Network Infrastructures

Prof. Francesca Cuomo

Part 1

Network functional areas

Access network

- An access network is that part of a communications network which connects subscribers to their immediate service provider

- It is contrasted with the core network

- The access network may be further divided between feeder plant or distribution network, and drop plant or edge network.

Metropolitan Area

POP

Backbone

Access Network

Access Node
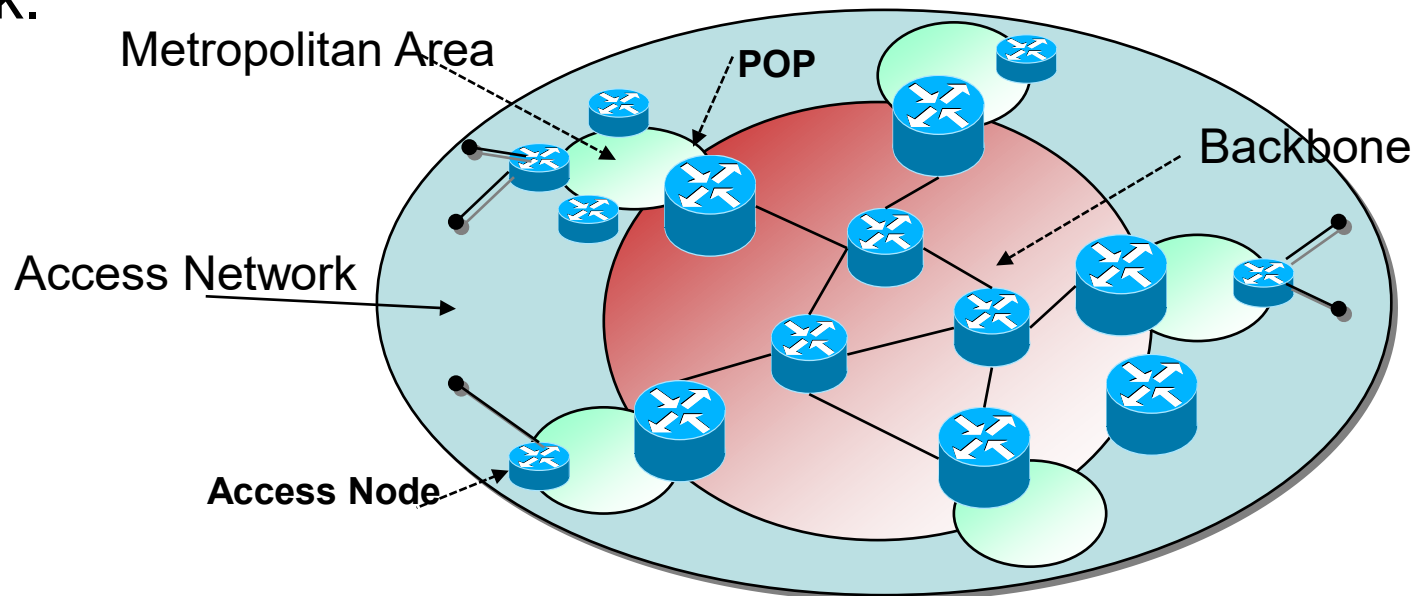
Access network

- The access network domain plays an important role in a network by connecting communications carriers and service providers with the individuals and companies they serve

- While communications carriers have historically used "**copper lines**" to offer phone service to individual subscribers, today the same line carries high-speed broadband services such as DSL (Digital Subscriber Loop or Digital Subscriber Line) in addition to telephone signals

- Carriers are also investing heavily in **optical fiber** as the transmission media for fixed broadband access
  - due to its high-speed and stable transmission characteristics

Core Network

- A core network is a backbone network:
  - usually with a mesh topology
  - provides any-to-any connections among devices on the network
  - consists of multiple switches (e.g., ATM- Asynchronous Transfer Mode) or consists of IP routers
  - is constituted by an optical backbone
- The Internet could be considered a giant core network
  - it really consists of many service providers that run their own core networks, and those core networks are interconnected
- Significant to core networks is "the edge," where networks and users exist

Edge of the network

- The edge may perform intelligent functions that are not performed inside the core network.
  - if the core network is using MPLS (Multiprotocol Label Switching), an edge switch may examine packets and select a path through the network based on various properties of the packet
- The core network then switches the packets (as opposed to doing hop-by-hop routing of the packets), which significantly improves performance
  - In this case, the core network is considered relatively "dumb" while the edge is considered "smart" because the path selection through the core is determined by the edge

Type of access

1. Wired Access

•*Description:* Wired access uses physical cables to connect to the network.

•*Advantages:* High reliability, stable and fast connections.

•*Use Cases:* Ethernet, Fiber-optic, DSL.

2. Wireless Access

•*Description:* Wireless access uses radio signals to connect to the network.

•*Advantages:* Mobility, flexibility, easy setup.

•*Use Cases:* Wi-Fi, Bluetooth, Cellular.

3. Satellite Access

•*Description:* Satellite access connects via communication satellites orbiting Earth.

•*Advantages:* Wide coverage, suitable for remote areas.

•*Use Cases:* Rural internet, global communication.

Type of access

4. Fiber-optic Access

•*Description:* Fiber-optic access uses thin glass or plastic fibers to transmit data using light.

•*Advantages:* High bandwidth, low latency, secure.

•*Use Cases:* High-speed internet, data centers.

5. DSL (Digital Subscriber Line) Access

•*Description:* DSL access uses telephone lines to transmit data.

•*Advantages:* Widespread availability, cost-effective.

•*Use Cases:* Home internet, small businesses.

6. Cable Access

•*Description:* Cable access uses coaxial cables to deliver internet and TV services.

•*Advantages:* High-speed internet, shared infrastructure.

•*Use Cases:* Residential broadband, cable TV.

Type of access

7. Cellular Access

•*Description:* Cellular access connects via mobile networks.

•*Advantages:* Mobile, on-the-go connectivity.

•*Use Cases:* Smartphones, mobile data.

8. Powerline Access

•*Description:* Powerline access uses electrical wiring for network connectivity.

•*Advantages:* Easy setup, no new cables needed.

•*Use Cases:* Home networking, extending Wi-Fi.

9. 5G Access

•*Description:* 5G access is the fifth generation of mobile networks, offering high-speed and low latency connectivity.

•*Advantages:* Ultra-fast, supports IoT and AR/VR.
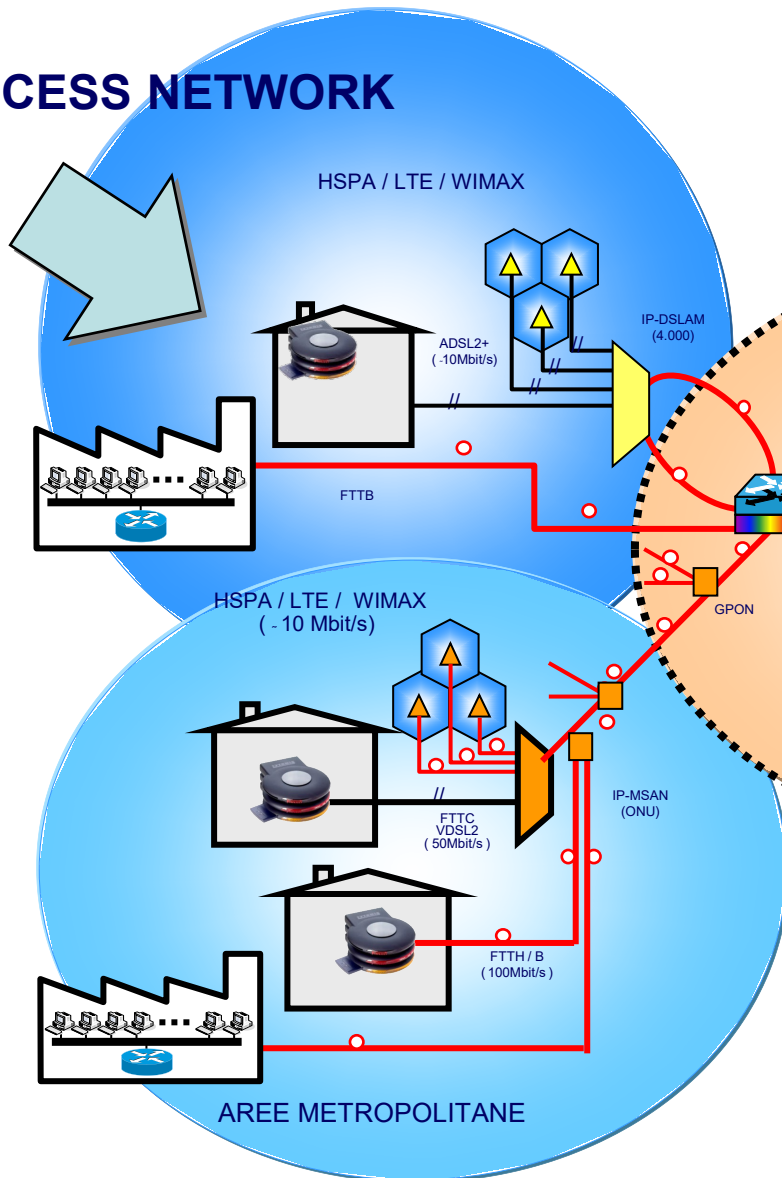
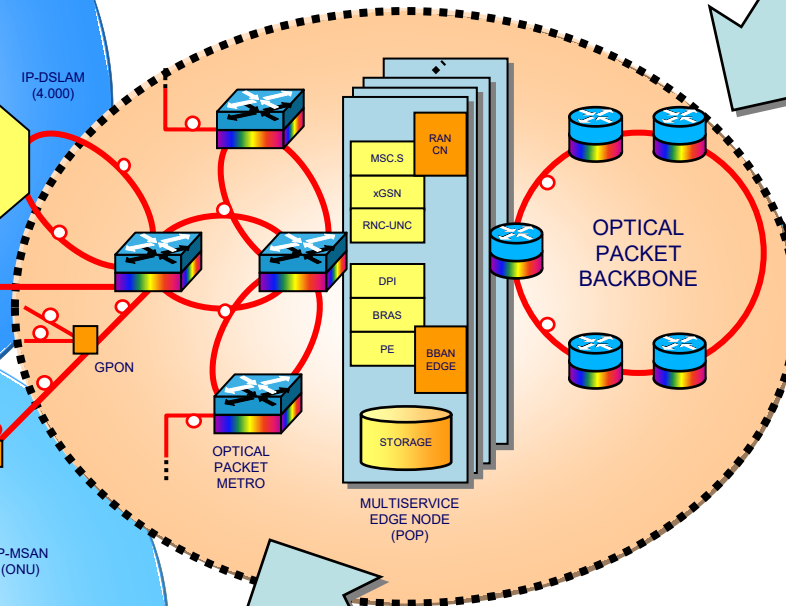•*Use Cases:* Emerging applications, smart cities.

