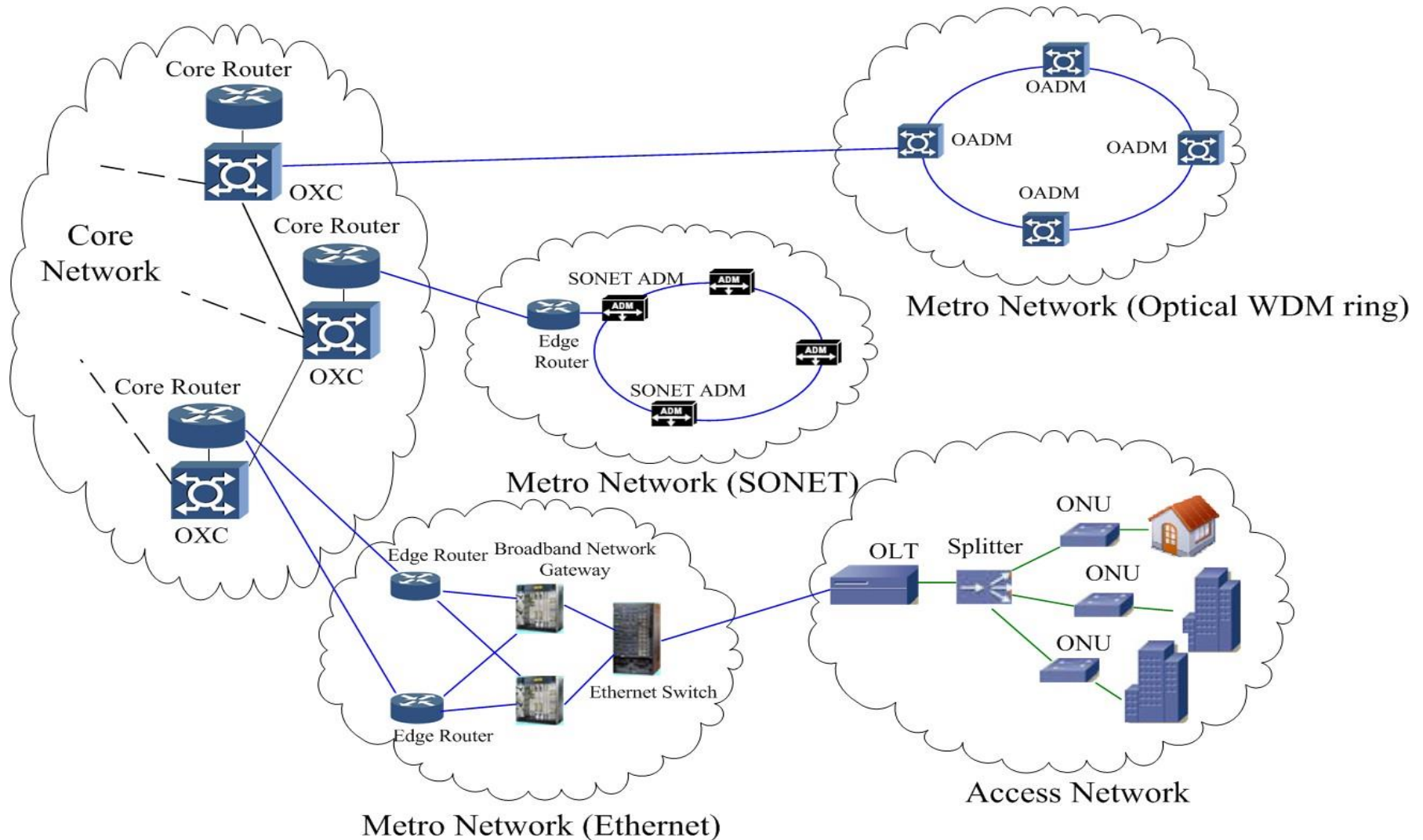
ADM: Add-Drop Multiplexer

Optical Transmission Components



- **Optical Line Terminal (OLT)**
 - Transmitter/Receiver + Mux/Demux
 - Point-to-point application
- **Optical Add-Drop Multiplexer (OADM)**
 - Add/drop a small number of wavelengths
 - Pass most wavelengths through

