SAPIENZA
UNIVERSITÀ DI ROMA

Network Infrastructures

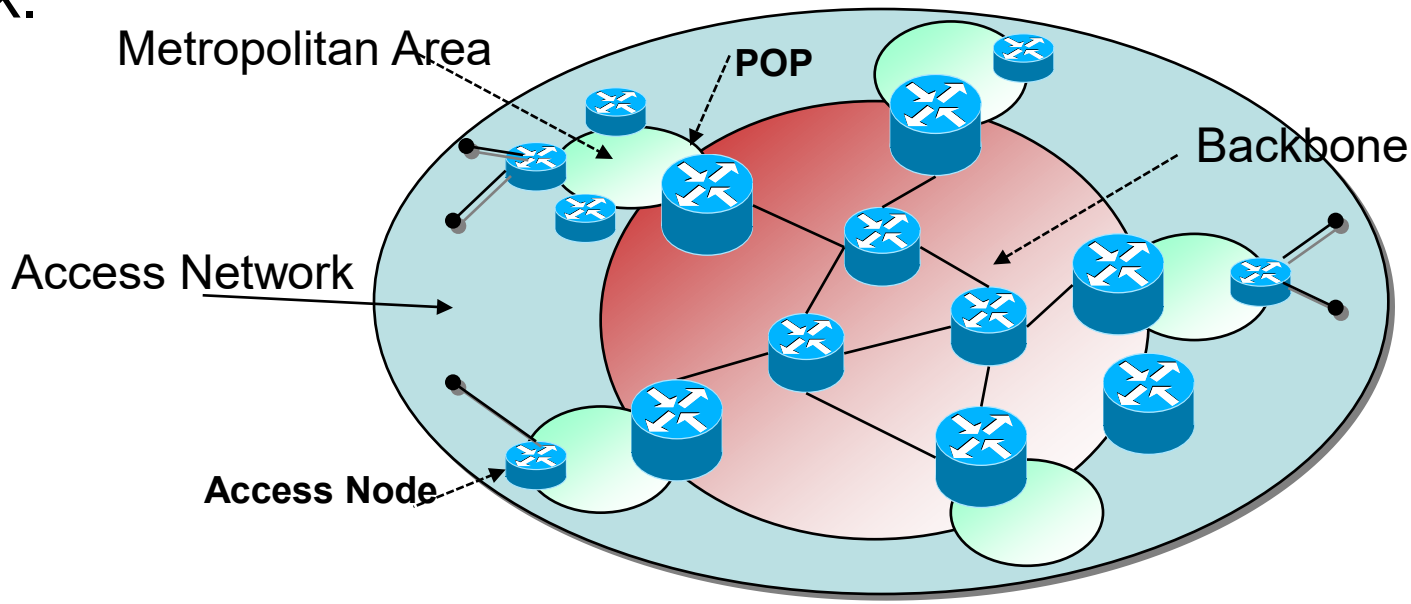
Prof. Francesca Cuomo

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.



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.

