R.O.A.D.

Rete Ottica di Accesso a Divisione di frequenza e/o di lunghezza d'onda per soluzioni Next Generation Network

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Unbundling in Passive Optical Networks

Brainstorming from the Italian Project ROAD-NGN

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Politecnico di Torino 1859 1906

Outline of the presentation

- The Italian PRIN research project ROAD-NGN
- Unbundling in today copper-based access networks
- Overview of the state of the art in optical access networks
- Unbundling in optical access networks
  1. FTTH using PON
  2. (FTTcab + VDSL)

The Italian research project ROAD-NGN

'Optical frequency or wavelength division multiple access techniques for next generation networks'

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ROAD-NGN main research topics

- Next generation optical access networks based on PON “beyond NG-PON2”
- Special emphasis on FDMA-PON and WDM-PON as an alternative to today TDMA-PON
- Special emphasis on unbundling techniques at the physical layer

Unbundling in today copper-based access networks

Unbundling terminology

- "Unbundling" means any technique that allows more than one operator to give it services over fixed access networks at fair and competitive prices

Some common terminology:

- Incumbent operator: the historical TELCO operator that "owns" the access network
  - Incumbent local exchange carrier (ILEC)
- Alternative operators: other TELCO operators that wants a fair access to the incumbent operator infrastructure
  - Other Licensed Operators (OLO)

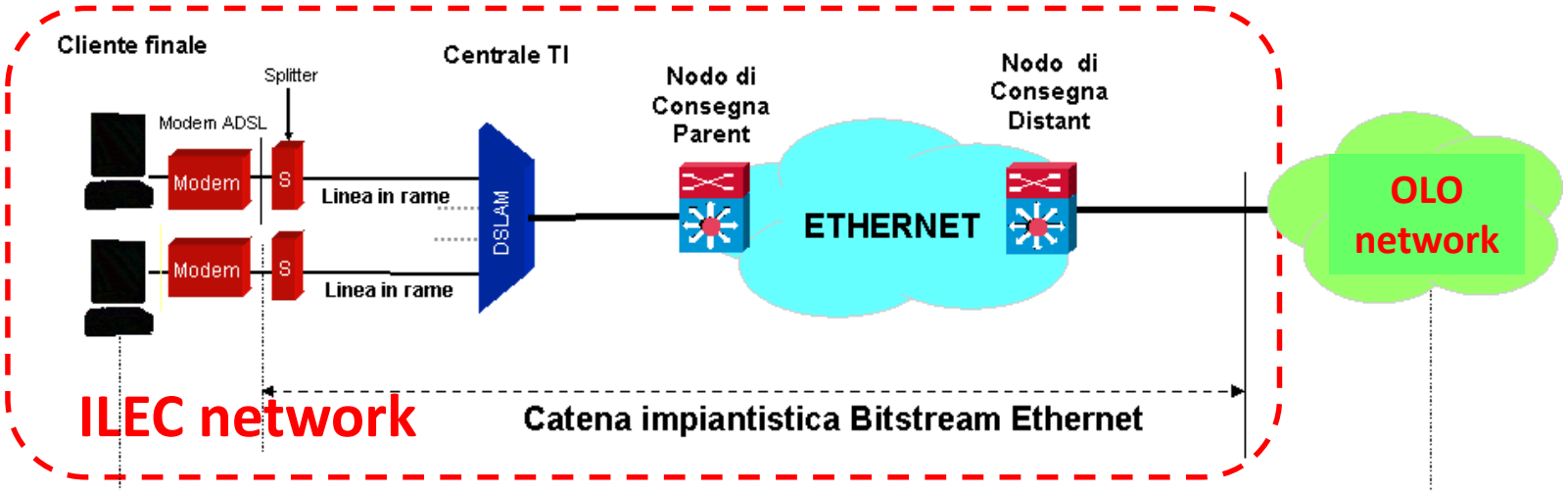
Unbundling in today ADSL access networks

- **Physical or "direct" unbundling:**
  - Obtained by physically moving twisted pair cables inside the central office (CO) from the incumbent DSLAM to the alternative operator DSLAM

- **Logical or "network layer" unbundling**
  - Obtained by switching the data traffic at the higher networking layers, using two different possible approaches
  1. Remotely, in some national OLO point-of-presence (a technique usually called "bitstream")
  2. locally inside the CO (virtual unbundling of the local loop, or VULA)

Logical unbundling

BITSTREAM



VULA

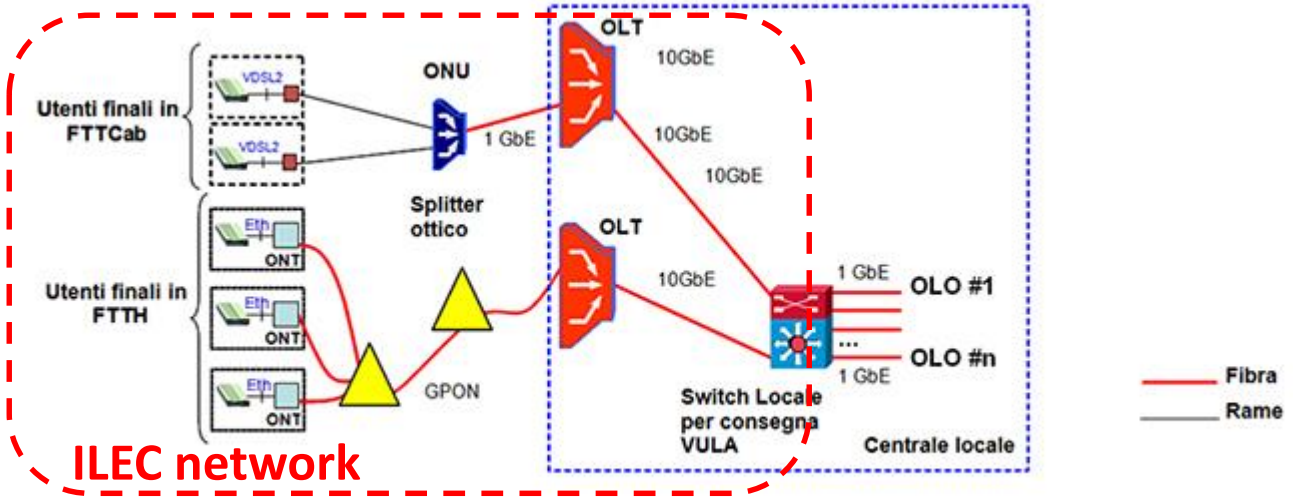


Figura 4 - Architettura di riferimento VULA

PROs and CONs

- Unbundling is not only an “engineering” issue, but it has very relevant regulatory and economic aspects

From an OLO point of view:

- Physical unbundling gives to the OLO a full control at all network layers
- Bitstream makes the OLO still strongly dependent on the ILEC
- VULA is somehow an intermediate case

Overview of the state of the art in optical access networks

But first of all…

- … why optical access networks?

