WDM Overlay of APON with EPON
- a carrier's perspective

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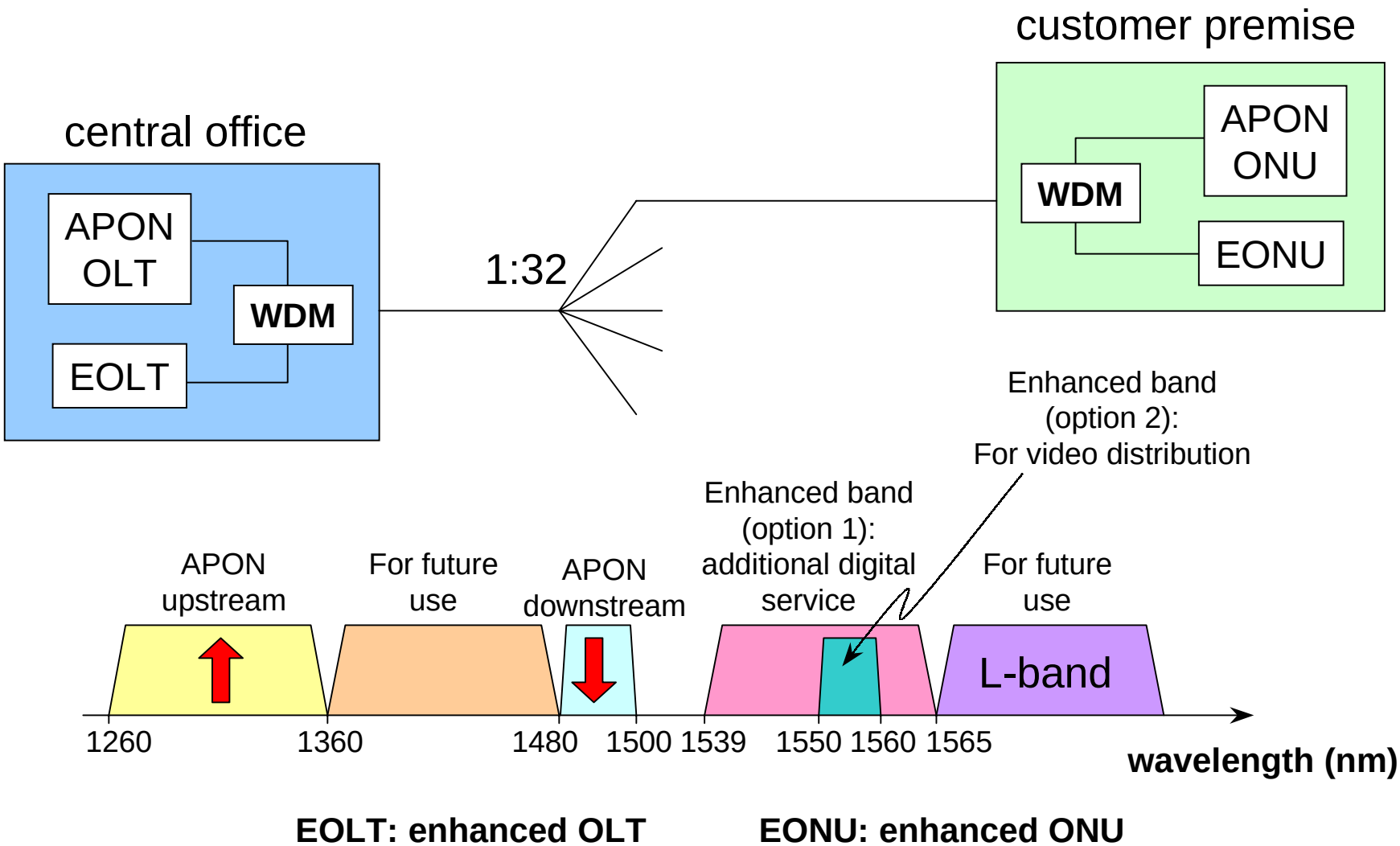
Wavelength Allocation in ITU-T Rec. G.983.3