Access / Core network

Fixed wireless acces

Core Network

Copper

LAN

PSTN/ISDN
ADSL

Fiber access

Cellular access

GSM/UMTS

LAN
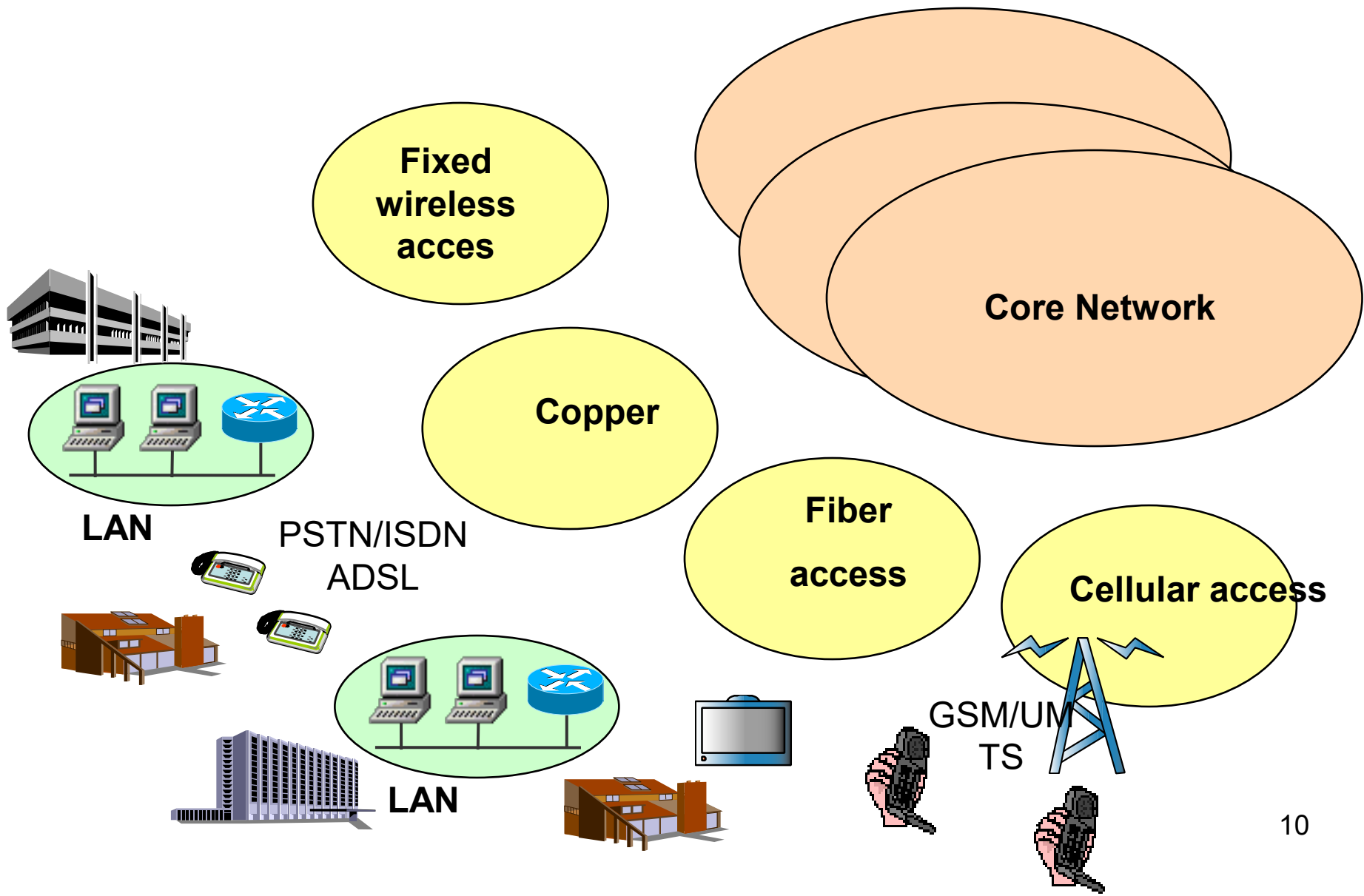
An example: Telecom Italia
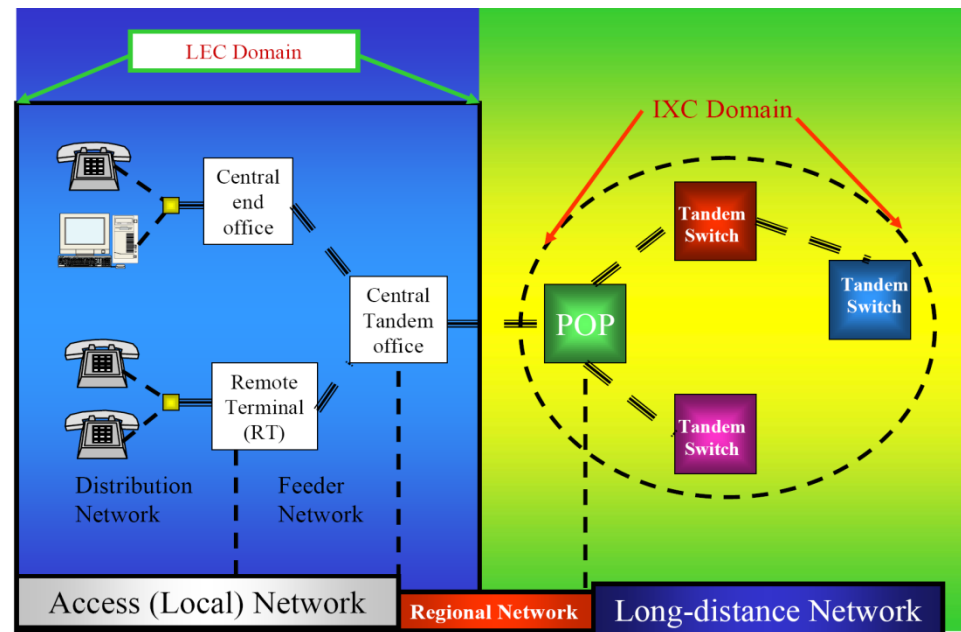
Network Terms

- Exchange Area
  - Local vs long distance
- LEC – Local Exchange Carrier
- ILEC – Incumbent LEC
- CLEC - Competitive LEC
- Trunks – fiber optical
- CO - Central Office
- LATA – Local access and transport area
- IXC – Inter-exchange Carrier
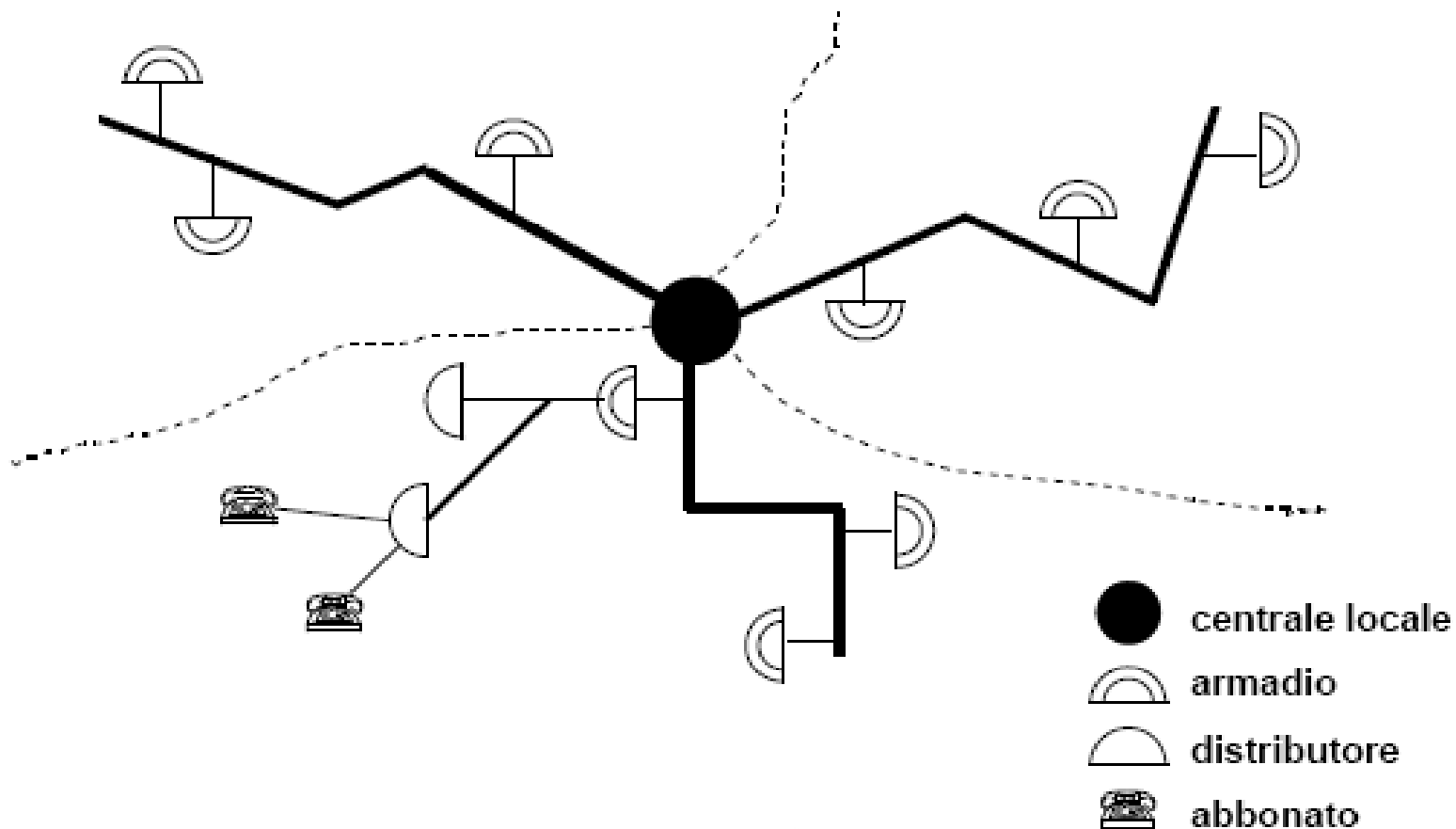 - Carry inter-LATA traffic

Some examples

Distribution frame where the copper pairs are connected one-by-one to the Central Office

Collocation space to permit CLECs to locate equipment in the central office

Distribution network

centrale locale
armadio
distributore
abbonato

Telecom Italia access Network

	Quantità	Unità misura
Borchia d'utente	33.576.000	Numero di borchie
Distributore	3.893.000	Numero di distributori
Armadio ripartilinea	142.500	Numero di armadi
Cavi a coppie simmetriche	105.700.000	km - circuito
Cavi (tracciato)	575.000	km
Palificazioni	8.893.000	Numero di pali
Infrastrutture di posa	20.000	km - tubazioni

Fonte: Telecom Italia 2007

Copper access

- Copper access :
  - This domain provides both high-speed broadband and existing phone service.
    - » ADSL and VDSL solutions that support high-speed broadband service
    - » phone migration solutions that can deliver existing phone service quality as a key infrastructure even as it evolves toward an IP network.
  - The major advantage of this network is its widespread availability.
  - The use of existing infrastructure is highly competitive in delivering various services, especially in well-covered areas.
  - Typically, the network is operated by the incumbent operator, often with public ownership.

Copper based access network

- Existing copper-based networks have gradually been expanded during several decades and their architectures are not optimized with regard to use of current technologies
- If an entirely new network were to be built today, it would not be based on use of copper-based technologies, and the design would therefore be very different from those of today's copper-based networks operated by the incumbent operators
- One problem is that networks are designed mainly for carrying POTS, while a growing share of the traffic is based on IP or other data communication protocols, and in some areas there are problems with capacity and quality of service.