EU Digital Agenda for 2020

- In 2010 the EU "Digital Agenda for Europe" (DAE) set the EU official objectives for Next Generation Access Network (NGAN)
  - By 2020, all European citizens should access the Internet at bit-rates greater than 30 Mbit/s
  - By 2020, not less than 50 percent of European households should be able to subscribe contracts at speeds over 100 Mbit/s

- *European Commission: "A Digital Agenda for Europe", COM(2010)245, available at: http://ec.europa.eu/europe2020/pdf/digital-agenda-communication-en.pdf*

Technical requirements

The traditional all-copper access network "as it is" cannot support these data rates

A "new" access network is required

Two main possible options:

1) Complete replacement with fiber from the CO to the user

Fiber to the home (FTTH)

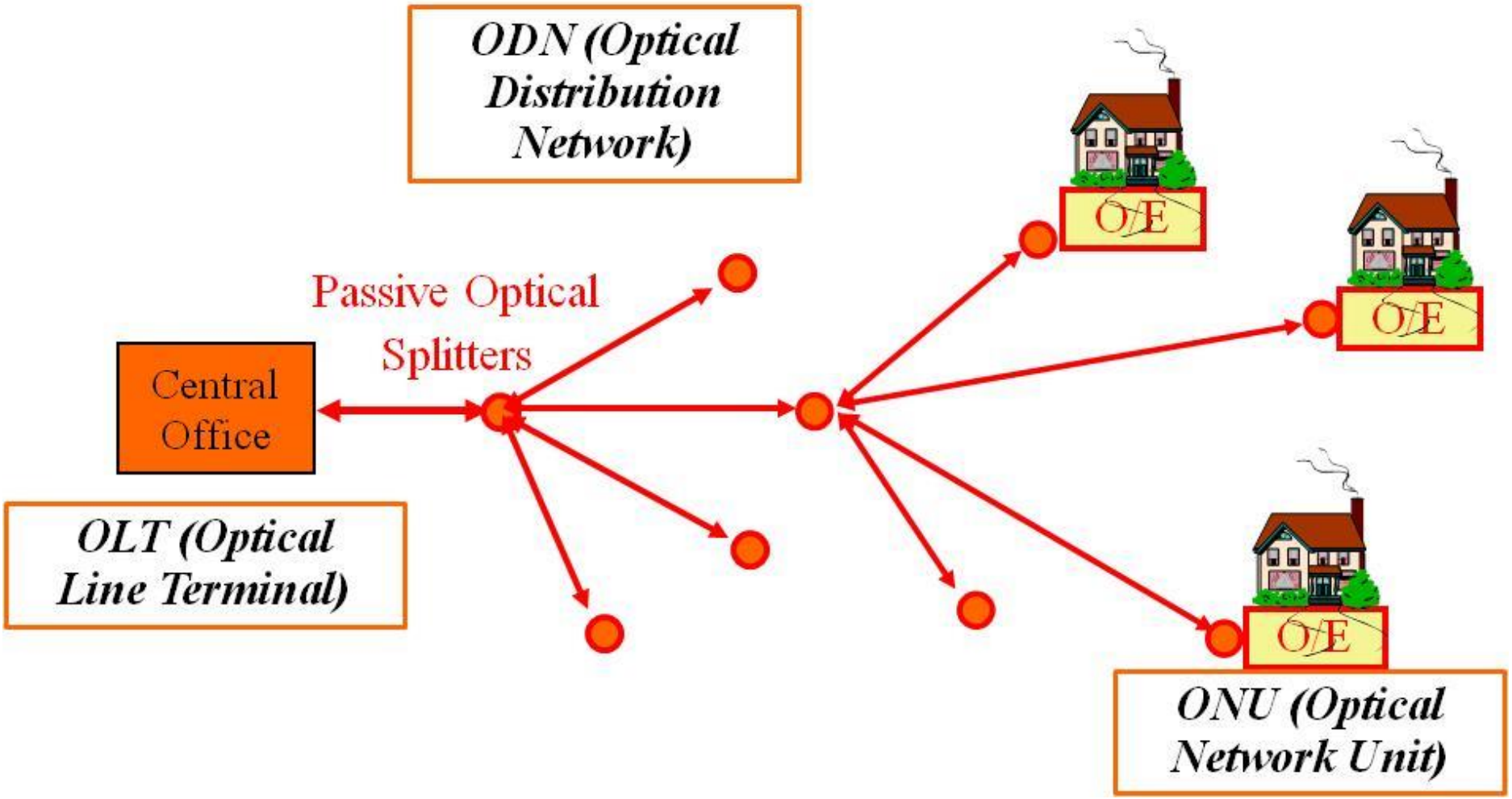
Typically using PON

2) Fiber down to the cabinet, then VDSL on the last few hundred meters

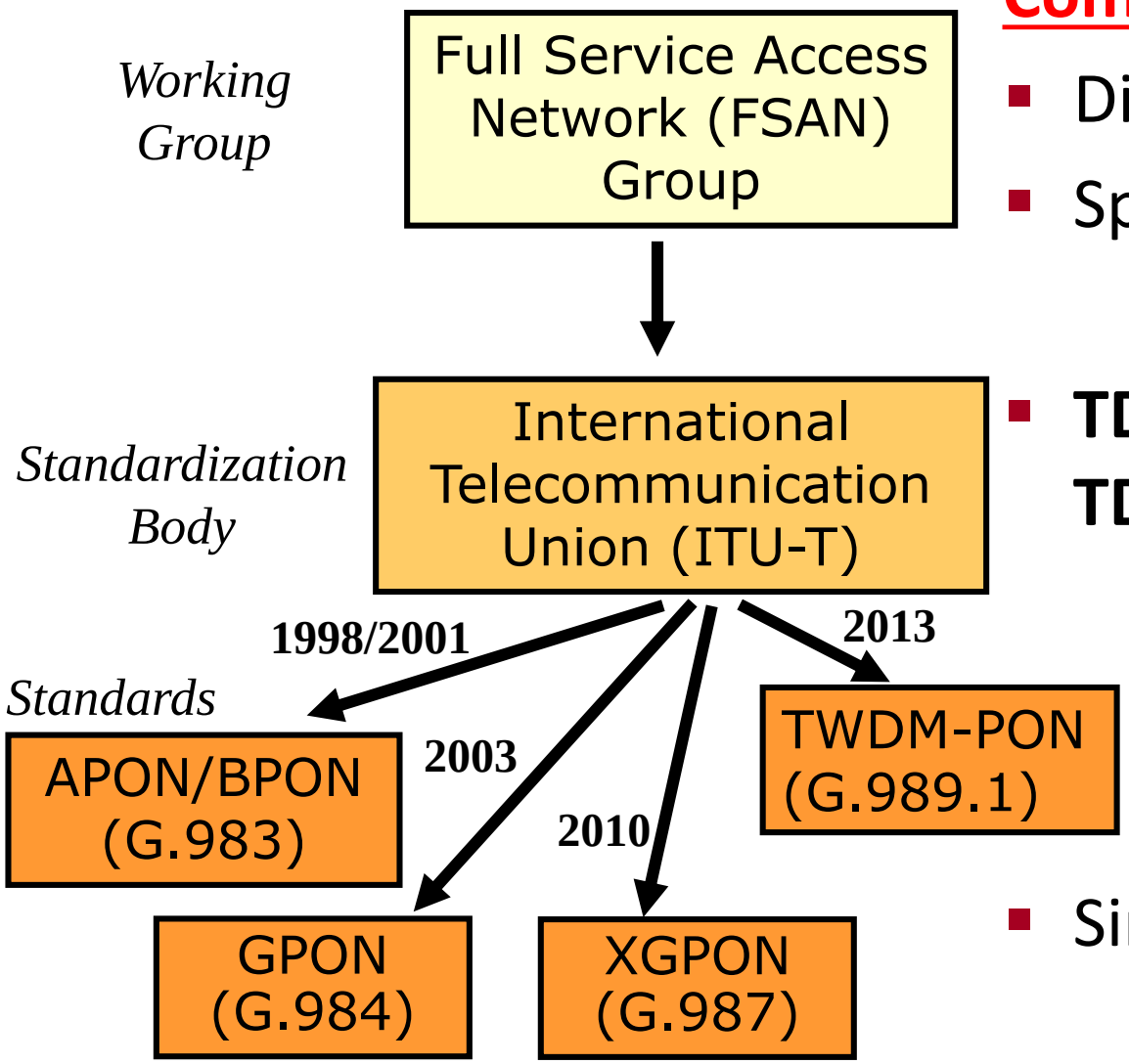
Fiber to the Cab (FTTCab)
Fiber to the Premises (FTTp)