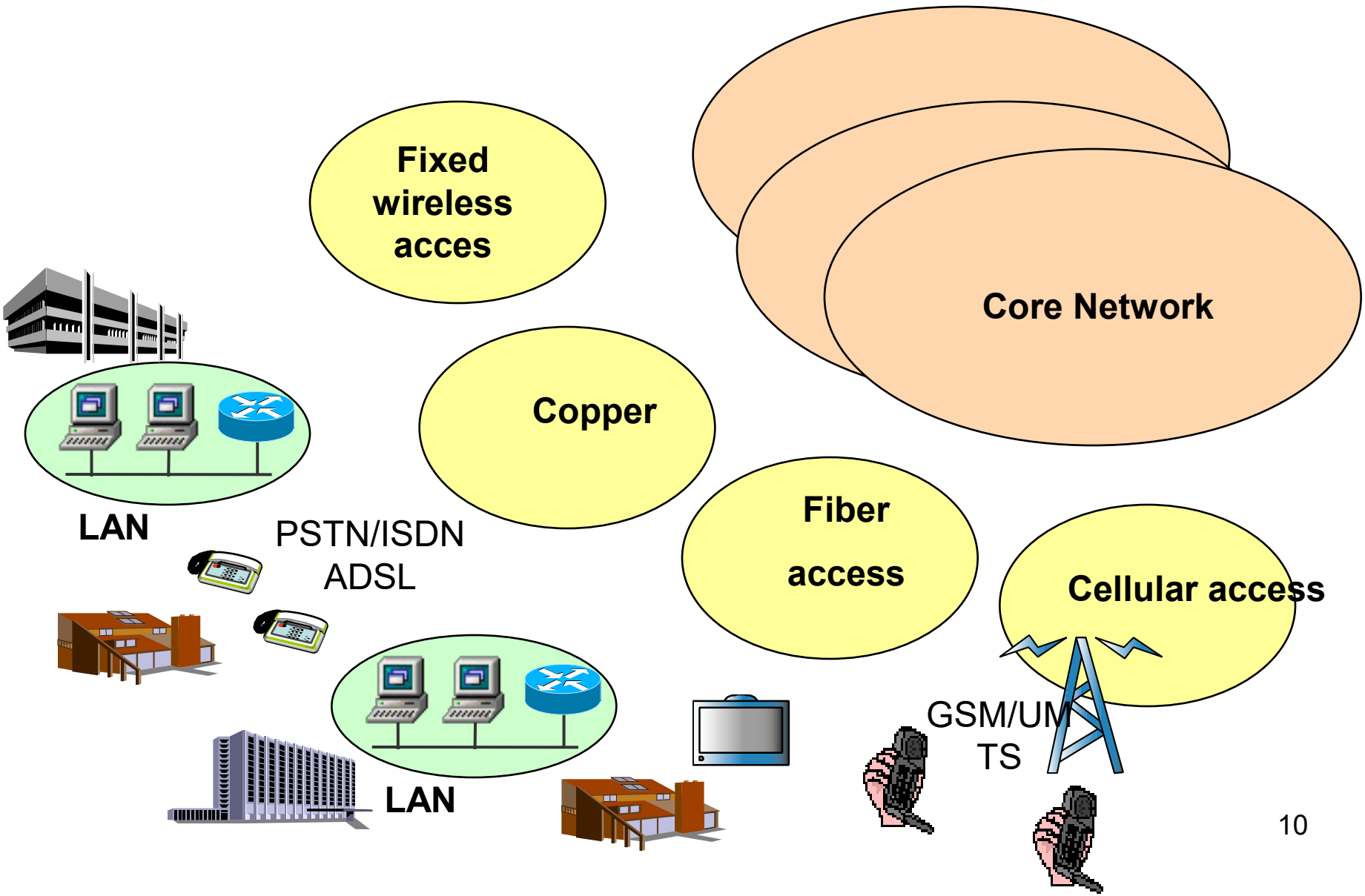
9. 5G Access

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

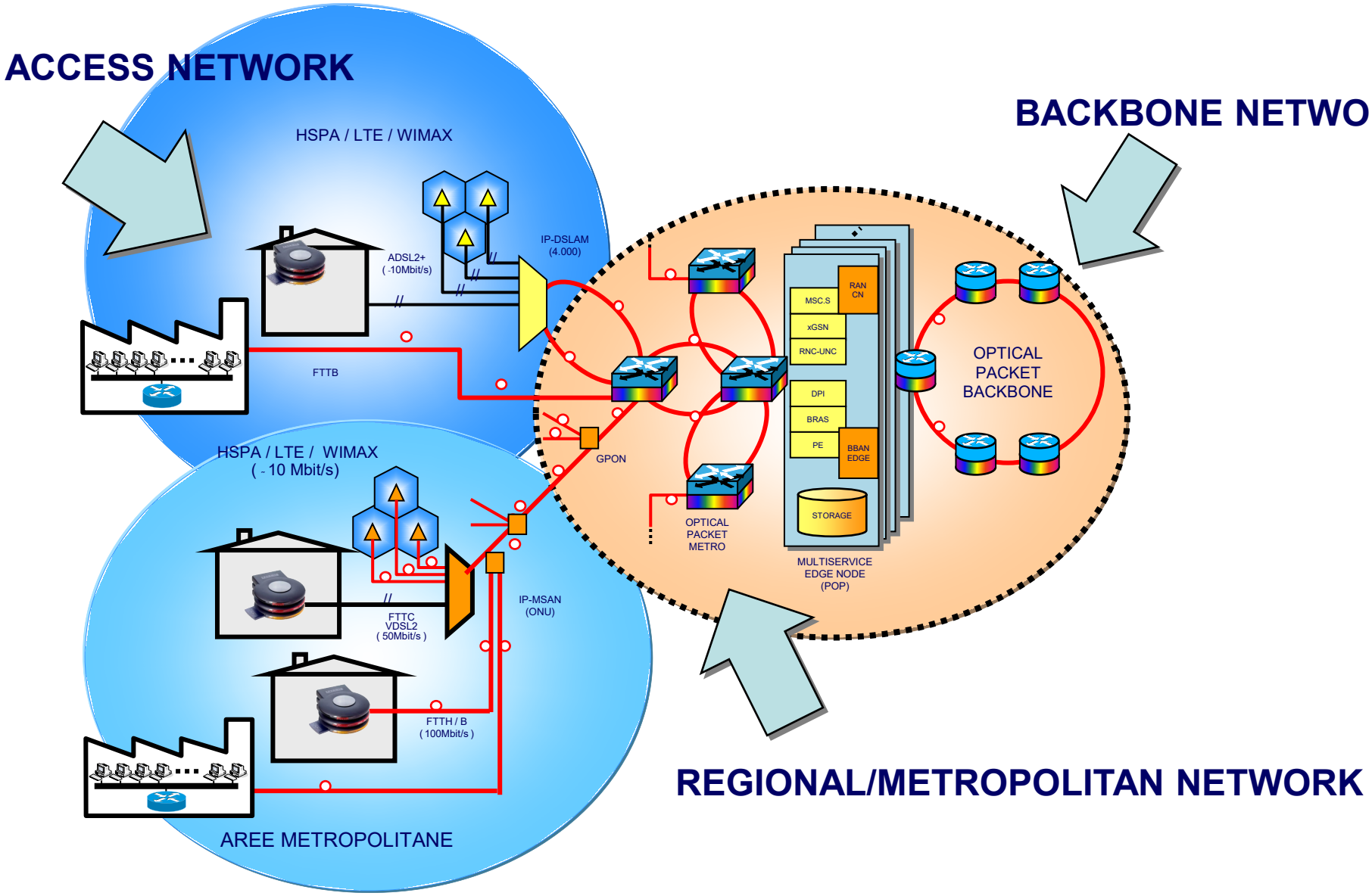
•*Advantages:* Ultra-fast, supports IoT and AR/VR.

•*Use Cases:* Emerging applications, smart cities.

