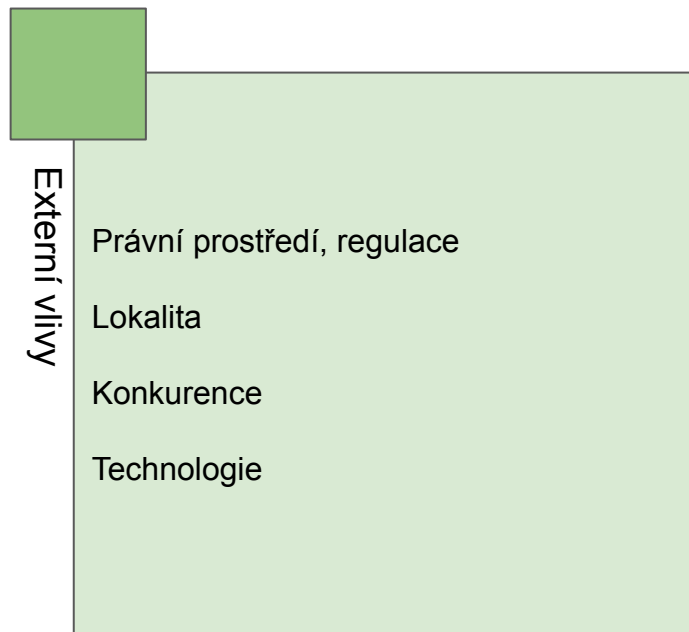
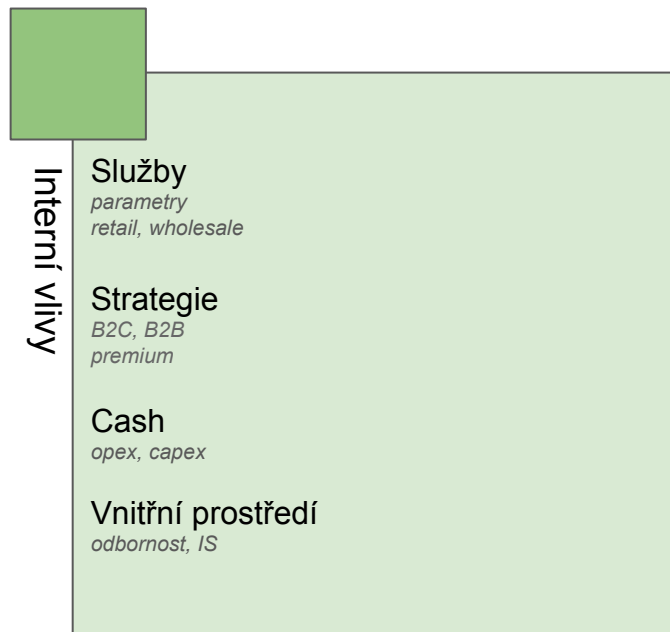


xPON v roce 2021

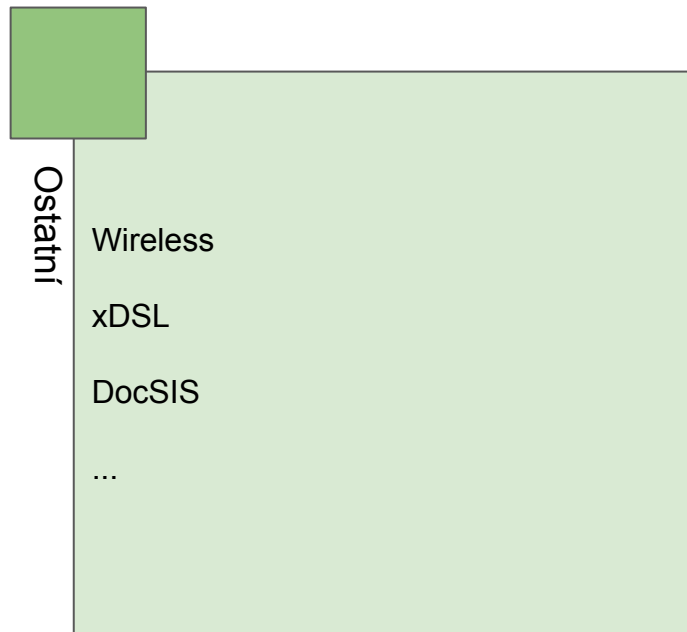
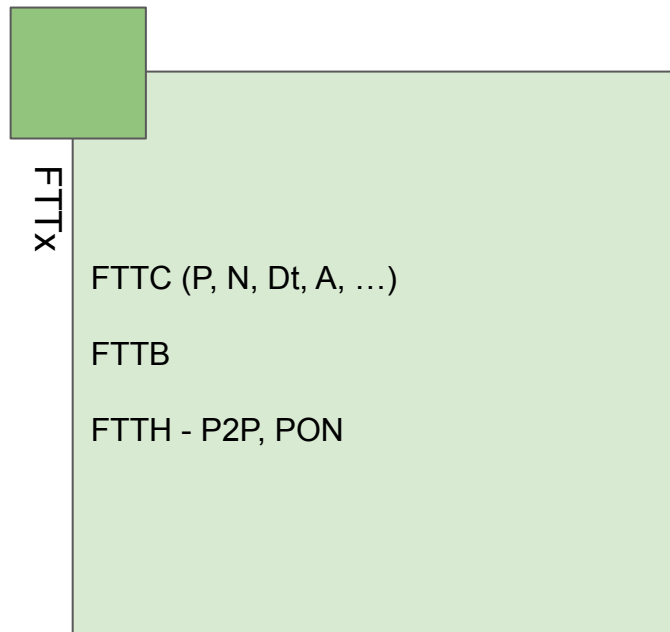
Štěpán Beneš



