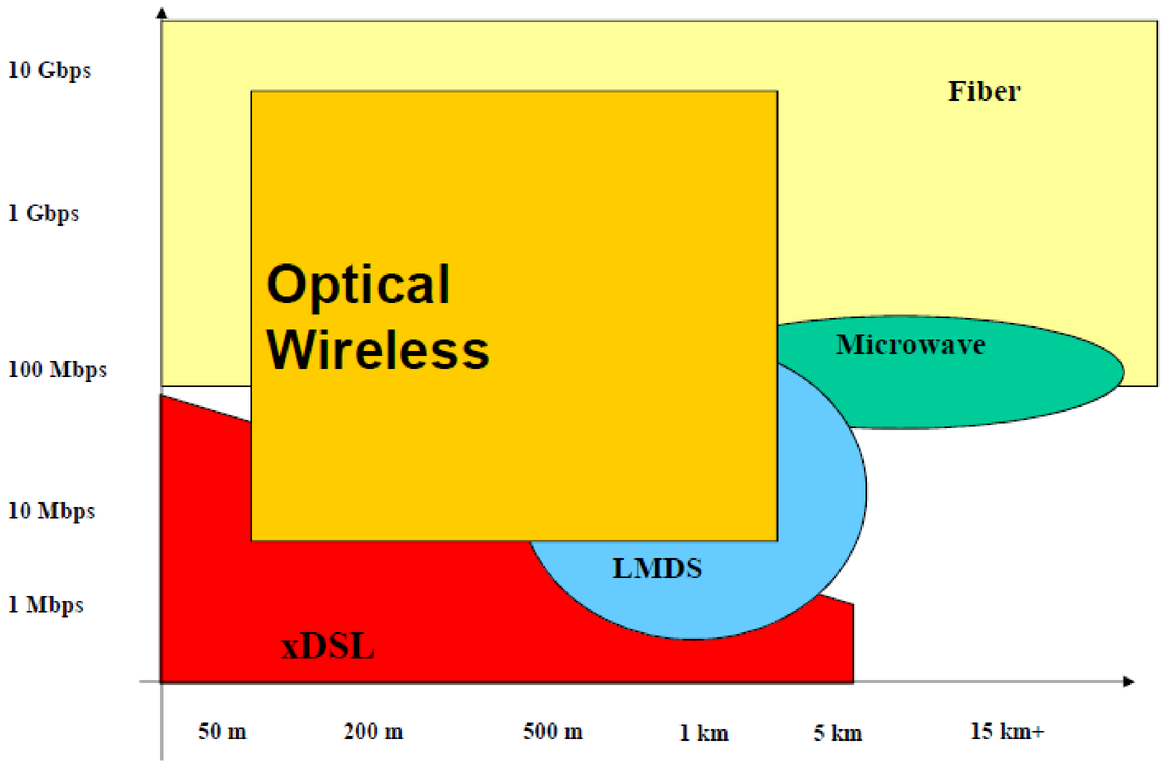
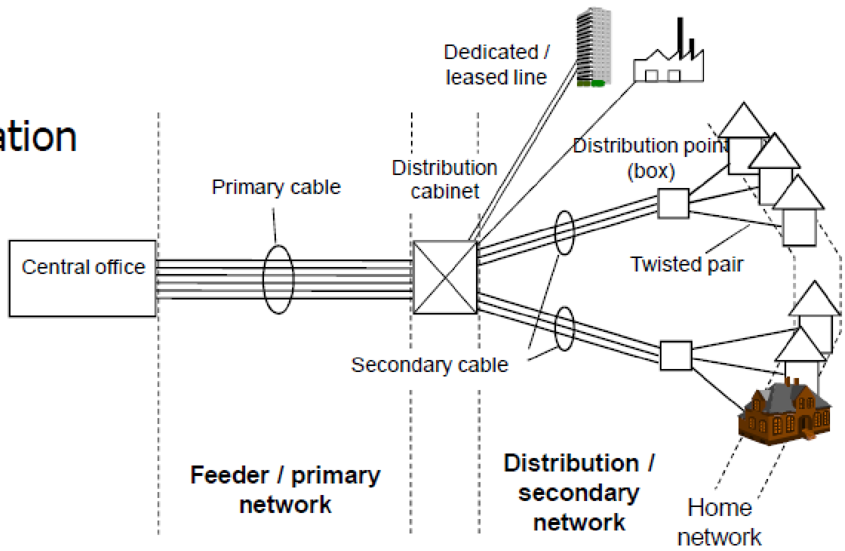
6. Passive optical network



PSTN architecture

- Primary network
  - High sharing
  - Cost minimization
- Secondary network
  - Flexibility
  - Branching
- Cables
  - Primary
    - 2400-2000 pairs
    - In duct or pipe
  - Secondary
    - 100-10 pairs
    - Trenched or aerial



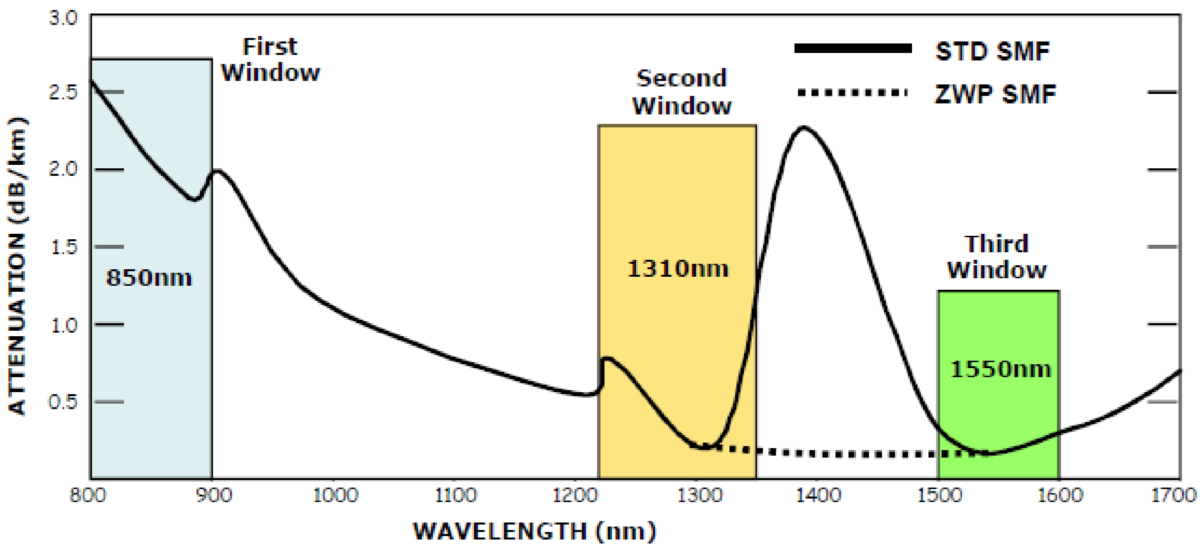
6.1 Optical Fiber

6.1.1 Attenuation

Single Mode Fiber (SMF) to achieve large distances:

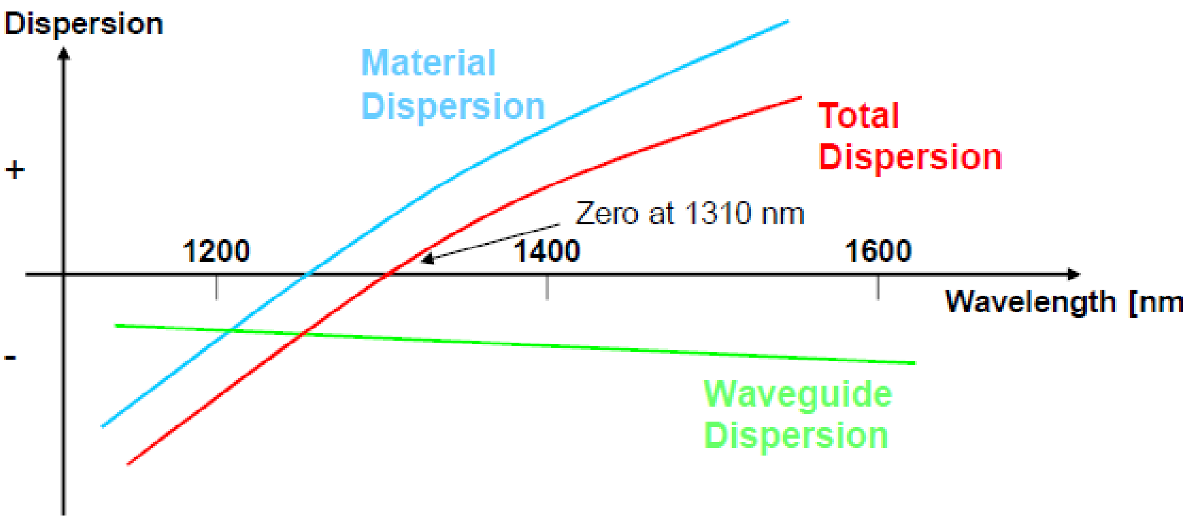
- ITU G.652 SMF (STD)