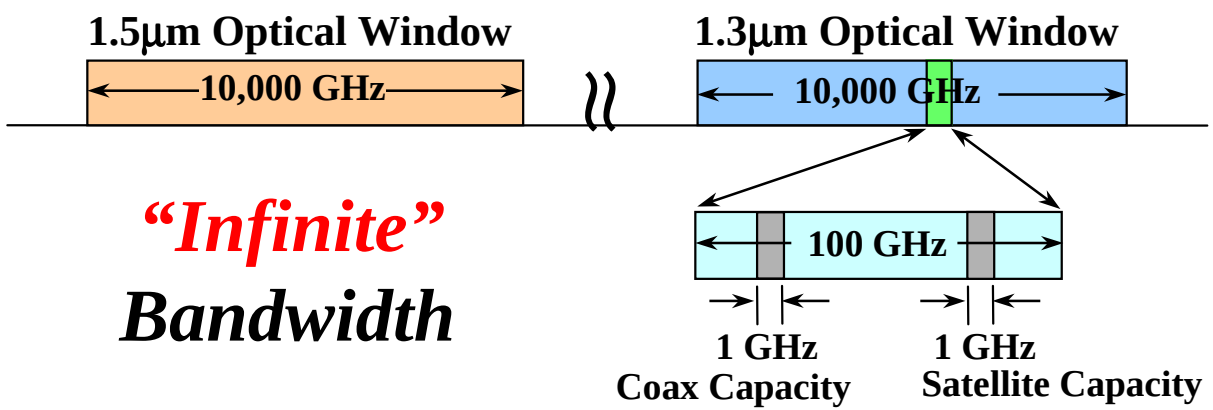
EOLT: enhanced OLT **EONU: enhanced ONU**

The Value of Fiber Plant

Estimated Cost per Building to Deploy Fiber in a Passive Optical Network

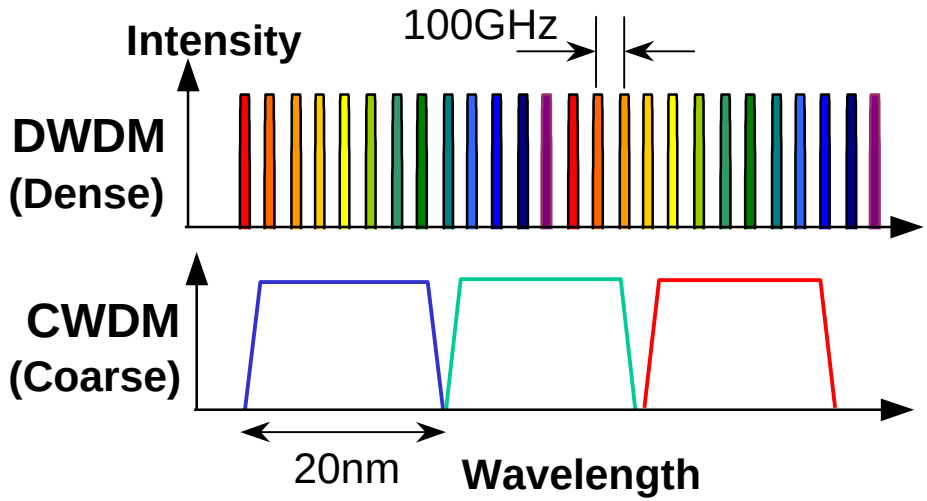
$ per building	Outside Plant	Labor	ONU	OLT	Total Cost
Aerial	4,161	3,787	4,435	1,247	**$13,630**
Exist Conduit	4,161	4,436	4,435	1,247	**$14,279**
Trench	4,161	14,199	4,435	1,247	**$24,042**
New Conduit	4,161	26,299	4,435	1,247	**$36,142**