Access / Core network

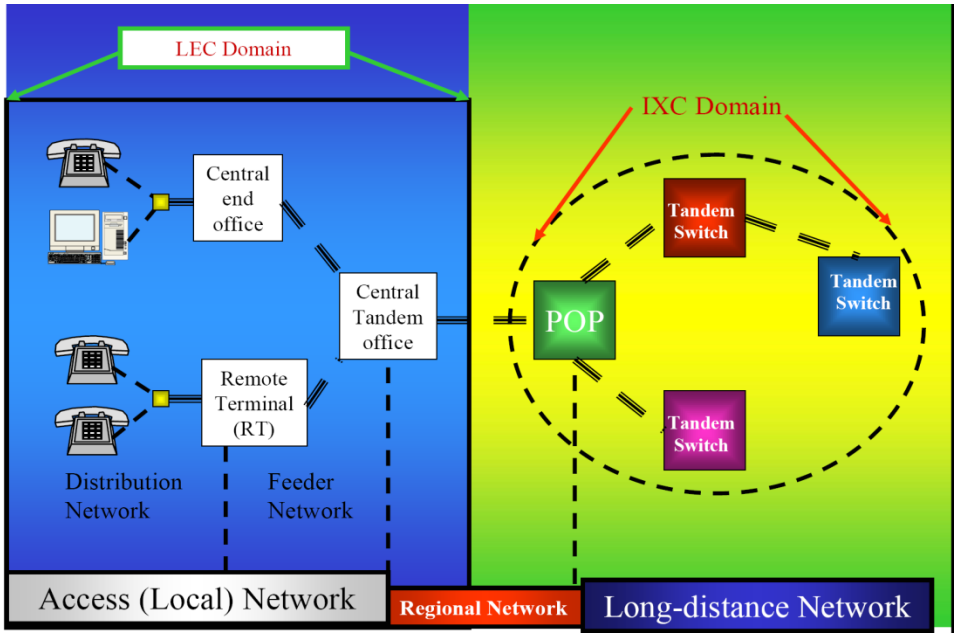


An example: Telecom Italia



Past 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

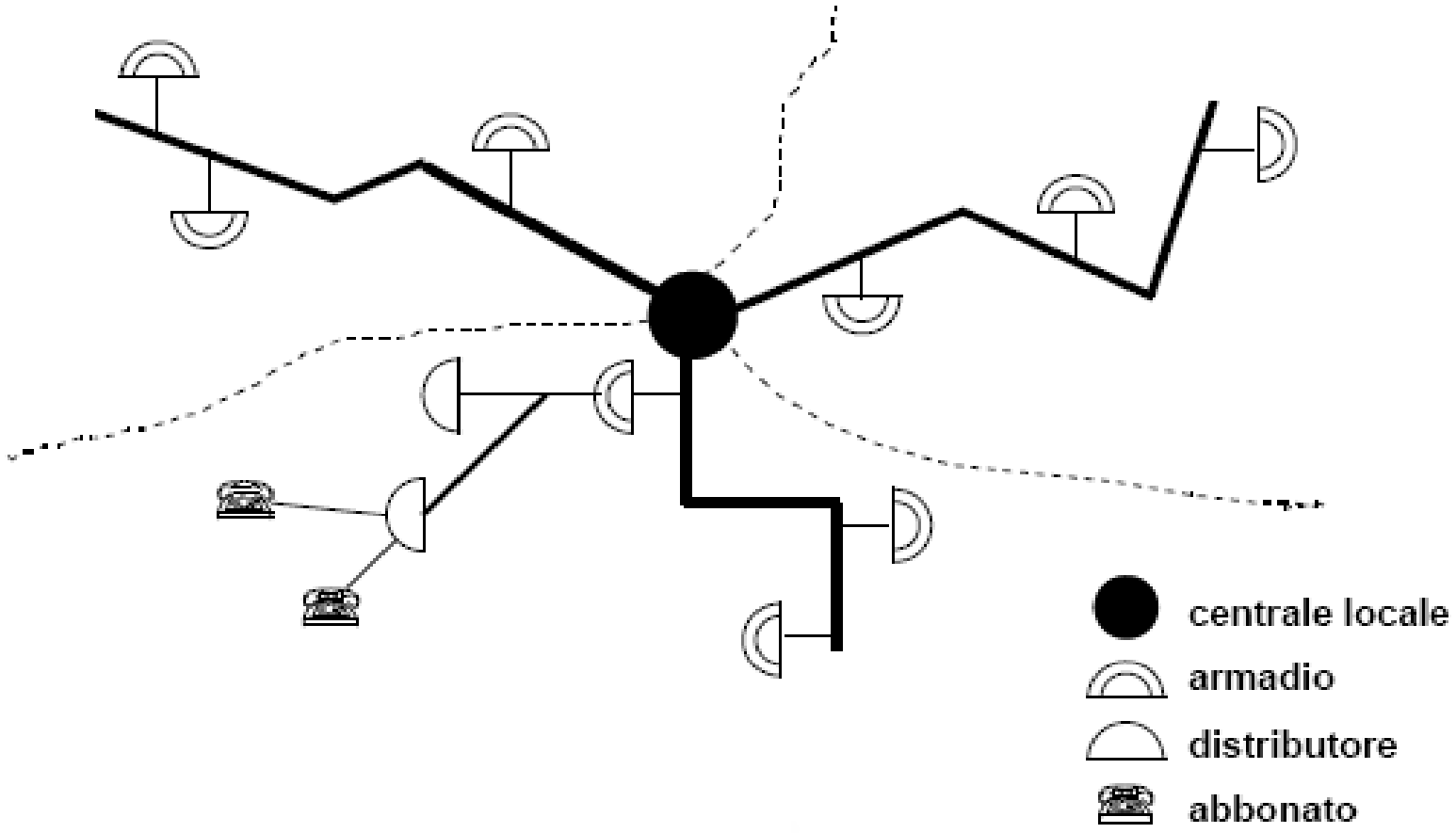


Some examples

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



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

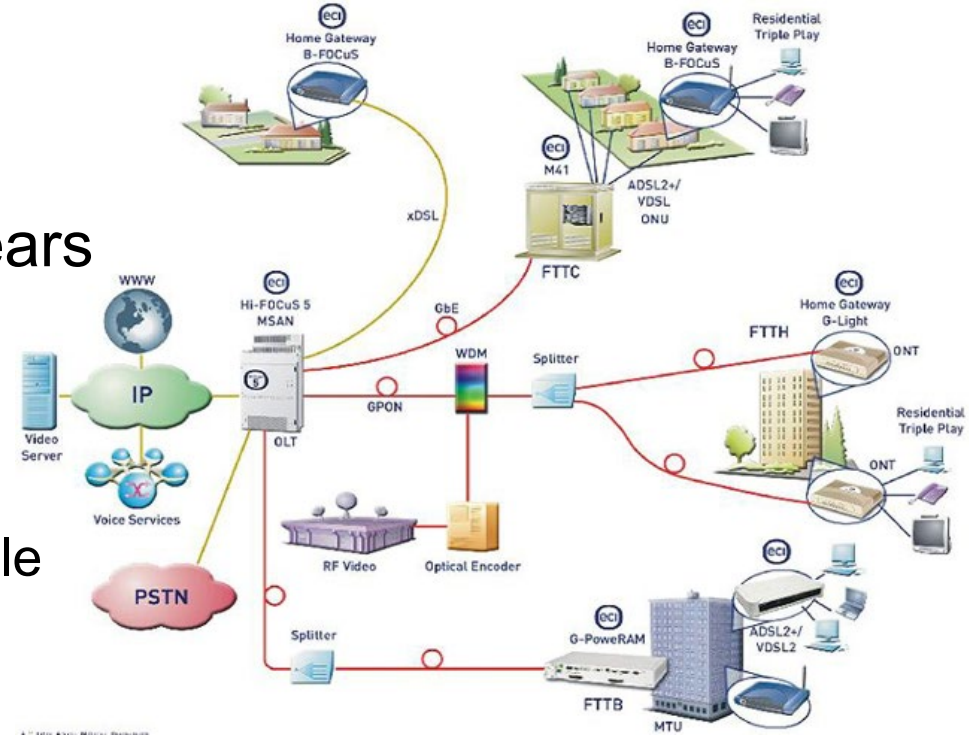
- Copper access :
  - This domain provides both high-speed broadband and existing phone service.