- ITU G652c/d SMF (ZWP)



6.1.2 Chromatic dispersion

Causes signal pulse broadening

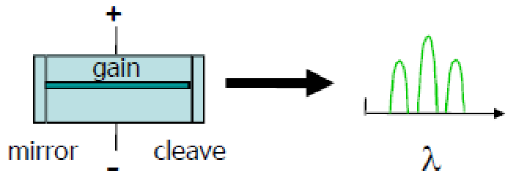


6.2 Components

6.2.1 Laser Diodes(LD)

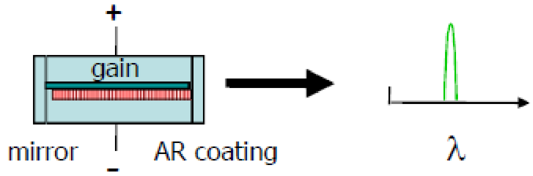
- Fabry-Perot (FP)
  - Cheap
  - Noisy
    - Sensitive to chromatic dispersion
  - Used on 1310 nm

Simple FP



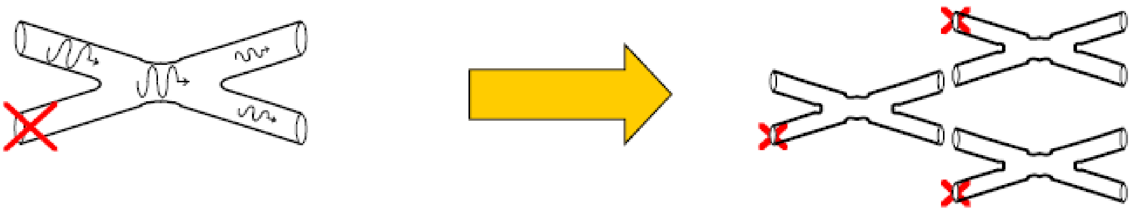
- Distributed Feedback (DFB)
  - More expensive
  - Narrow spectral width
    - Less sensitive to chromatic dispersion
  - Used on 1550 nm (or 1310 nm)

DFB



6.2.2 Passive splitters

- 1x2 Splitter
- 1xN Splitter



The basic element consists of two fibers fused together

Every time the signal is split two ways, the signal is reduced by *10log(0.5)=3dB*

- Loss ~*3dB* x *log*$_2$*(#ONUs)*

	Conventional	Low-loss
Splitter 1x2	3.7dB	3.4dB

6.2.3 PhotoDiodes (PD)

PIN:

- Good optical sensitivity (~-22 dBm)
- Silicon for shorter lambda's (eg 850nm)
- InGaAs for longer lambda's (eg 1310/1550nm)

Avalanche

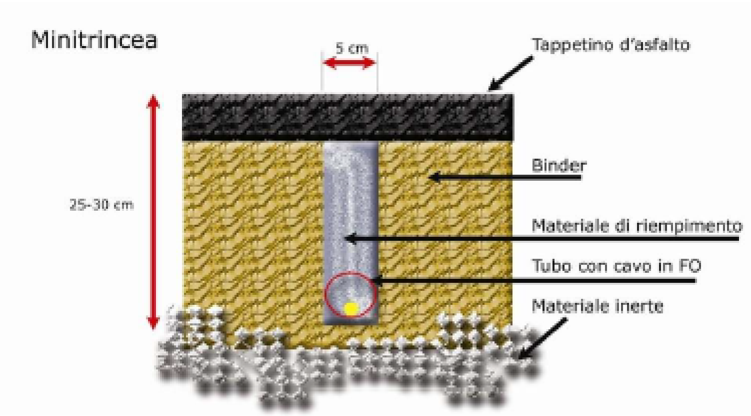
- Higher sensitivity (~-30 dBm)
- Primarily for extended distances in Gb/s rates
- Much higher cost than PIN diodes

6.2.4 Transceiver assumptions

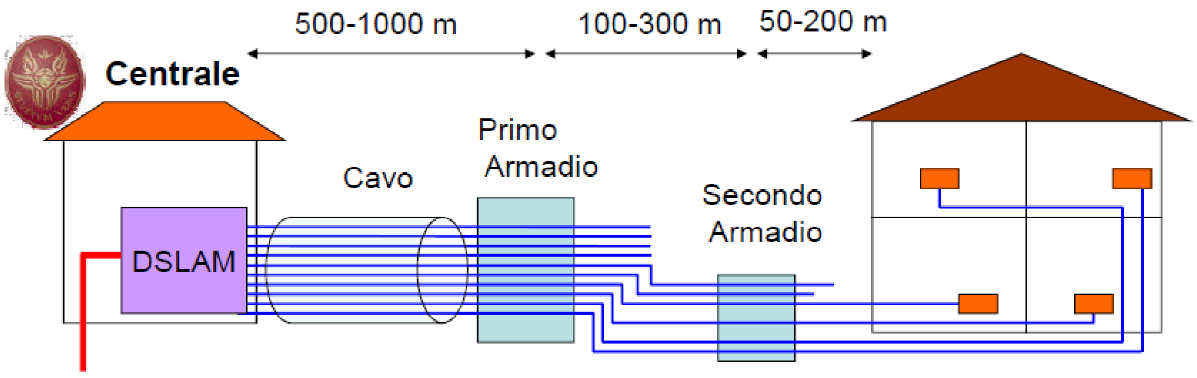
	TX Power	RX Sensitivity
ONU (FP+PIN)	0 dBm	-22 dBm
OLT (DFB+APD)	1 dBm	-30 dBm

- **Upstream (@1310nm) Power Budget = 30 dB**
- **Downstream (@1490nm) Power Budget = 22 dB**