Source: Merrill Lynch, Corning Cable Systems



Low Cost Coarse WDM Technology

- DWDM:
  - High-cost, high-capacity
  - Core network technology
- CWDM:
  - Low-cost, moderate-capacity
  - Suitable for metro & access (i.e.: the FIRST MILE)



CWDM Usage

- 10GBASE-LX4 (IEEE802.3ae):
  - Low cost CWDM parallel PHY standard for 10Gb/s Ethernet
  - 20nm bands centered at: 1290, 1310, 1330 & 1350nm
- De facto standard:
  - 20nm bands centered at 1491, 1511, 1531, 1551nm...

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Wavelength Accuracy Requirements

- ITU-T 983.3 standard temp requirements.
  - OLT: 5 to 40°C
  - Indoor ONU: -5 to 45°C
  - Outdoor ONU: -45 to 45°C
- DFB laser accuracy
  - temp coefficient: 0.08nm/°C
    ⇒ 7.2nm over 90°C for uncooled DFB
- Athermal thin film CWDM
  - temp coefficient: 2pm/°C ⇒ 1.8nm over 90°C
- Use 10nm band with 20nm separation
  - 15 available bands between 1300nm and 1600nm

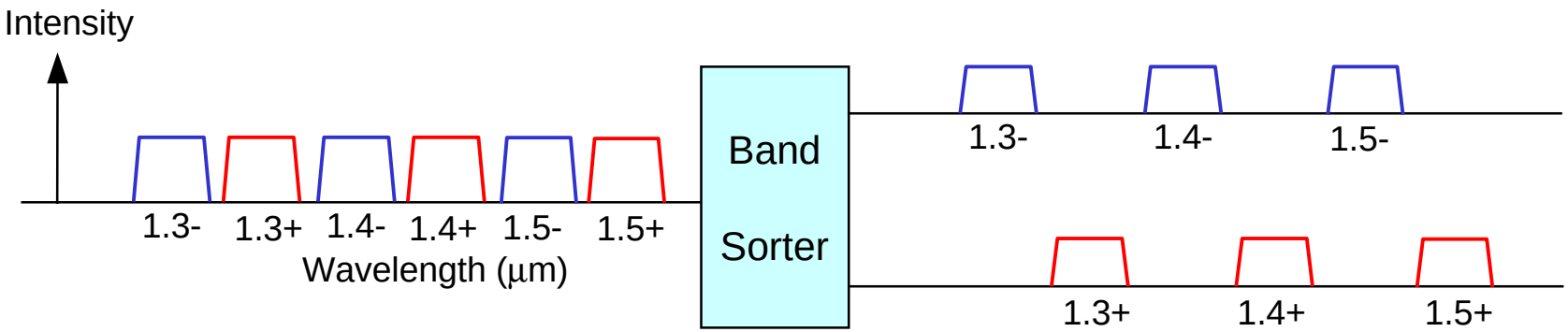
Cost Considerations

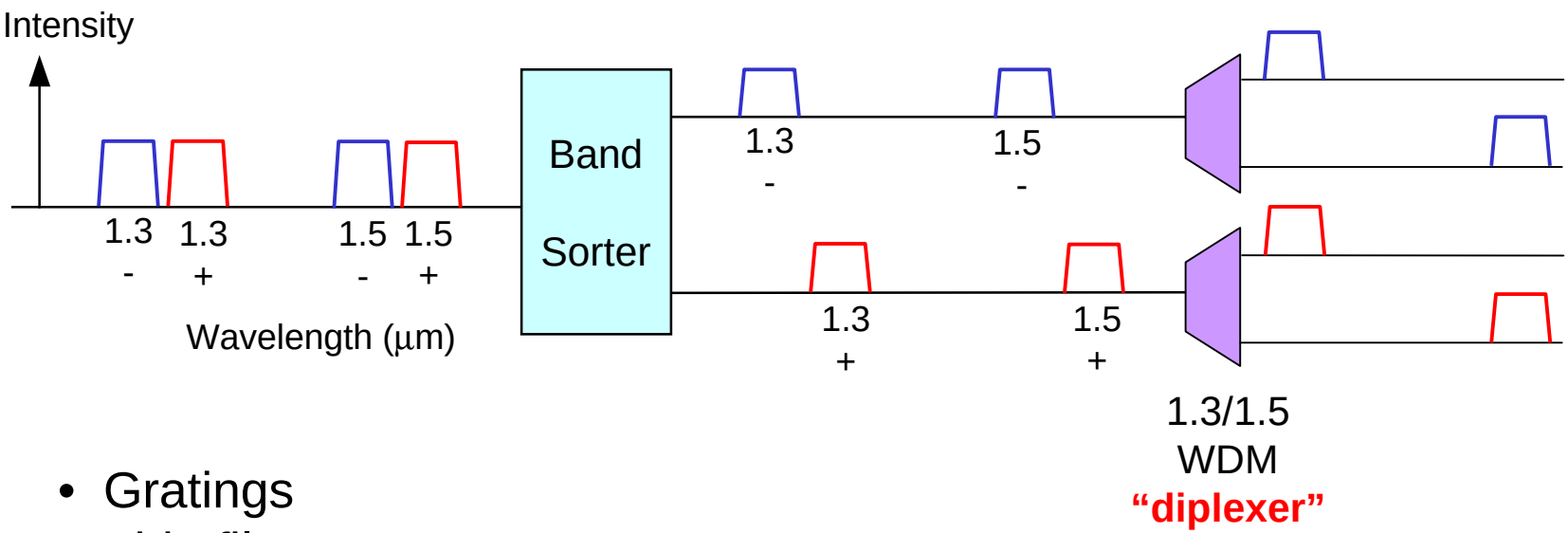
- DWDM.
  - ITU grid DFB laser: $1,000
  - DWDM Mux-Demux: $200 - $500 per wavelength
  - Temperature control required.
- CWDM
  - Uncooled DFB: $50 - $100
  - CWDM: $50-100 per wavelength

Fiber plant costs at least ~$14,000 per user...

