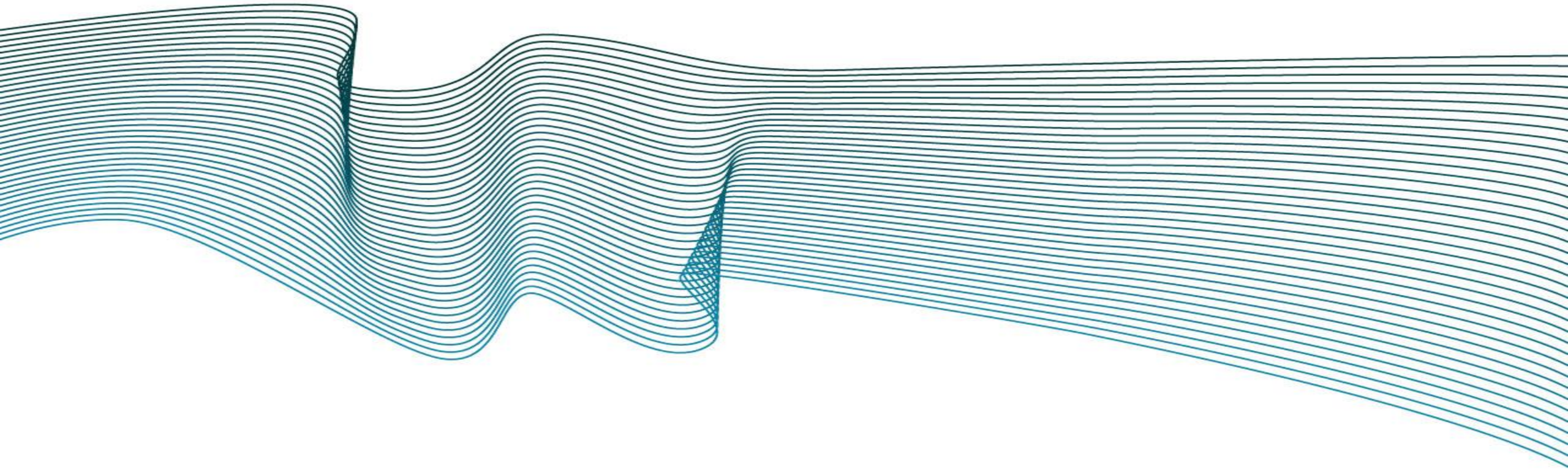

TAXONOMY OF PON

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State of the Optical Technology

- **IEEE 802.3 members last evaluated the maturity of optical technology for FTTx in 2006 while were preparing for 10G-EPON CFI.**
  - Re-evaluate the state of technology and recent developments
  - Decide if the WDM technology has matured enough to justify multiple wavelengths (CWDM, DWDM), tunable transceivers, etc.

- **Architectural choices**
  - Multiple or single wavelength per direction per PON?
  - Multiple or single wavelength per direction per ONU?
  - Shared or dedicated channel(s) per ONU?
    - If shared, centrally-scheduled or self-arbitrated?
  - On/Off (NRZ) or multi-level modulation?
    - Focus on PON only or PON and P2P?