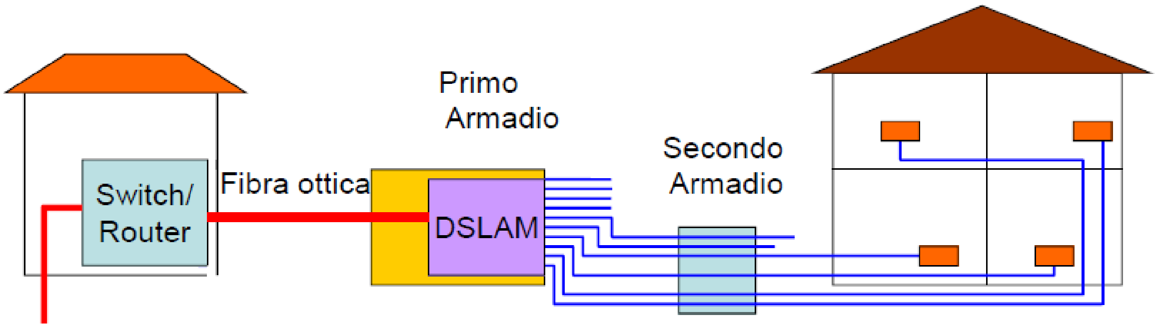
6.2.5 Fiber installation



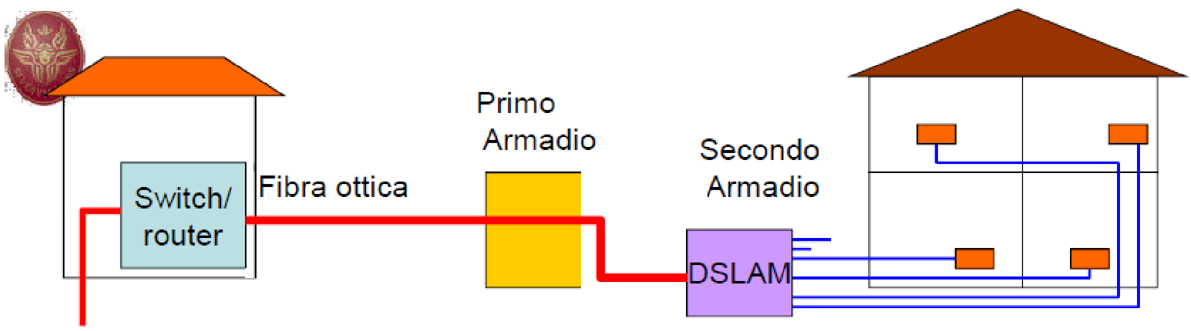
6.3 Fiber rchitectures



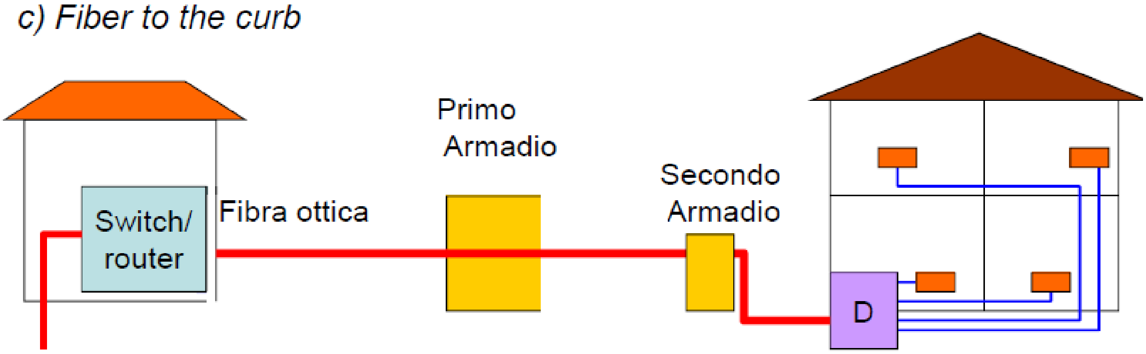
a) Best current architecture



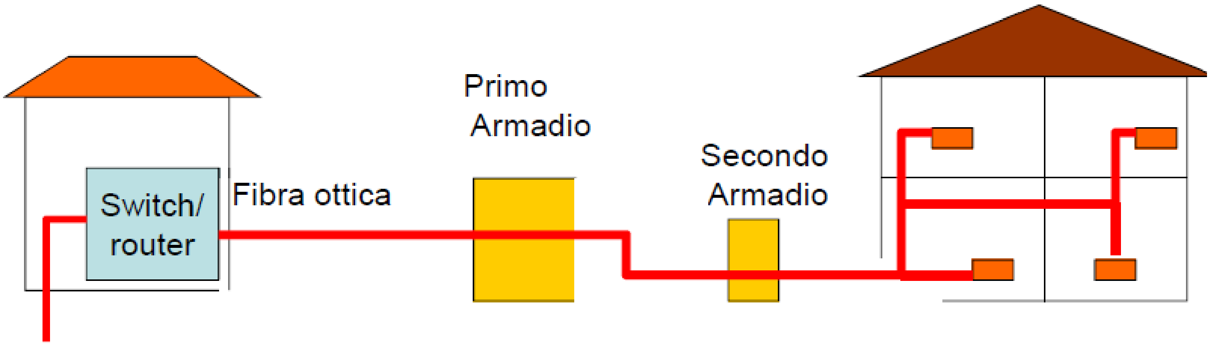
b) Fiber to the cabinet



c) Fiber to the curb

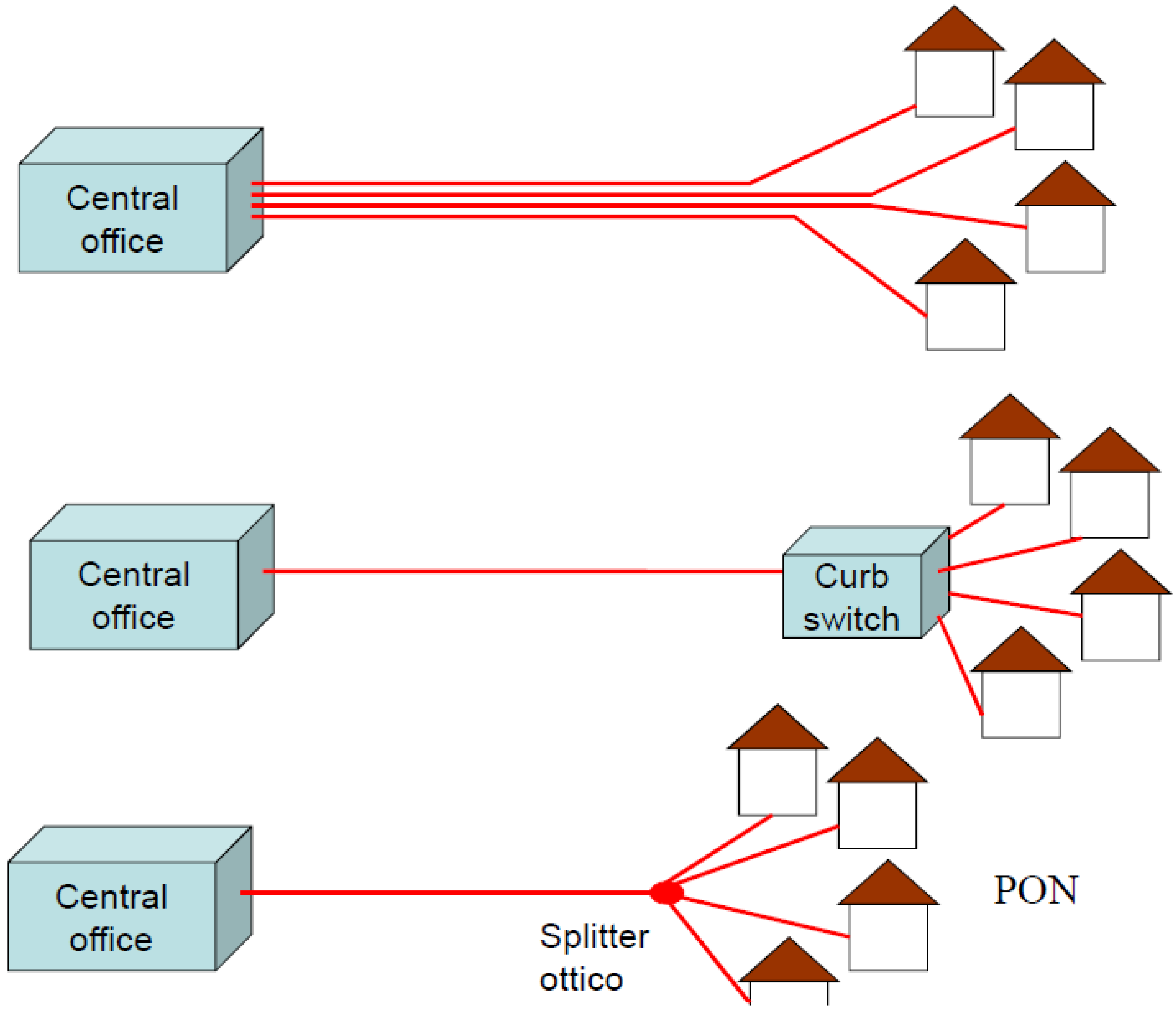


d) Fiber to the building



e) Fiber to the home

6.4 PON



6.4.1 Basic PON operations

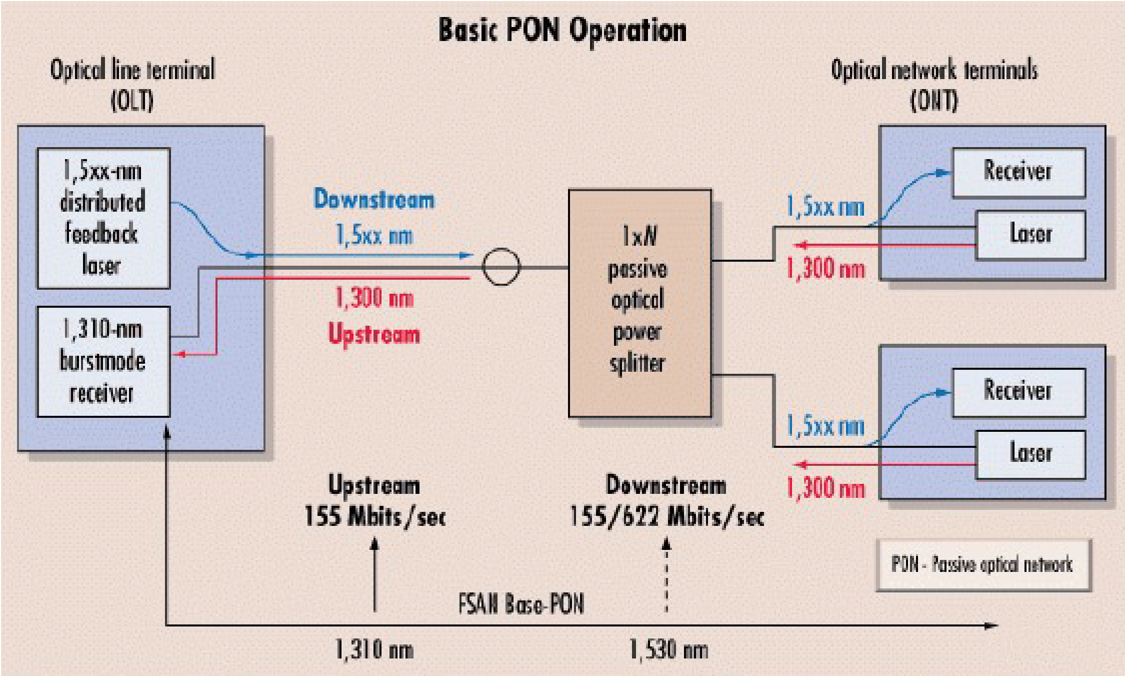
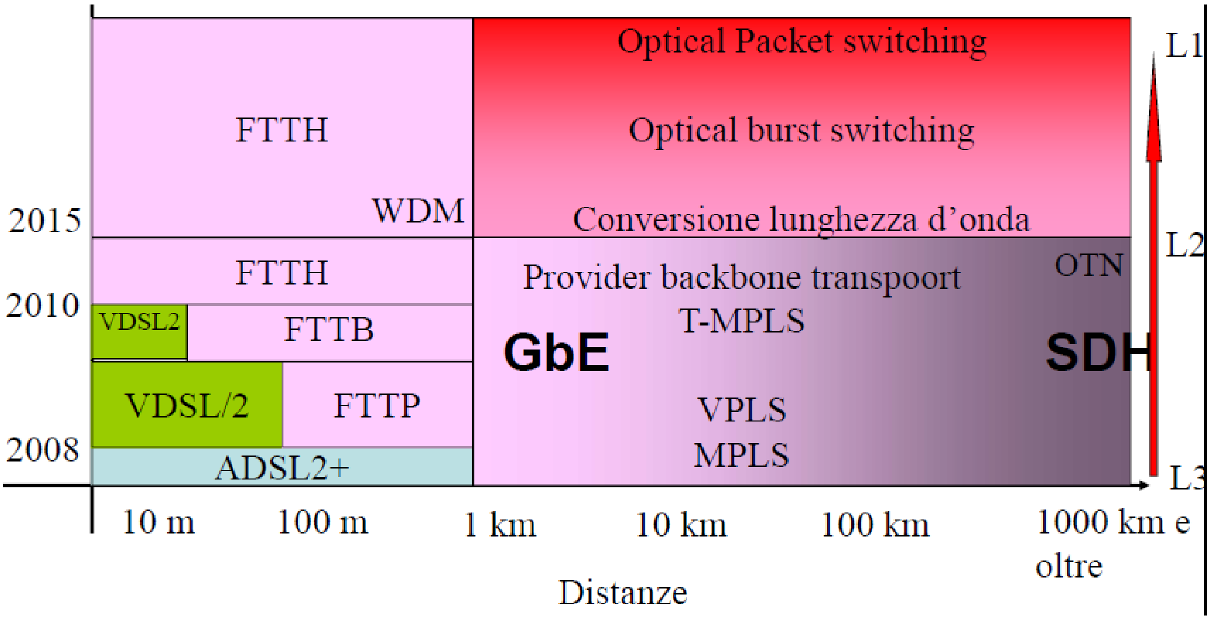


Figure 1. A basic passive-optical-network operation enables service to as many as 32 optical-network terminals (ONTs). Each ONT, in turn, can be connected to multiple subscribers, making fiber more affordable for access networks.