    - » ADSL and VDSL solutions that support high-speed broadband service
    - » phone migration solutions that can deliver existing phone service quality as a key infrastructure even as it evolves toward 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.



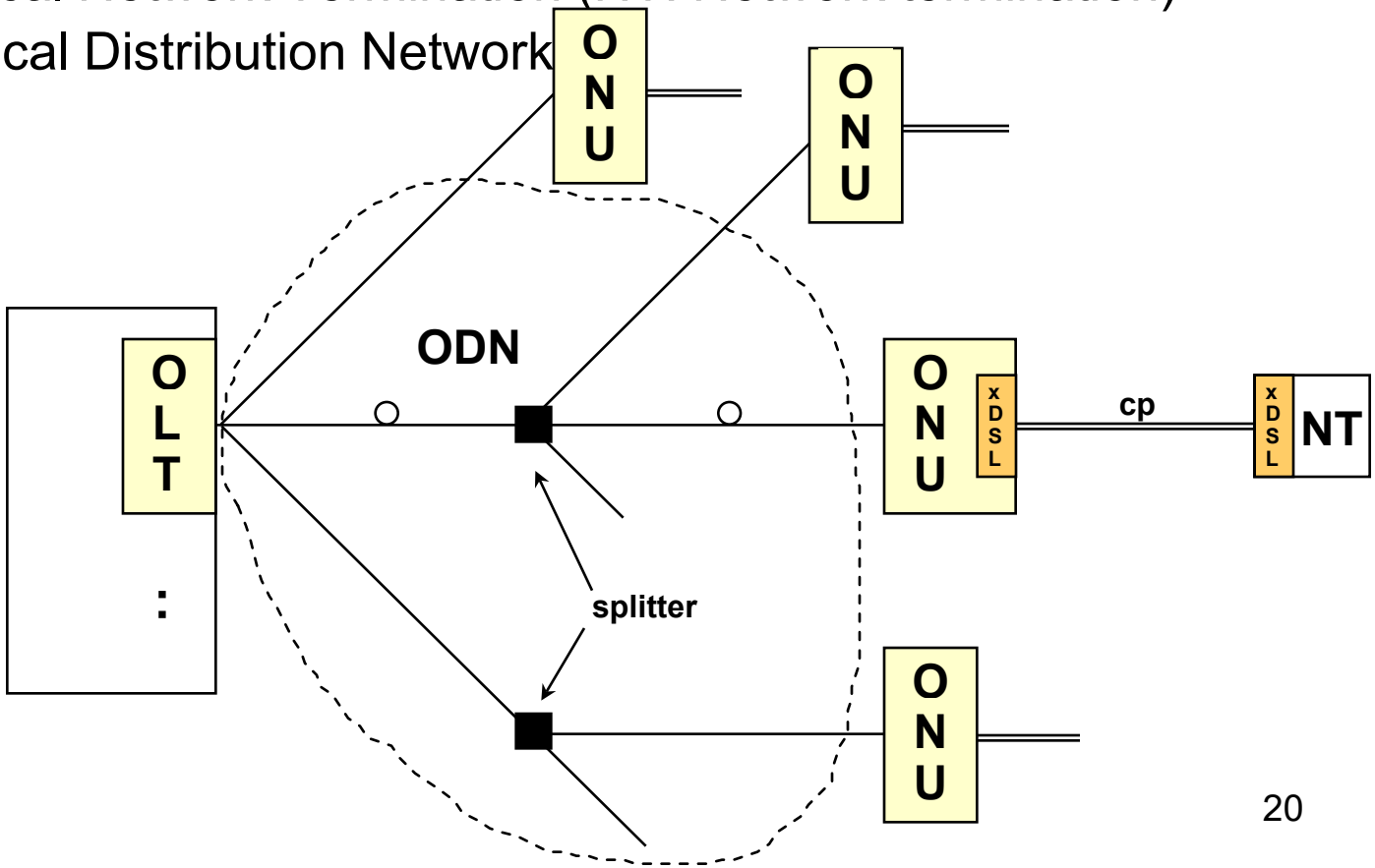
GE: Gigabit Ethernet
PON: Passive Optical Network
COF: Code Division Multplexing over Fiber