PON Types and Names

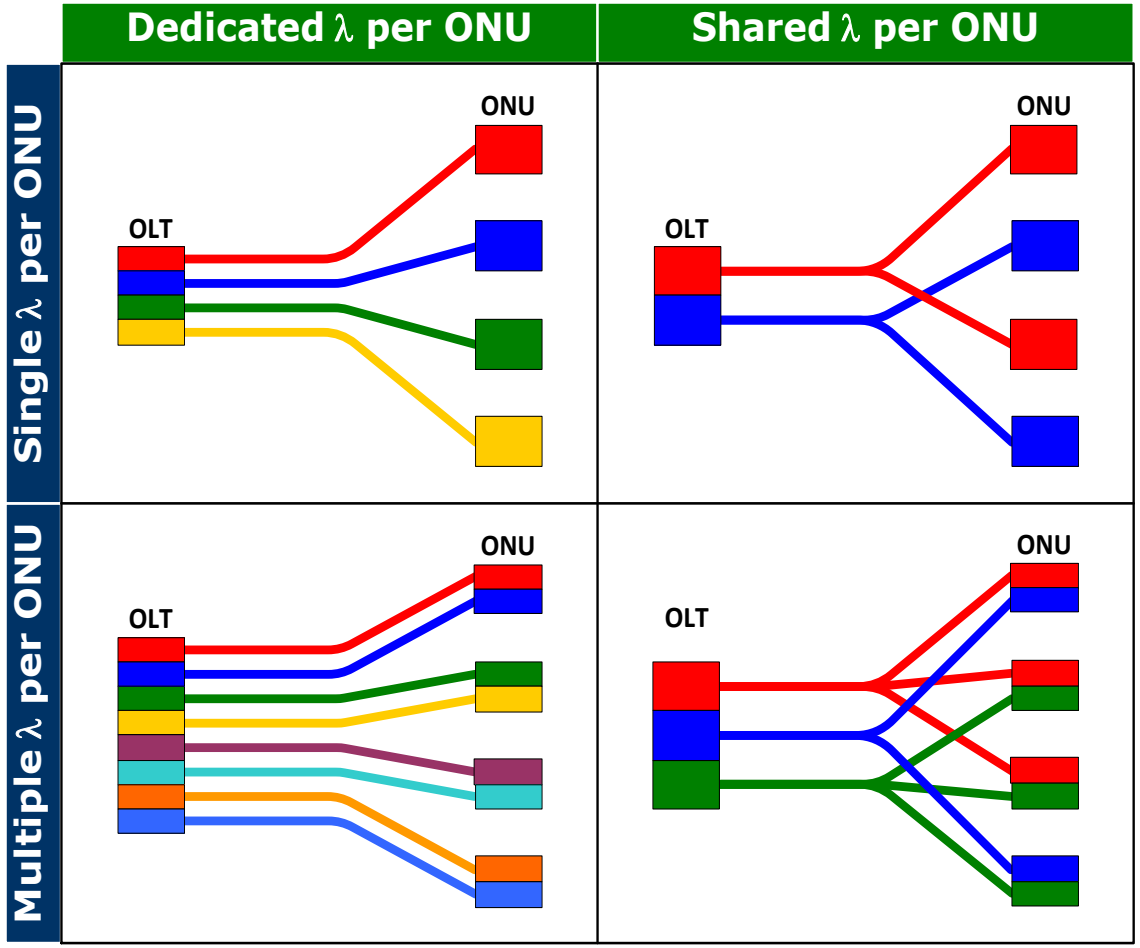
PHY channels per PON per direction {one, many}	PHY channels per ONU per direction {one, many}	PHY channel connectivity type {P2P, P2MP, mix}		Type (name) of network*
one	one	P2P	→	**Point-to-point link**
		P2MP	→	**EPON, 10G-EPON, GPON, XG-PON**
many	one	P2P	→	**WDM-PON1**
		P2MP	→	**TWDM-PON1**
	many	P2P	→	**WDM-PONn**
		P2MP	→	**TWDM-PONn (AKA hybrid PON)**
		mix	→	**?**

* **These names are used when a PHY channel represents a wavelength.**
Other PHY channels are possible, e.g., OFDM channel, CDM channel.