6.4.2 Time vs. Spectrum Sharing

Downstream → point-to-multipoint network

- The OLT manages the whole bandwidth

Upstream → multipoint-to-point network

- ONUs transmit only towards the OLT

- ONUs cannot detect other ONUs transmissions
- Data transmitted by ONUs may collide

Need of a channel separation mechanism to fairly share bandwidth resources

TDMA (Time Division Multiple Access) ↔ WDMA (Wavelength Division Multiple Access)

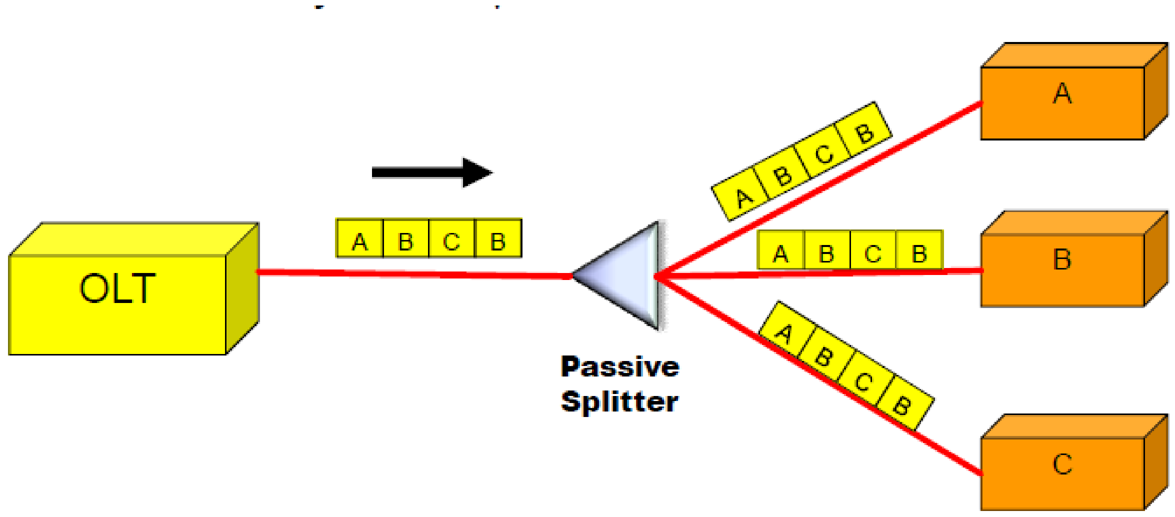
TDM-PONs: standardized, few wavelengths, cheaper, limited power, traffic dist.