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

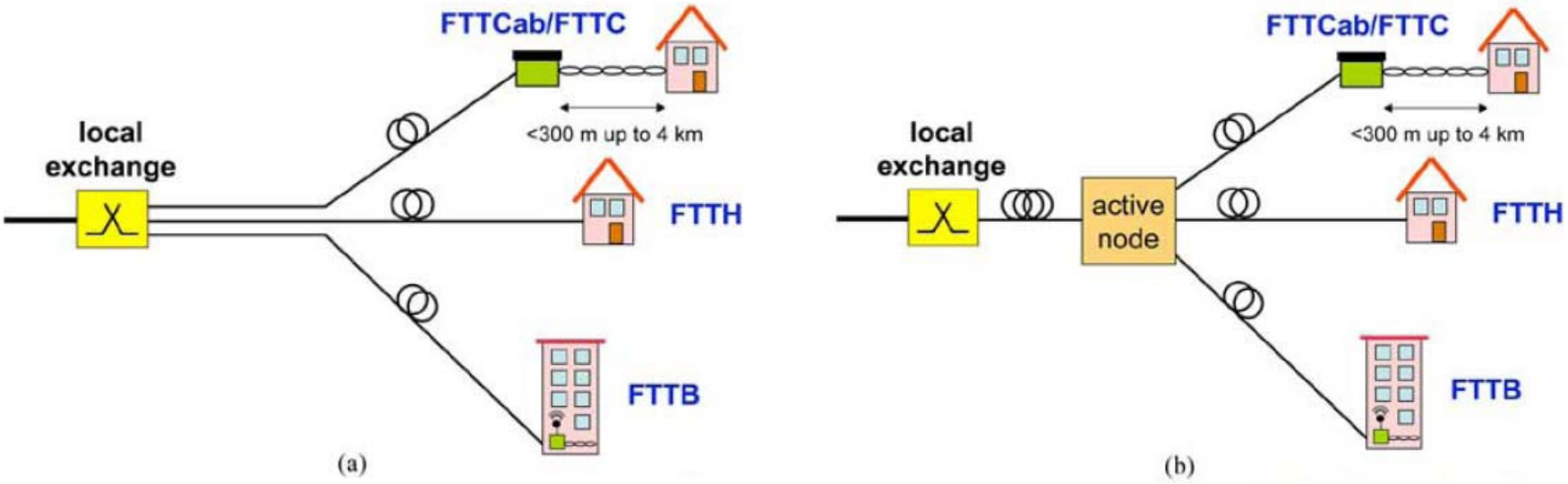
FTTx: reference architectures

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



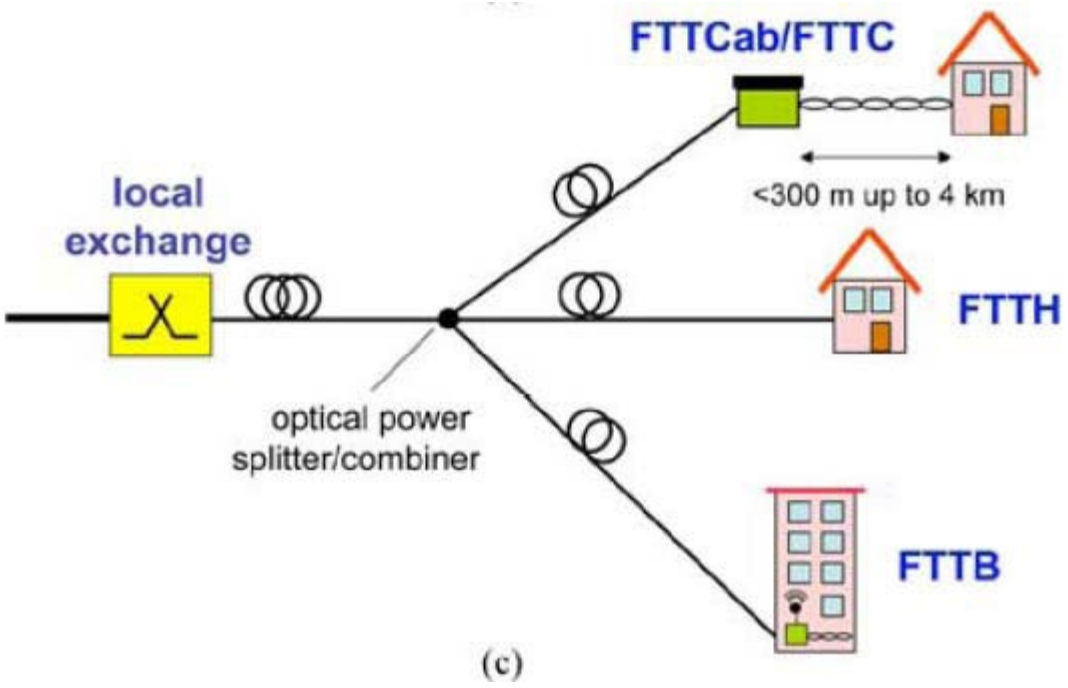
FTTx: reference architectures

- **AON (Active Optical Network),** *also called Point-to-Point (P2P)*