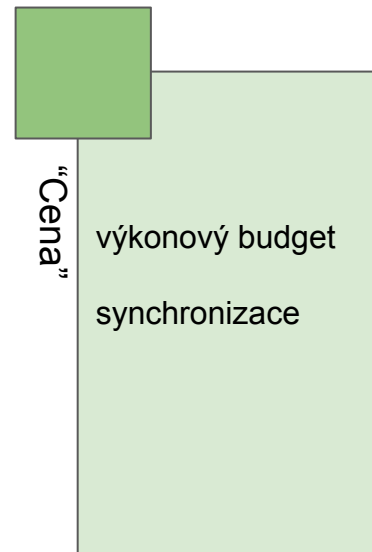
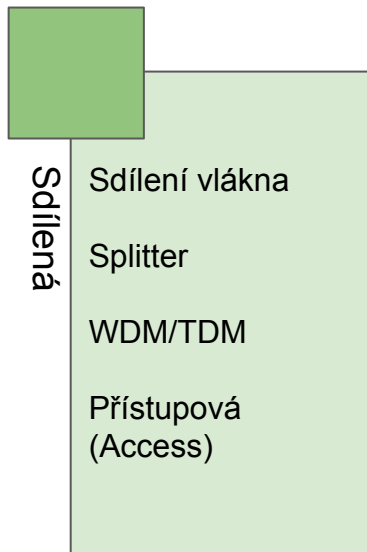
Jakou technologií a proč ?



Jakou technologii a proč ?



Co to je PON ?



Co to je PON ?

celkový útlum:

$$\mathbf{A = A_d + A_z \text{ [dB]}}$$

útlum dělení:

$$A_d = 10 * \log_{10}(N) \text{ [dB]}$$

$$A_d = 10 * \log_{10} 2 * \log_2(N) \text{ [dB]}$$

$$A_d = n * 10 * \log_{10} 2 \text{ [dB]}$$

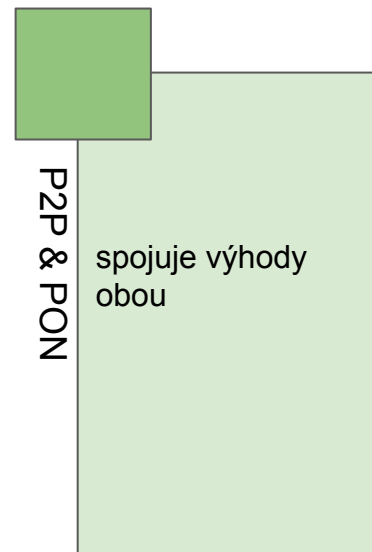
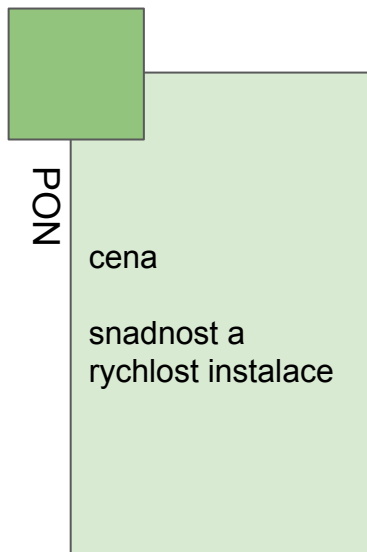
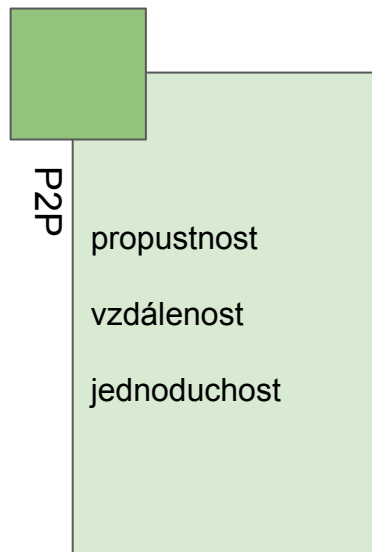
$$A_d = n * 3.01 \text{ [dB]}$$

$$\mathbf{Ad = n * 3 \text{ [dB]}}$$

zbytkový útlum:

$$A_z = 10 * \log_{10}(P_{in} / \text{sum}(P_{out})) \text{ [dB]}$$

FTTH - P2P vs. PON



Jak stavět pasivní část ?