Optical access

- Optical access :
  - This domain will be the mode of choice for fixed access in the coming years
    - » GE-PON (individual),
    - » GPON (enterprise),
    - » and COF (long-distance)
    - » represent systems capable of delivering ultra-high-speed, high-reliability performance.
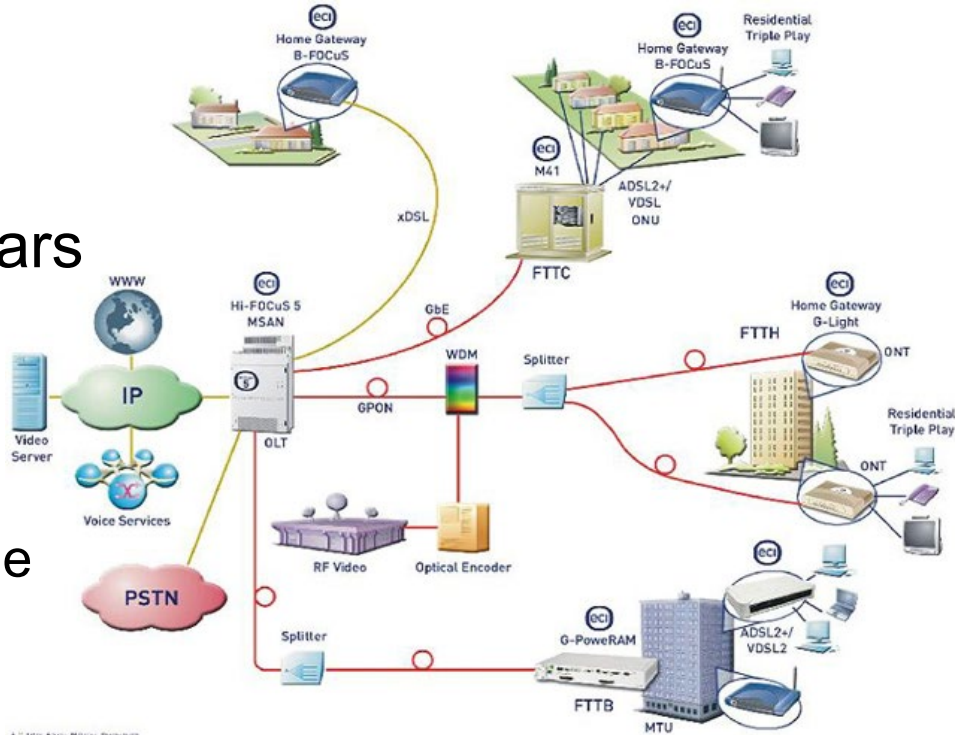
GE: Gigabit Ethernet
PON: Passive Optical Network
COF: Code Division Multplexing over Fiber

FTTx = Fiber-to-the-x

- FTTH - Home
- FTTC - Curb
- FTTN - Node or Neighborhood
- FTTP - Premise
- FTTB - Building or Business
- FTTU - User
- FTTZ - Zone
- FTTO - Office
- FTTD - Desk

FTTx: reference architectures

- FTTx elements:
  - OLT: Optical Line Terminal
  - ONU: Optical Network Unit
  - ONT: Optical Network Termination (NT: Network termination)
  - ODN: Optical Distribution Network
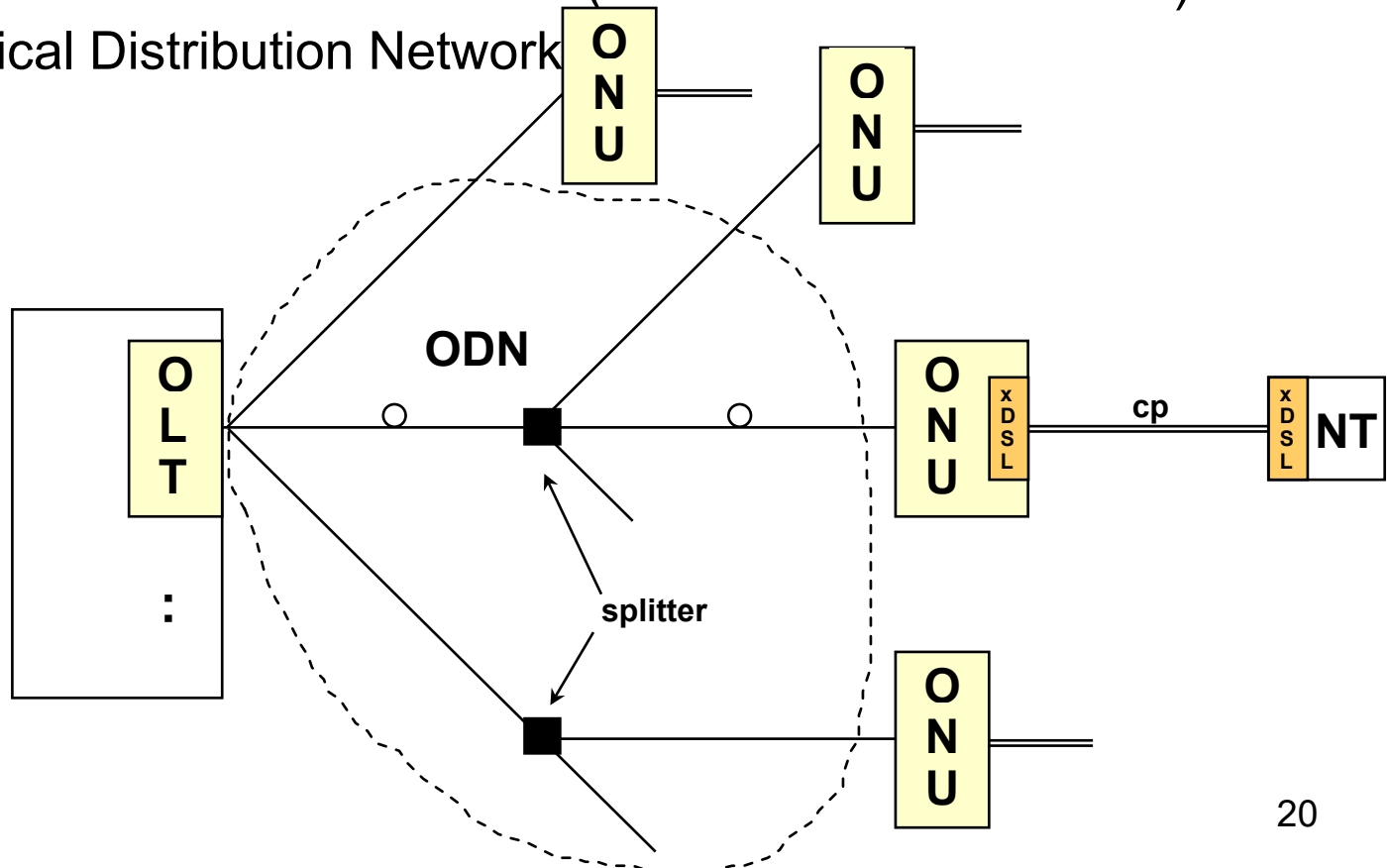
FTTx: reference architectures

- **AON (Active Optical Network),** *also called Point-to-Point (P2P)*
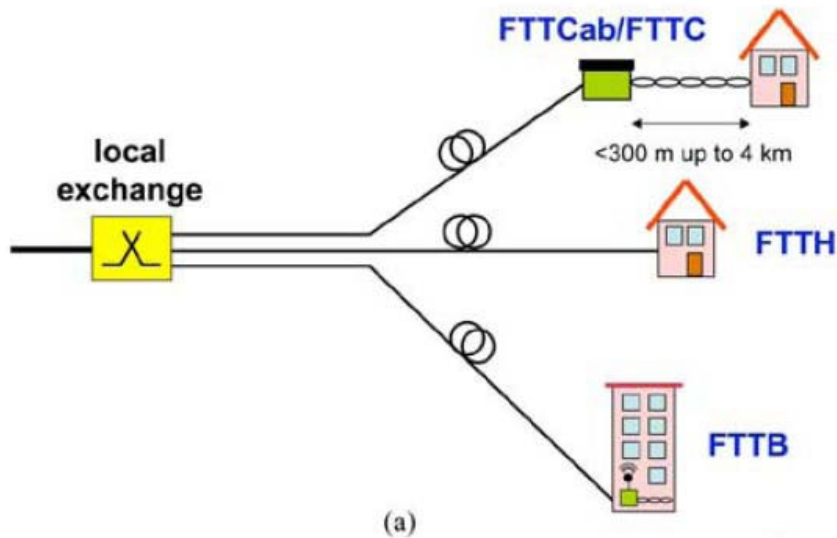
FTTx: reference architectures

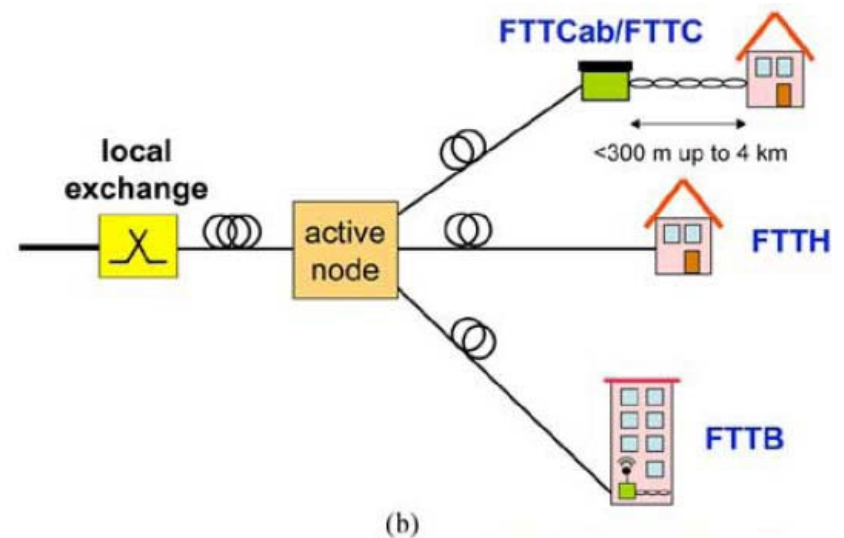- **PON (Passive Optical Network)**: passive branching of fibes via optical spiltters and tree-based topologies
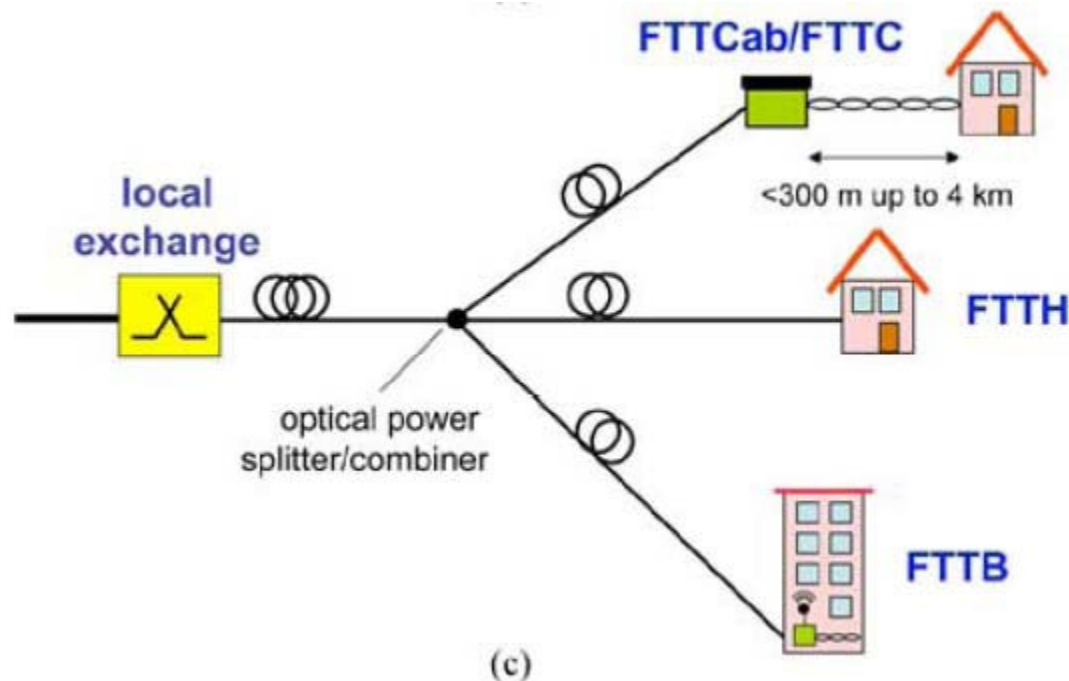
FTTx