PON:
state of the art

FTTH using Passive Optical Networks (PON)



PON Standards today



Common features:

- Distances up to **20-40 km**
- Splitting factor: **64 users**
- **TDM in downstream, TDMA in upstream**
- Similar standards by IEEE

PON Standards in ITU-T

GPON (currently deployed, volumes: millions per year)

- 2.5 Gbps downstream
- 1.25 Gbps upstream

XG-PON (currently ready for deployment, little volumes for the moment)

- 10 Gbps downstream
- 2.5 Gbps upstream

TWDM-PON (in ratification by ITU-T, “NG-PON2”)

- 4 or 8 “parallel” XG-PON using different lambdas
- Thus offering, at least 40 Gbps downstream, 10 Gbps upstream

Unbundling in PON access networks

Unbundling in optical access networks

- Physical unbundling at the central office is "relatively easy" in today copper-based ADSL networks since these are physically point-to-point networks
  - A dedicated twisted pair connects the central office to each residential user

- The situation is completely different for the PON FTTH architectures shown in the previous slides, since these networks intrinsically have a point-to-multipoint structure

PON and unbundling - I

- Physical unbundling using today deployed standards (GPON, XGPON, EPON) is impossible
  - There is only one fiber going into the central office, and the *N* users are time-domain multiplexed with a very strict master-slave coordination from the CO
  - So it is not possible to “move” a fiber to the OLO rack (as it is done for copper)
  - The only solution is to deploy different fibers that belong to the same cable. That is, if there is a cable going from the CO to the building different providers can use different fibers in the same cable, managing two or more PON in parallel

- Thus, all deployed unbundling solutions on existing PON are based on logical unbundling
  - Bitstream or VULA

PON and unbundling - II

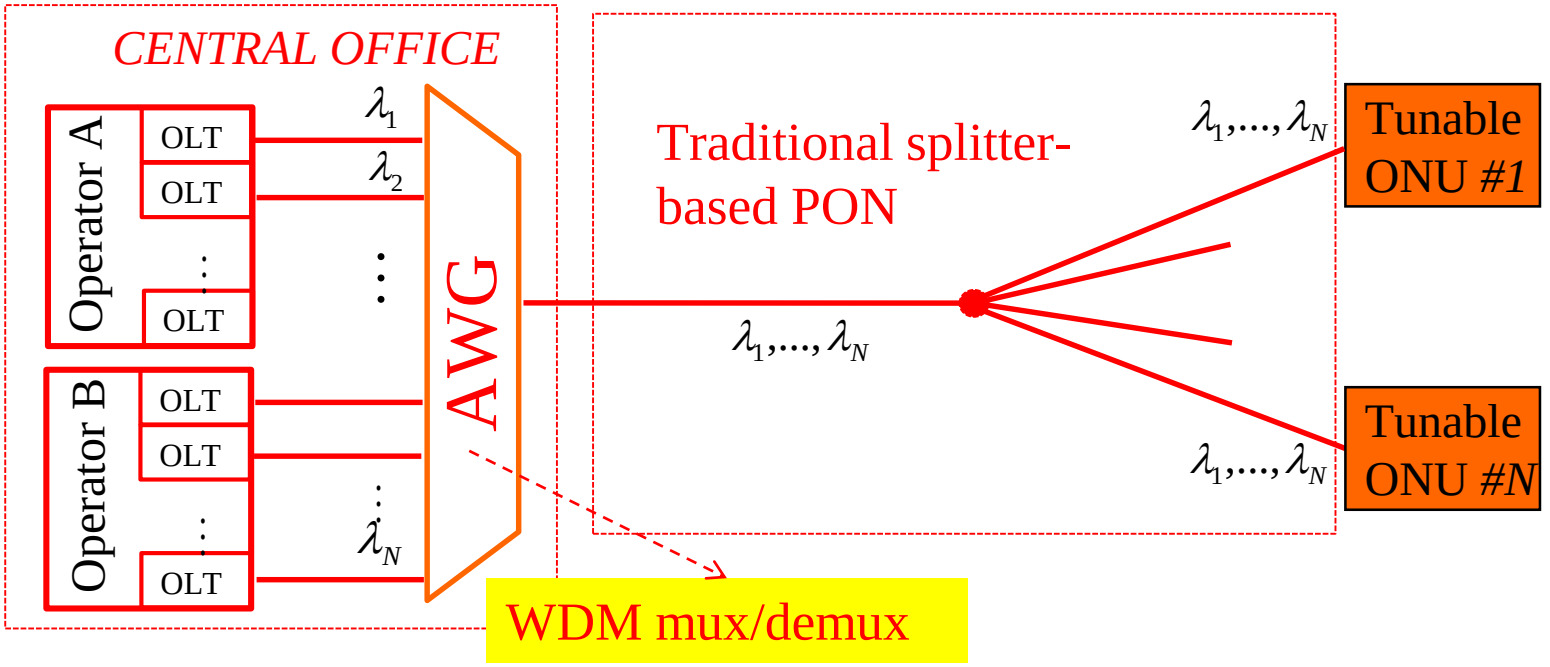
- Anyway, National Regulators always prefer to have (also) the option of physical unbundling