Jakou rychlost budu potřebovat ?

Table 5. Fixed broadband speeds (in Mbps), 2018–2023

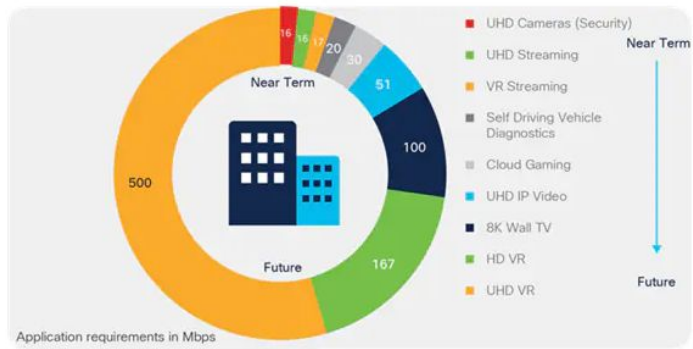
Region	2018	2019	2020	2021	2022	2023	CAGR (2018–2023)
Global	45.9	52.9	61.2	77.4	97.8	110.4	20%
Asia Pacific	62.8	74.9	91.8	117.1	137.4	157.1	20%
Latin America	15.7	19.7	34.5	41.2	51.5	59.3	30%
North America	56.6	70.1	92.7	106.8	126.0	141.8	20%
Western Europe	45.6	53.2	72.3	87.4	105.6	123.0	22%
Central and Eastern Europe	35.0	37.2	57.0	65.5	77.8	87.7	20%
Middle East and Africa	9.7	11.7	25.0	29.0	34.9	41.2	33%

Source: Cisco Annual Internet Report, 2018–2023

Jakou rychlost budu potřebovat ?

- Globální IP traffic vzrostl od roku 2016 (93 ExaB/měs) do roku 2021 3x (271 ExaB/měs)
- ve špičkách narostl dokonce 5x
- roste náročnost jednotlivých aplikací
 - (u)HD streaming
 - (u)HD VoD (10+ Mbps)
- objevují se nové
 - cloud gaming (30+ Mbps)
 - Immersive VR (350 Mbps)
- CoVID
 - změna chování
 - virtuální office
- Obchodní výhoda
- vs. představa “mým uživatelům stačí ...”

Figure 13. Significant demand for bandwidth and video in the connected home of the future