- **Fiber to the Exchange:** the optical fiber terminates to the Central Office (CO) and the CO is connected with the user via a copper based line (e.g., ADSL)
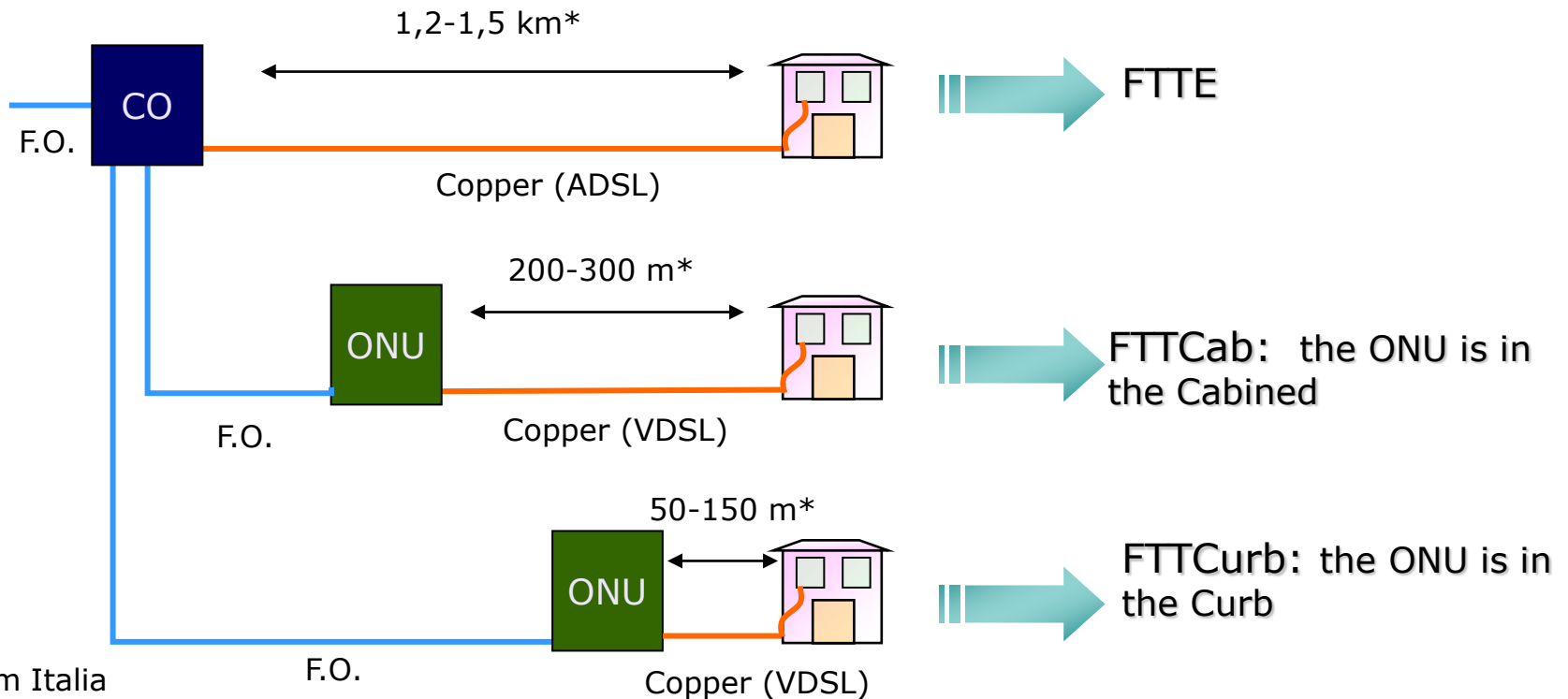
1,2-1,5 km*

CO

F.O.

Copper (ADSL)

FTTE

200-300 m*

ONU

F.O.

Copper (VDSL)

FTTCab: the ONU is in the Cabined

50-150 m*

ONU

F.O.

Copper (VDSL)

FTTCurb: the ONU is in the Curb

*Telecom Italia

Cub/Curb – Distribution network
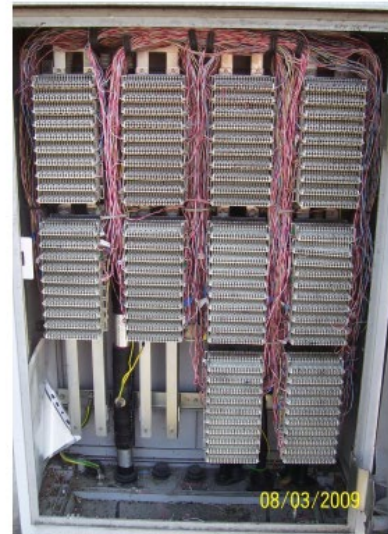
FTTP/FTTB/FTTH

- **Fiber to the Premises** the fiber cables arrive to the users'premises
  - **Fiber to the Building**
  - **Fiber to the Home**

Wireline access

E.g. Telecom Italia access network

1,2-1,5 km

1-1,2 km

200-300 m

50-70 m

(~10K)

(~140K)

(~5M)

(~22M)

Current telco broadband

Exchange	Cabinet	Curb	Premises

DSLAM / ATM aggregation — ADSL/ADSL2+ — DSL modem

FTTCab

Aggregation — DSLAM — VSDL/VDSL2 — DSL modem + set-top + home GW

FTTCurb

Aggregation — GE/EPON/GPON — ONU — VDSL2 — DSL modem + set-top + home GW

FTTH

OLT — GE/EPON/GPON — ONT + set-top + home GW

— Fiber   — Copper
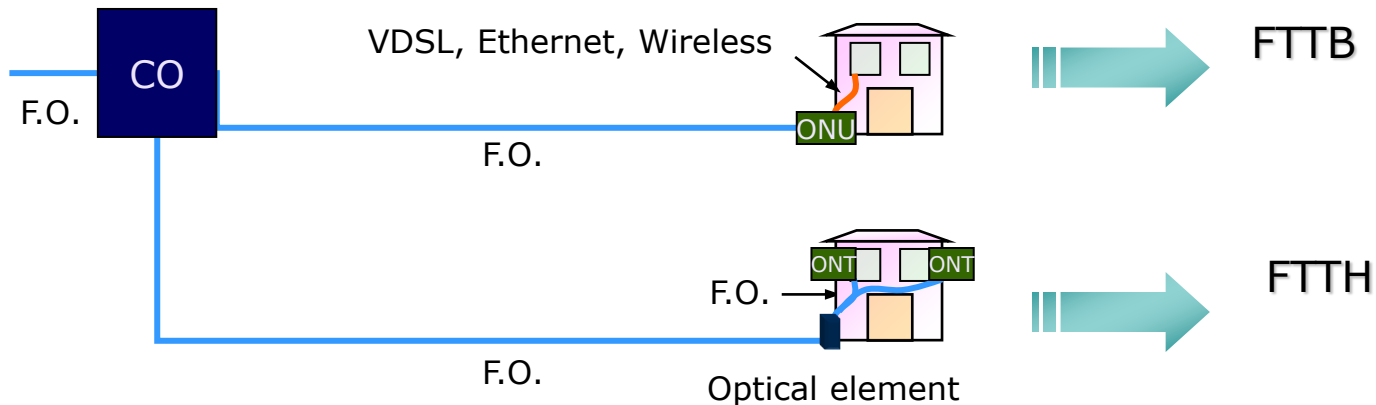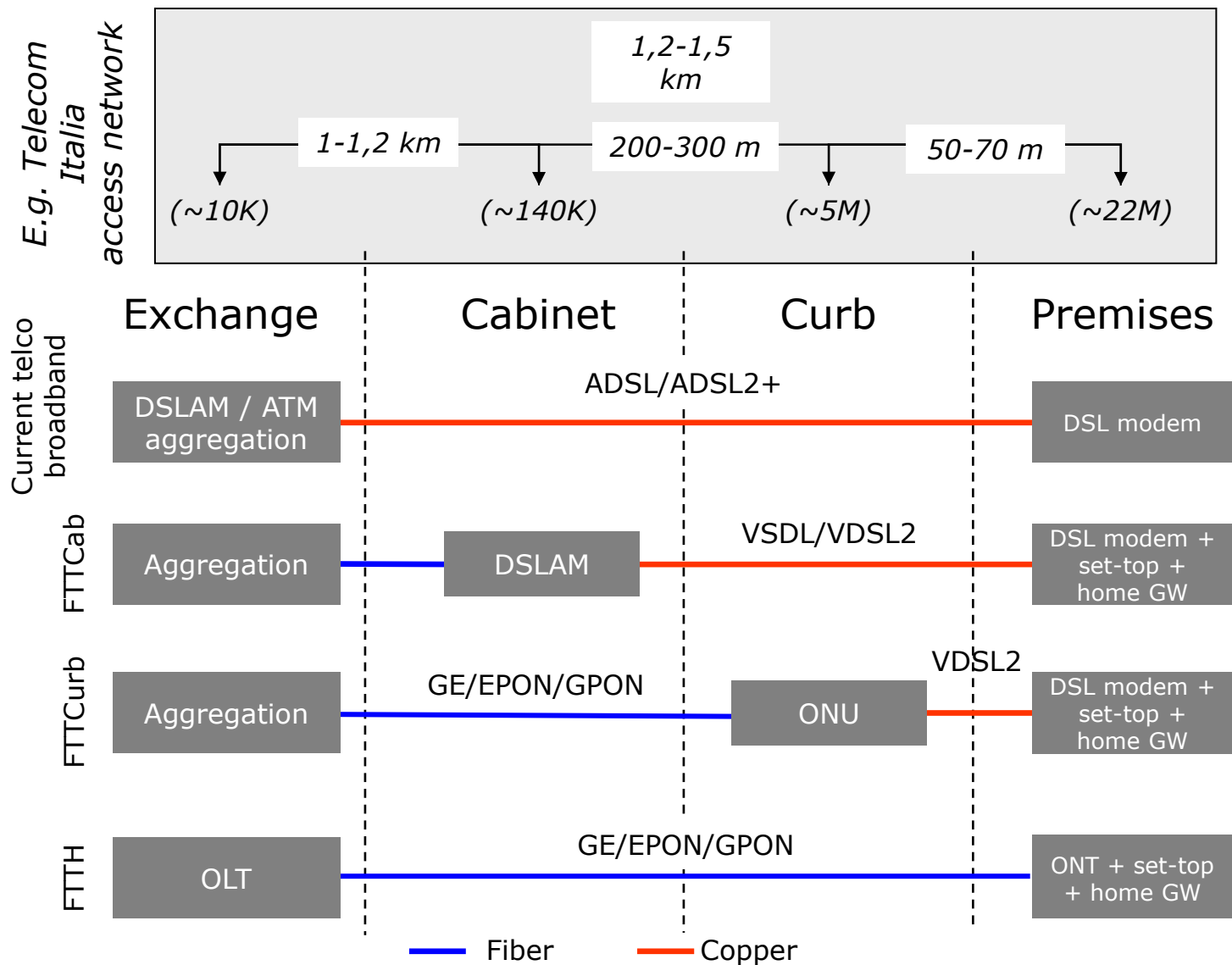
Bandwidth requirements

Source:Telecom Italia

Fiber based access network

Numbers today

- Open data available at https://rete.gruppotim.it/

Broadband access Italy 2018

(DATI MARZO 2018)

9° VA 171.556
3° MI 450.087
4° TO 341.824
7° BG 216.766
6° BS 240.353

BZ 99.556
SO 29.458
BL 40.469
UD 96.377

UN COLPO D'OCCHIO
A LIVELLO NAZIONALE

Questa cartina rappresenta in maniera immediata il numero di linee a banda larga esistente a marzo 2018 a livello nazionale e mette in evidenza la "top ten" delle province italiane con più linee.