WDM-PONs: proposed in literature and/or demonstrated, long-reach and bandwidth

6.5 Streams

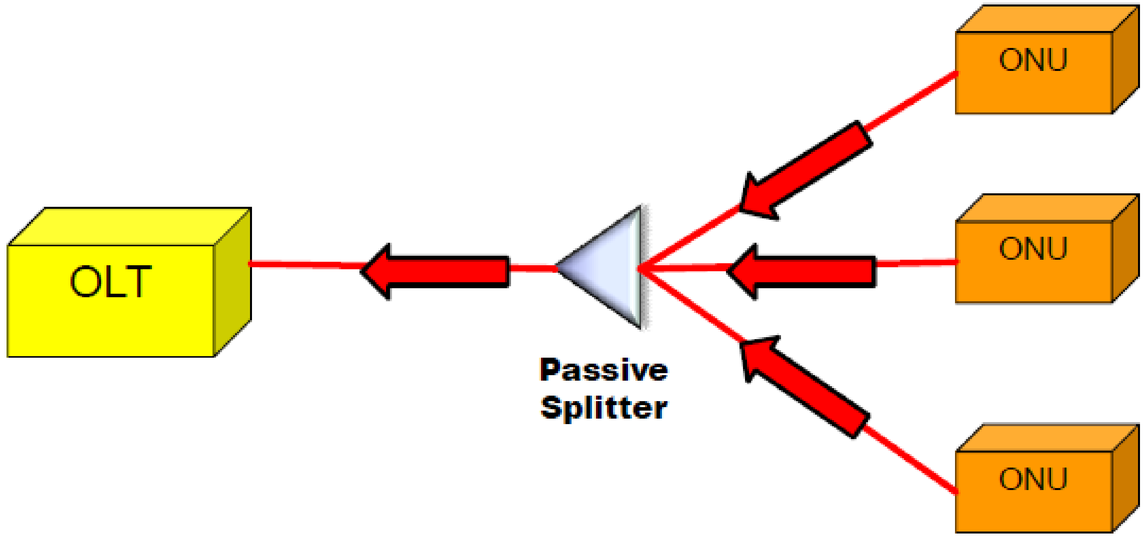
6.5.1 Downstream

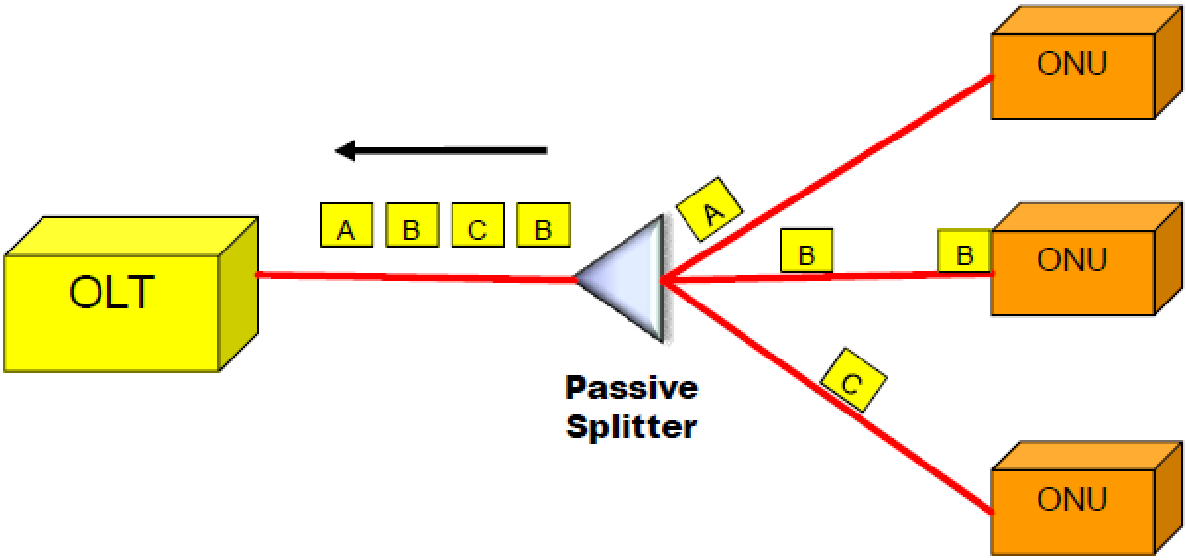
OLT schedules traffic inside timeslots (TDM)



6.5.2 Upstream

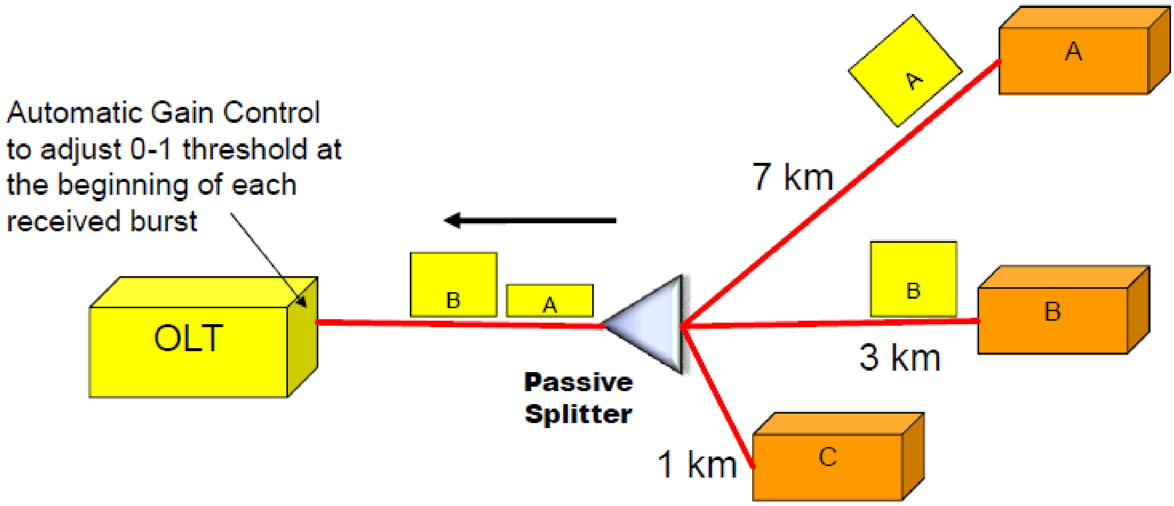
All ONUs share the same upstream channel (Collisions)





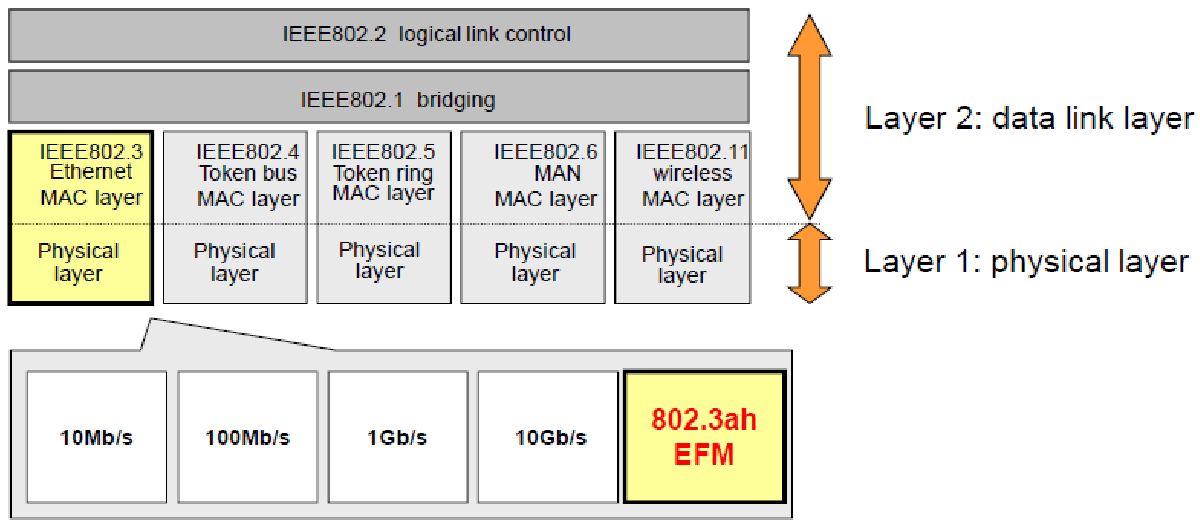
The OLT receives frames with different powers

- difficult to recover synchronism (clock and data recovery)
- Burst Mode Receiver (complex) @ OLT



6.6 Ethernet PONs

Standards:



