

# Dal Digital Divide alle Reti di Nuova Generazione (NGN)

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**Forum P.A.**

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Fondazione Ugo Bordoni



# Outline

- ❑ Ruolo della FUB:
  - sperimentazioni e supporto tecnico, normativo ed economico al Ministero dello Sviluppo Economico
  - Ricerca scientifica nel campo delle reti di TLC
- ❑ Panoramica sulle reti di TLC..qualche definizione
- ❑ Situazione italiana
- ❑ NGN nell'accesso: tecniche FTTx
- ❑ NGN nelle reti metro e core
- ❑ Conclusioni



# Definizione di NGN

*(Next Generation Network)*

- ❑ E' l'insieme delle reti di TLC che prevedono alcune evoluzioni chiave come:
  - Connessione degli utenti con bande garantite elevate:  
(20 Mb/s, 50, 100) Mb/s
  - la convergenza dei servizi (triple e quadruple play);
  - il trasporto su pacchetti IP/Ethernet (All IP).
  
- ❑ E' richiesto:
  - Interventi in area di accesso: fibra ottica
  - Adeguamento della rete metro e core
  - Garanzia della Qualità del Servizio



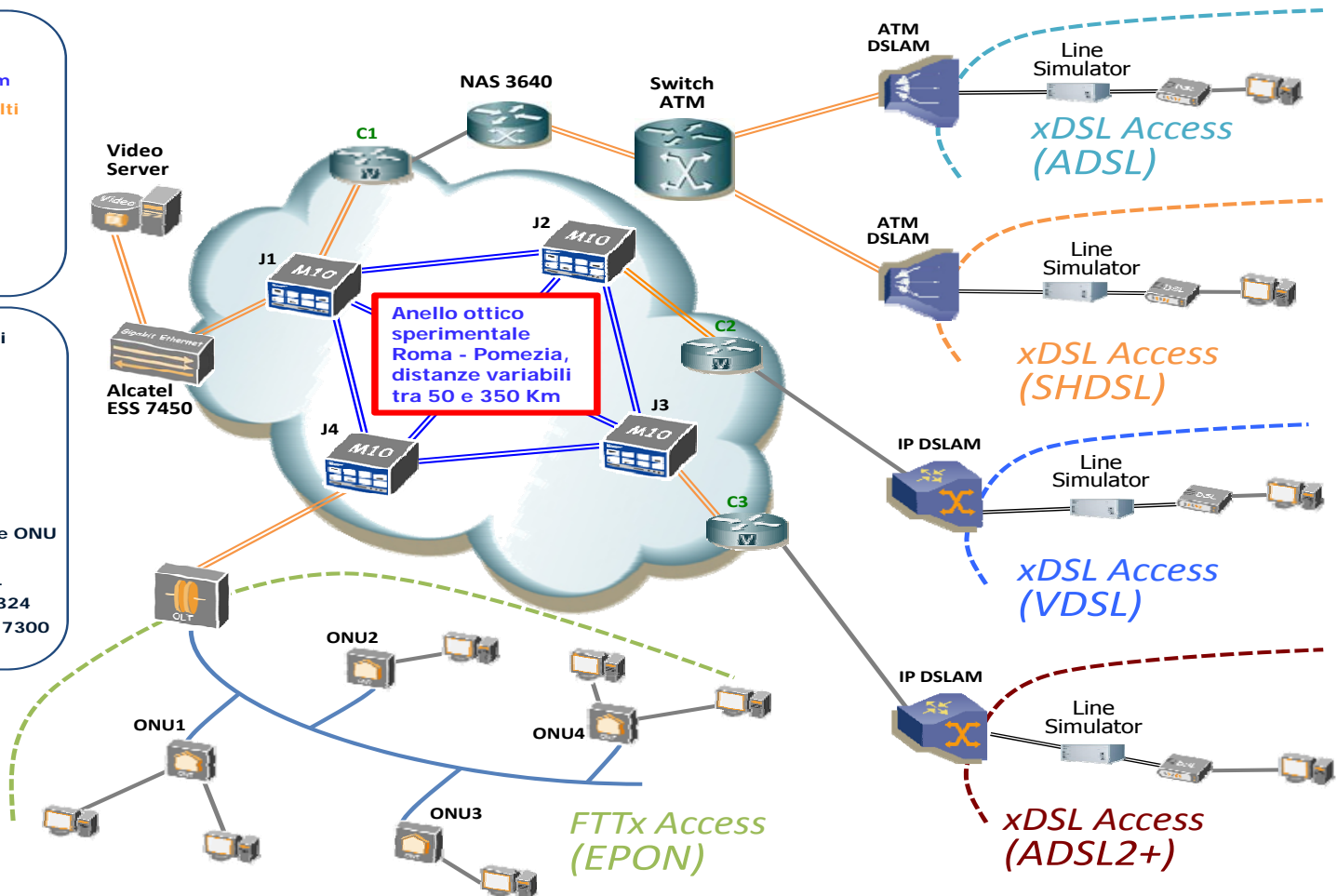
# La situazione italiana

- ❑ In Italia penetrazione larga banda troppo bassa (17%). Praticamente unica infrastruttura di accesso (doppino)
- ❑ 20 Mb/s è ormai commerciale, ma funzionerà a regime? (interferenze nei doppini se troppi utenti). L'obiettivo è 50/100 Mb/s per utenza, ma almeno **20 Mb/s certi!**
  - TV HD=10 Mb/s (MPG4), TV HD tridimensionale=14 Mb/s
- ❑ Come 20/50/100 Mb/s per utente?
  - Digital Divide: circa 2000 comuni vanno ancora connessi al backbone con alta capacità (occorre fibra ottica!). Per situazione immediate WI-MAX, HSPA, LTE
  - Centri urbani: FTTx, fibra fino all'edificio (EPON/GPON, Active Optical Network)
  - Costi, scorporo rete di accesso, ridefinizione del concetto di unbundling per reti ottiche
- ❑ Convergenza IP DVB (TV digitale terrestre): decoder ibridi

# Il test bed di rete IP ISCTI-FUB

- Roma – Pomezia  
Anello Ottico 50 Km  
single mode 1550 nm
- Optical link 50 m multi  
mode 850 nm
- EPON  
UP 1310 nm  
DOWN 1480 nm
- Fast Ethernet
- Doppino telefonico

- Juniper M10 e M10i
- Cisco 3845
- Alcatel ESS 7450
- Cisco 3640
- FiberHome OLT e ONU
- ALCATEL  
IPDSLAM 7324  
ASAM 1000 e 7300