Multi-Wavelength Solutions

- **WDM is a technology for the physical layer**
- **L2 protocols are only concerned with whether the logical connections between CO and users are point-to-point or point-to-multipoint.**

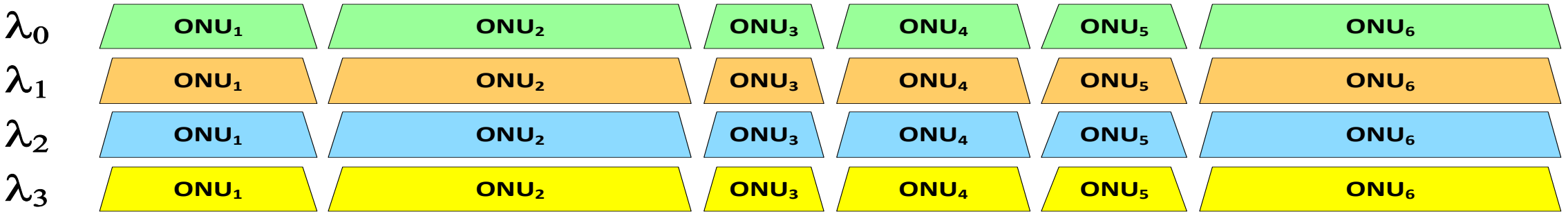
- **Dedicated wavelength(s) per ONU (WDM-PON)**
  - Logical P2P
  - No scheduling
  - Channel transparency
  - Most of the resources are idle most of the time
  - **Ethernet is the best suited technology here (lowest cost for the performance)**
    - (10Gbps, 40Gbps, or 100Gbps)



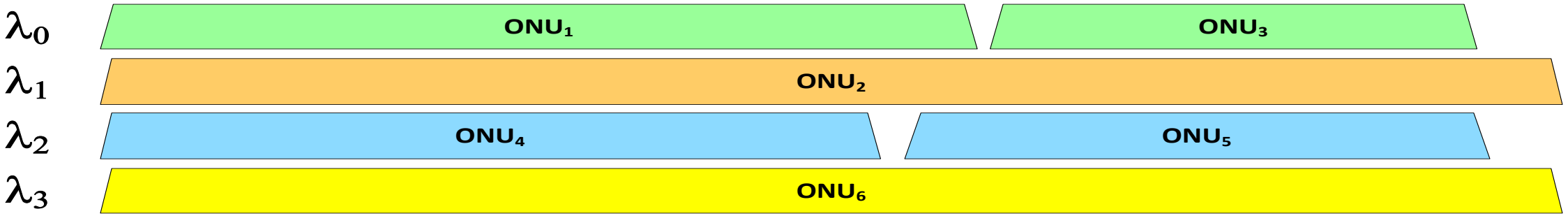
- **Shared wavelength(s) per ONU (hybrid-PON)**
  - Logical P2MP
  - Lower cost
  - More efficient resource allocation
  - Fewer wavelengths achieve equal performance to P2P
  - Scheduling is required
  - **EPON or GPON protocols can be used.**