Optics in Core, Metro and Access

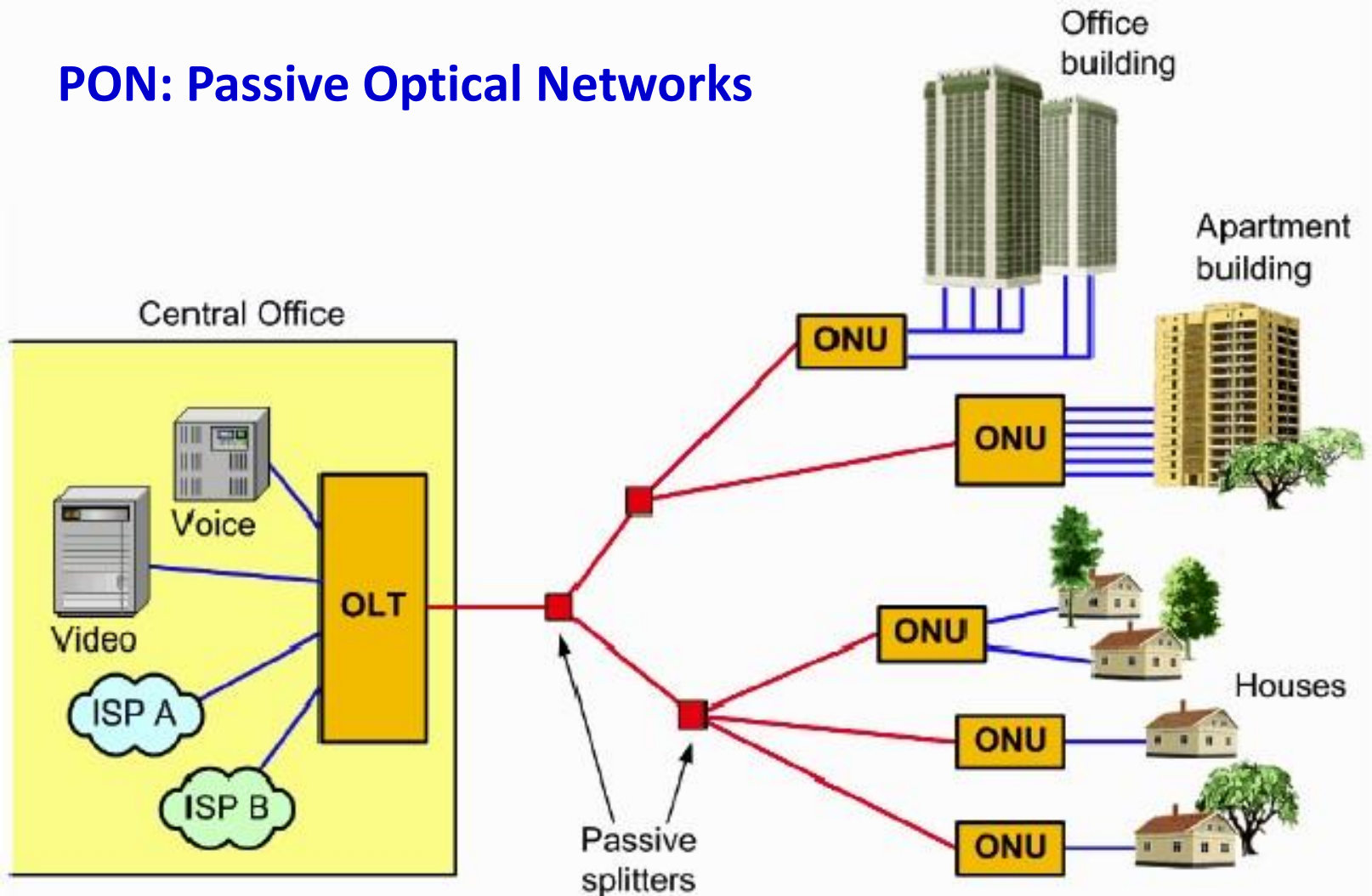


ONU: Optical Network Unit

SONET: Synchronous Optical Networking

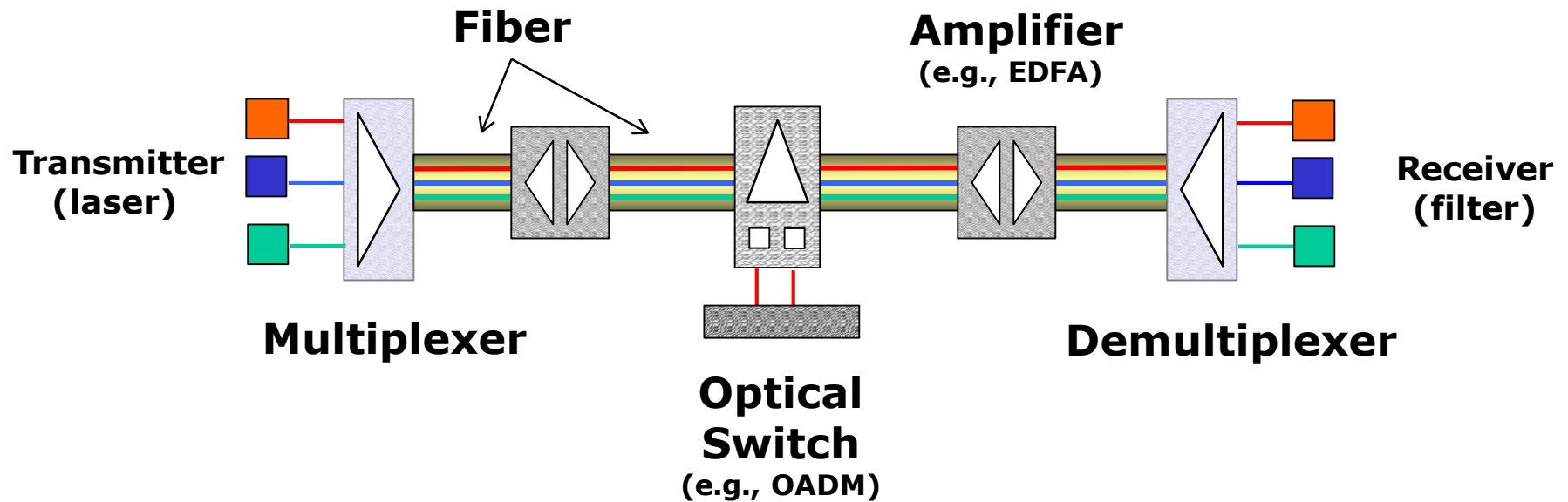
Optical Access Network

PON: Passive Optical Networks



Building Blocks

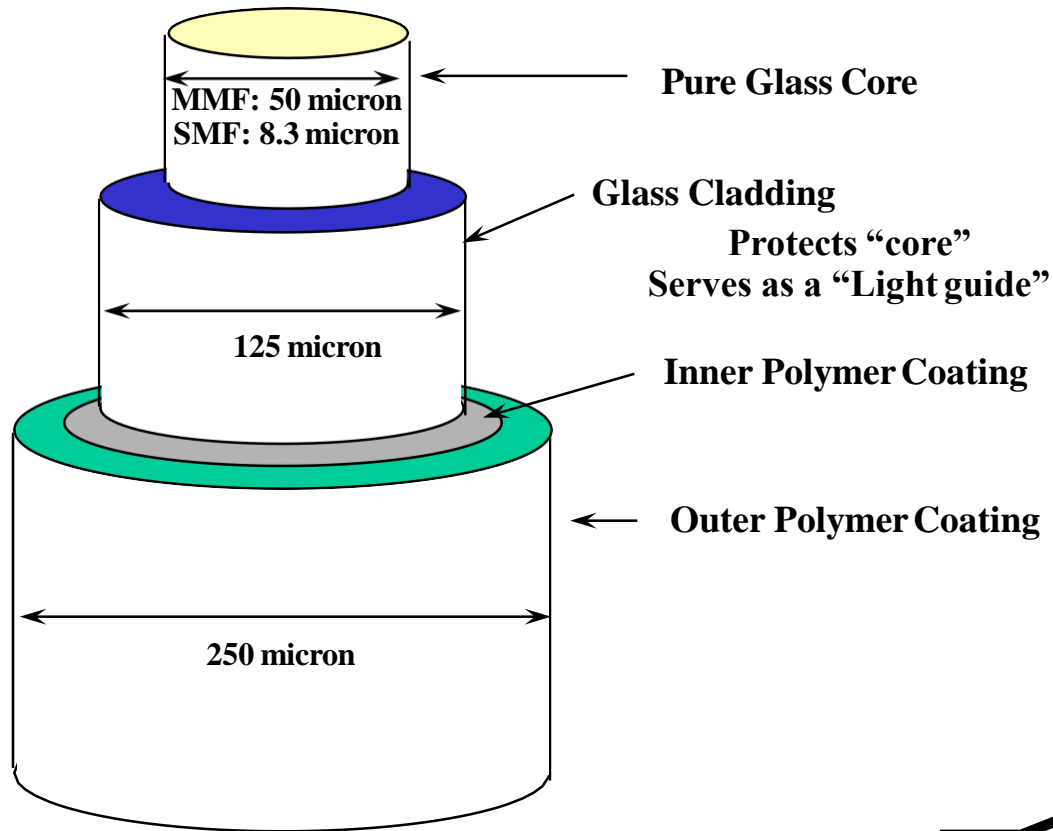