This is the research target of the ROAD-NGN project

- The physical unbundling strategies that we studied are based on
  1. Wavelength division multiplexed PON (WDM-PON)
  2. Frequency division multiplexing on each single wavelength used in the PON (FDM-PON or OFDM-PON)

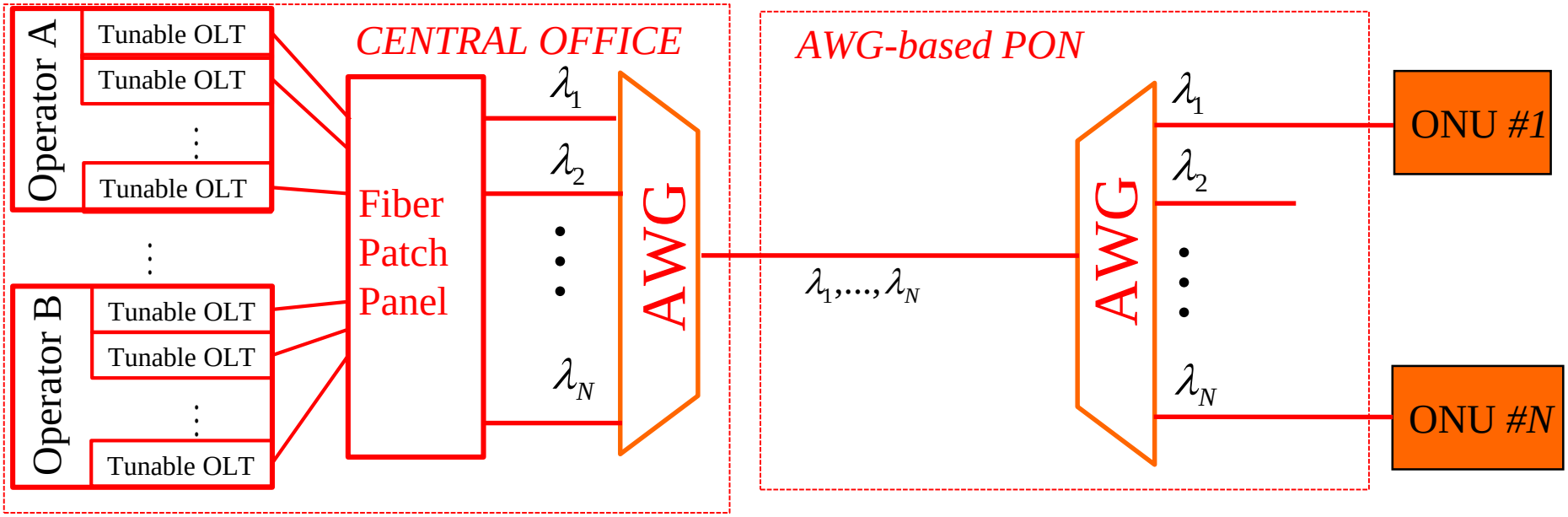
Unbundling in PON using WDM

Splitter-BASED WDM-PON



- Each operator is assigned a group of dedicated wavelengths
- Each ONU should be tunable (in RX and TX) on those wavelengths

AWG-BASED WDM-PON



- Each user is assigned a dedicated wavelength pair (TX/RX)
- The OLO that needs to reach that user should tune its transceiver on that wavelength pair
  - To be colorless also the ONU should still be tunable inupstream transmission

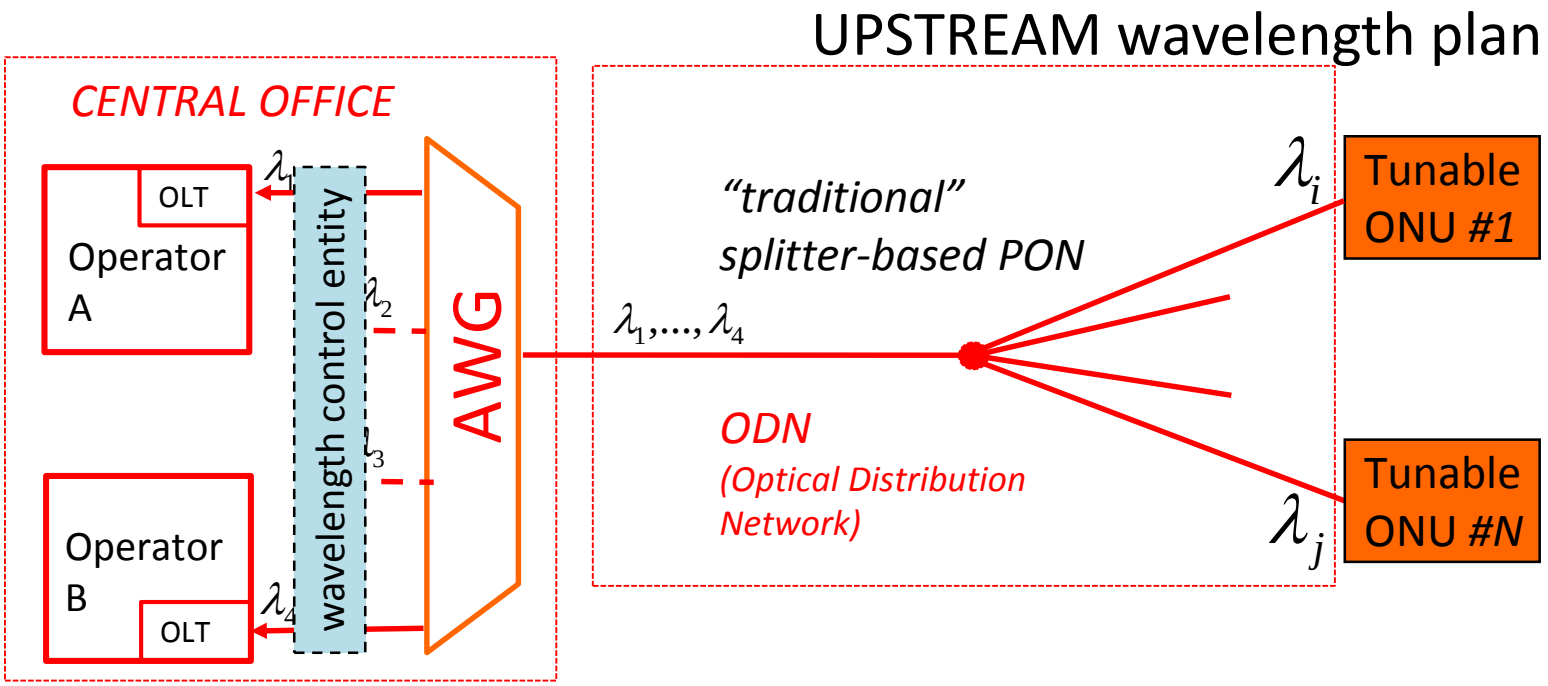
WDM-PON: PROs and CONs

- **PROs:**
  - Very high capacity available
  - It creates again a physical "point-to-point" connection
    → For unbundling, it is again possible to have a direct physical layer implementation at the lowest level (i.e., at the fiber)
- **CONs**
  - Tunable lasers and/or tunable filter at ONU
    → perceived as very critical in terms of cost -> long term solution?
    → In ROAD-NGN we are studying reflective solutions to solve this issue
  - The splitter-based WDM-PON (preferred by the operator since it allows backward compatibility with previous PON standards) is very critical in terms of link power budget
    → In ROAD-NGN, we are studying also this point