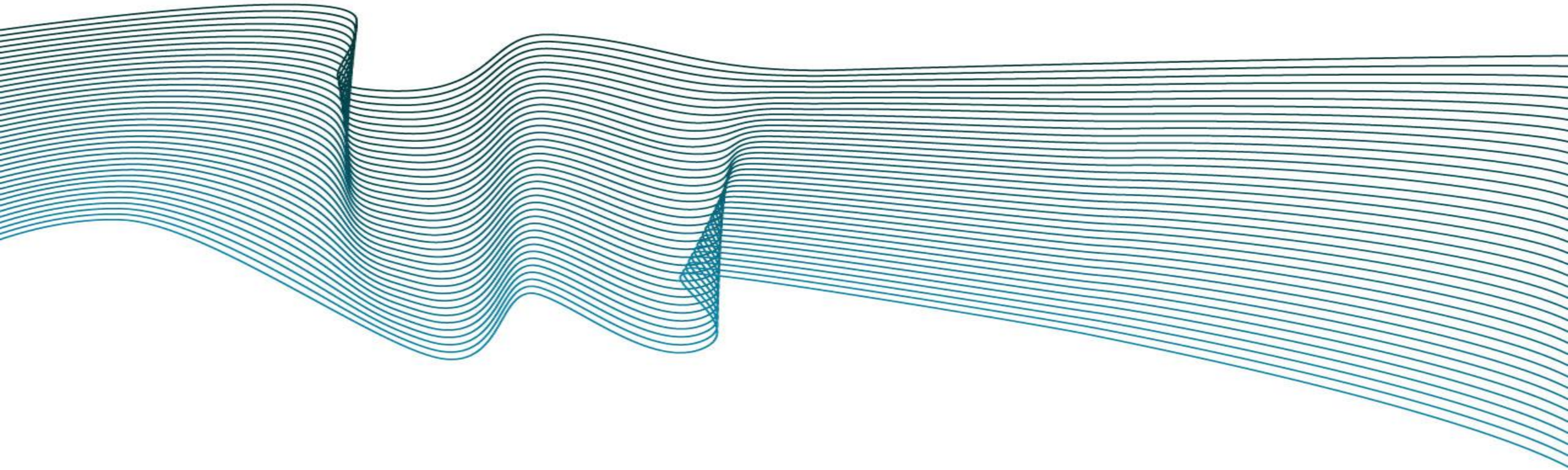
Multi-Wavelength Scheduling Options

- **Multiple wavelengths / Single scheduling domain**



- **Multiple wavelengths / Multiple scheduling domains**





COEXISTENCE

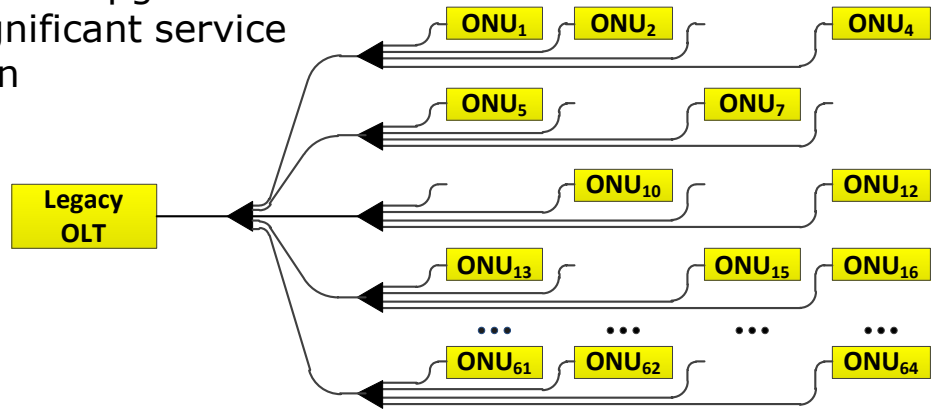
Coexistence

- **Coexistence with previous generation of EPON is a key ingredient of EPON's success**
- **Gradual and seamless upgrade is a mandatory requirement**
  - Operators should be able to upgrade one user at a time without interrupting the rest of the users.
- **Maintaining coexistence of three generations is difficult.**
  - Will operators need to support three generations of ONUs on the same PON?