Source: Cisco Annual Internet Report, 2018-2023

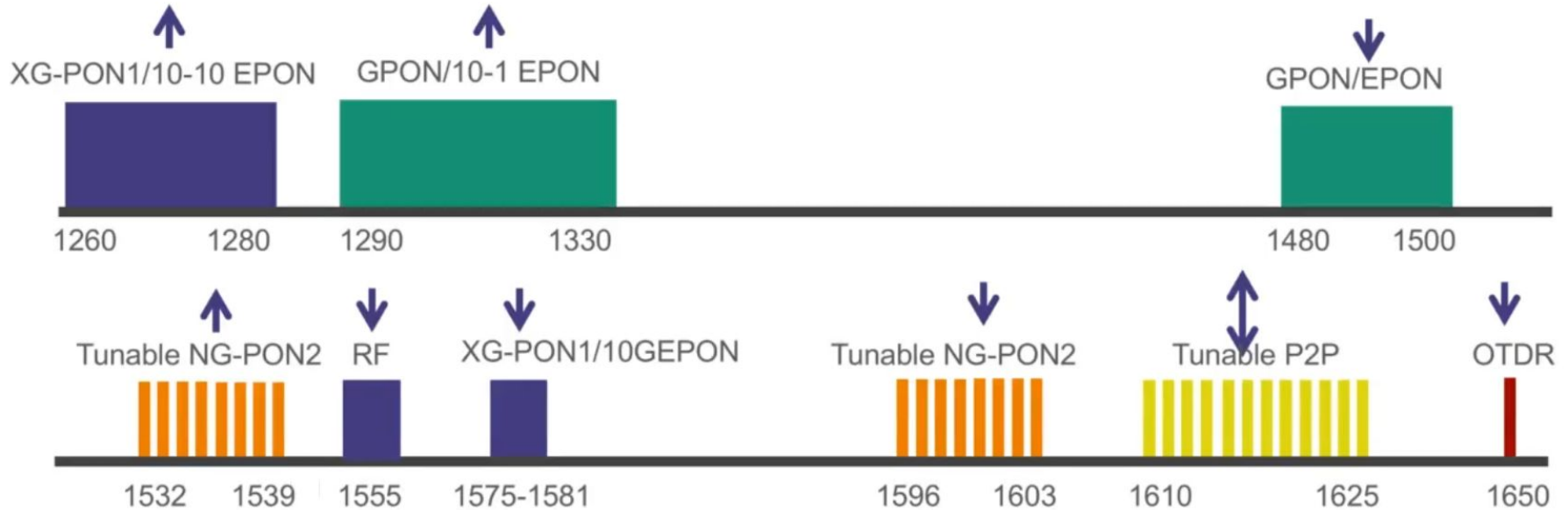
Vývoj xPON



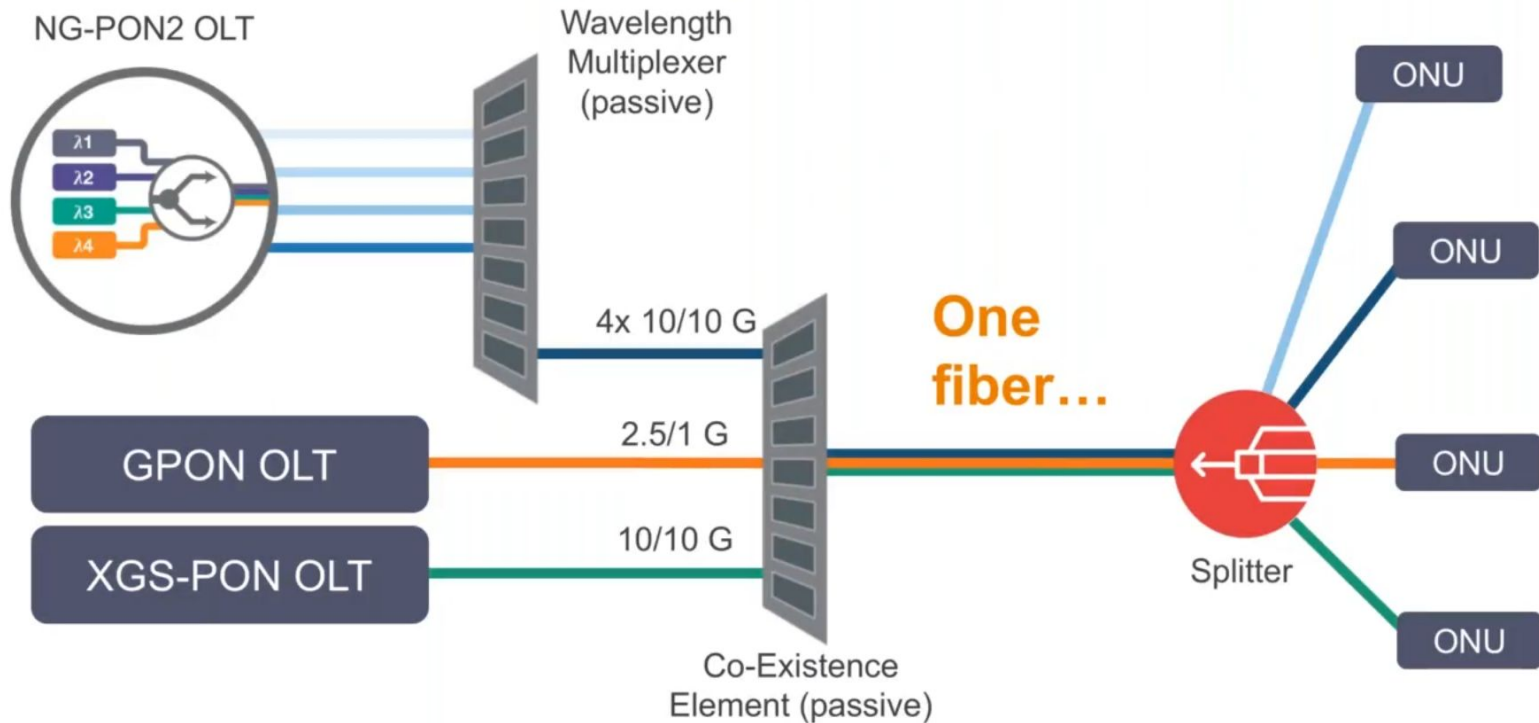
ITU(GPON) vs. IEEE (EPON)