- Need a standard for “plug-N-play” CWDM technology

Emerging Low Cost WDM Components …

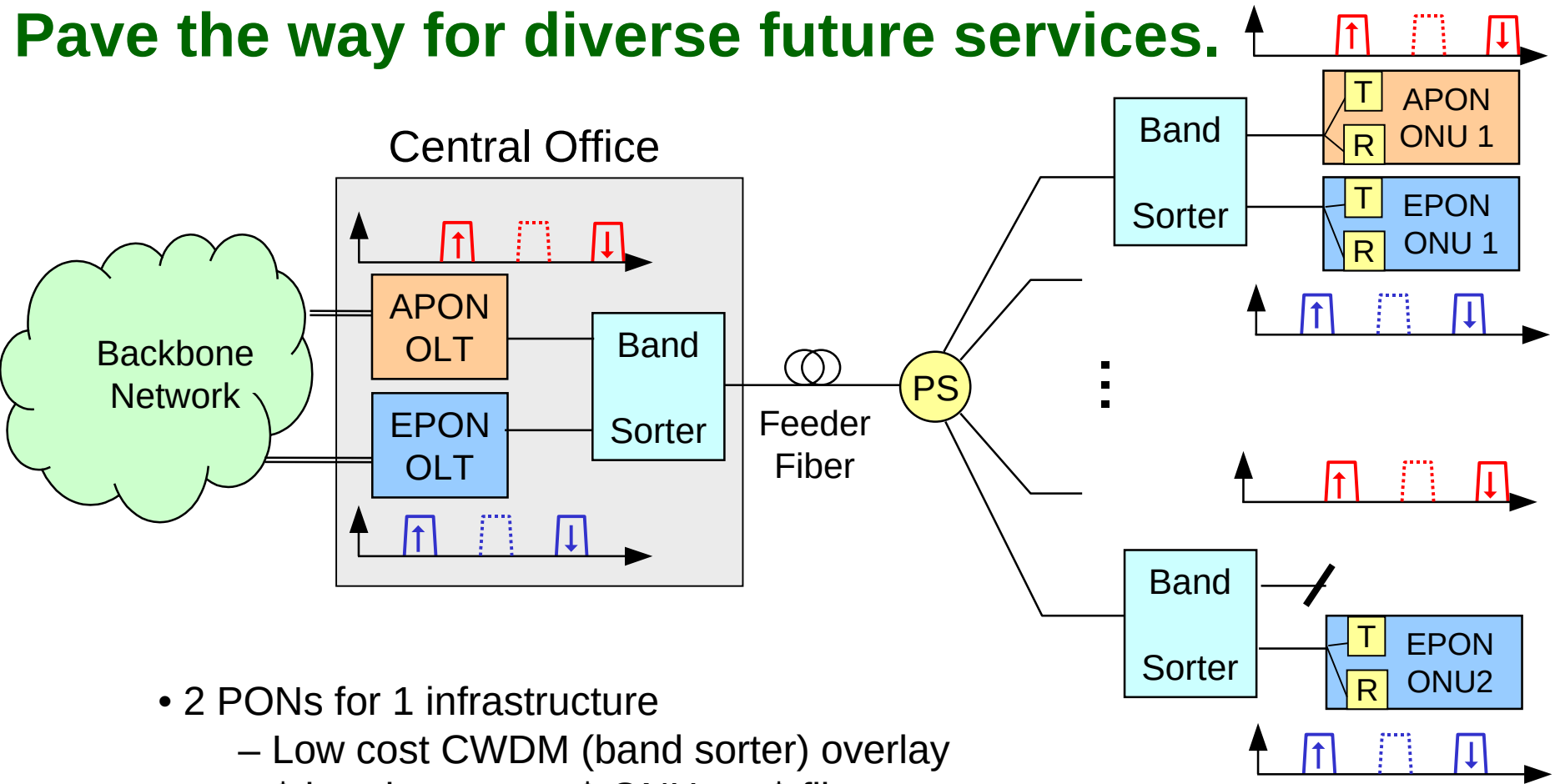




- Gratings
- Thin films
- Planar waveguide circuits

… Overlaying APON with EPON

Pave the way for diverse future services.



- 2 PONs for 1 infrastructure
  - Low cost CWDM (band sorter) overlay
  - $ band sorter << $ ONU << $ fiber
- Flexible service provisioning
  - e.g. video overlay in other bands like in ITU-T Rec. 983.3