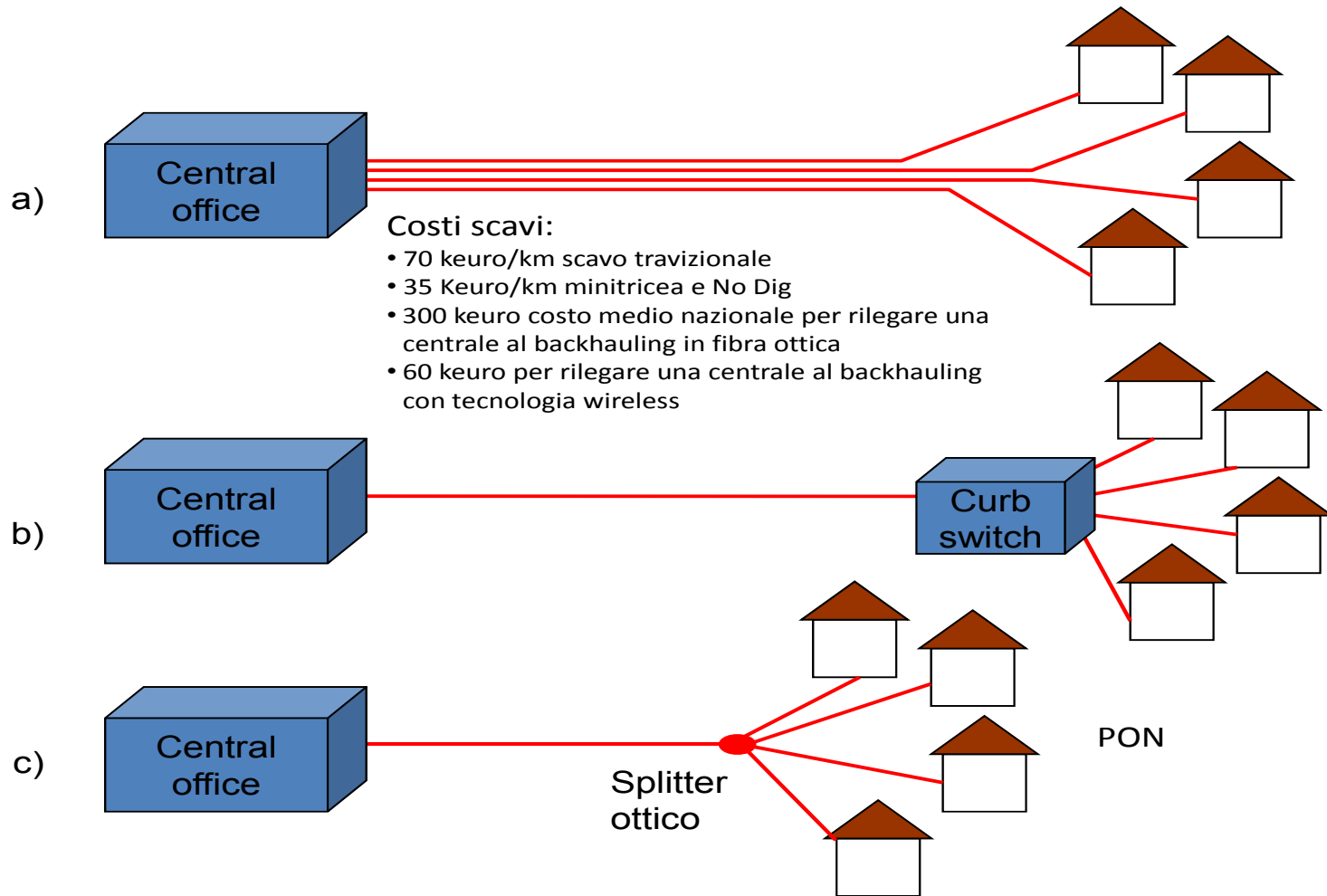


# Ruolo del test bed

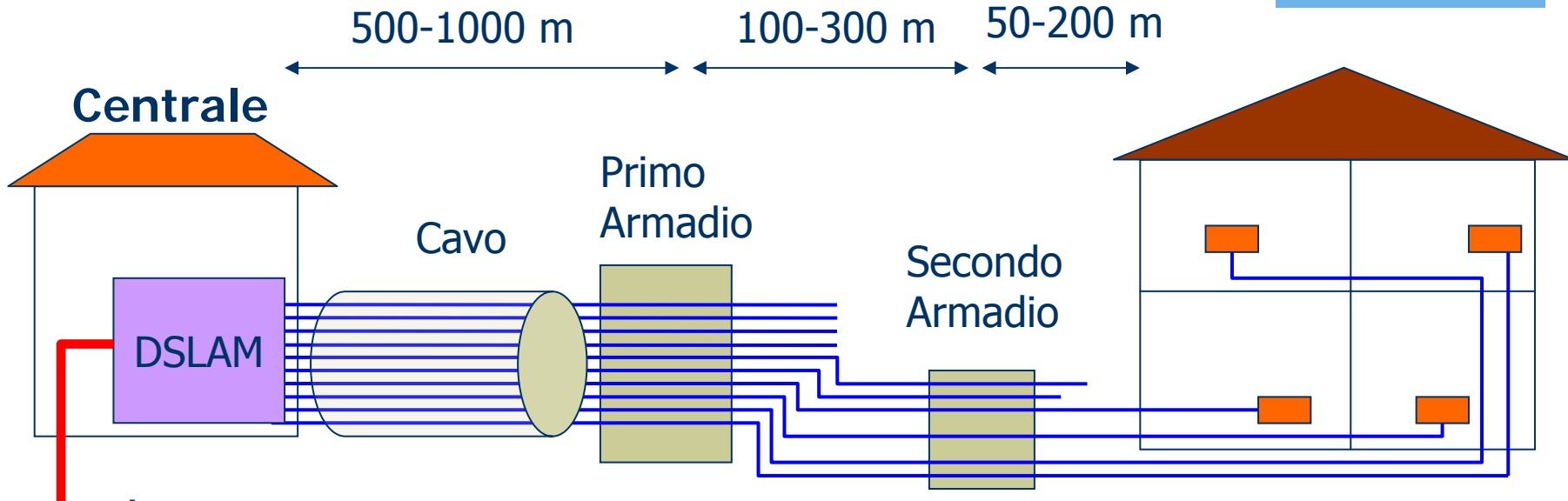
- ❑ Analisi della Quality of Service (QoS) per servizi di rete fissa a supporto del Ministero dello Sviluppo Economico (Dipartimento Comunicazioni)
- ❑ Supporto alle imprese
- ❑ Ricerche:
  - Instradamento basato su livelli sempre più bassi della PILA OSI (dal 3 verso 1 - *All optical*)
    - ◆ Dal livello 3 verso il livello 2:
      - ✓ DiffServ-MPLS
      - ✓ Virtual Private LAN Service (VPN L2, molto importante per operatori)
      - ✓ Provider Backbone Transport (PBT)
    - ◆ Verso il livello 2: OBS, OPS, All Optical Wavelength Routing



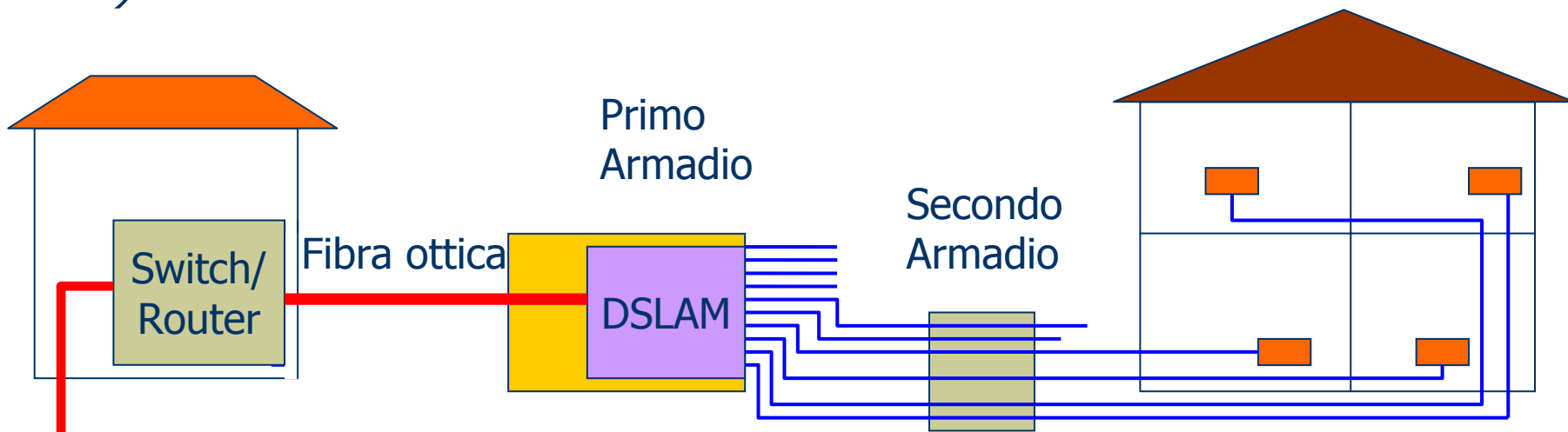
# Possibili scenari



# Architetture FTTx (1/3)

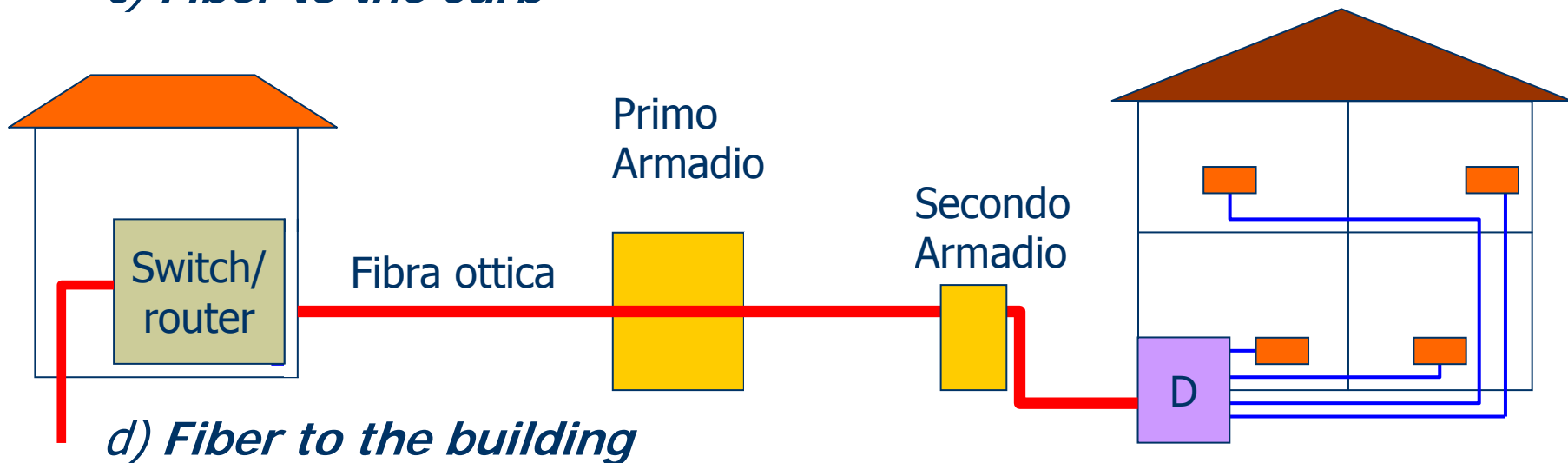
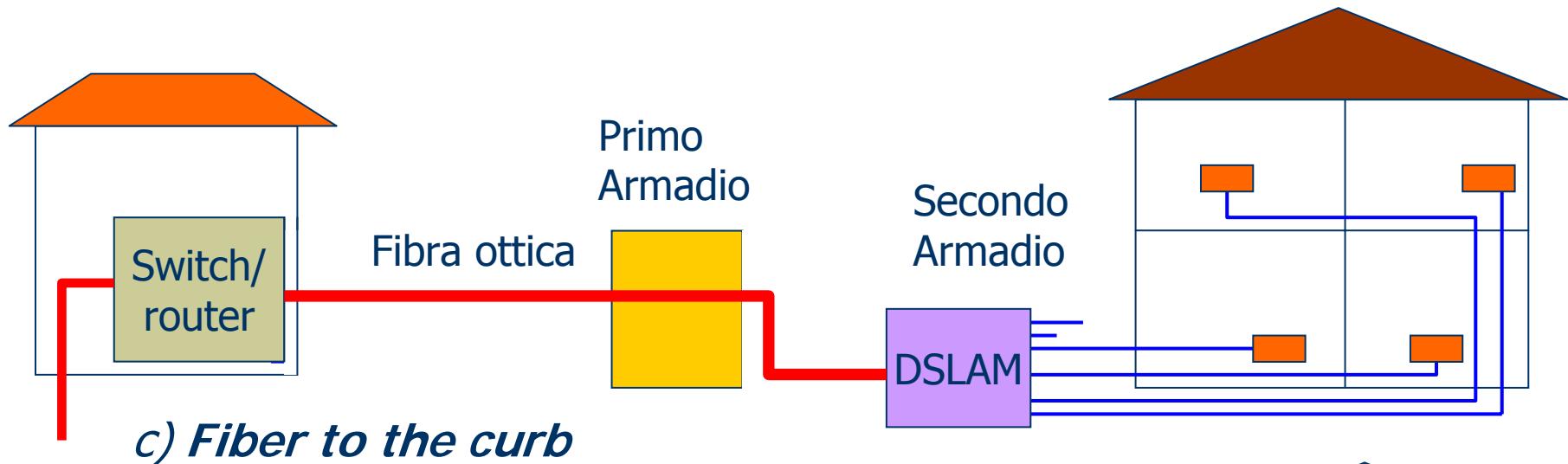