VB 25.010
AO 26.596
VC 30.867
CO 131.366   LC 73.278
TN 113.372
TV 151.969   PN 56.686   GO 27.709
VI 160.150   VE 164.345   TS 49.545
MB 144.111
VR 164.088
10° PD 170.583

NO 61.327
BI 33.961   PV 124.603   CR 77.452   RO 37.233
LO 47.202   MN 94.927
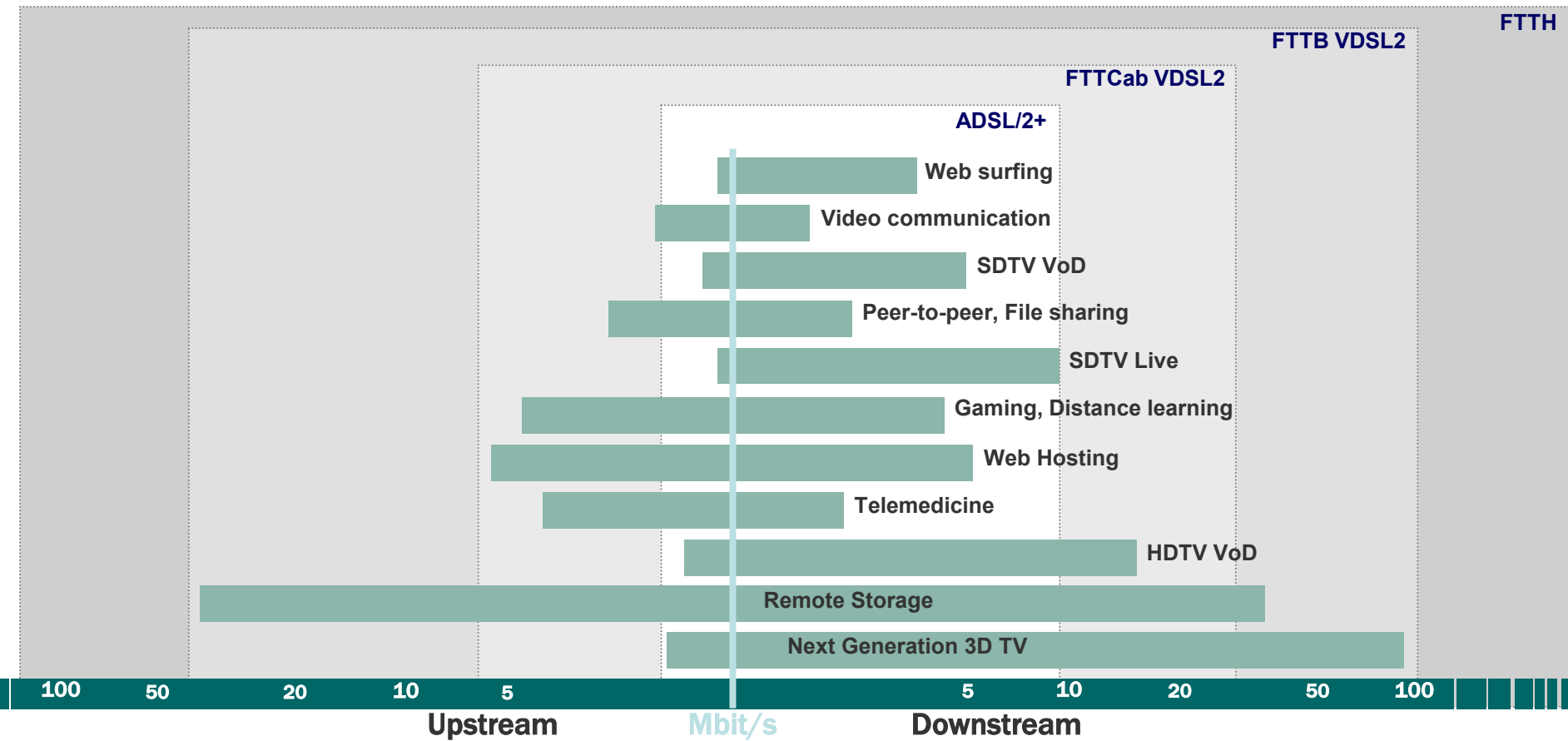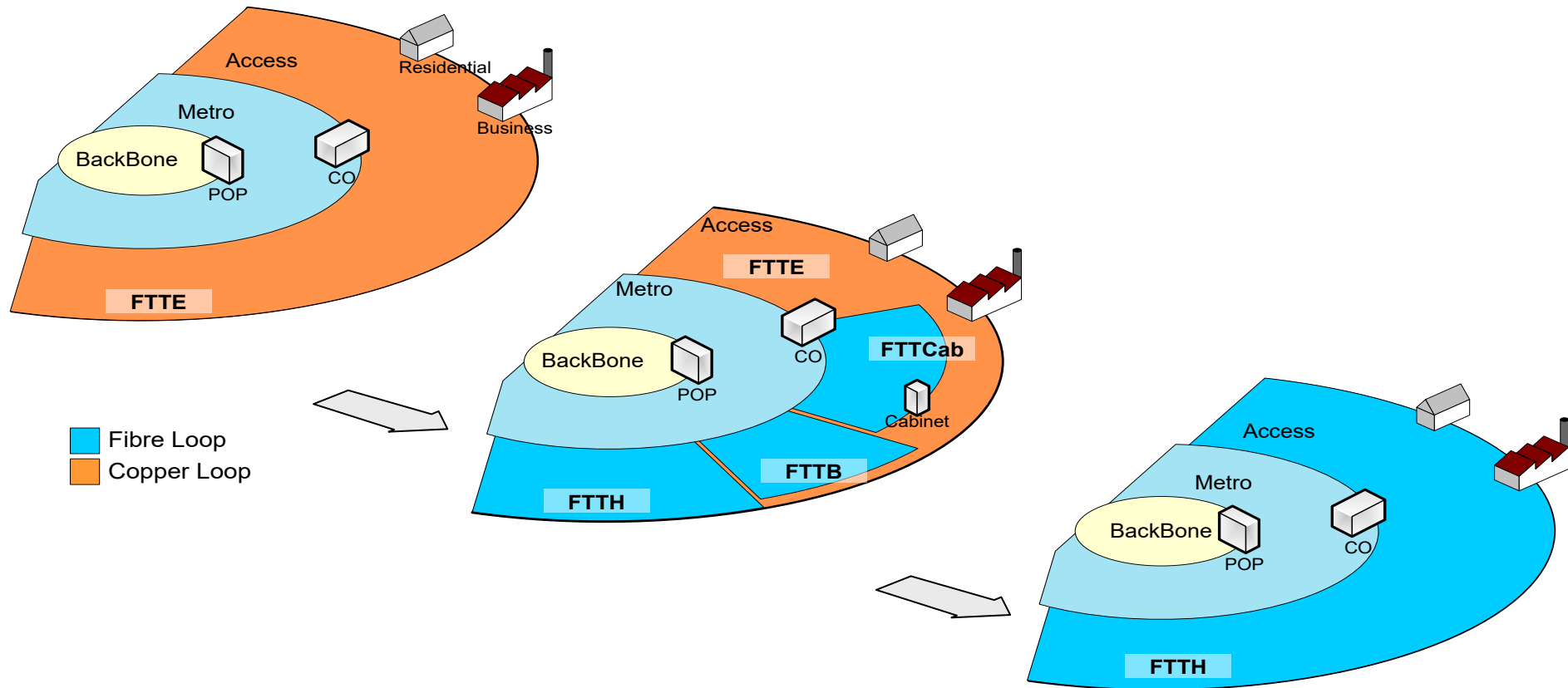PC 55.698   RE 106.673   FE 60.708
AL 62.318   PR 89.999   RA 82.998
AT 30.573   GE 136.171   MO 138.814   RN 64.899
CN 100.424   MS 31.301   PO 52.391
SV 49.656   SP 48.948   PT 59.525   FC 72.101
IM 35.623   LU 84.620   PU 78.365   AN 96.213
PI 99.636
AR 74.825   MC 66.516   FM 34.826
LI 67.014   SI 70.836   PG 117.378   AP 45.663
GR 48.787   TR 43.167   TE 52.350
VT 64.889   RI 28.461   PE 53.930
5° FI 242.023   CH 67.353
AQ 43.706   CB 33.085
IS 12.620
FR 85.499   FG 82.835
LT 93.970   BN 47.108   BT 32.981
CE 140.172   AV 70.525   BA 148.000
SS 80.217   BR 40.395
NU 30.821
1° RM 790.541   PZ 46.410   MT 25.783   TA 66.927   LE 98.661
OR 22.071   SA 168.775   CS 117.805
2° NA 525.734   KR 22.835
SU 48.097   CZ 60.327
CA 55.199   VV 24.326
PA 160.658   ME 110.294   RC 86.512
TP 48.595   EN 25.877   CT 151.343
AG 55.104   CL 31.681   SR 64.738
RG 36.966