	GPON (ITU-T G.984) 2003	(G)EPON (IEEE 802.3ah) 2004	10GePON (IEEE 802.3av) 2009	XGPON (ITU-T G.987) 2010	XGS-PON (ITU-T G.9807.1) 2016	NG-PON2 (ITU-T G.989) 2015-8
přenosová rychlost	2.5G/1.25G	1G/1G	10G/1G 10G/10G	10G/2.5G	10G/10G	WDM 4-8x 10G/10G 8 * P2P@100MHz channel bonding
fyz. vrstva	2.48832G 1.24416G	1.25G	10.3125G 1.25G	9.95328G 2.48832G	9.95328G 9.95328G	WDM
překódování	NRZ scrambling	10/8b (20%)	66/64 (3%)	NRZ scrambling	NRZ scrambling	NRZ scrambling
frekvence	1480-1500 1260-1360	1480-1500 1260-1360	1575-1580 1260-1280(1360)	1575-1580 1260-1280	1575-1580 1260-1280	1596-1603 1532-1539 1610-1625*8 P2P (100Mhz)

Koexistence xPON



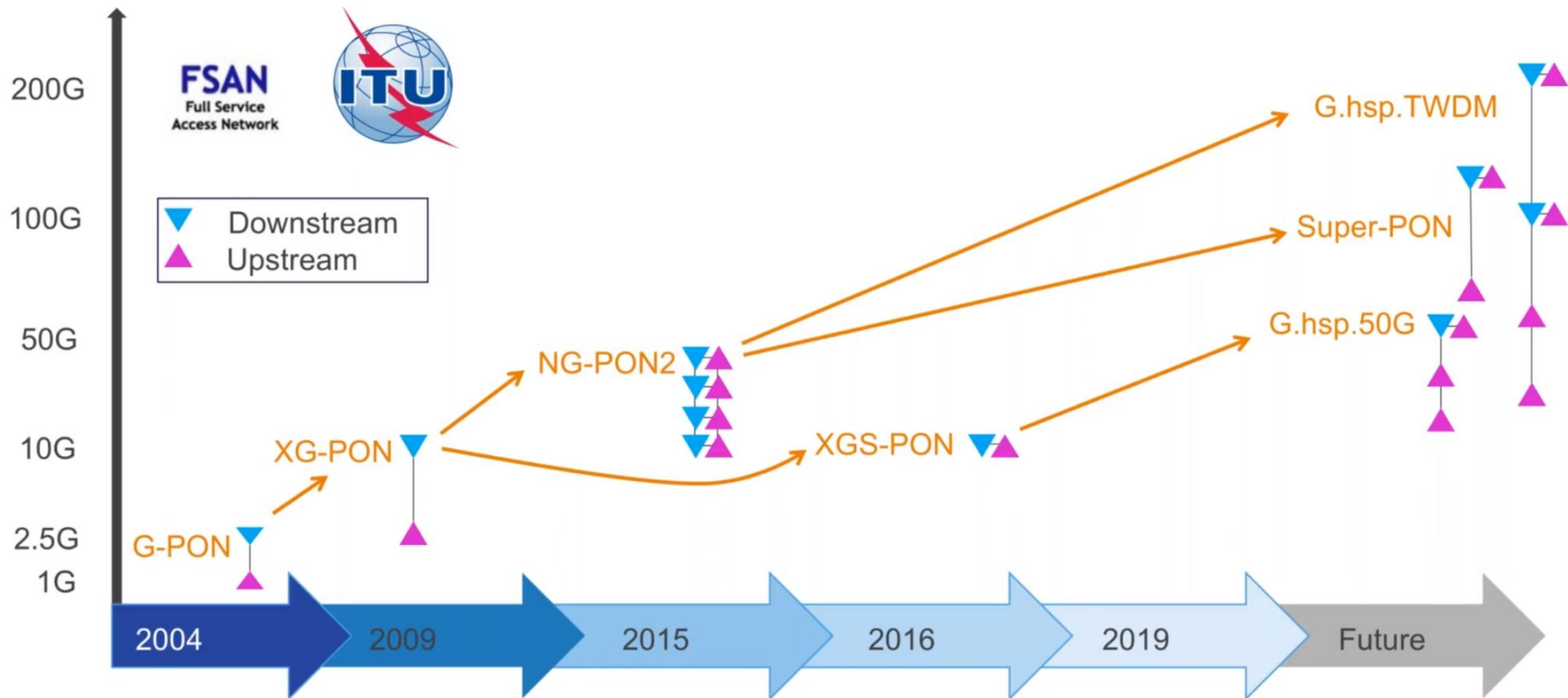
Koexistence xPON



Koexistence xPON



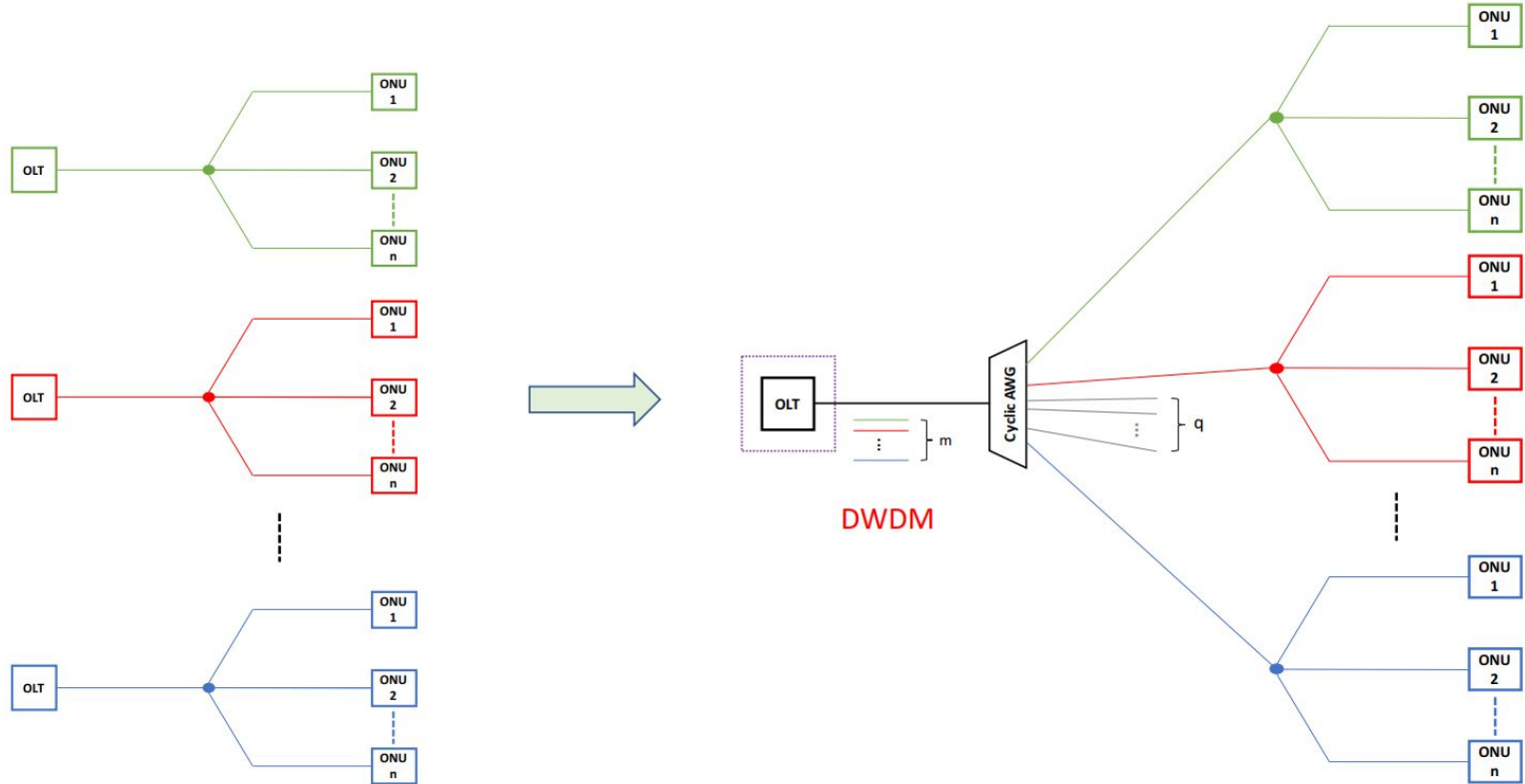
Vývoj xPON



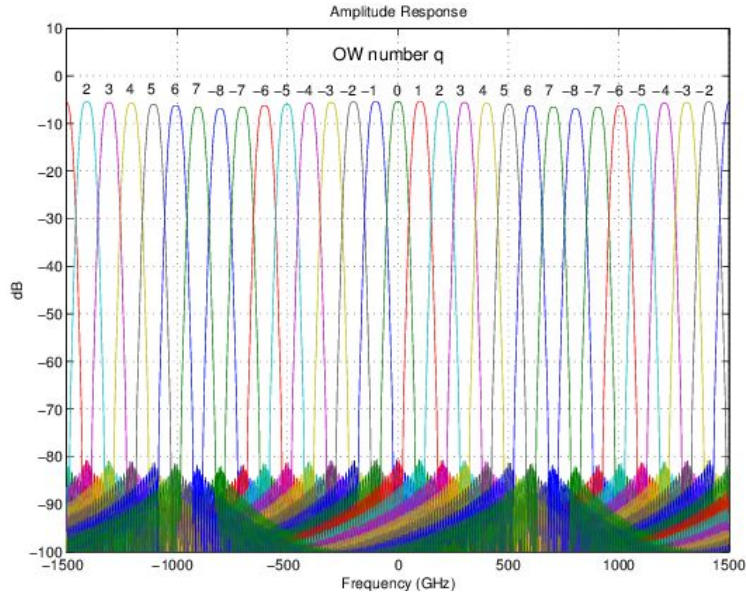