ITU-T G.989 TWDM-PON

- Most recent ITU-T standard for PON
- Four wavelengths per direction (4x10Gbps DS, 4x2.5 Gbps US)
- Suitable for “wavelength unbundling” using one wavelength pair per operator

ITU-T G.989 TWDM-PON & Unbundling



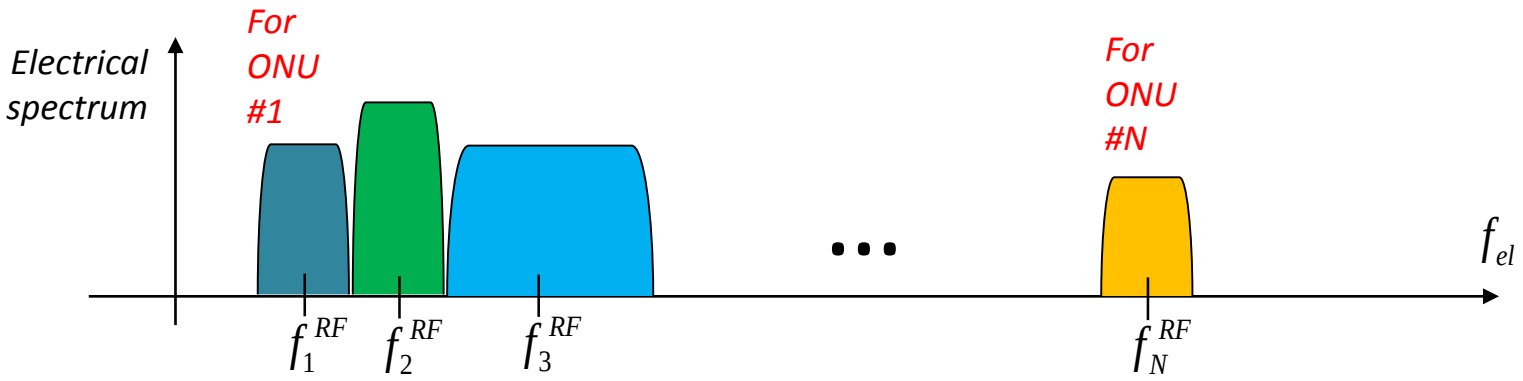
- The remaining issues for TWDM-PON in ITU are mostly in the coordination of the upstream wavelengths
- A centralized control of the upstream wavelengths will probably be implemented from the central office side.
- In a nutshell, a central office "wavelength control entity" will remotely drive the ONU's wavelength setting
- Thus, the Central Office OLTs will still need a centralized strict wavelength control coordination (with the required proper US/DS signaling)

Unbundling in PON using electrical FDMA

FDMA-based PON

A new proposal in ROAD-NGN:

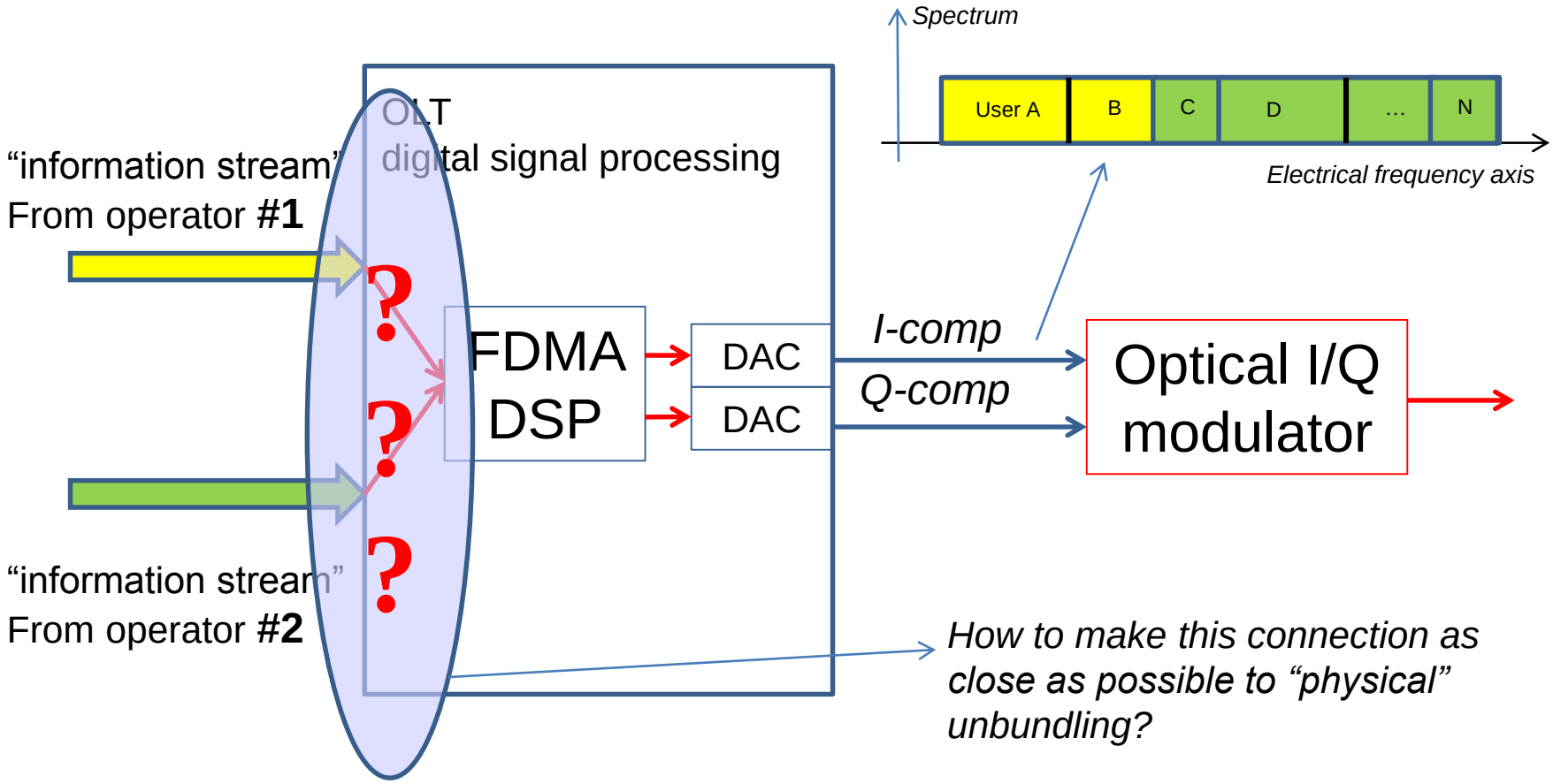
- Over each wavelength pair, we implement (electrical) frequency division multiple access (FDMA) in a "radio-over fiber"-like way