*a) Best current architecture*

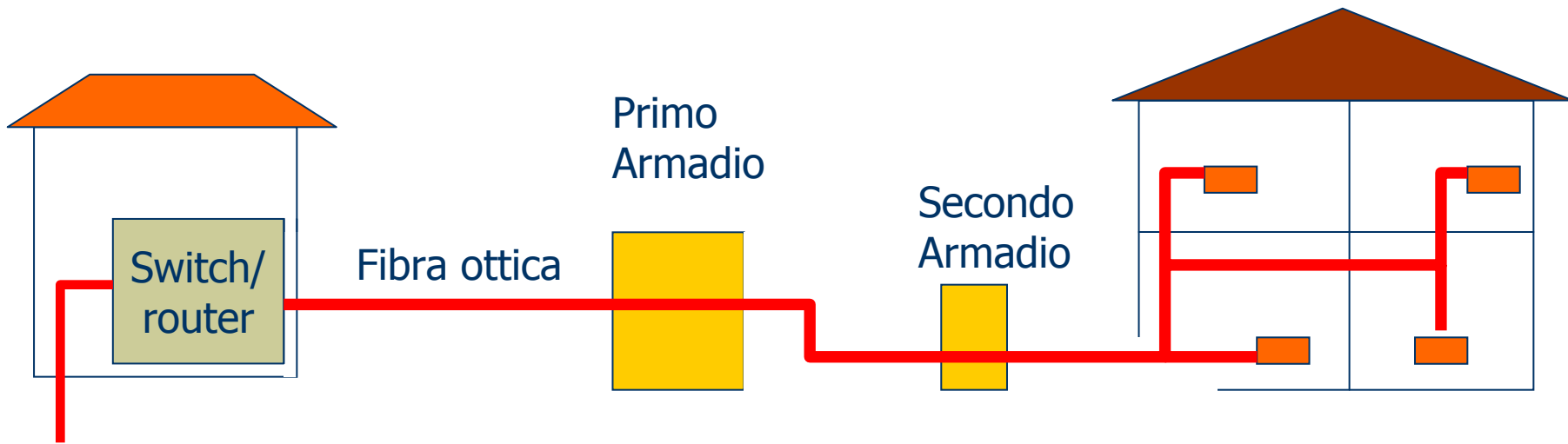


*b) Fiber to the cabinet*

# Architetture FTTx (2/3)



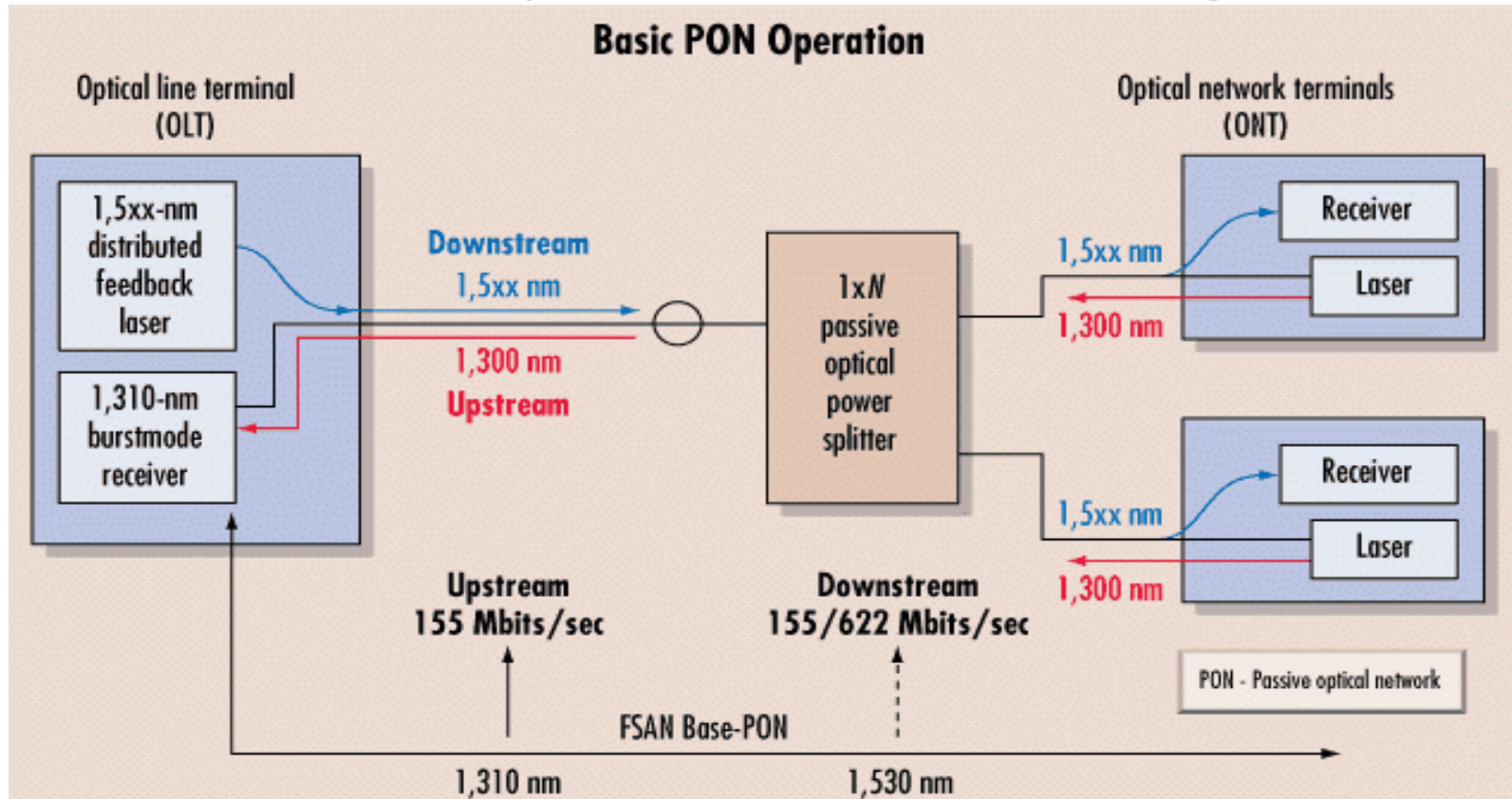
# Architetture FTTx (3/3)



*e) Fiber to the home*

# Basic PON operations

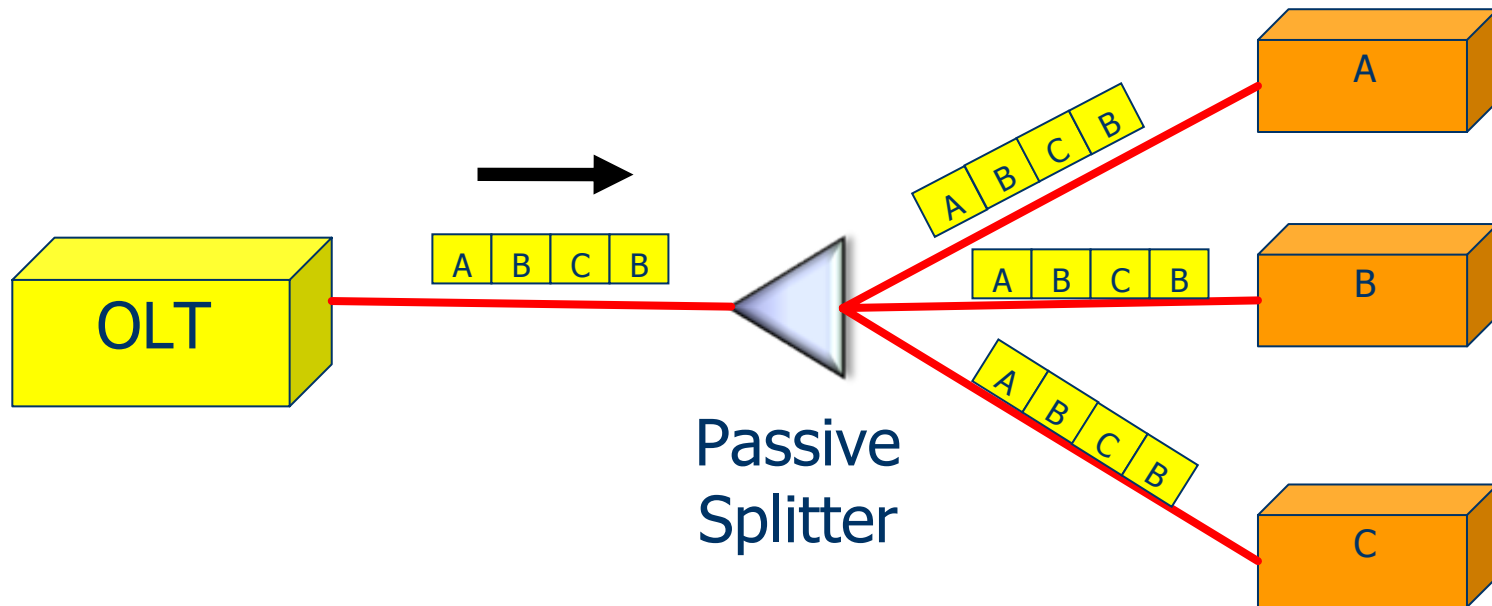
- The optical line terminal (OLT) broadcasts data downstream on 1,510 nm and the ONTs burst data back upstream on 1,310 nm in their assigned time slots.