Gradual and seamless upgrade

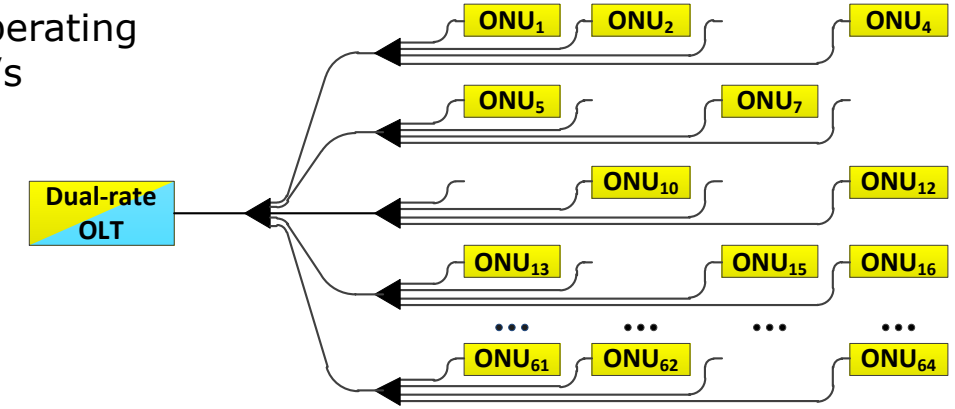
Current EPON

- Allows gradual upgrade without significant service interruption



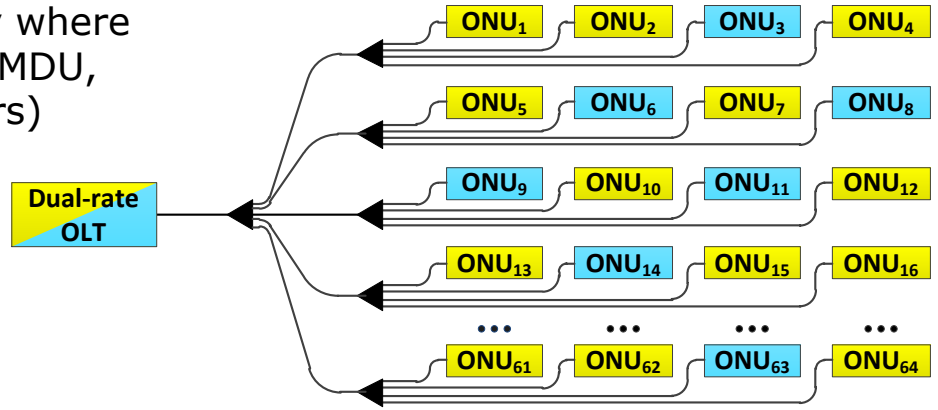
1. OLT is upgraded

- Existing ONUs continue operating at 1.25 Gb/s



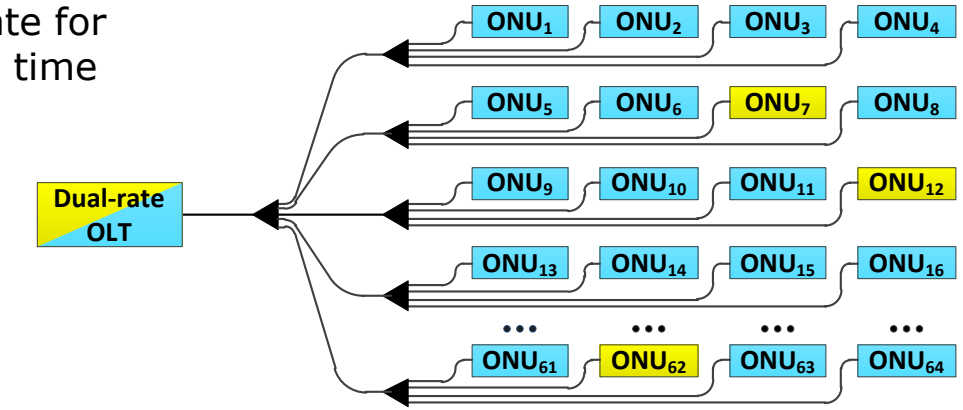
2. Higher-speed ONUs are added

- Does not affect deployed ONUs
- 10G ONUs are added only where required (MDU, power users)