Budoucnost xPON

25/50G-EPON IEEE 802.3ca (2020)	High speed EPON	2 x 25G DOWN 2 x 10/25G UP	High O-Band Down Low O-Band Up
50G-PON G.hsp.50G ITU G.9804.3 (2021)	High speed GPON	50G DOWN 10/25/50G UP	High O-Band Down Low O-Band Up
100G/200G-PON G.hsp.TWDM	High speed GPON	2-4 * 50G DOWN 2 - 4 * 10/25/50G UP	High O-Band Down Low O-Band Up
Super PON IEEE 802.3cs	Long reach 50 km Large split 1:1024	16 * 10G DOWN 16 * 2.5/10G UP	L-Band Down C-Band Up (NG-PON2)
Super PON ITU G.9807.3	Long reach 50 km Large split 1:1024	1:32	1:32**

Super PON



Super PON AWG Splitter - λ router



$$\lambda_c = \frac{n_c \times \Delta L}{m}$$

$$m = a - 1, a, a + 1, a + 2 \dots$$

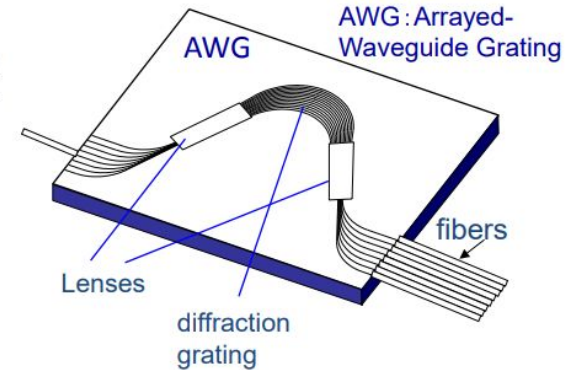
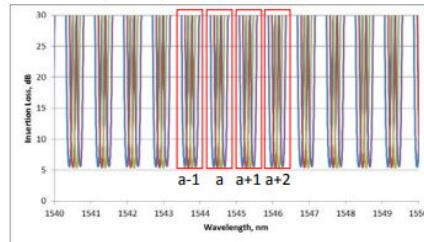
ΔL : Waveguide path length difference