*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 fibre more affordable for access networks*

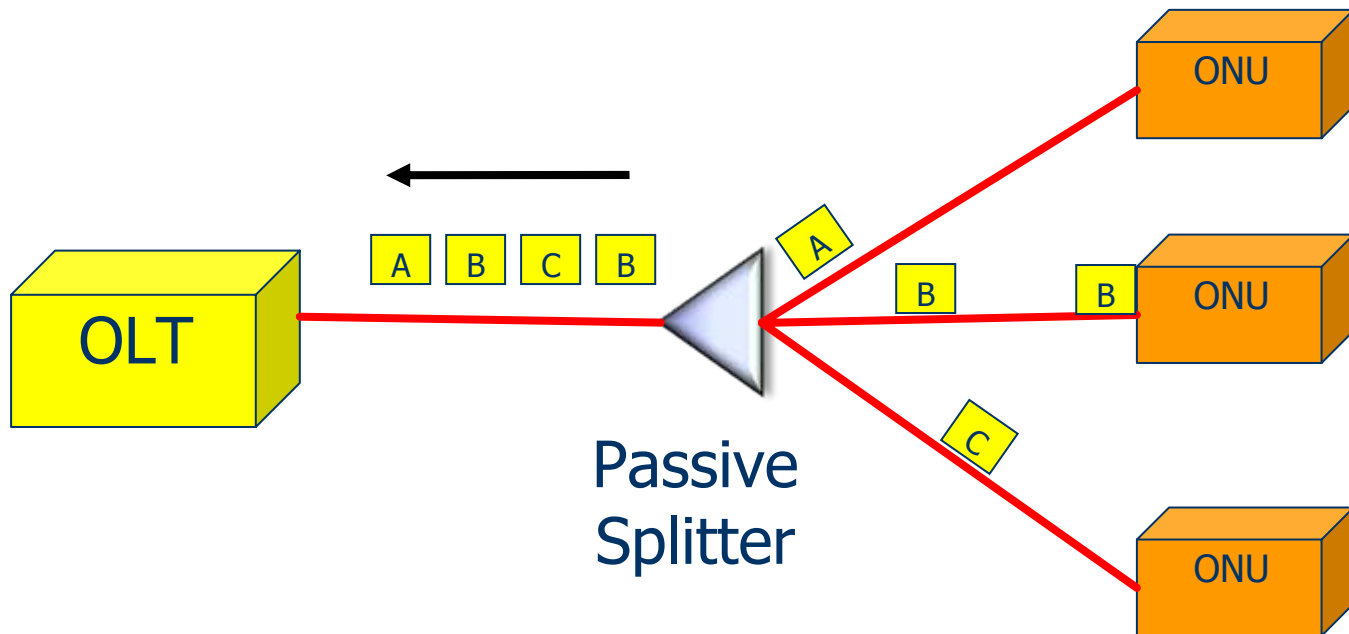
# Downstream Traffic Scheduling

- ❑ OLT schedules traffic inside timeslots
  - Time Division Multiplexing (TDM) scheme
- ❑ Time slots can vary from  $\sim\mu\text{s}$  to  $\sim\text{ms}$

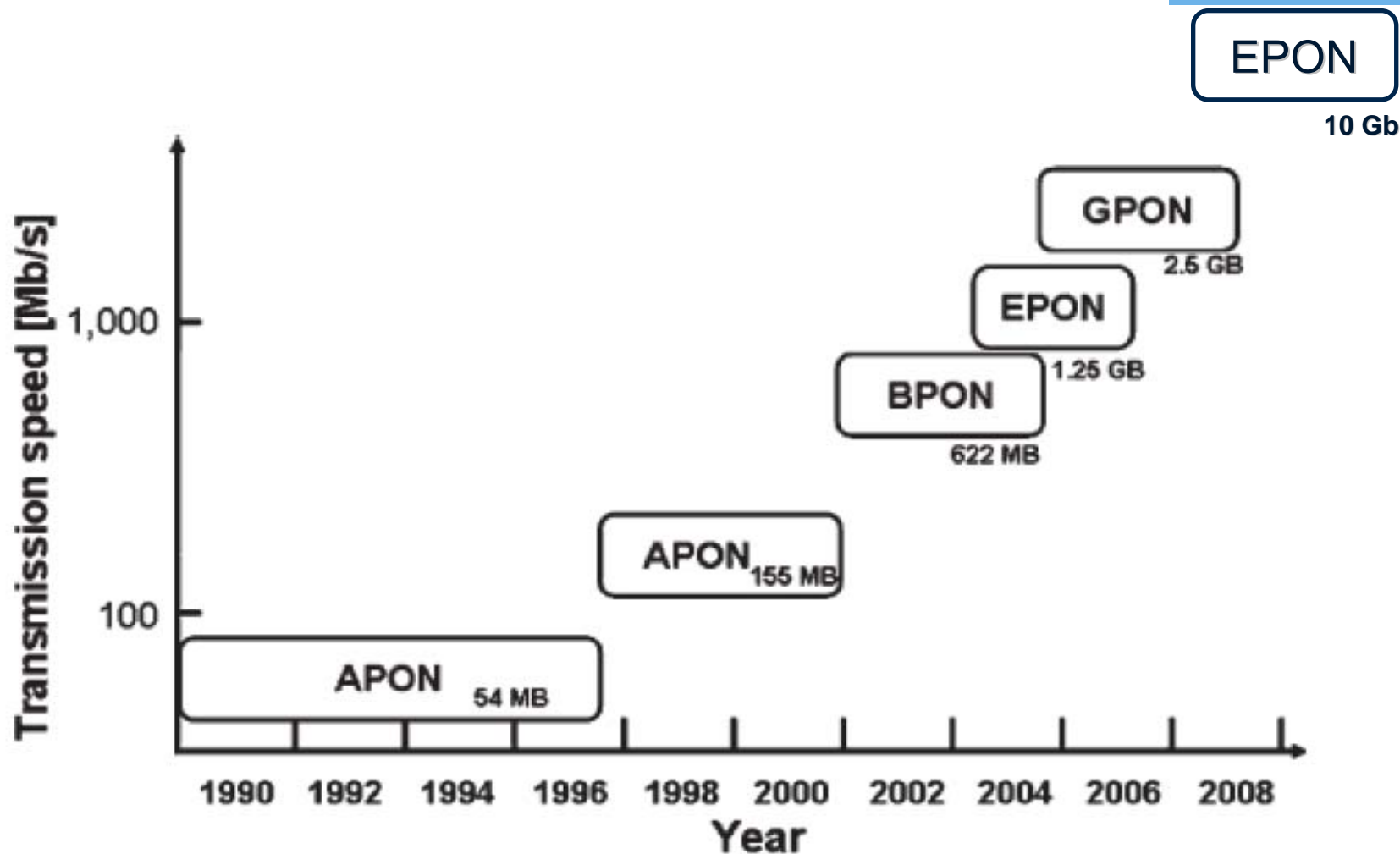


# Upstream Traffic Scheduling

- In general, PON standards propose Time Division Multiplexing Access (TDMA) schemes
  - Upstream time slicing and assignment



# Evolution of the standards





# Fiber in the loop (1/2)

*PON standardization: a brief history*

## □ ATM PON (A-PON)

- Traffic is carried using ATM raw-cell format and framing
- 1982: idea of PON (British Telecom)
- 1987 – 1999: PON testbeds by BT, Deutsche Telekom (Eastern Germany), NTT (Japan), BellSouth (Atlanta, USA)
- 1995: 622 Mbit/s APON testbed (RACE BAF project)
- 1996: beginning of Full Service Access Network (FSAN) works
- 1997-'98: ACTS BONAPARTE and EXPERT/VIKING projects

## □ Broadband PON (B-PON)

- APON system is standardized by ITU-T with a new name to indicate that the PON can offer full broadband service and not just ATM
- Line rates: 155 Mbit/s symmetrical or 622/155 Mbit/s down/upstream; ONU/OLT max distance: 20 km; max. # ONUs: 64
- 1998-'00: ITU-T G.983.1 (physical aspects) and G.983.2 (ONT management and control)
- 2001-'02: other ITU-T G.983.x and Q.834.x, e.g.
  - ◆ G.983.4/.7: Dynamic Bandwidth Assignment (DBA), providing statistical multiplexing (⇒ more users per ONU) and Quality of Service (QoS) enforcement
  - ◆ G.983.3: adoption of WDM to increase capacity or to carry video signals



# Fiber in the loop (2/2)

*PON standardization: a brief history*

## □ Ethernet PON (EPON)

- Traffic is carried using Ethernet framing
  - ◆ Cheaper user equipment than BPON
  - ◆ Ethernet much more widespread than ATM
- Higher subscriber rates (up to 1.25 GbE symmetrical), **16 ONU** (power budget)
- 2001: IEEE 802.3ah Study Group “Ethernet in the First Mile (EFM)”
- First documents in Sept. 2003)
- 2004: final approval of **Standard IEEE 802.3ah**

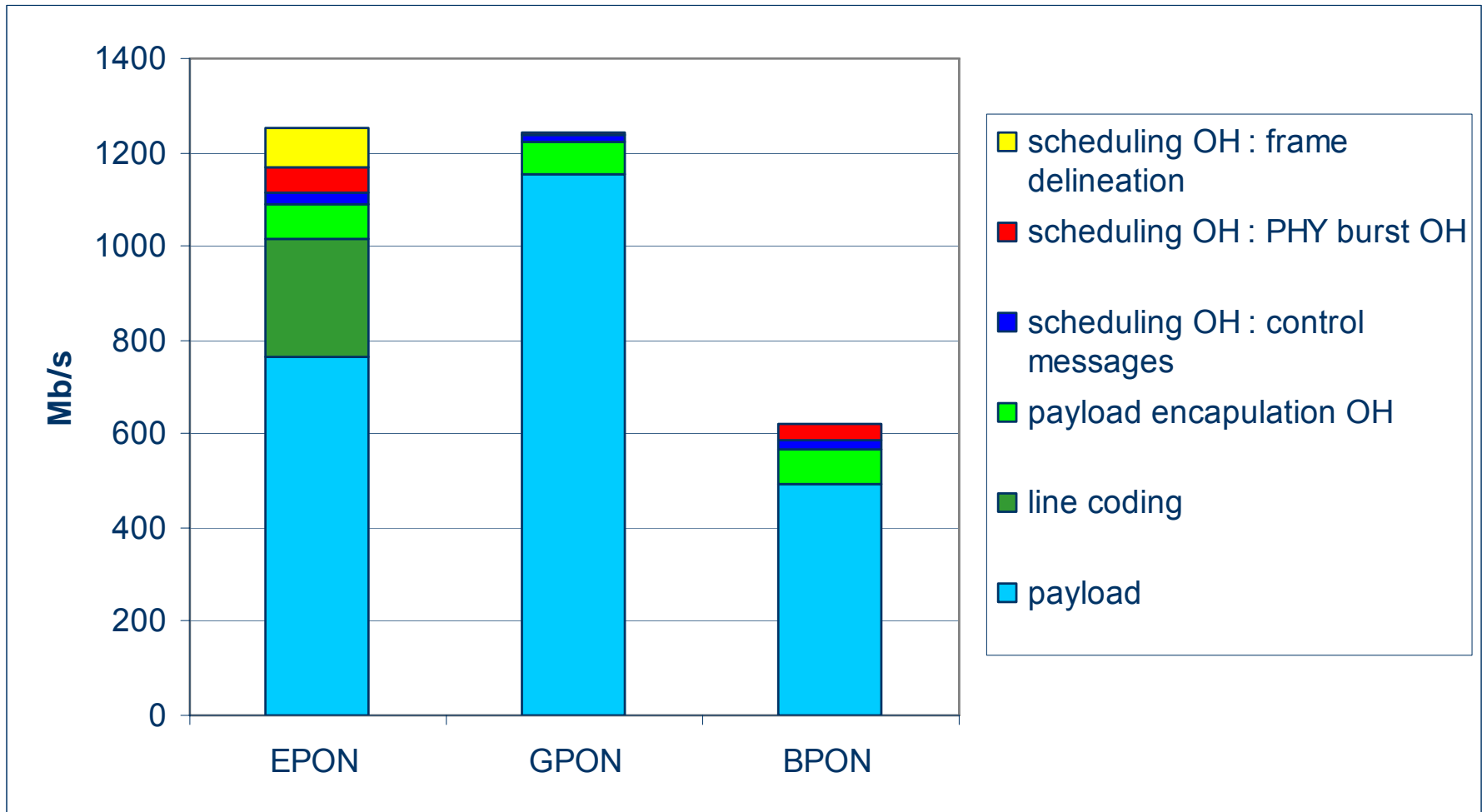
## □ Gigabit-capable PON (G-PON)