3. Fully upgraded EPON.

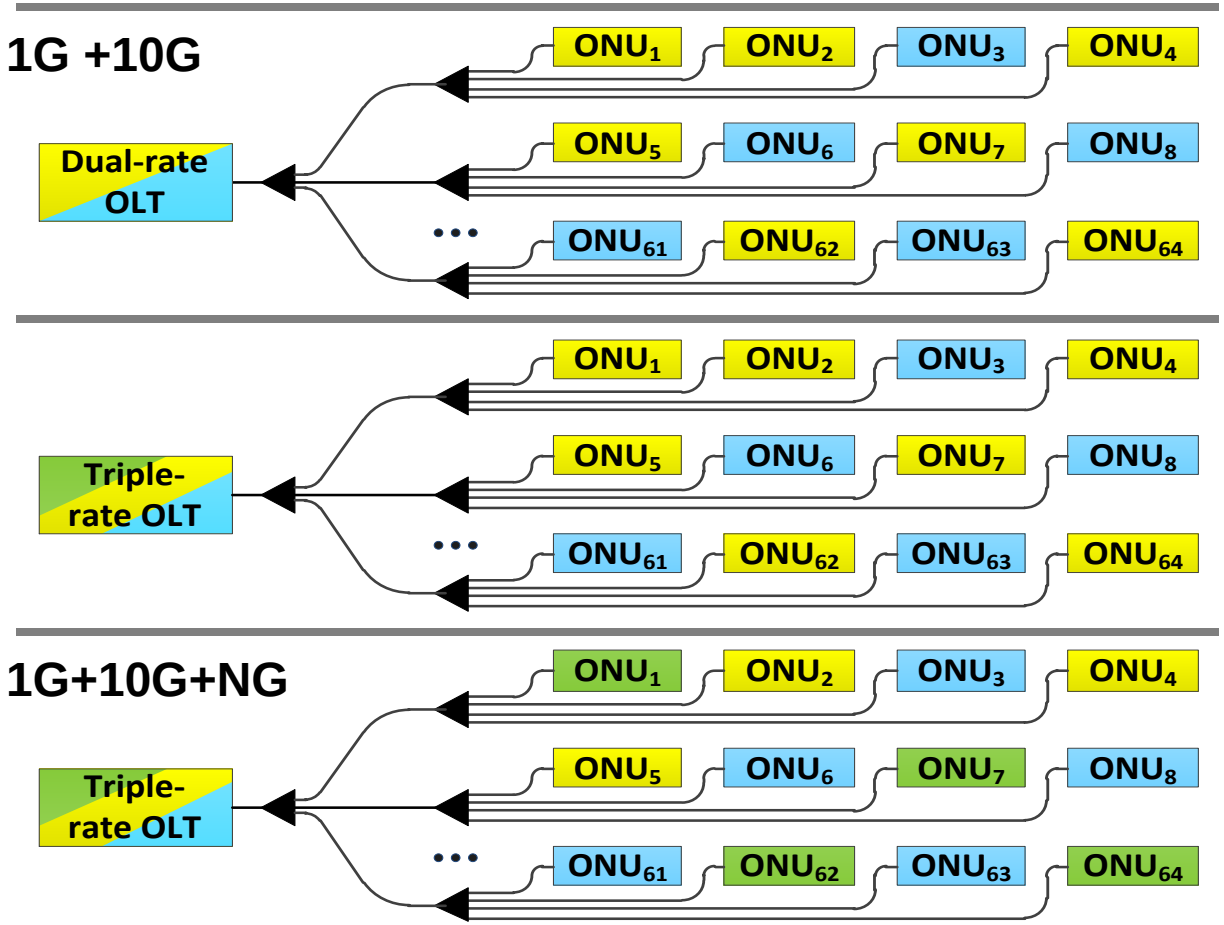
- Eventually most ONUs may be converted to 10Gb/s
- Network may operate at mixed rate for a very long time



Three-Generation Coexistence

- **Spectrum exhaustion**
  - 1G-EPON used 100 nm upstream band
- **Triple-rate OLT is difficult**

1. **Replace 1G/10G OLT with a triple-rate OLT (1G/10G/NG)**
2. **Deploy NG ONUs, allowing a mix of 1G, 10G, and NG ONUs.**



Two-Generation Coexistence

- NG-EPON reuses 1G-EPON wavelengths
- EOL 1Gb/s ONUs before deploying NG-EPON ONUs

1. Replace all remaining 1G ONUs with 10G ONUs
2. Upgrade 1G/10G OLT to 10G/NG OLT
3. Deploy NG ONUs