-All packets carried in EPON are encapsulated in Ethernet frames

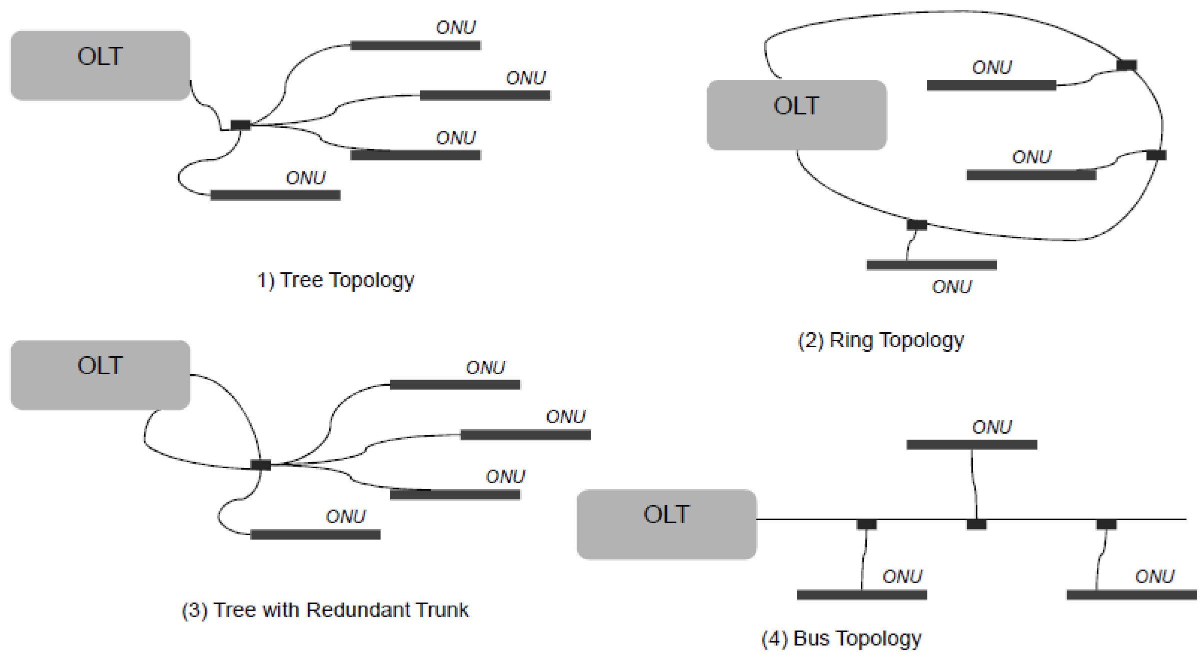
-Similar wavelength to BPON

-Max rate 1Gbps

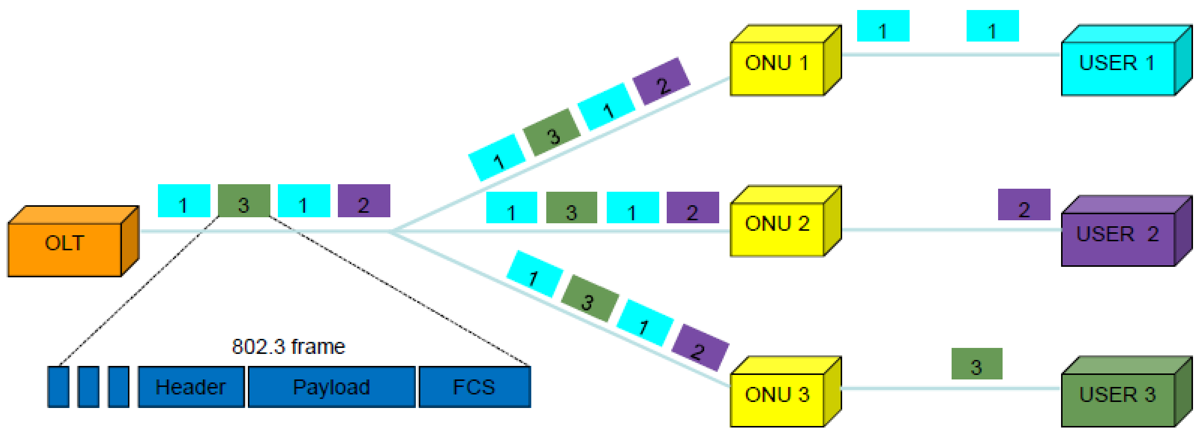
-Max reach 10-20km

-Min splits: 16

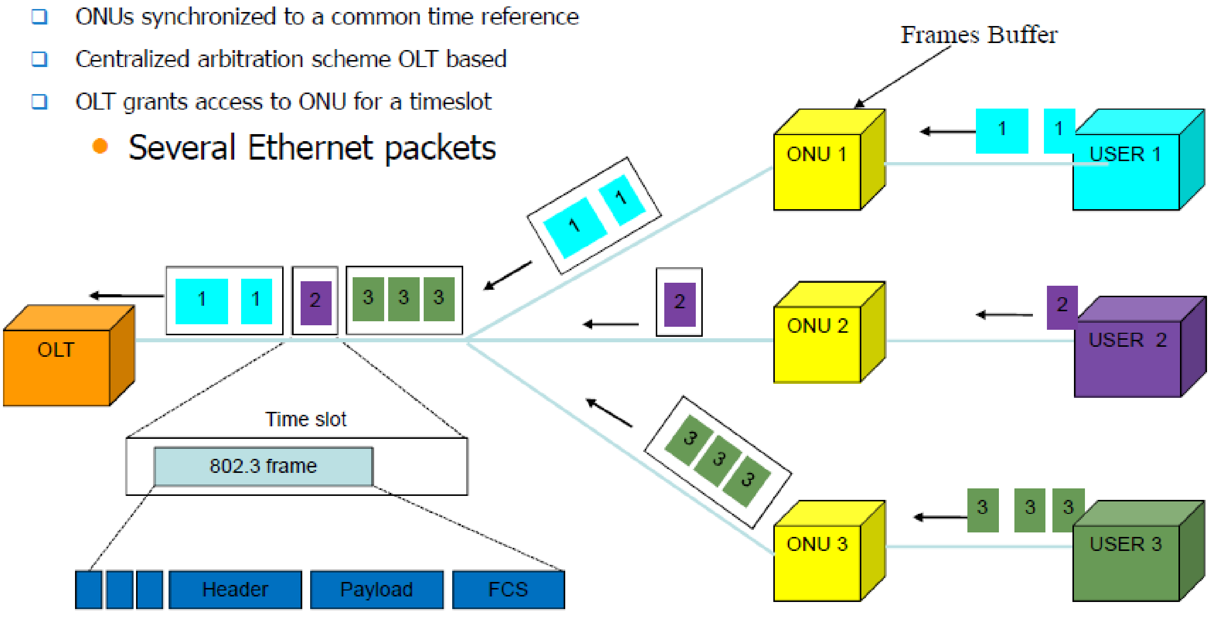
Configurations



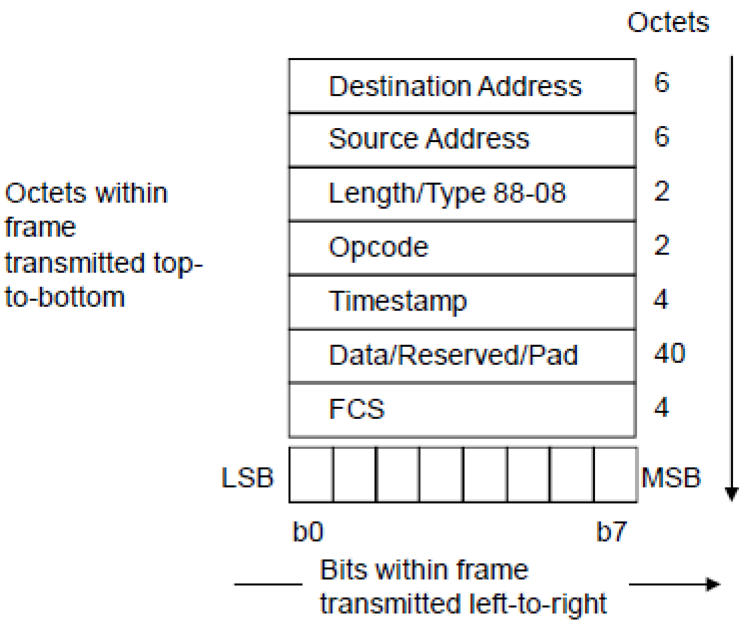
6.6.1 Downstream



6.6.2 Upstream



MPCP (Multi-Point Control Protocol) is a new function of the MAC control sublayer. It is developed to support dynamic capacity allocation but the algorithms are an equipment vendors choice (Dynamic Bandwidth Allocation - DBA)



Autodiscovery mode

3 control messages:

- Register, start message sent by OLT;

- Register_Request, answer message from ONU not registered yet;
- Register_Ack, message by OLT that allows ONU registration.