m : Diffraction order

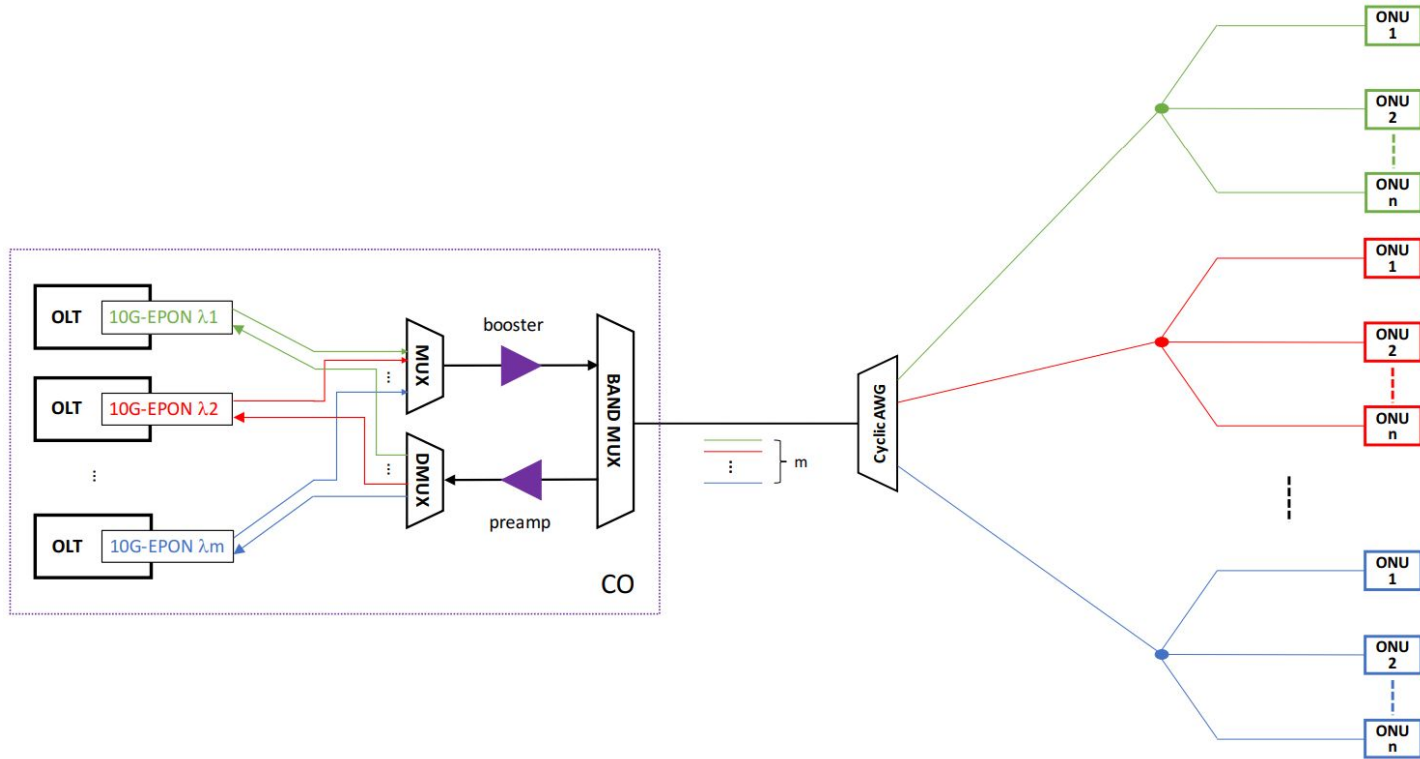
FSR: Free Spectral Range

$$FSR = N \frac{\lambda_c}{m}$$