- We target the following goals:
  - The possibility to unbundle portion of the spectrum to each operator
  - A very fine granularity in the assignment of each user bandwidth

Unbundling using FDMA

- Focusing on the downstream
  - (a similar approach is possible also for the upstream)

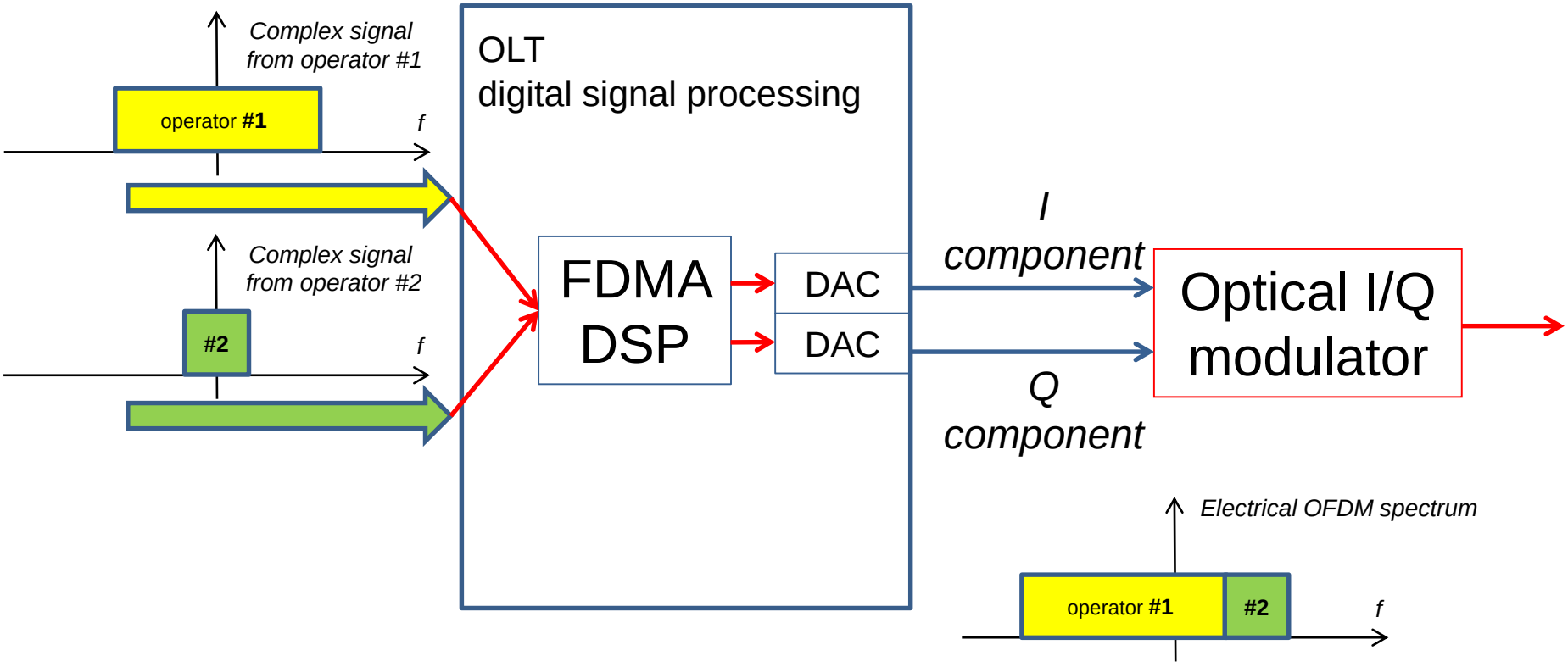


Use of digitized radio-over-fiber approach

- We can use the CPRI standard

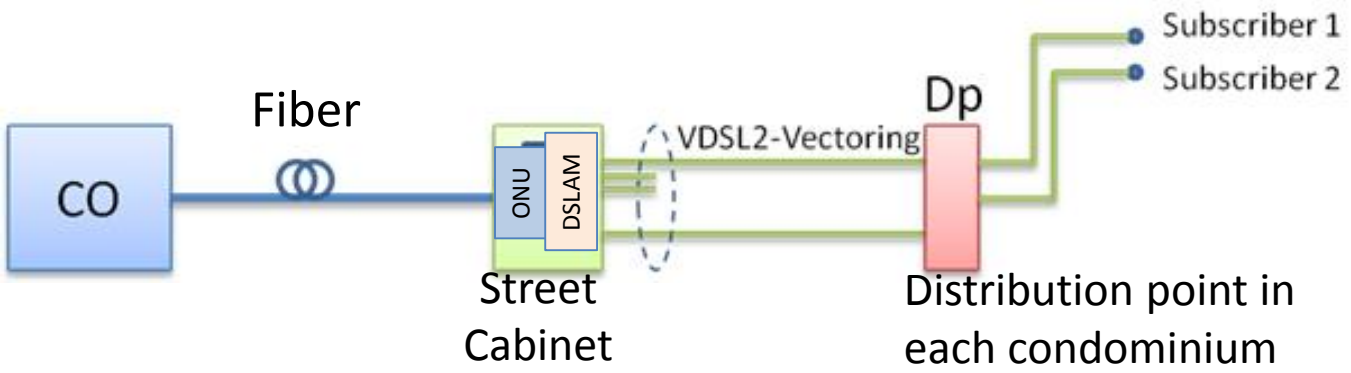
CPRI
Common Public Radio Interface

- Every operator sends to the “main” OLT a digitized version of the complex envelope of its allocated spectrum