- Traffic is carried by using different possible framings: ATM (G.983 base) or via G-PON Encapsulation Method (GEM), which can interface SDH (G.707 base) or Ethernet (IEEE802.3 base).
- Various line rates, up to 2.4 Gbit/s symmetrical, ONU/OLT max distance: 20 km; max. # ONUs: **64-128**
- 2001: activity initiated by the FSAN group
- 2003: ITU-T G.984.x

# Technical Standards Comparison

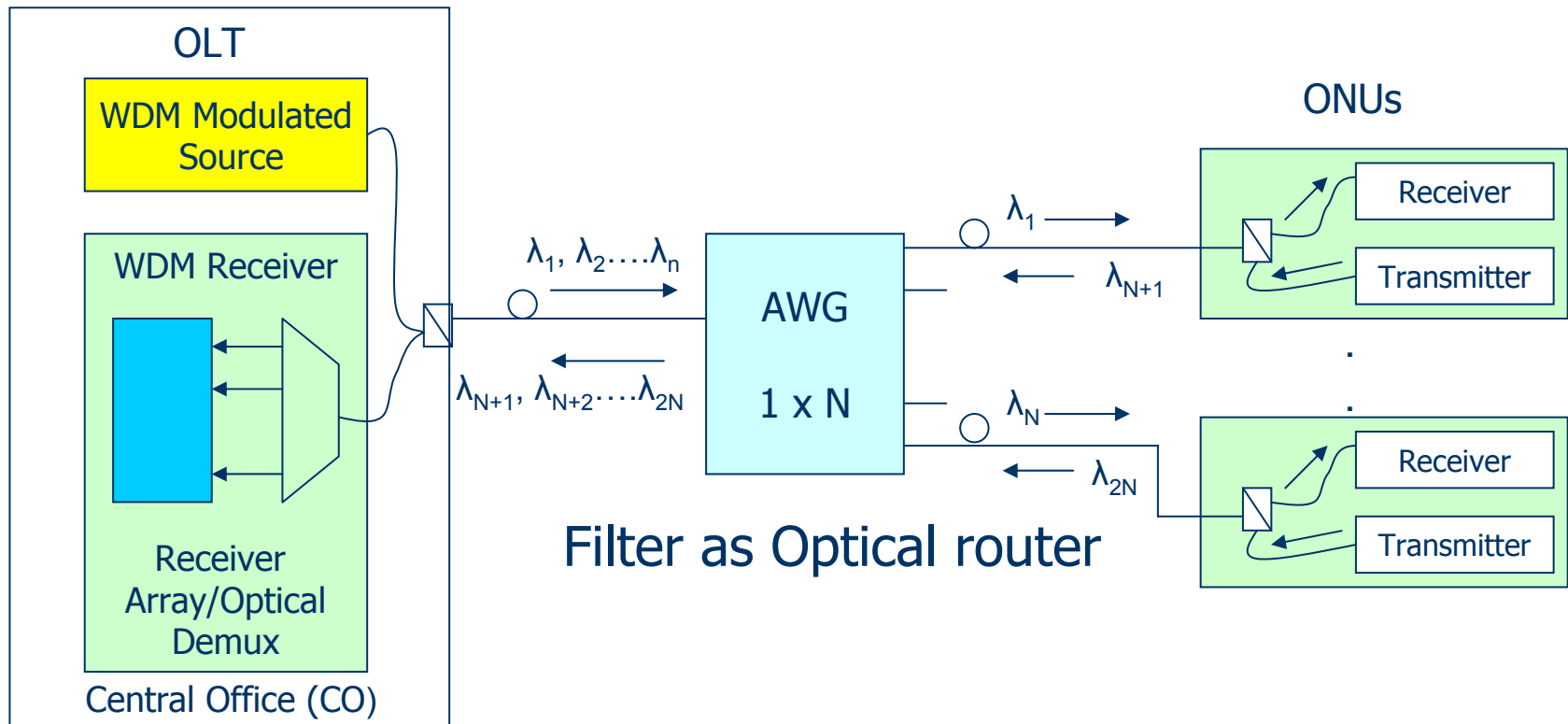
Technology	Standard	Downstream/ Upstream Bandwidth	# ONT served	Lambda	Framing/ Protocol	Distance
<b>APON/BPON</b> (ATM PON/ Broadband PON)	ITU-T G.983.x	155, 622 or 1244 Mbit/s down  155 or 622 Mbit/s up	Limited by power budget and ONU addressing limits:  16 to 32 splitter	1490 nm Down 1310 nm Up (1550 nm Down for RF video )	ATM	20 km
<b>GPON</b> (Gigabit PON)	ITU-T G.984	1.2 or 2.4 Gbit/s down  155, 622, 1.2 or 2.4 Gbit/s up	Up to 64(physical) Up to 128 (logical)	1490 nm Down 1310 nm Up (1550 nm Down for RF video)	GEM: G-PON Encapsulation Method (supports Ethernet), ATM	10/20 km (up to 60 km )
<b>EPON</b> (Ethernet PON)*	IEEE 802.3ah	Symmetric 1.25 Gbit/s	Up to 16	1550 nm Down 1310 nm Up	Ethernet	10/20 km
<b>10GEPON</b> (10 Gigabit Ethernet PON)	IEEE 802.3av (Working Task Force)	10 Gbit/s down 1 Gbit/s up  (symmetric 10 Gbit/s in the future?)	32 (maybe more?)	1480-1500 nm Down ? 1260-1360 nm Up ? 1550-1560 Video overlay ?	Ethernet	20 km

# Transmission Efficiency

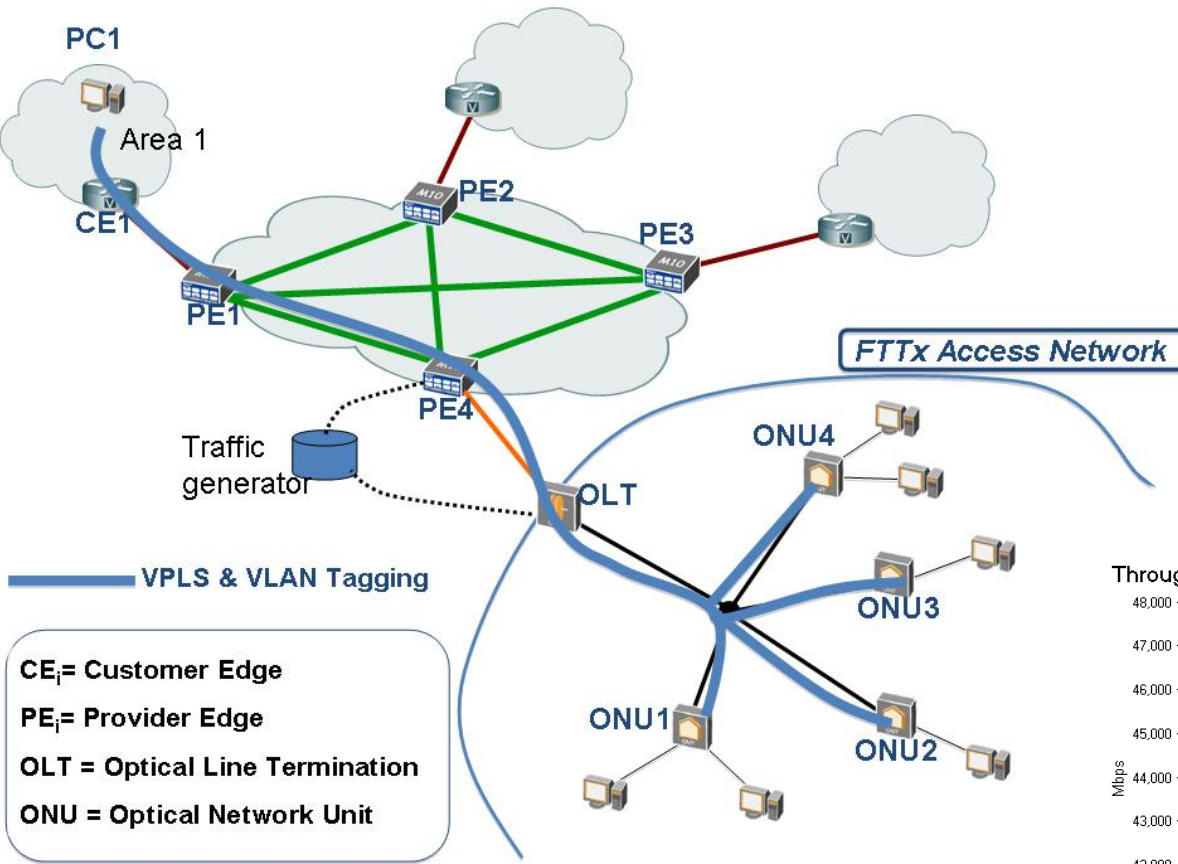


# Simple WDM-PON

- ❑ Number of ONUs limited by wavelengths
- ❑ Point-to-point topology
- ❑ Long-reach (almost point-to-point reach)