8° BO 193.244

Cloud computing

DC MI CESANO MADERNO
3.552 mq
11 SALE

DC BOLOGNA
4.965 mq
24 SALE

DC PADOVA
4.112 mq
15 SALE

CS FIRENZE
594 mq
5 SALE

IDC RM POMEZIA
7.091 mq
19 SALE

CS TORINO
1.129 mq
8 SALE

DC BARI
2.028 mq
6 SALE

IDC MI ROZZANO
7.813 mq
24 SALE

DC RM ORIOLO ROMANO
3.502 mq
14 SALE

DC RM ACILIA
4.057 mq
7 SALE

CS NAPOLI
554 mq
4 SALE

CS PALERMO
461 mq
3 SALE
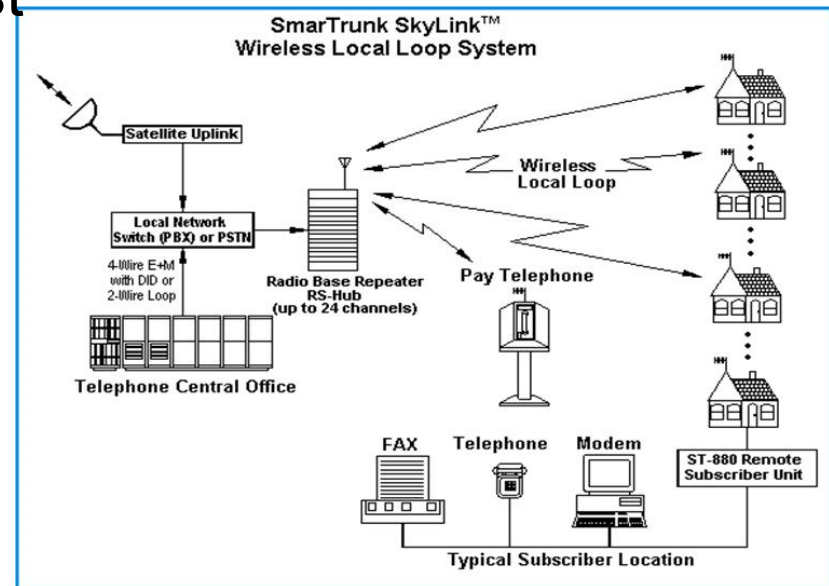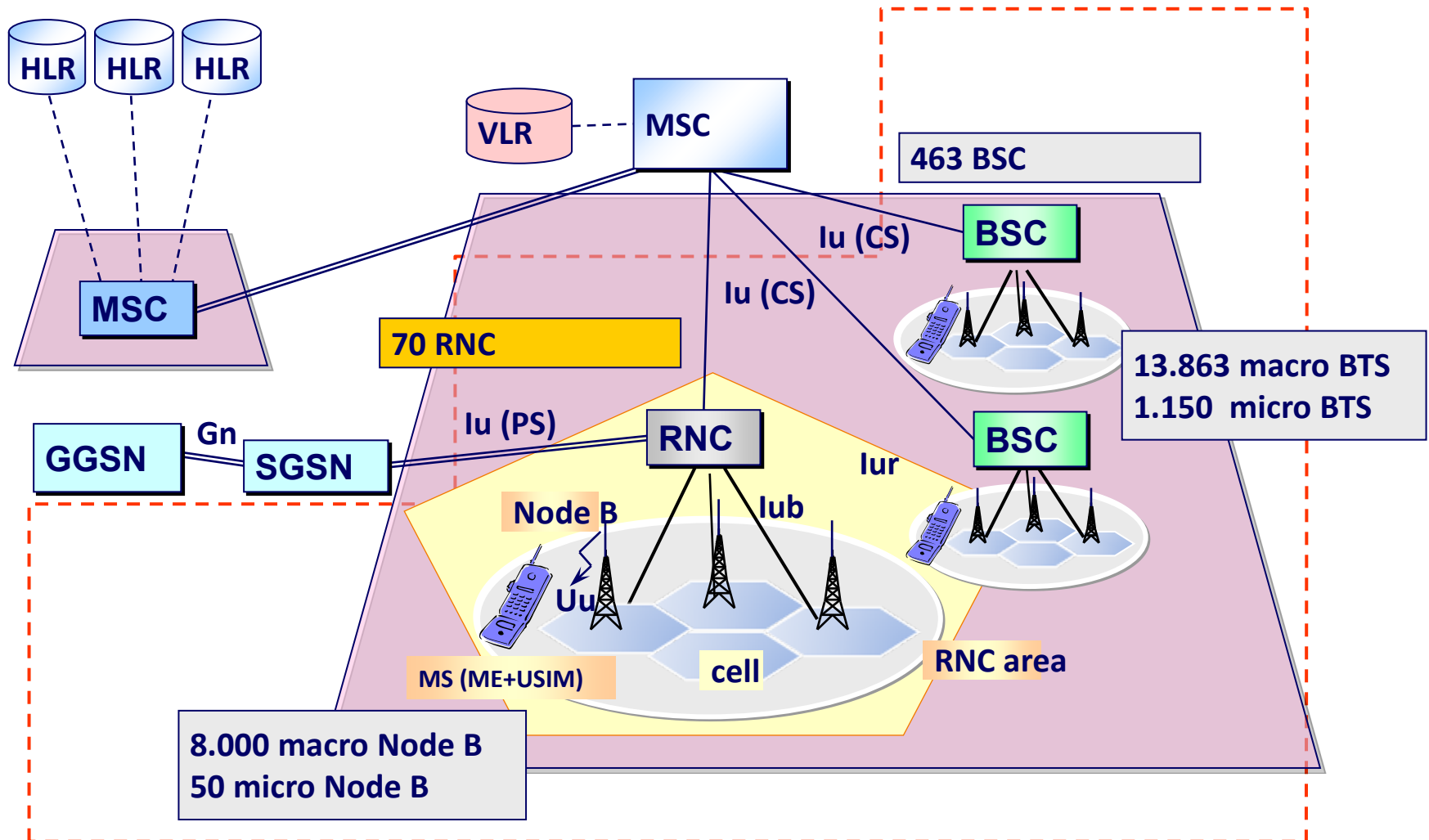
Wireless access

- Wireless access :
  - This domain enjoys the highest expectations from the standpoint of ubiquitous networking
    - » WLL
    - » 3G mobile networking
    - » WiMAX solutions
    - » support seamless communications and high-speed broadband service, providing both fixed and mobile access in a single system

SmarTrunk SkyLink™
Wireless Local Loop System

Satellite Uplink

Local Network Switch (PBX or PSTN)

4-Wire E+M with DID or 2-Wire Loop

Telephone Central Office

Radio Base Repeater RS-Hub (up to 24 channels)

Wireless Local Loop

Pay Telephone

FAX   Telephone   Modem

ST-880 Remote Subscriber Unit

Typical Subscriber Location

2G and 3G architecture

HLR   HLR   HLR

VLR   MSC

463 BSC

MSC

Iu (CS)   BSC

Iu (CS)

70 RNC

13.863 macro BTS
1.150 micro BTS

GGSN   Gn   SGSN

Iu (PS)   RNC

Iur

BSC

Node B   Iub

Uu

MS (ME+USIM)   cell   RNC area

8.000 macro Node B
50 micro Node B

GSM network

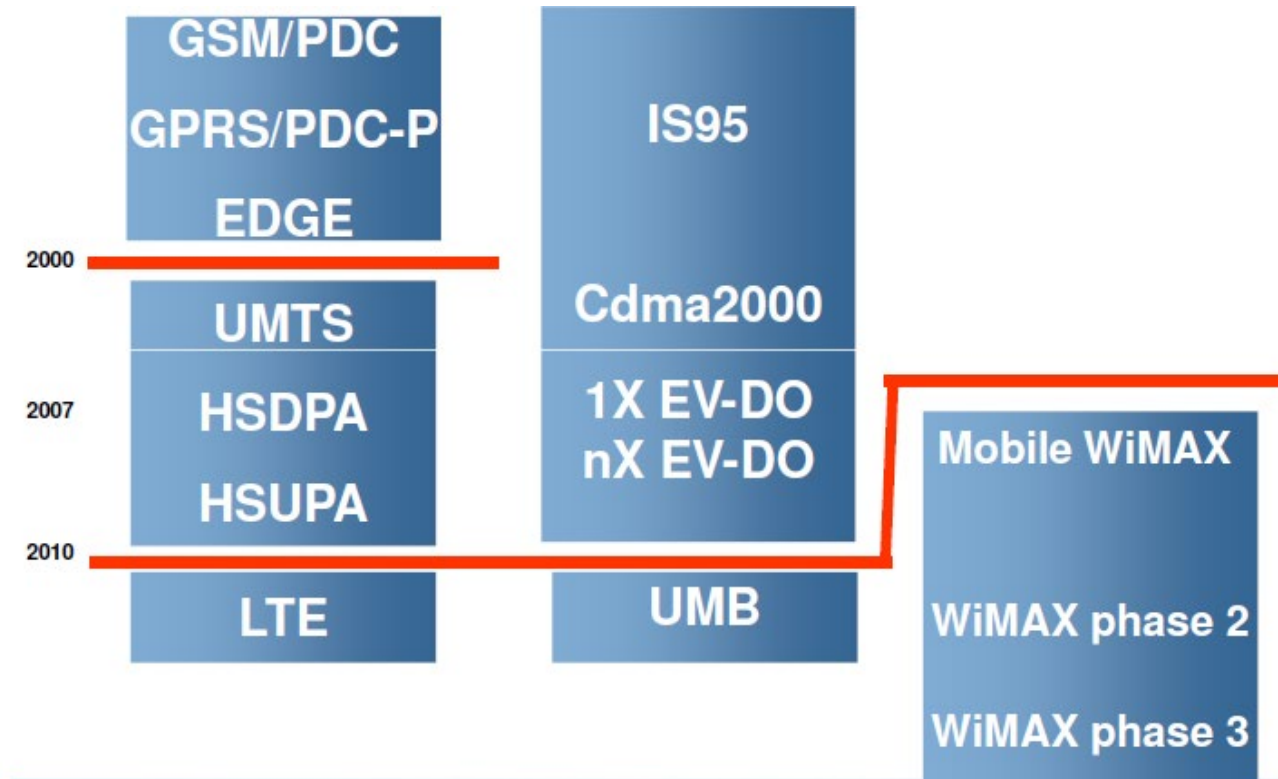|	Quantità	Unità misura
Siti per antenne radiomobili	14.000	Siti dei tralicci
Stazioni radio BTS	13.865	Numero stazioni radio
Controllori stazione BSC	463	Numero di BSC
Trasmettitori	90.090	Numero di TXT
Celle	24.522 (900 MHz) – 7.551 (1800 MHz)	Numero di celle
Canali	556.264 (900 MHz) – 164.458 (1800 MHz)	Numero di canali

3G network

	Quantità	Unità misura
Siti per antenne UMTS	8.030	Siti dei tralicci
Stazioni radio - Nodi B	8.030	Numero stazioni radio
Controllori stazione RNC	70	Numero di RNC
Celle	22.094	Numero di celle
Canali	834.752	Numero di canali
Frequenze	10 (2100 MHz)	MHz

Wireless Access: cont'd

Wireless Access: cont'd

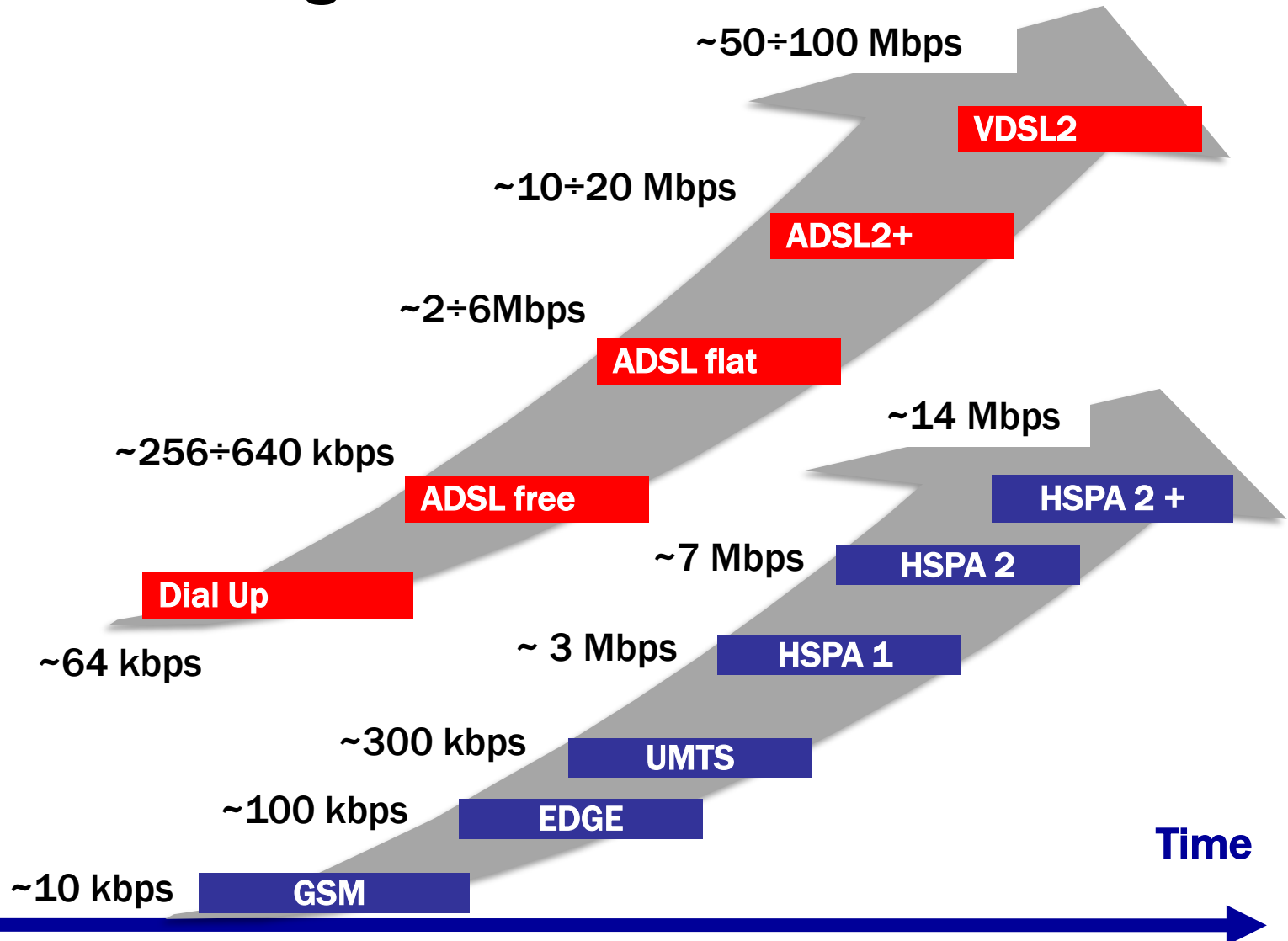|	
RAN	Interactive TV - IEEE 802.22 – WiRAN
MAN	Mobile WDSL - IEEE 802.16 – Mobile WiMAX
LAN	Fixe WDSL - IEEE 802.16 – WiMAX
	Wi-Fi – IEEE 802.11
PAN	Wimedia – IEEE 802.15
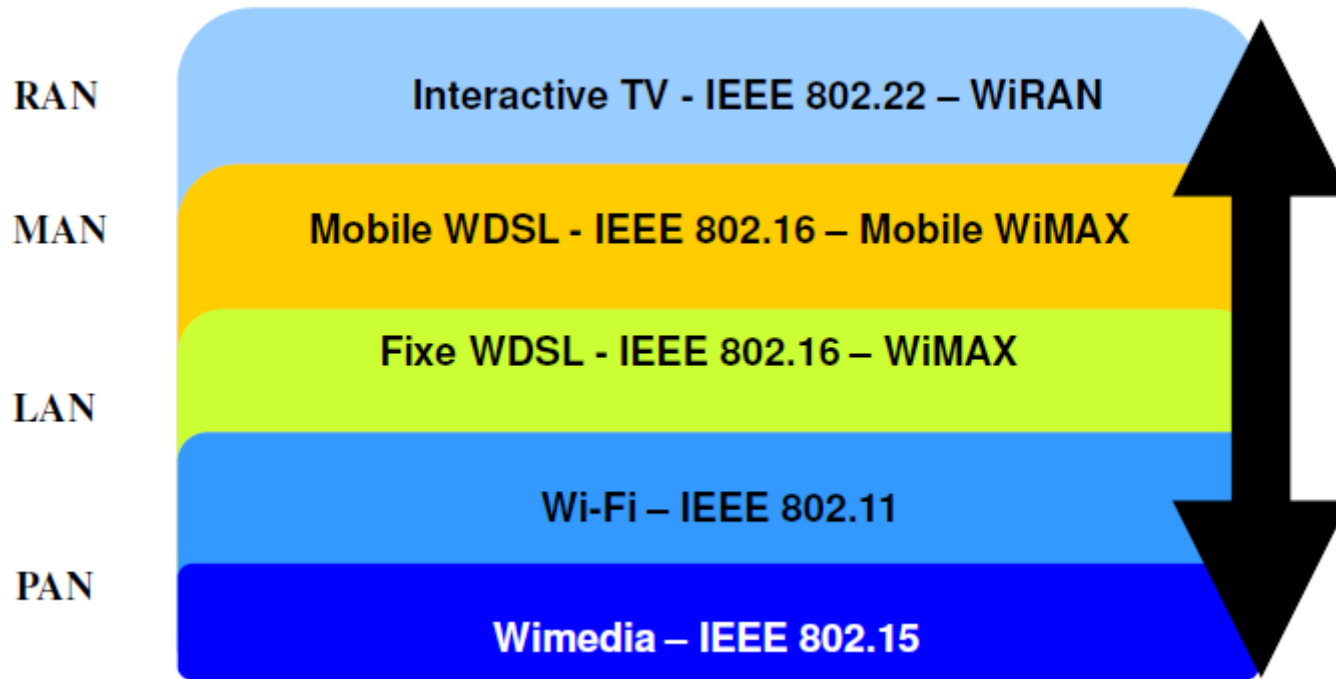
- As ubiquitous service-anytime, anywhere, anyone-becomes the norm, demand for technologies such as conventional cellular phone service and wireless LAN access is being augmented by an increasingly noticeable desire for mobile high-speed broadband service and otherwise seamless communications