Unbundling in FTTcab+VDSL access networks

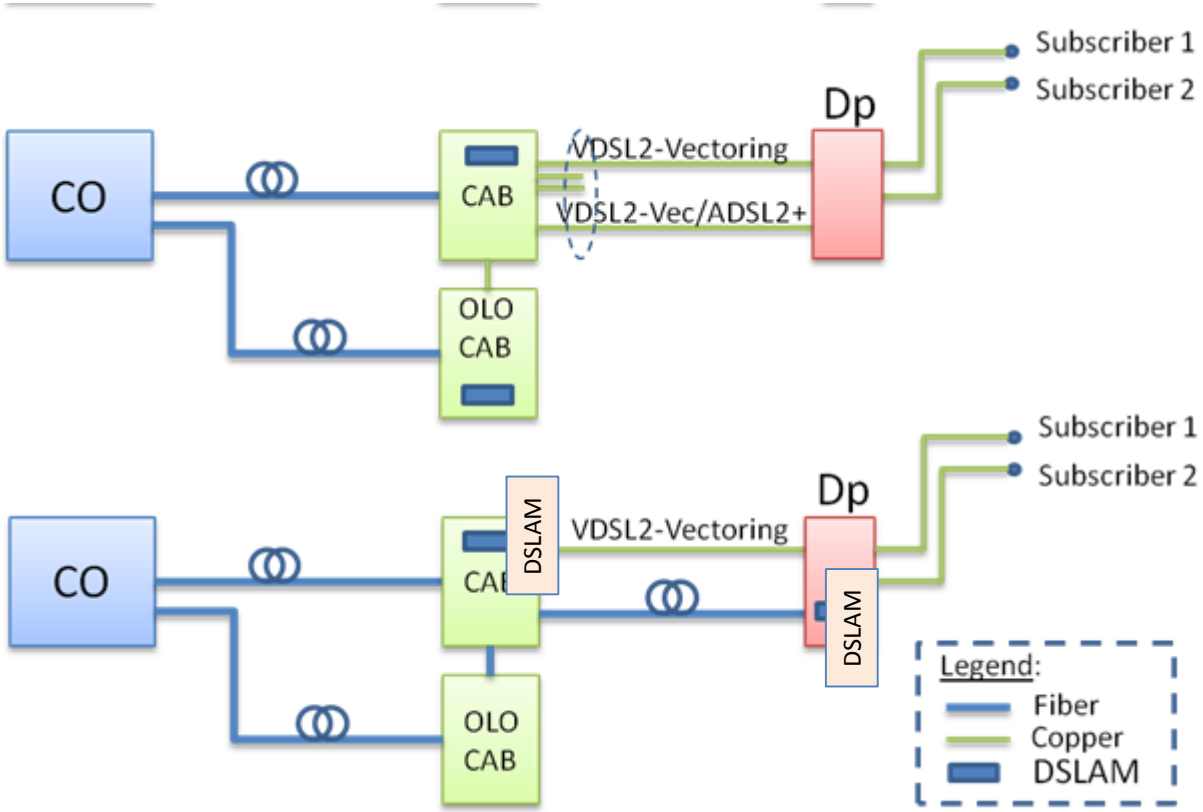
FTTCab + VDSL



- Many EU incumbent operators (including Telecom Italia) have recently decided to implement Fiber down to the street cabinets or distribution point, then VDSL on the last few hundred meters (FTTCab + VDSL)
  - This solution is today perceived has the best price-performance compromise
- To reach the EU digital agenda (for the 100 Mbit/s per user target), it requires implementation of "vectoring" techniques on VDSL

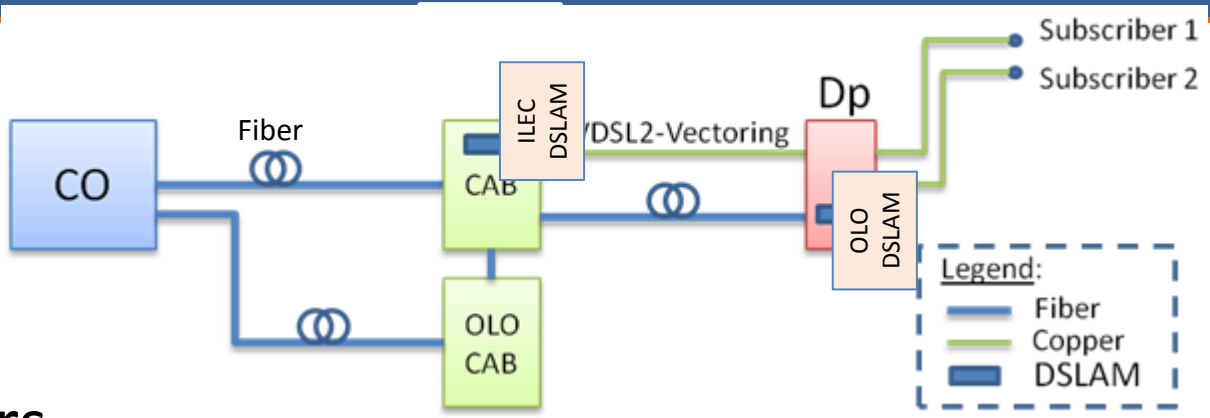
FTTCab + VDSL and unbundling

- Vectoring works very well when there is a single DSLAM controlling all twisted pair simultaneously



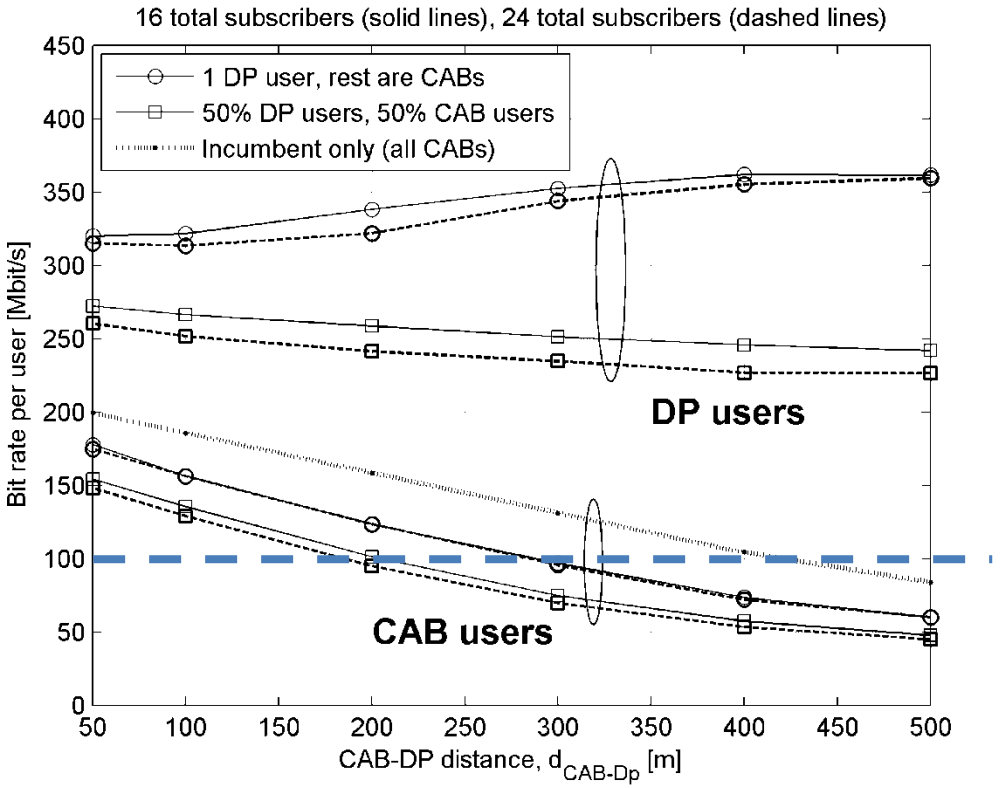
- As soon as a second operator (an OLO) starts independently transmitting on the same bundle of twisted pairs, vectoring advantages quickly disappears

FTTCab + VDSL: Simulation results



Assumptions:

- Incumbent users have VDSL vectoring from the cabinet
- OLO users have fiber down to the distribution point, then ADSL2+



Conclusions

Conclusion

- The request of physical unbundling is very demanding for next-generation access networks
- For the FTTH scenario based on PON, possible unbundling strategies can be based on WDM or electrical FDM
  - In both cases, some level of coordination is anyway required at the central office among different operators OLT
- There is not yet a good solution also for FTTCab+VDSL

Thank you for your attention!