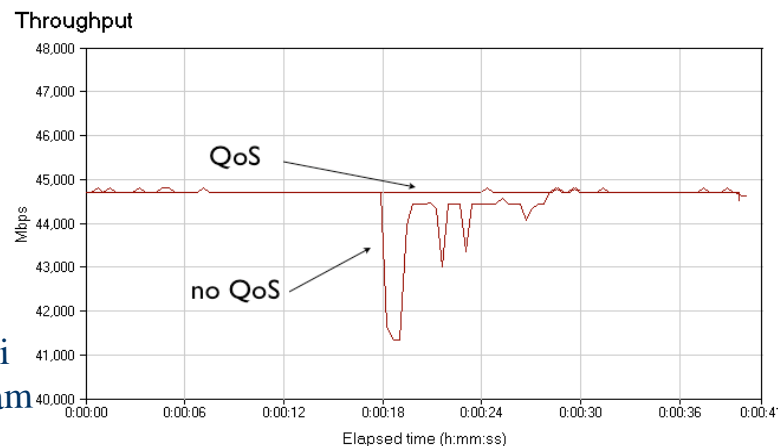
# Sperimentazioni FUB-ISCTI su PON



Unbundling di livello 2:  
 Garanzia di QoS e banda in  
 tutta le rete fino alla ONU  
 grazie al VPLS&VLAN  
 TAG

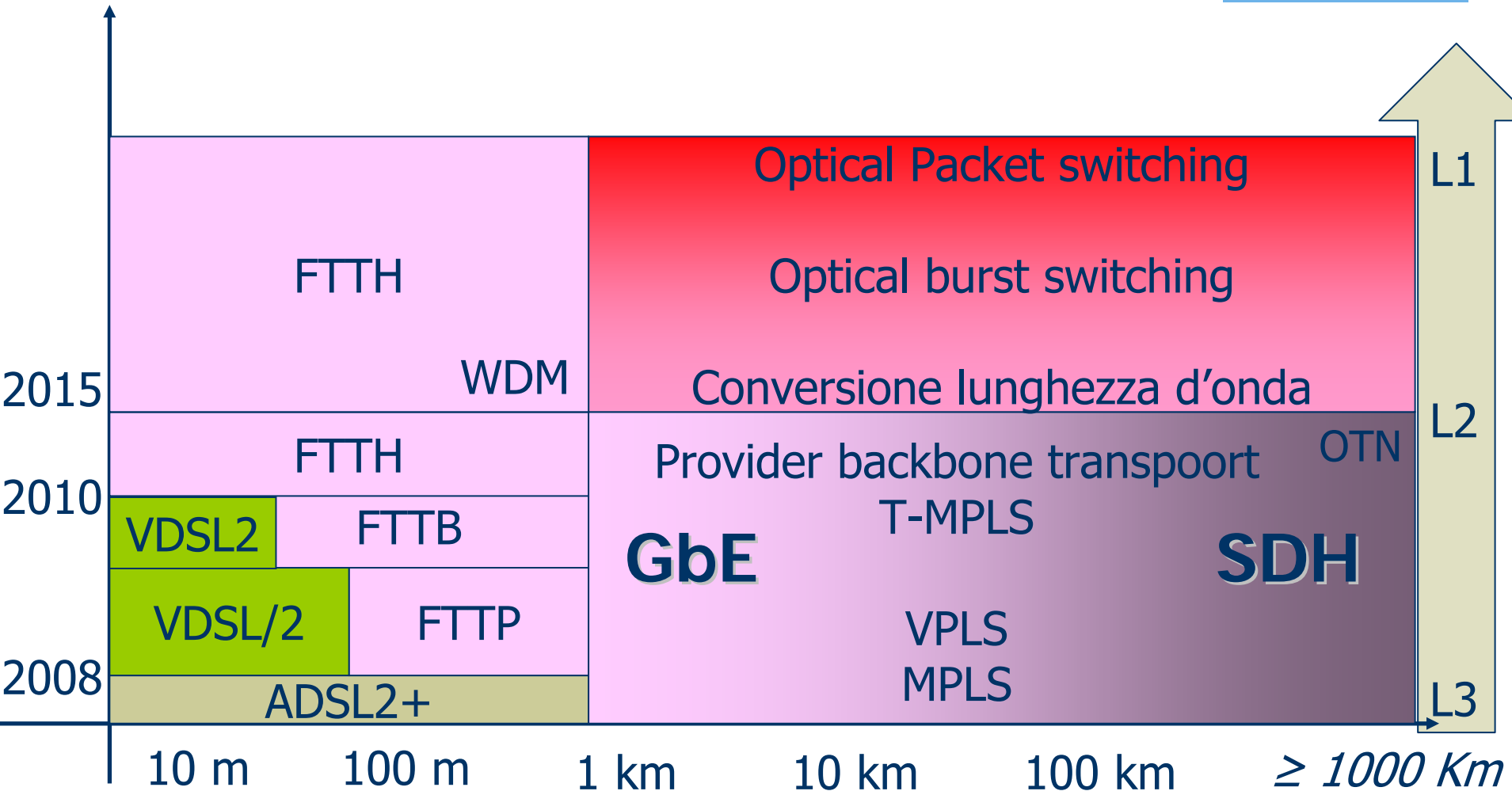
In press on IEEE/OSA Journal of Optical  
 Networking and Communication

Garanzia della QoS su una profilatura di  
 banda a 40 Mb/s in upstream/downstream  
 in EPON anche con congestione in rete





# Photonics Evolution



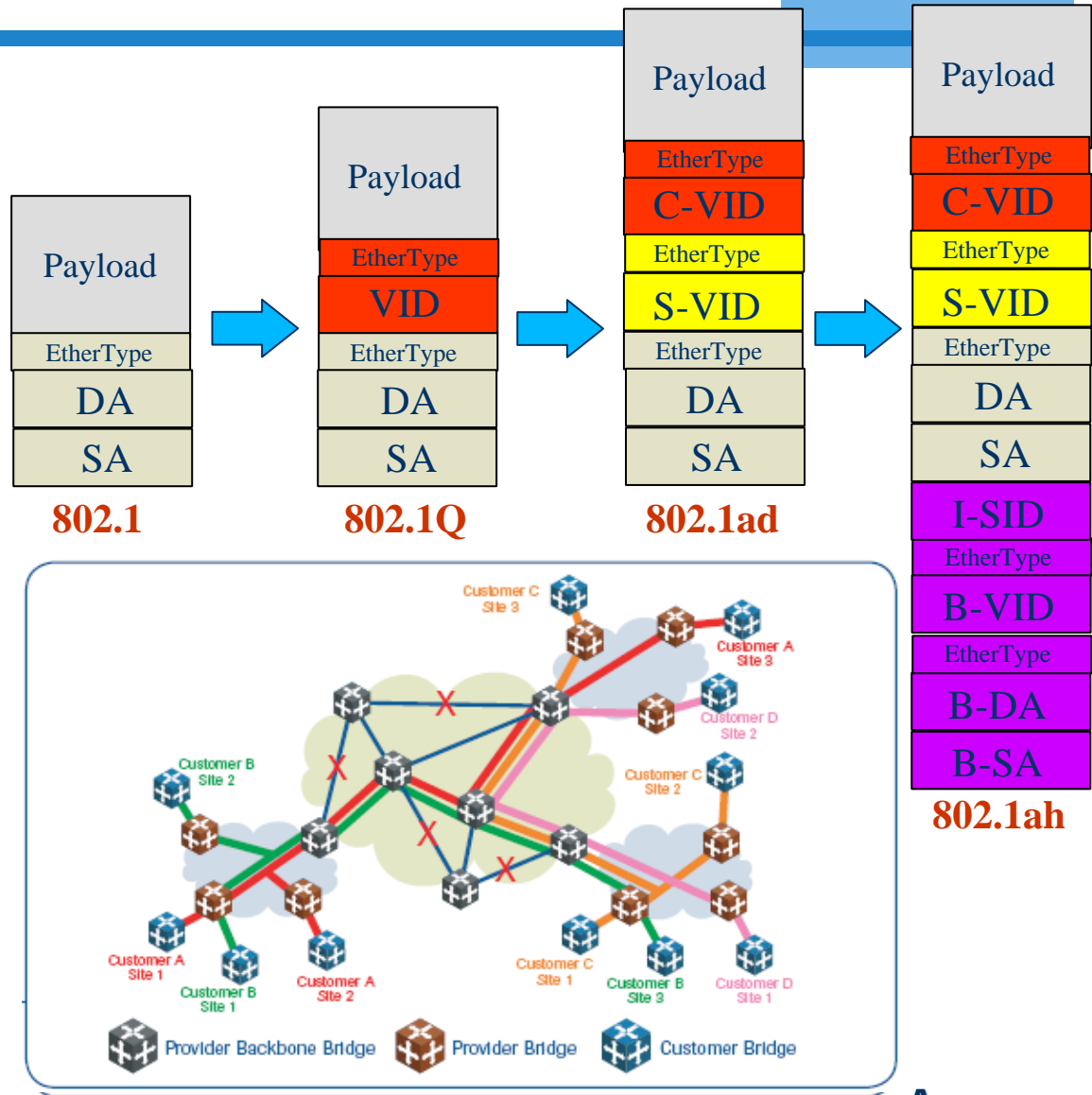
*Distanze*

# Evolution of Ethernet hierarchy (2/2)

- Without a hierarchy Ethernet networks have a flat structure
- Q-tag identifies VLAN
- Q-inQ identifies customer
- MAC-in-MAC allows to transparently transport customer frame from UNI to UNI