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Techologies and bandwidths

~50÷100 Mbps

VDSL2

~10÷20 Mbps

ADSL2+

~2÷6Mbps

ADSL flat

~14 Mbps

~256÷640 kbps

ADSL free

HSPA 2 +

~7 Mbps

HSPA 2

Dial Up

~64 kbps

~ 3 Mbps

HSPA 1

~300 kbps

UMTS

~100 kbps

EDGE

Time

~10 kbps

GSM

Backbone: the logical topology

OPB (Optical Packet Backbone)

- 32 PoP

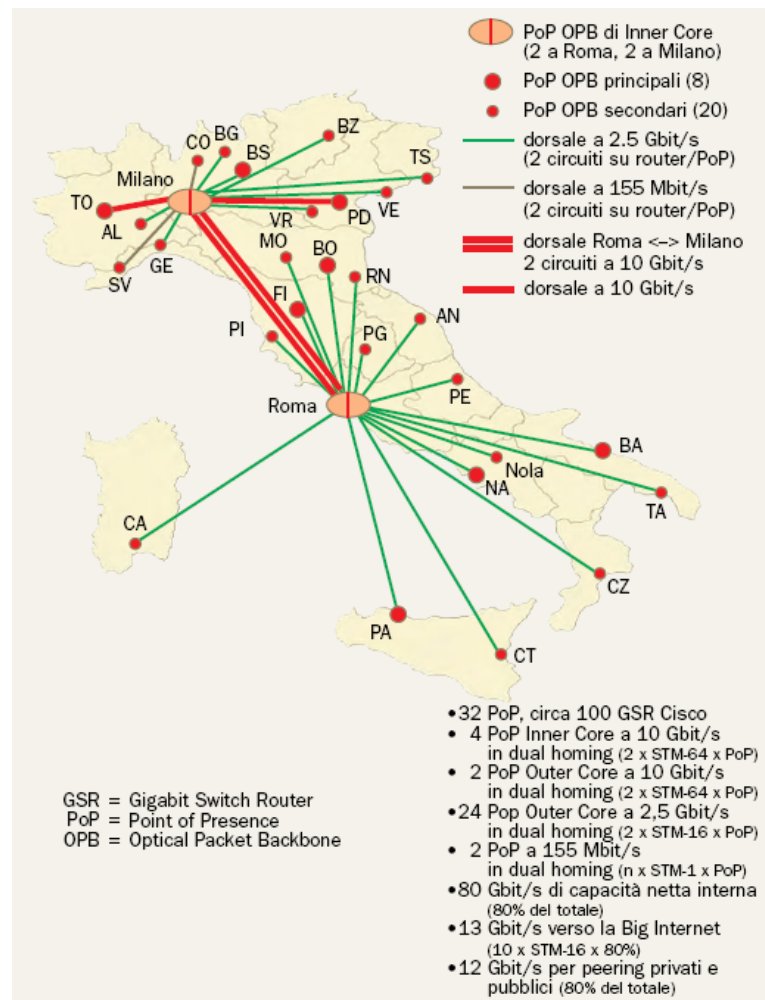- Inner Core: 4 PoP (2 in Rome,, 2 in Milan)

- Outer Core: 28 PoP

- Inner Core: 10 Gbit/s (STM-
- 64)
- Outer Core: 10 Gbit/s (STM-64),
- 2,5 Gbit/s (STM-16) and 155 Mbit/s (STM-1)
- Link used at 50%

PoP OPB di Inner Core
(2 a Roma, 2 a Milano)
PoP OPB principali (8)
PoP OPB secondari (20)
dorsale a 2.5 Gbit/s
(2 circuiti su router/PoP)
dorsale a 155 Mbit/s
(2 circuiti su router/PoP)
dorsale Roma <–> Milano
2 circuiti a 10 Gbit/s
dorsale a 10 Gbit/s

GSR = Gigabit Switch Router
PoP = Point of Presence
OPB = Optical Packet Backbone

- 32 PoP, circa 100 GSR Cisco
- 4 PoP Inner Core a 10 Gbit/s
  in dual homing (2 x STM-64 x PoP)
- 2 PoP Outer Core a 10 Gbit/s
  in dual homing (2 x STM-64 x PoP)
- 24 Pop Outer Core a 2,5 Gbit/s
  in dual homing (2 x STM-16 x PoP)
- 2 PoP a 155 Mbit/s
  in dual homing (n x STM-1 x PoP)
- 80 Gbit/s di capacità netta interna
  (80% del totale)
- 13 Gbit/s verso la Big Internet
  (10 x STM-16 x 80%)
- 12 Gbit/s per peering privati e
  pubblici (80% del totale)

Source: Telecom Italia

Backbone: the physical topology

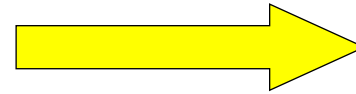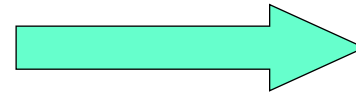Physical network build up on the Optical Transport Network
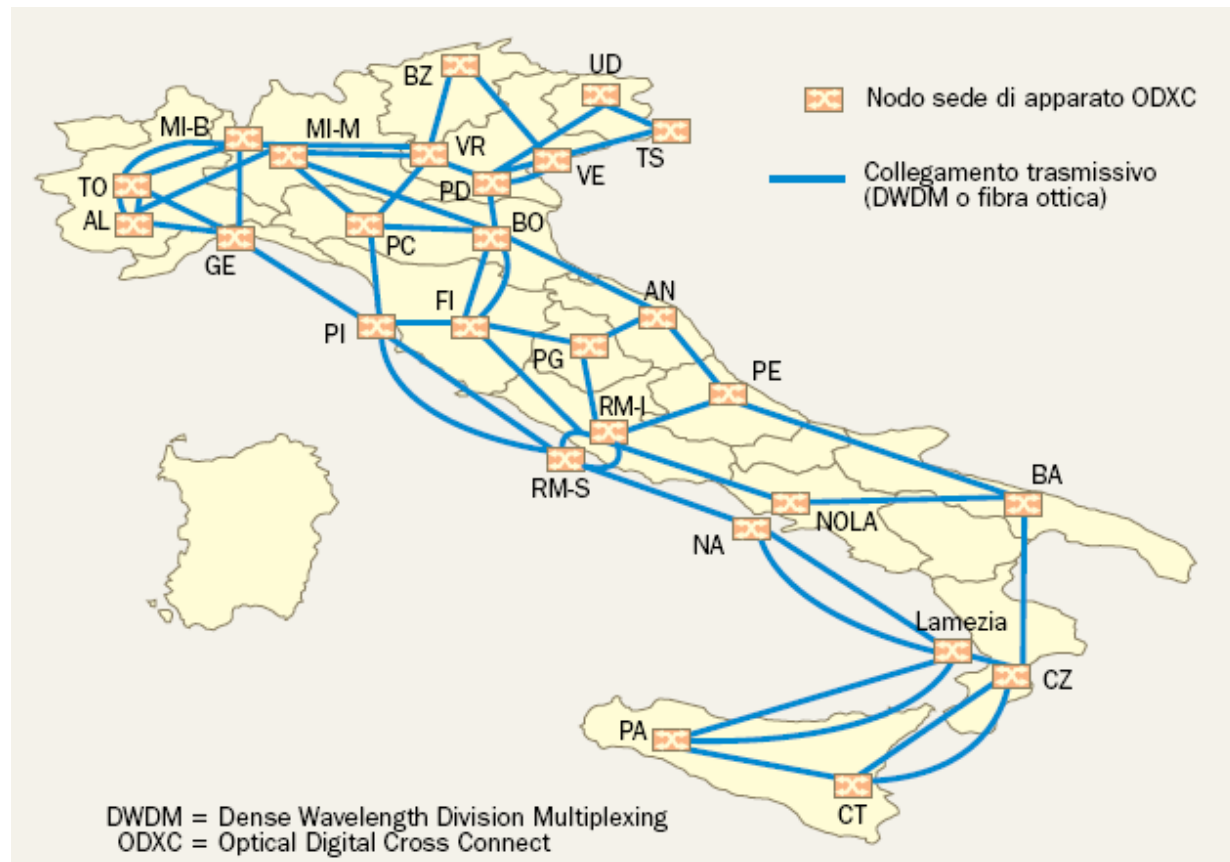
Source: Telecom Italia