6.7 GPON (Gigabit-capable PON)

Item	Target	
Bit rates	1.25Gbit/s symmetric or higher (2.4 Gbit/s). Asymmetric with 155/622Mb/s upstream	
Physical reach	Max. 20 km or max. 10 km	
Logical reach	Max. 60 km	
Branches	Max. 64 in physical layer	
Wavelength allocation	Downstream: 1480 – 1500nm Upstream: 1260 – 1360nm	Downstream video wavelength (1550 – 1560nm) may be overlaid

6.7.1 Encapsulation Mode

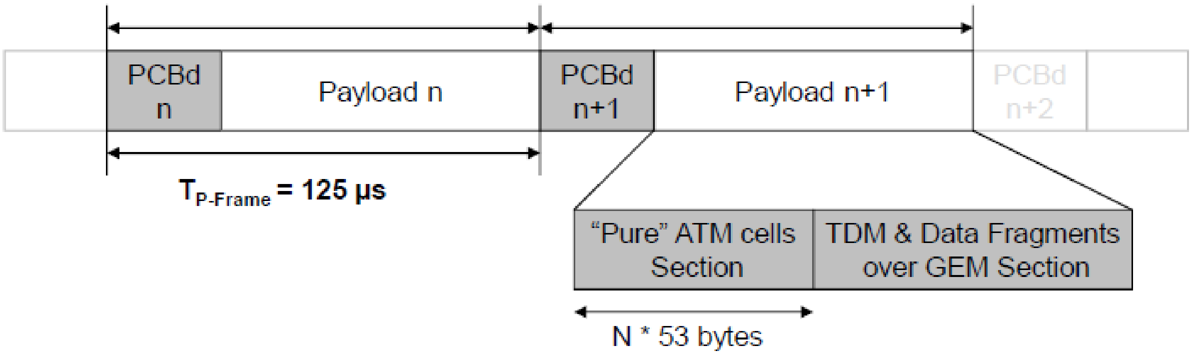
GEM provides a Generic Frame where to carry both TDM and packet traffic over fixed data-rate channels

Consists of:

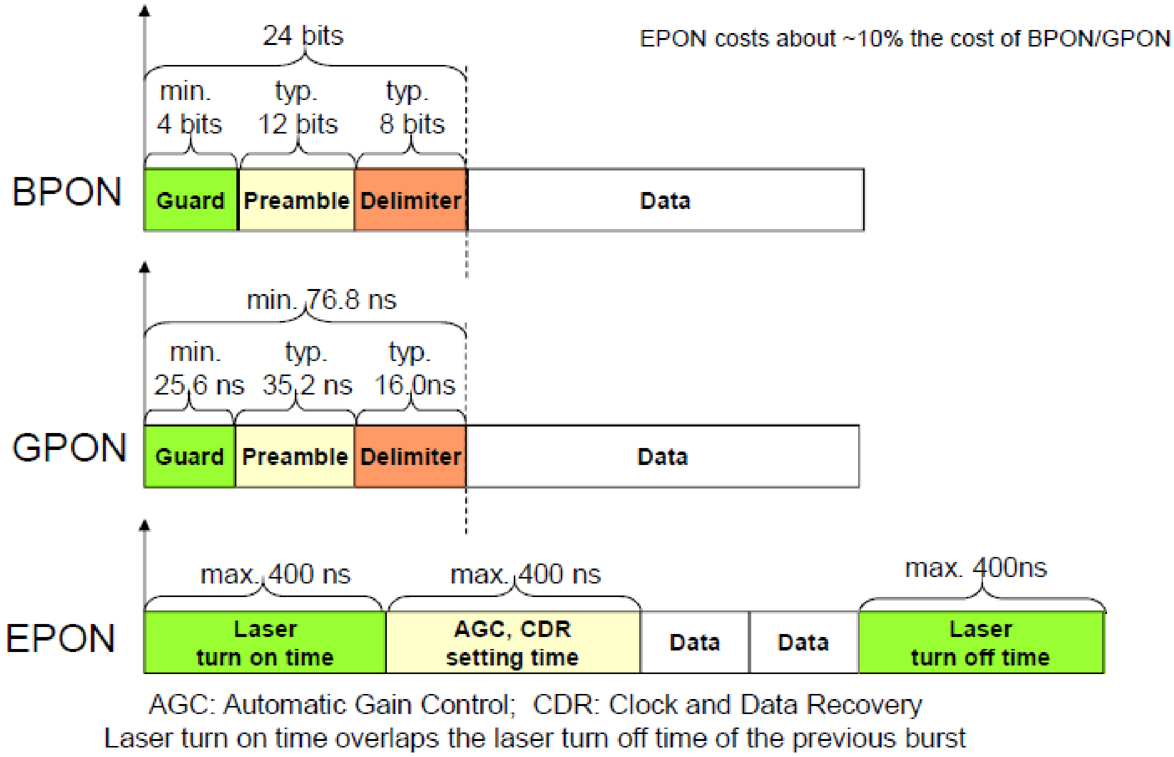
- a core header
- a payload header
- an optional extension header
- a payload
- an optional frame check sequence (FCS).

6.7.2 Downstream frame

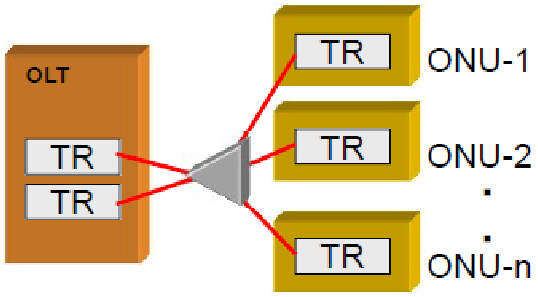
It consists of
- a Physical Control Block Downstream (PCBD)
- the ATM partition (N×53 bytes)
- the GEM partition



Headers' comparison

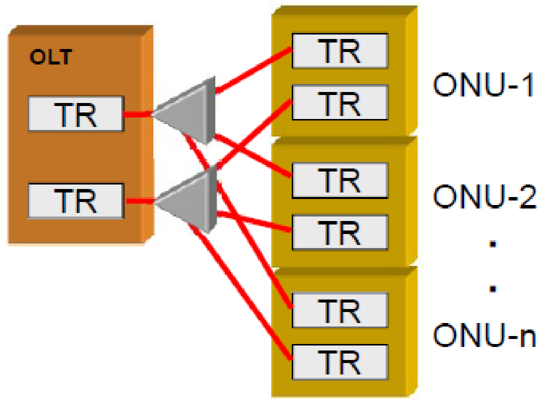


Protection Mechanisms



B type
1+1 protection of OLT

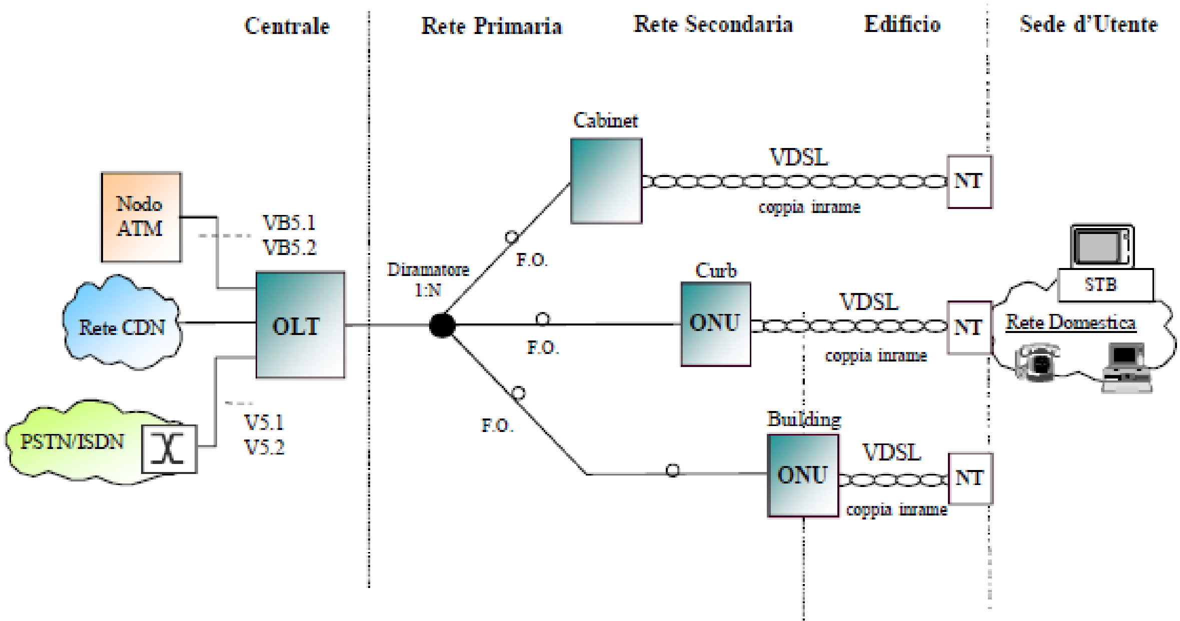
- Cost-effective
- Redundant feeder
- Redundant OLT transceivers



C type
1+1 protection of PON

- Most secure and expensive
- Redundant feeder and drops
- Redundant transceivers