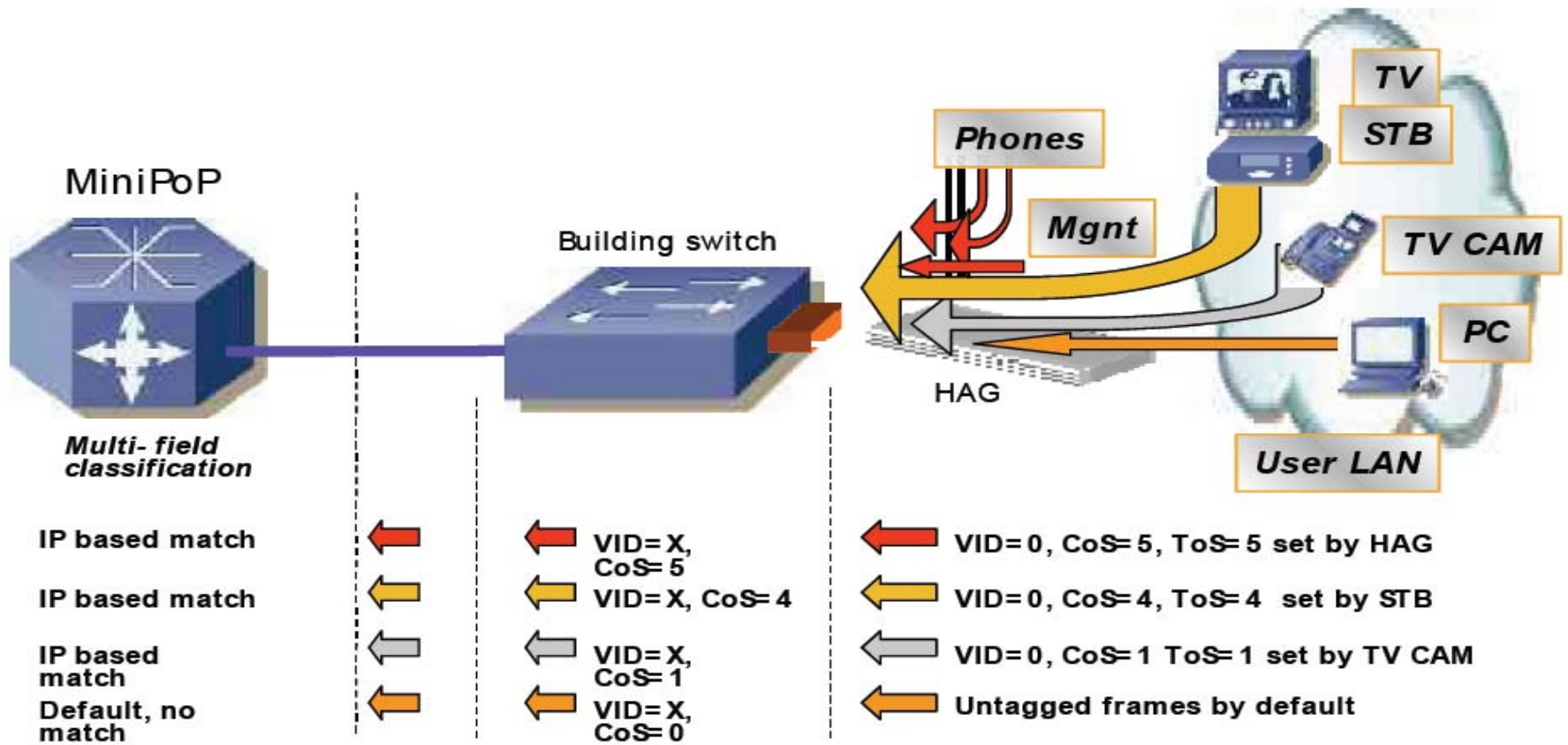
Separating infrastructure end points from service end points has profound implications as to what Ethernet is capable of

STP, flooding and learning are still the basic rules to decide paths.