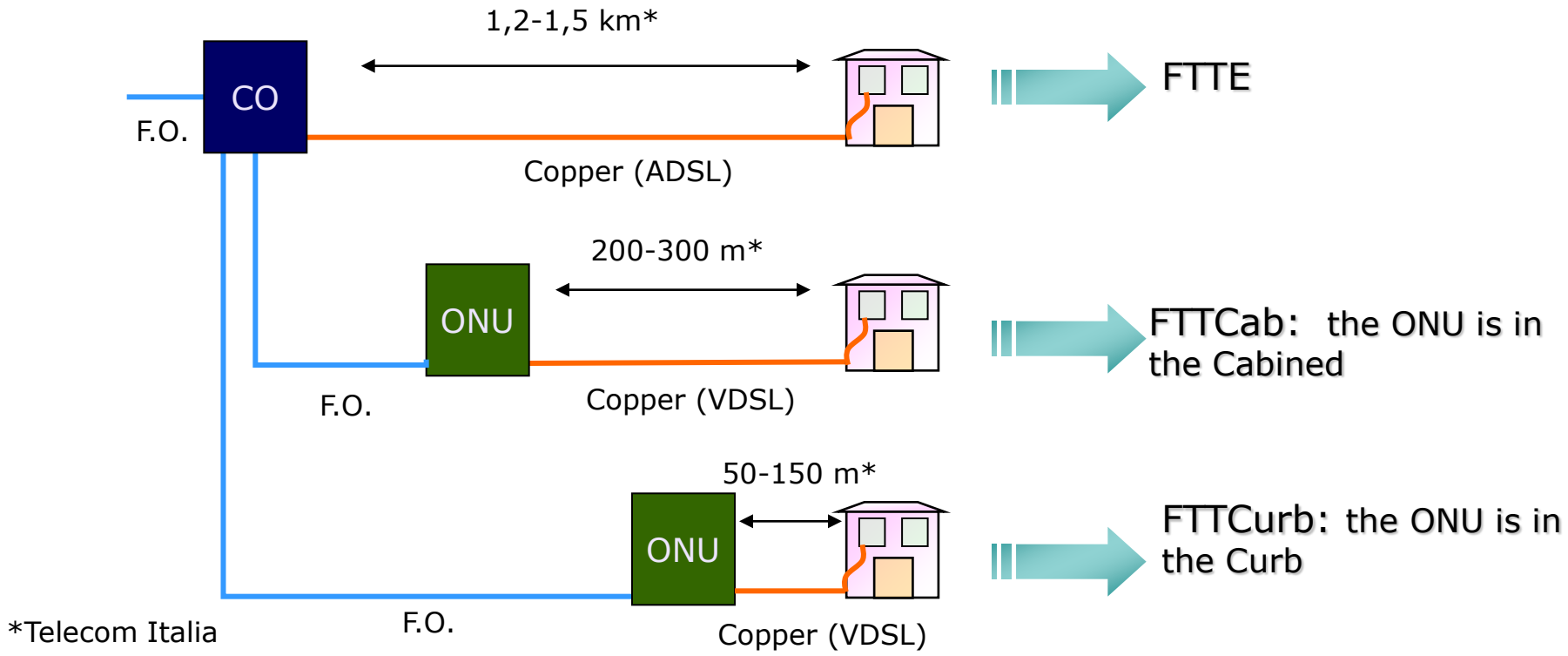
FTTx: reference architectures

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



FTTx

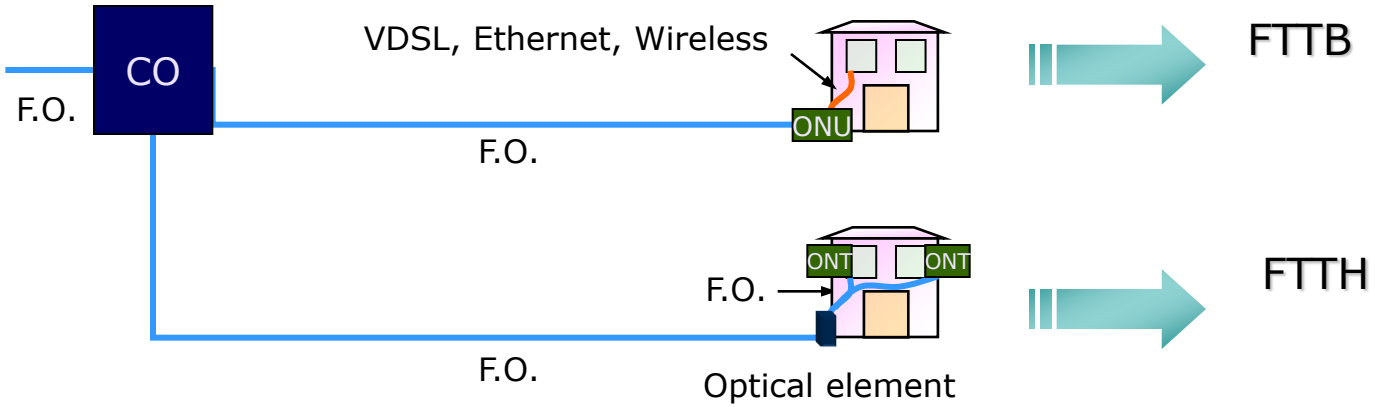
- **Fiber to the Exchange:** the optical fiber terminates to the Central Office (CO) and the CO is connected with the user via a copper based line (e.g., ADSL)