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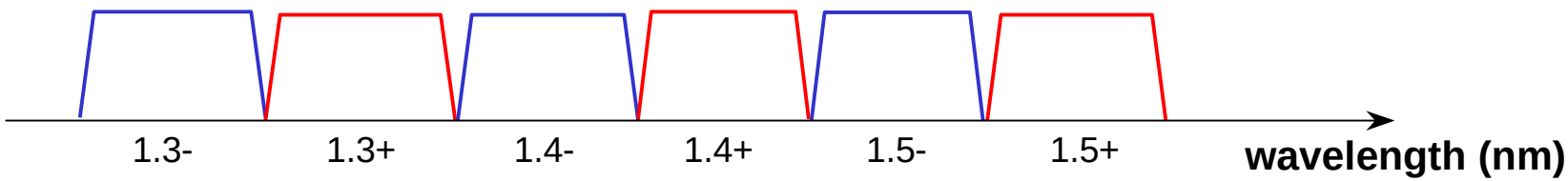
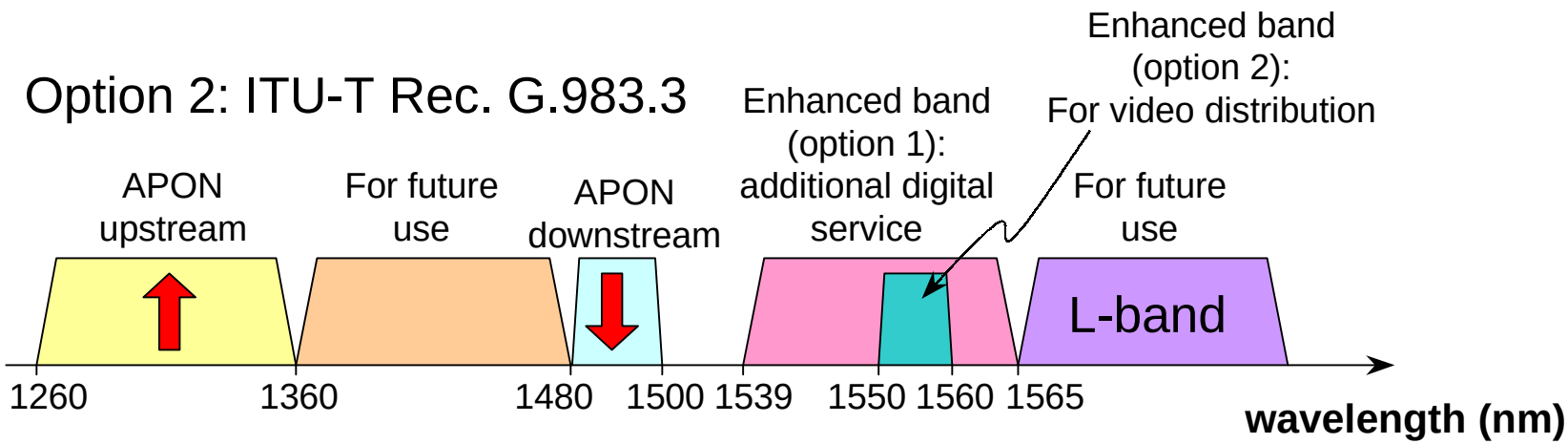
Which One to Choose?

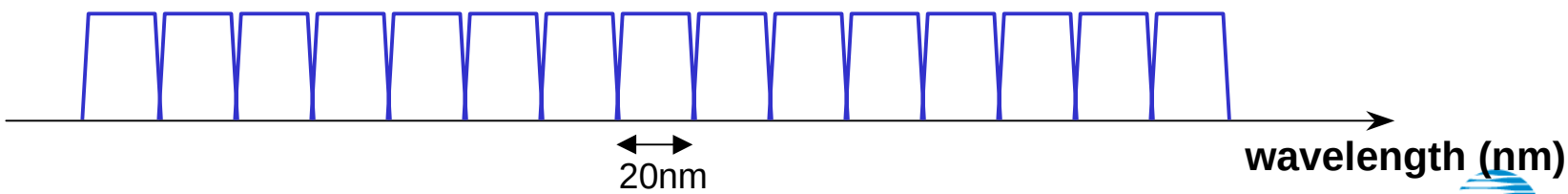
Option 1: band sorter



Option 2: ITU-T Rec. G.983.3



Option 3: de facto CWDM standard



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Power Budget Consideration

- ITU-T REC 983.3
  - class B: 25dB between OLT and ONU
  - class C: 30dB between OLT and ONU
- CWDM:
  - Extra wavelength filters add additional loss
  - 8dB (4dB mux + 4dB demux) CWDM loss (average value for commercial 8 band CWDM devices)
  - EPON/GbE (1.25Gb/s) requires 3dB more power than 622Mbps APON
  - Amplification over 200-300nm wide optical band is not easy
- Solutions:
  - Apply higher power LDs (lasers are getting better everyday!)
  - Use APD detectors (10 to 15dB gain)
  - Use FEC (~10dB gain)
  - Reduce splitting ratio
  - Reduce fiber reach