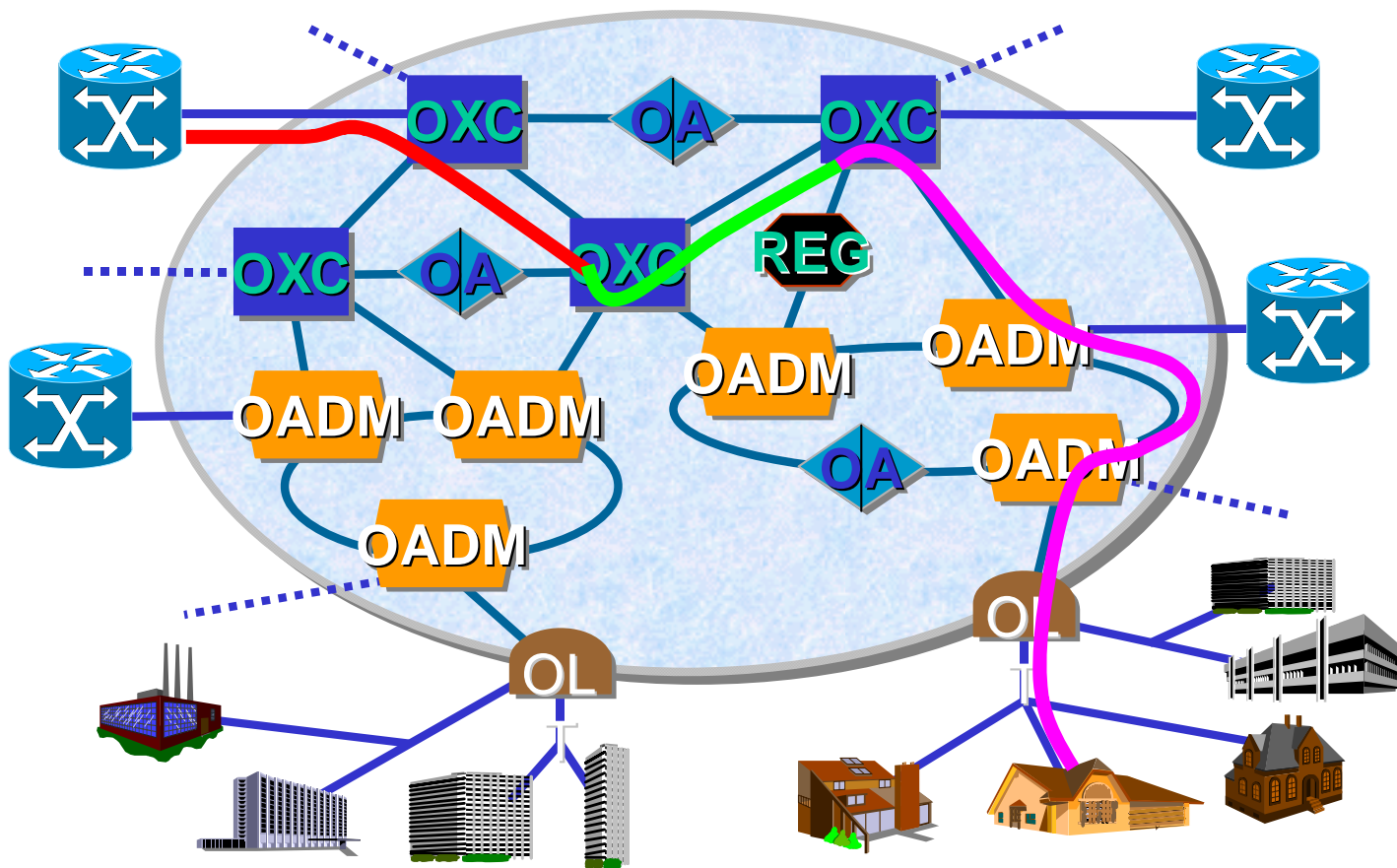




# Gestione della QoS: DiffServ over MPLS



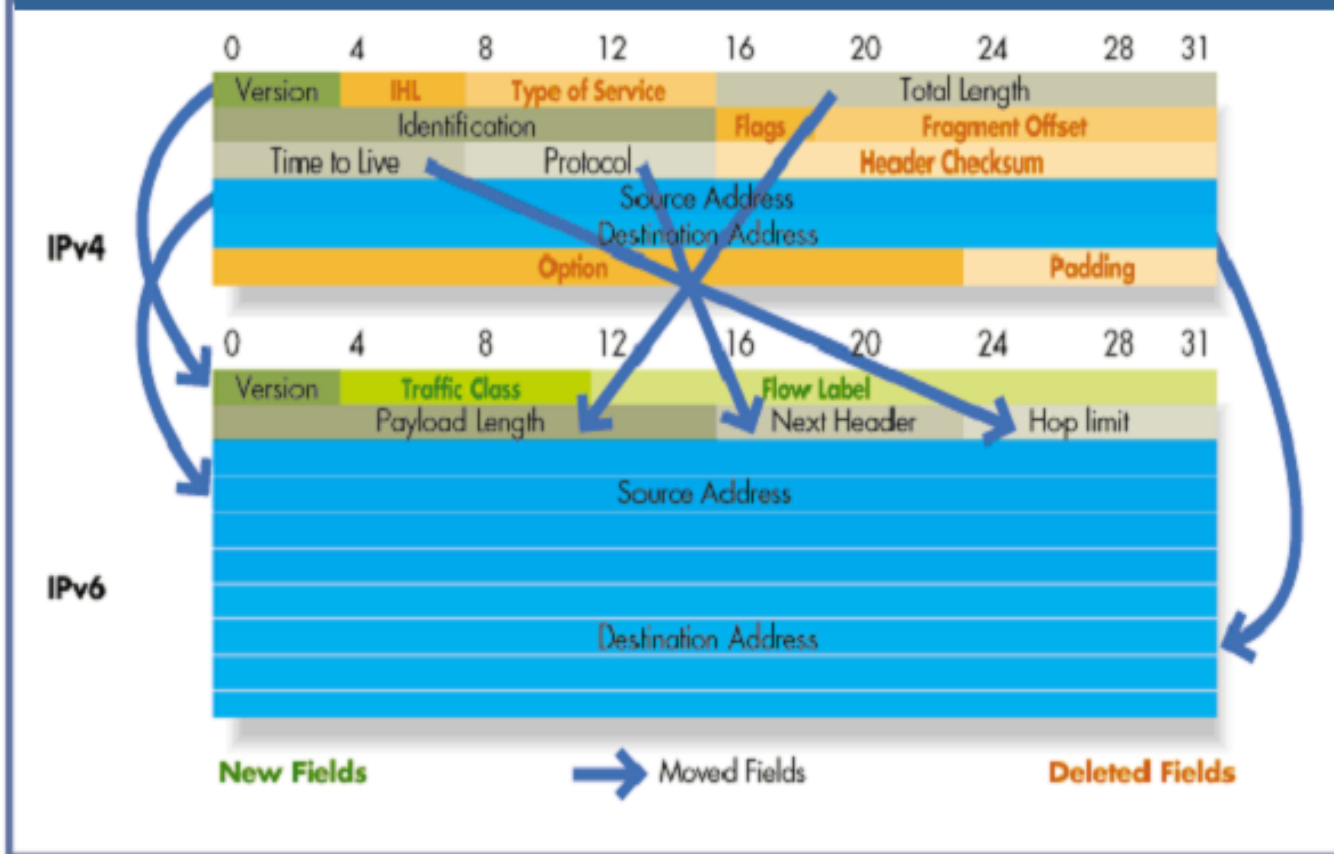
# Verso il processamento ottico



Reti GMPLS

# E IPv6?

Fig. 1 Formato dell'Header in IPv4 e IPv6

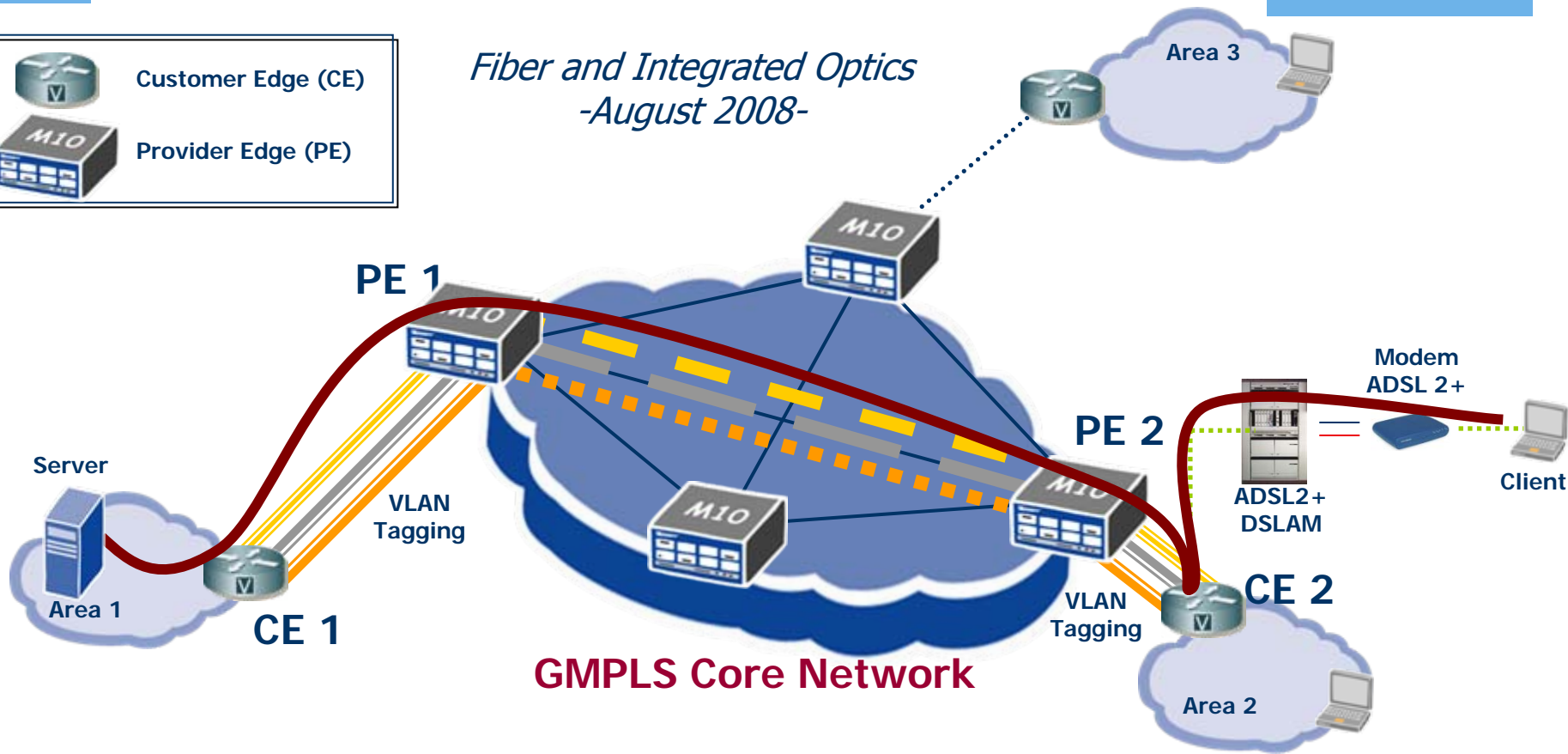


Maggiori indirizzi, controllo della QoS, sicurezza, mobilità...

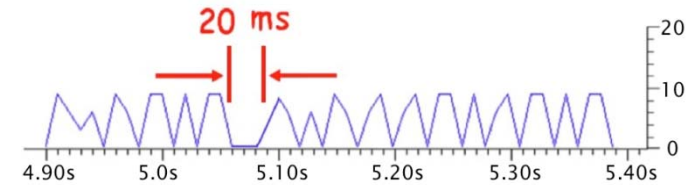
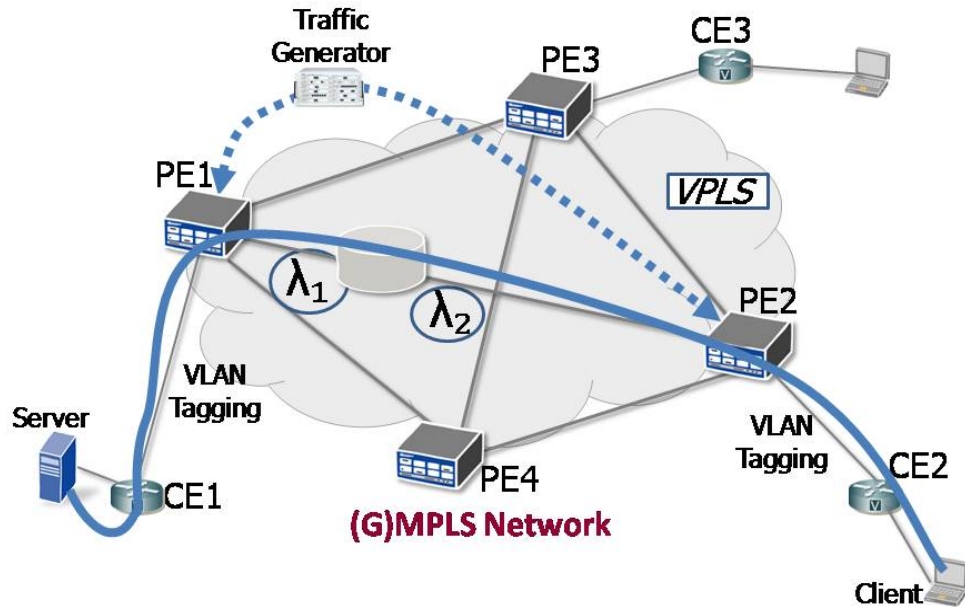


# Towards Carrier Ethernet: Virtual Private LAN Service (VPLS) Configuration

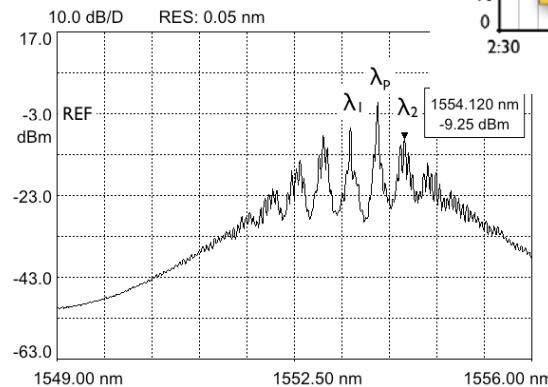
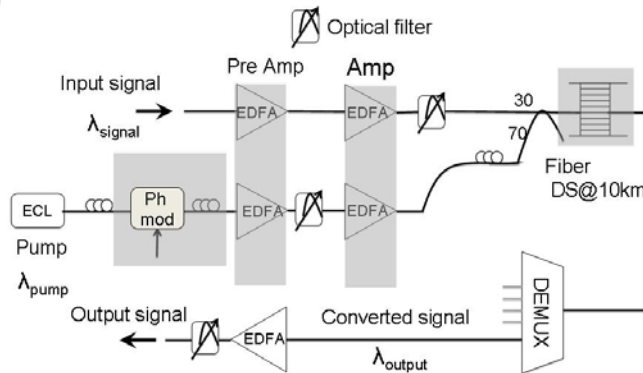
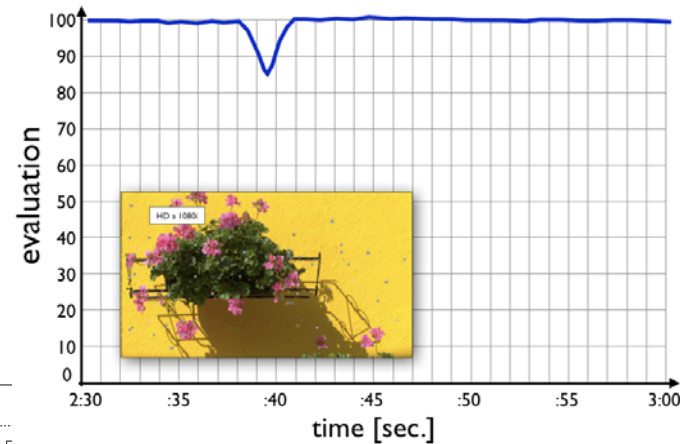
*Fiber and Integrated Optics  
-August 2008-*



# Optical process in GbE network: introduction of wavelength conversion



HD IPTV test



In press on IEEE Photonics  
Technology Letters, december  
2008



## Conclusioni

- ❑ Per le NGN occorrono enormi investimenti: 10-15 miliardi di Euro
- ❑ Sono indispensabili
- ❑ Almeno 20 Mb/s certi per utenza
- ❑ Portare la fibra a tutti è un investimento per il futuro!
- ❑ Fibra ottica indispensabile anche per le reti mobili
- ❑ Il trasporto tutto su Ethernet sarà un vantaggio in termini di costi e semplicità
- ❑ Importanza delle reti PON per FTTx, ma attenzione al dimensionamento  $n \times 20$  Mb/s