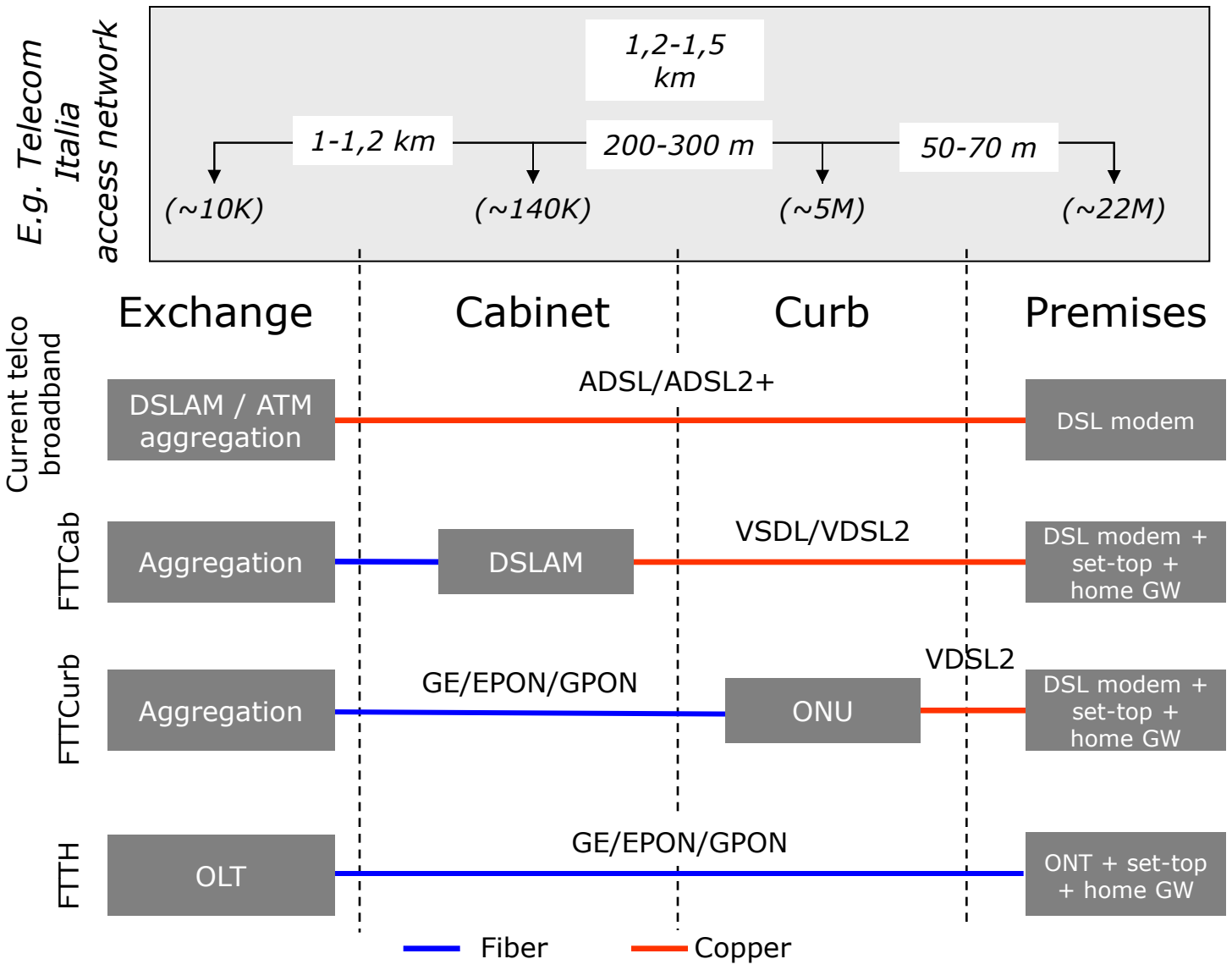
Cub/Curb – Distribution network

FTTP/FTTB/FTTH

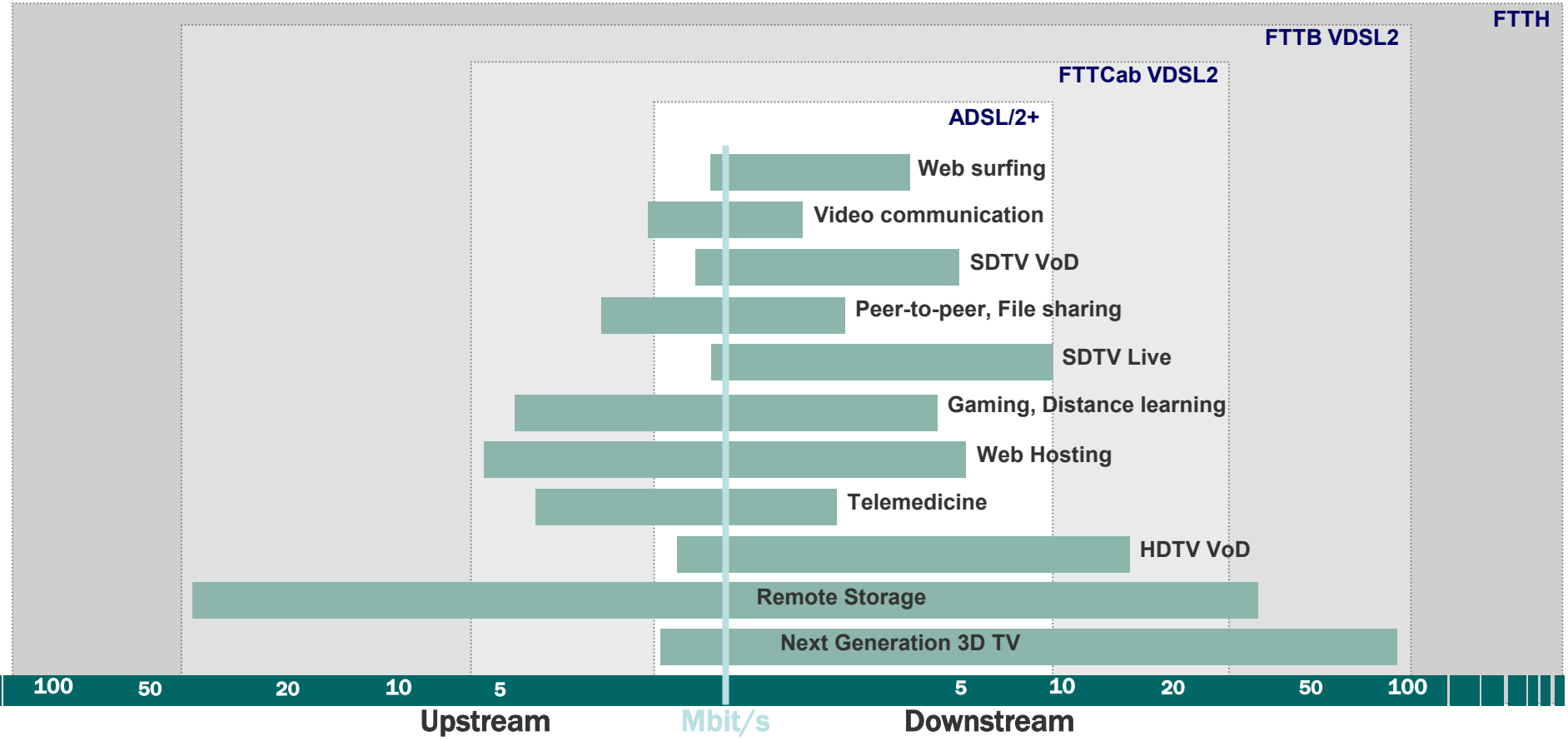
- **Fiber to the Premises** the fiber cables