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BACKUP

slides

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

A Digital Agenda for Europe

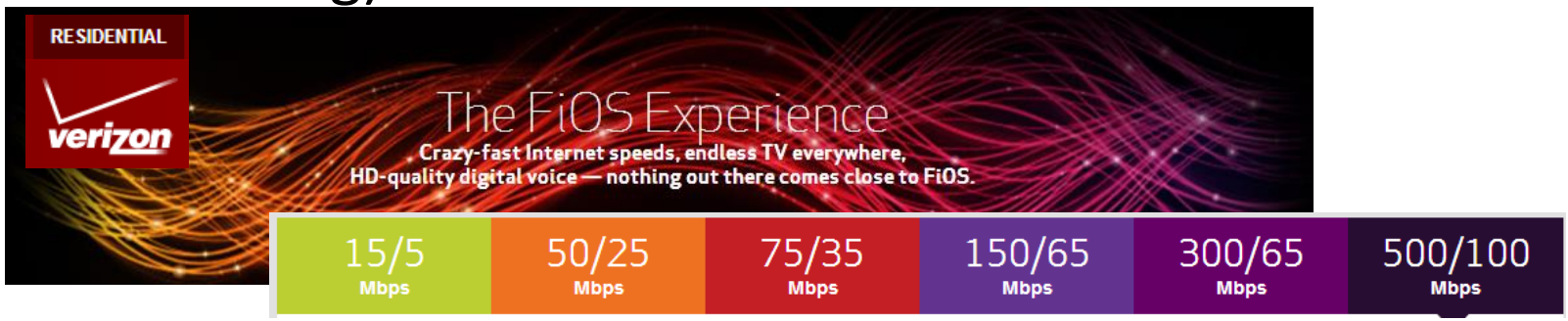
Brussels, 19.05.2010
COM(2010) 245

The future economy will be a network-based knowledge economy with the internet at its centre. Europe needs widely available and competitively-priced fast and ultra fast internet access. The Europe 2020 Strategy has underlined the importance of broadband deployment to promote social inclusion and competitiveness in the EU. It restated the objective to bring basic broadband to all Europeans by 2013 and seeks to ensure that, by 2020, (i) all Europeans have access to much higher internet speeds of above 30 Mbps and (ii) 50% or more of European households subscribe to internet connections above 100 Mbps.

To reach these ambitious targets it is necessary to develop a comprehensive policy, based on a mix of technologies, focusing on two parallel goals: on the one hand, to guarantee universal broadband coverage (combining fixed and wireless) with internet speeds gradually increasing up to 30 Mbps and above and over time to foster the deployment and take-up of next generation access networks (NGA) in a large part of the EU territory, allowing ultra fast internet connections above 100 Mbps.

Fiber to the Home (FTTH)

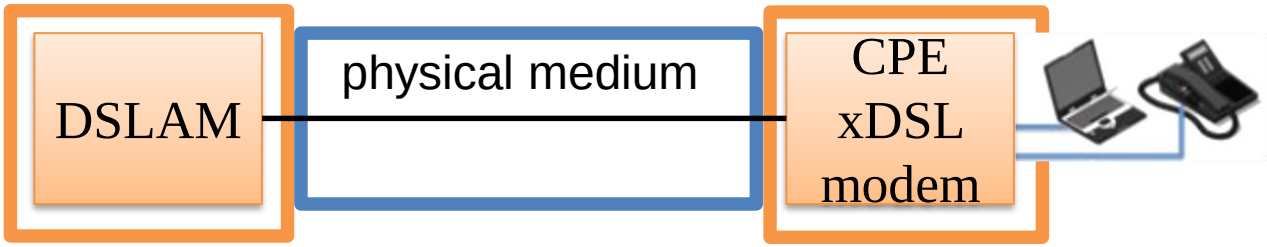
- FTTH is today massively deployed in some countries
  - Japan, Korea, Sweden, USA (Verizon FIOs commercial offering)



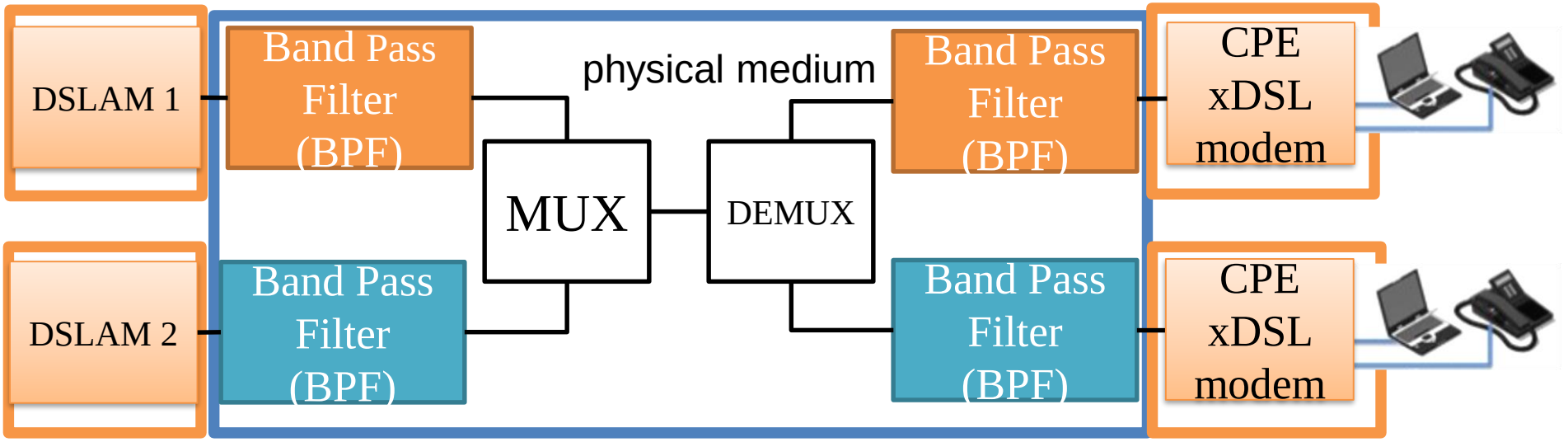
  - Developing countries (such as Estonia, Lithuania)

- The Countries that adopted a massive FTTH commercialization mostly use the "Passive Optical Network" architecture (PON)
  - Standards: ITU-T GPON or IEEE EPON

Physical Unbundling: direct access



Physical Unbundling: frequency access



Logical Unbundling: bitstream access