Technologies and protocols

Multi Protocol Label Switching (MPLS) ⟶ **Layer 3**

Asynchronous Transfer Mode (ATM)
Gigabit Ethernet (GbE) ⟶ **Layer 2**

Synchronous Digital Hierarchy (SDH)
Wavelength Division Multplexing (WDM) ⟶ **Layer 1**
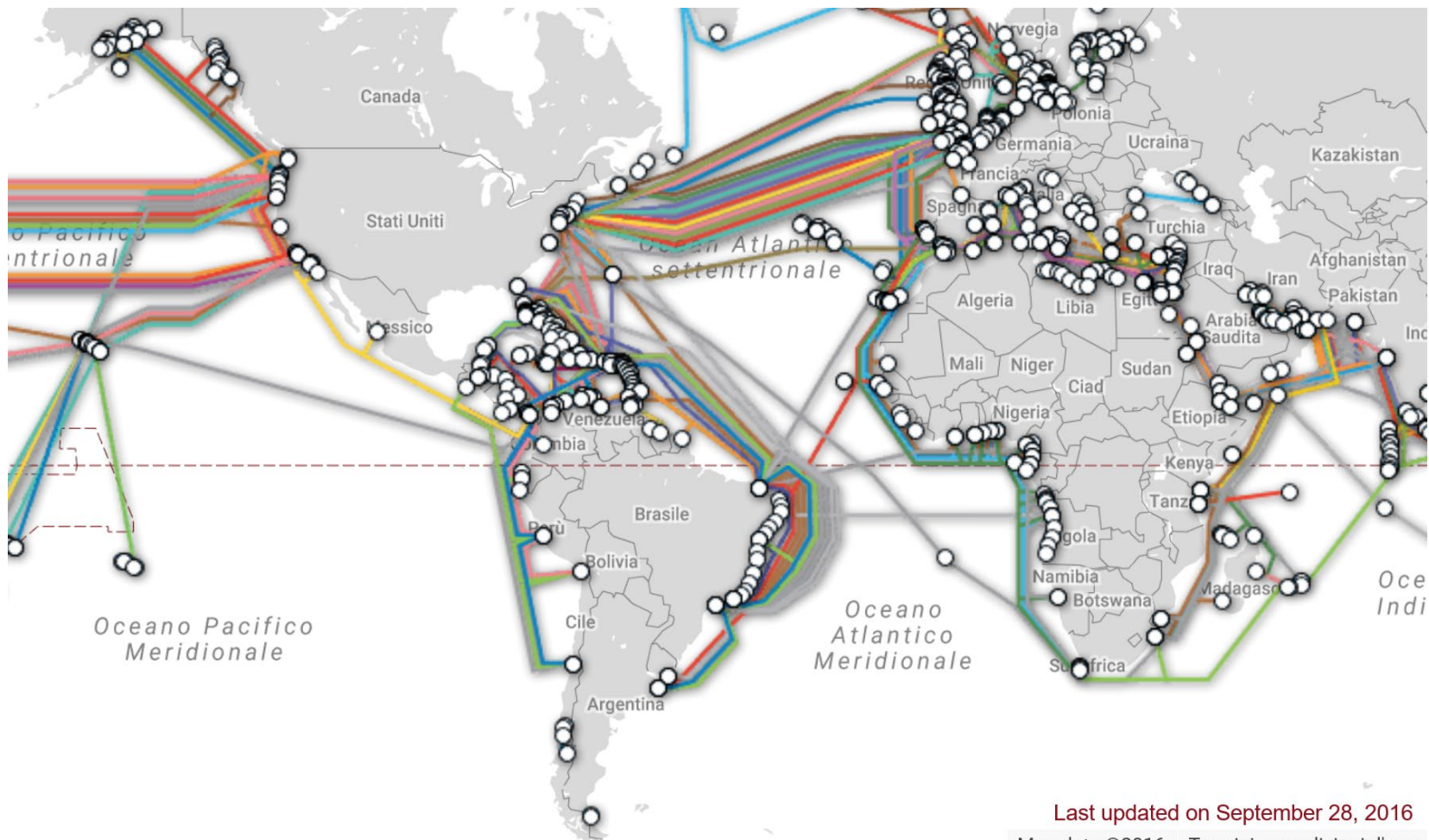
Towards the Next Generation Network

Find out some current statistics

- To be filled by students……

Examples of network infrastructures (http://www.submarinecablemap.com/)

Examples of network infrastructures (http://opensignal.com/coverage-maps/Italy/
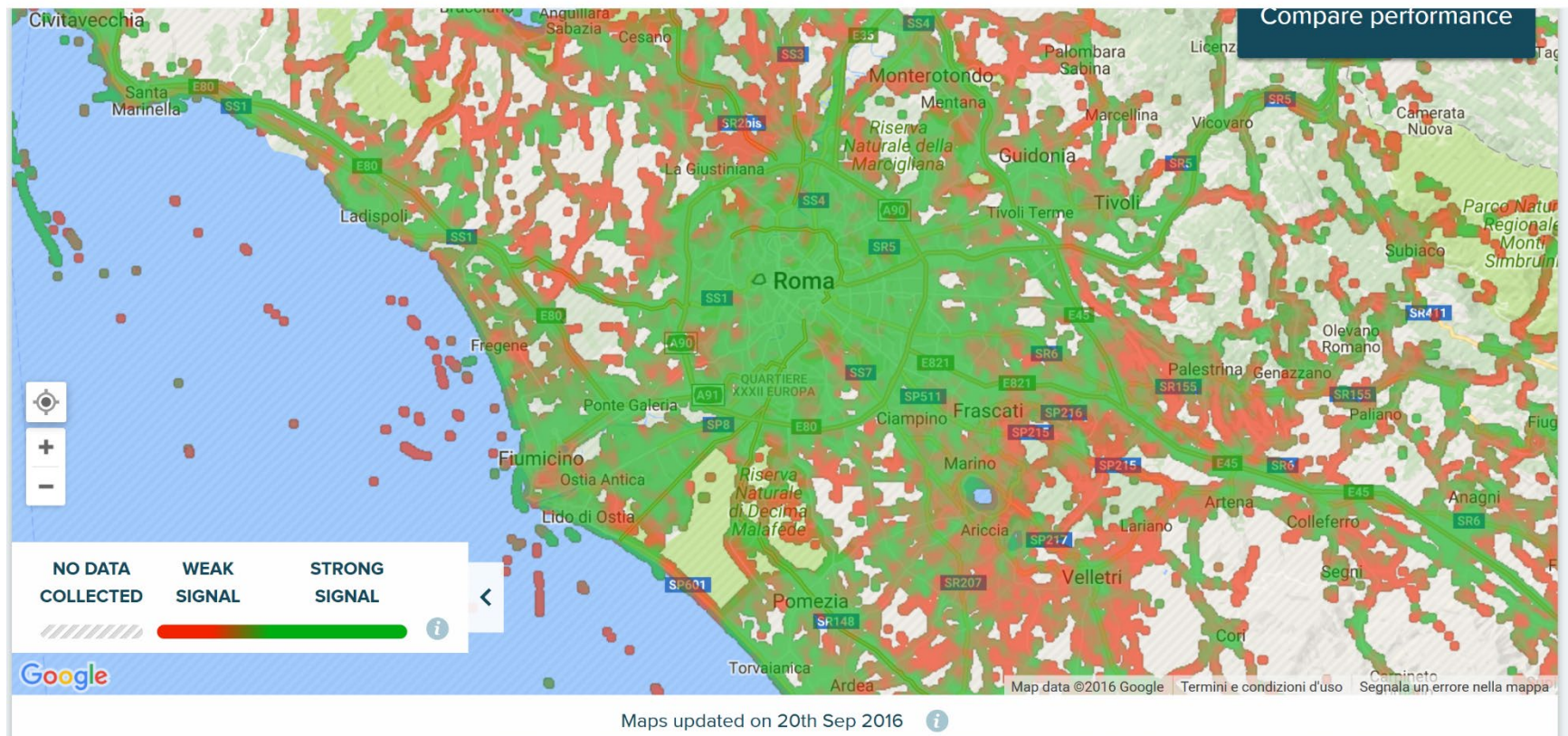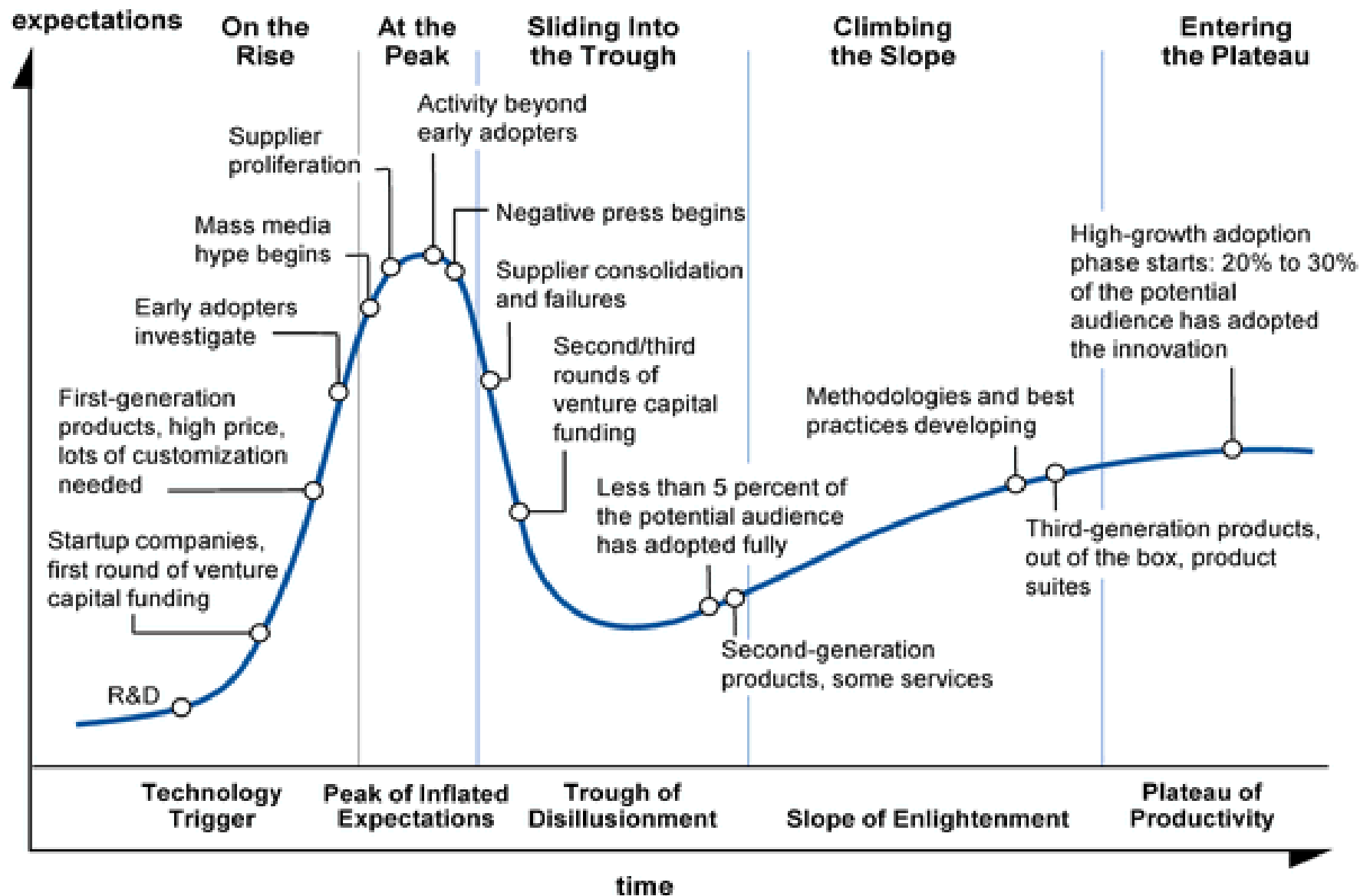
Gartner hype cycle

2023

Hype Cycle for Emerging Technologies, 2023