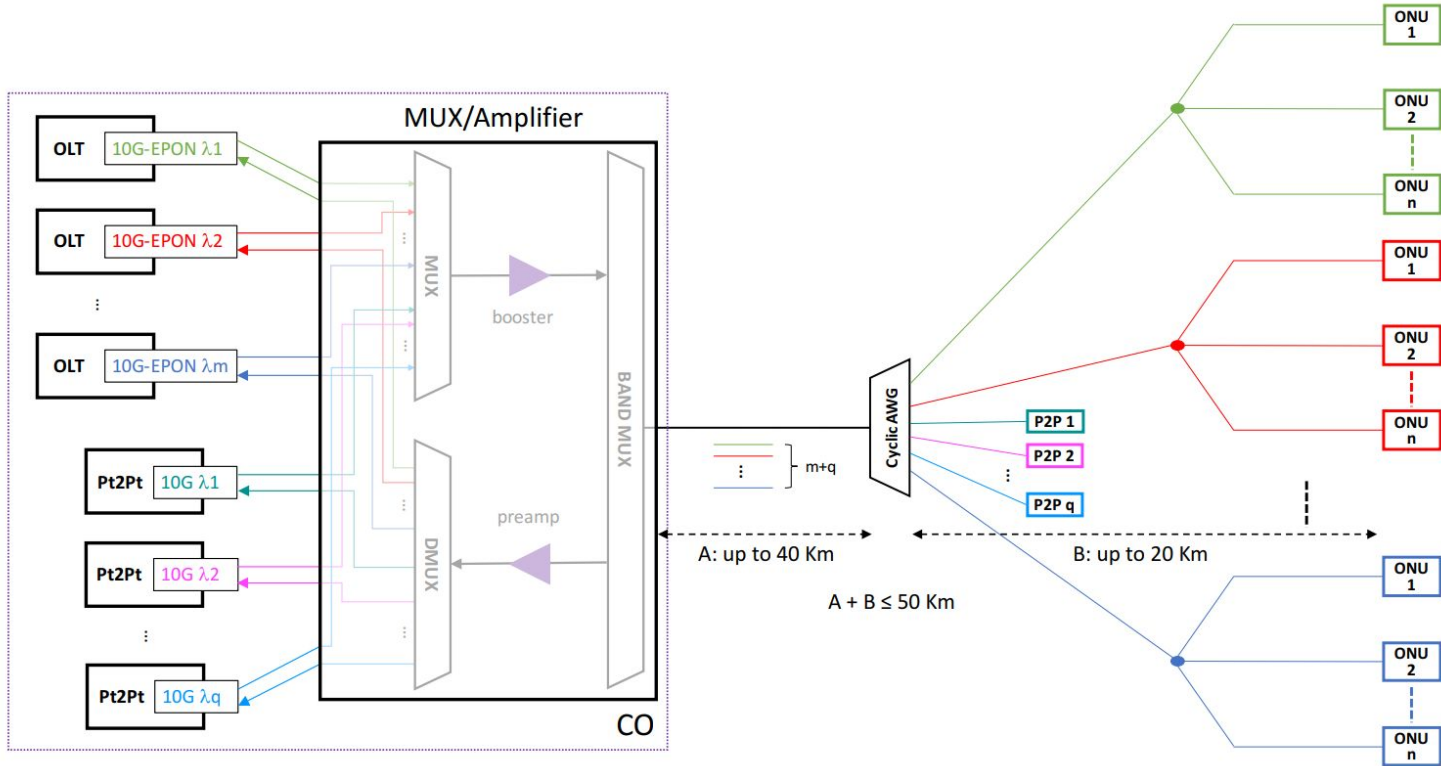
Example Cyclic AWG Spectrum



Super PON



Super PON



IPv6