Optical Components



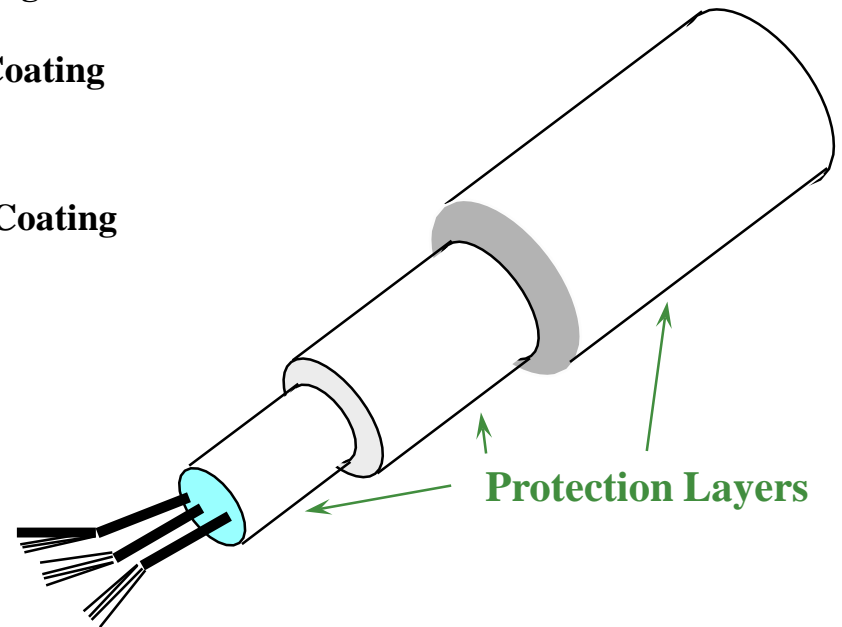
Building Blocks

- ▷ **Optical Fibers**
- ▷ Optical Transmitters
- ▷ Optical Receivers
- ▷ Switching Elements

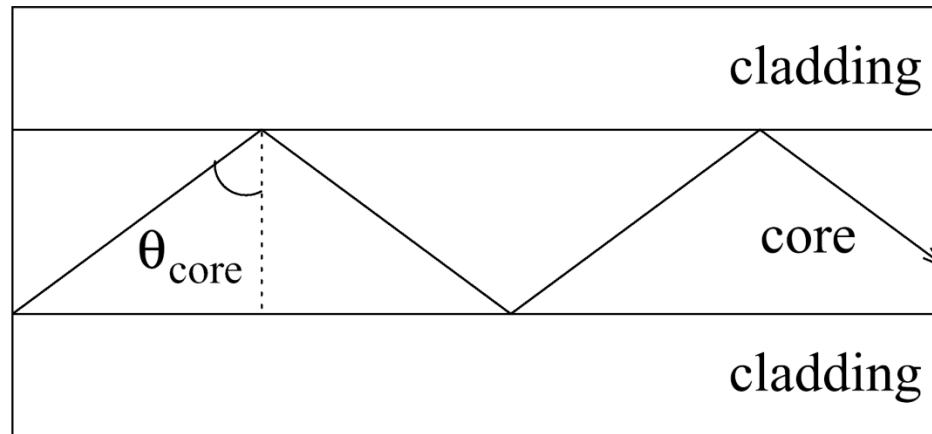
Optical Fiber: Structure



Single Fiber



Total Internal Reflection within a Fiber



- ▷ *refractive index:* $n_{\text{mat}} = c/c_{\text{mat}}$ ($n_{\text{air}}=1$)
where c = velocity of light in vacuum = 3×10^8 m/s
- ▷ *critical angle* $c_{\text{mat}} \cong 2 \times 10^8$ m/s $\rightarrow n_{\text{fiber}}=1.5$
- ▷ *step-index fiber*

Thank you