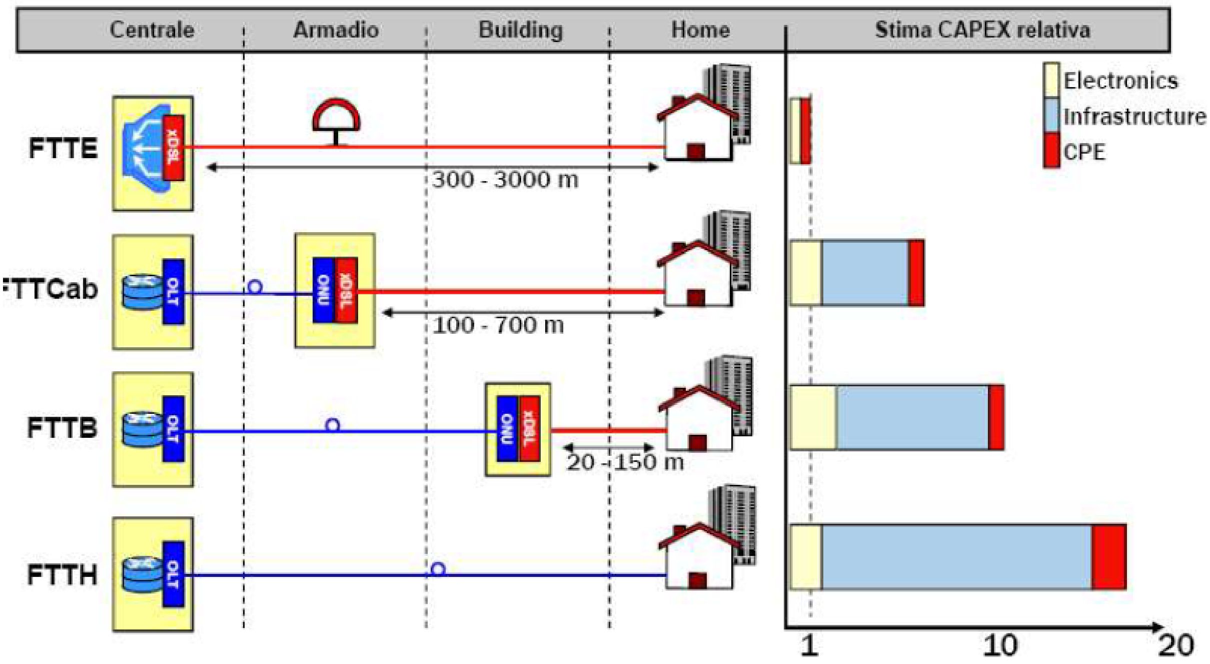
Elements of a PON



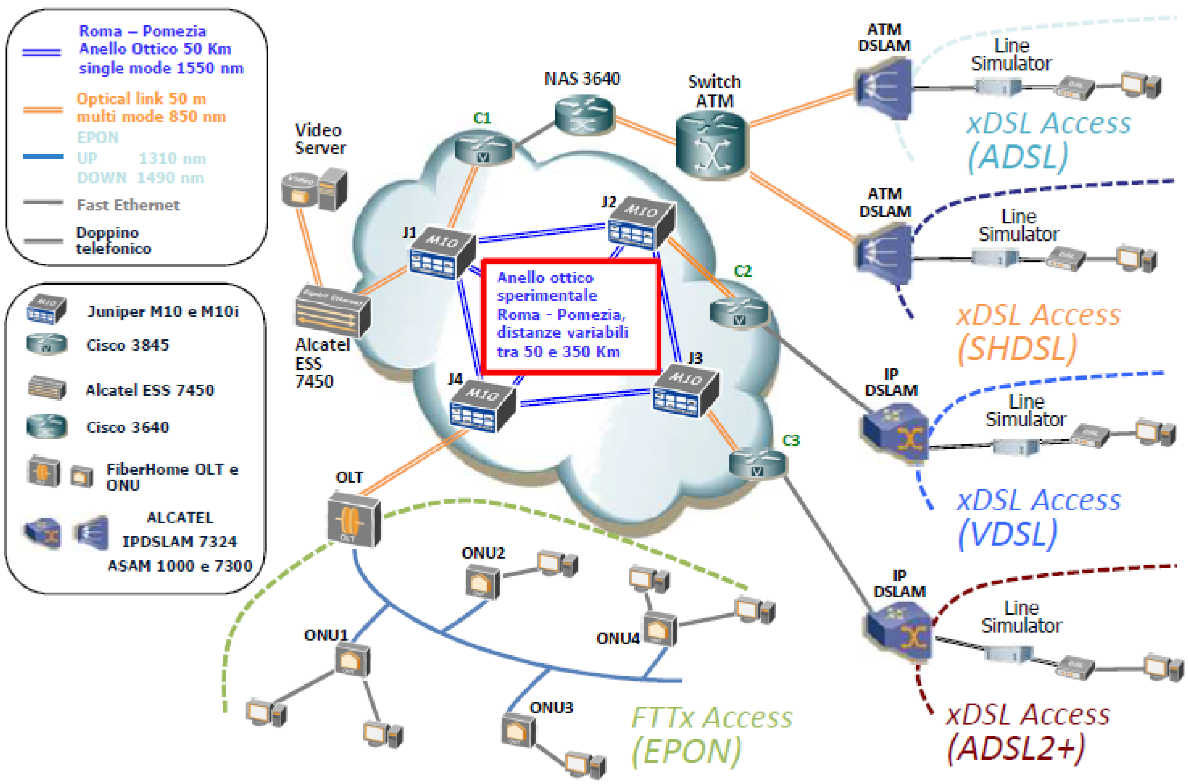
OLT: Optical Line
VDSL: Very high bitrate Subscriber Loop
STB: Set Top Box

ONU: Optical Network Unit
NT : Network Termination

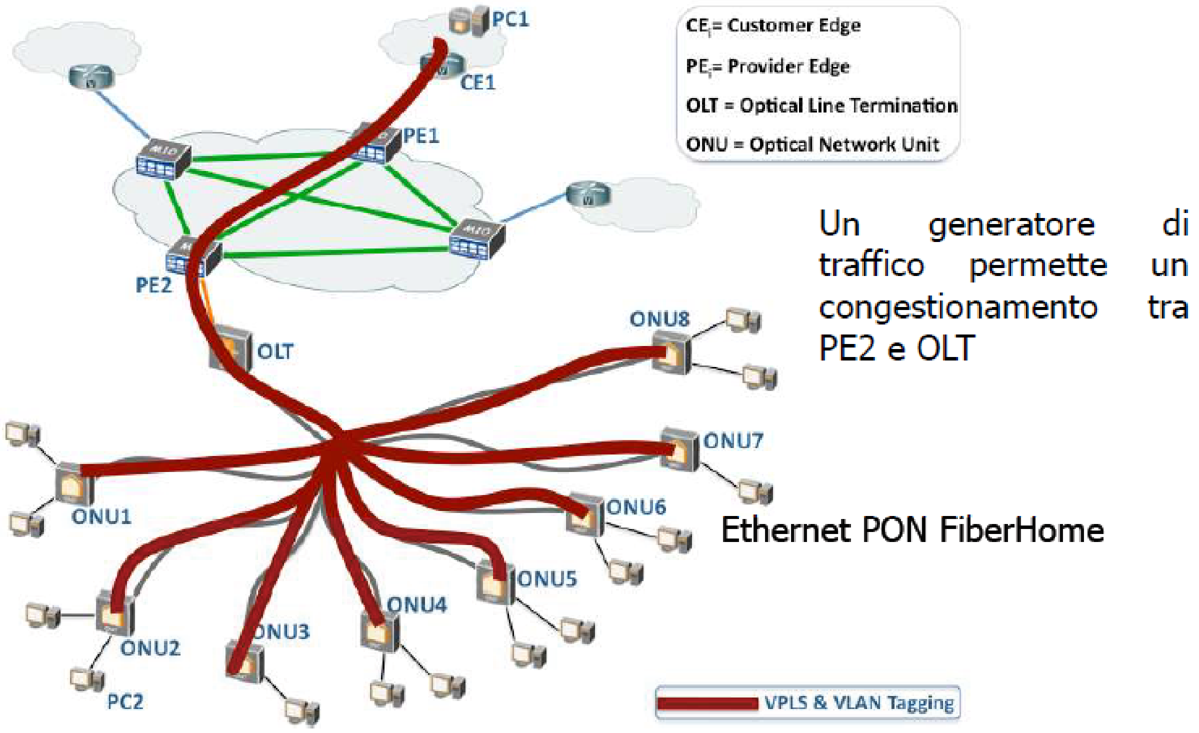
FTTx costs



FUB Experiments on EPON



Logical network by means of VPLS&VLAN Tagging



Conclusions

- FTTx necessary for NGN
- PON is the best current solution
- Problems for investments and network properties