arrive to the users'premises
  - **Fiber to the Building**
  - **Fiber to the Home**



Wireline access

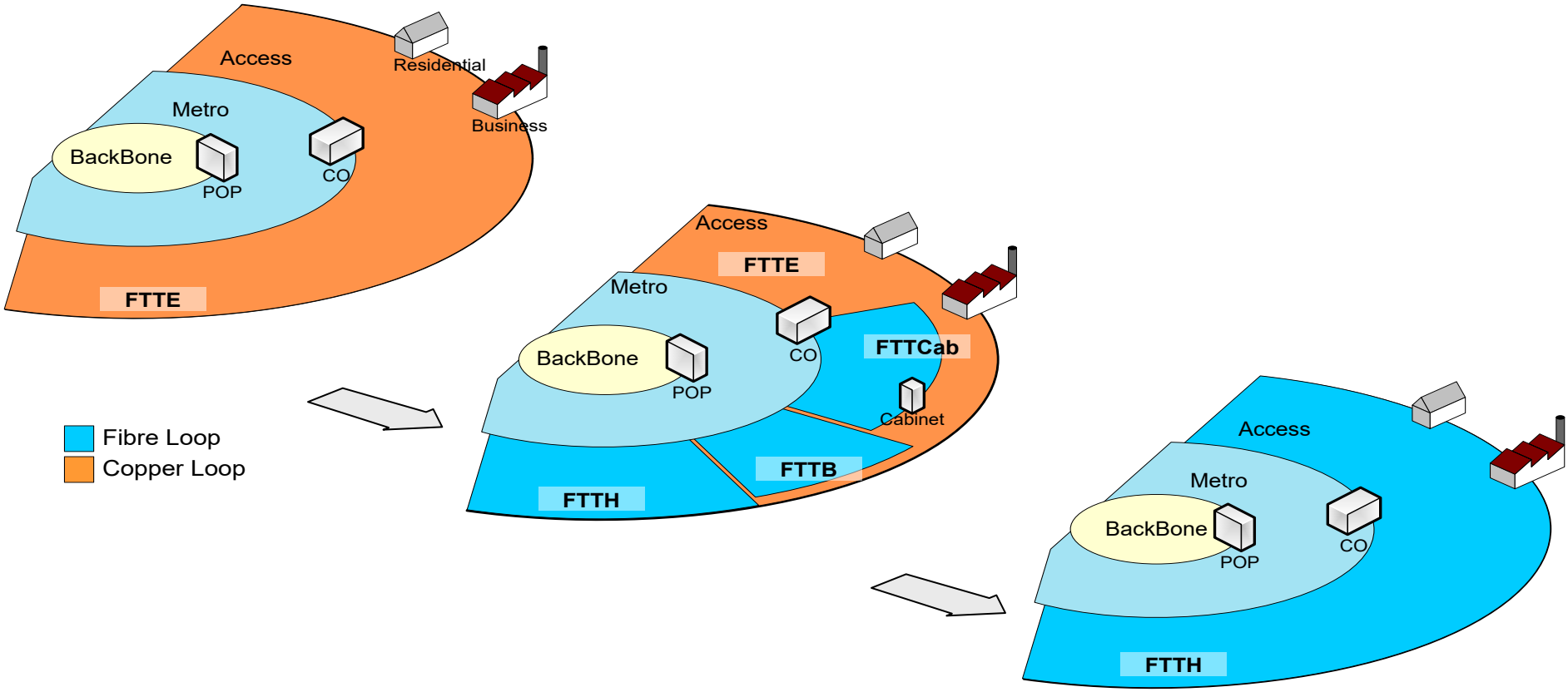


Bandwidth requirements



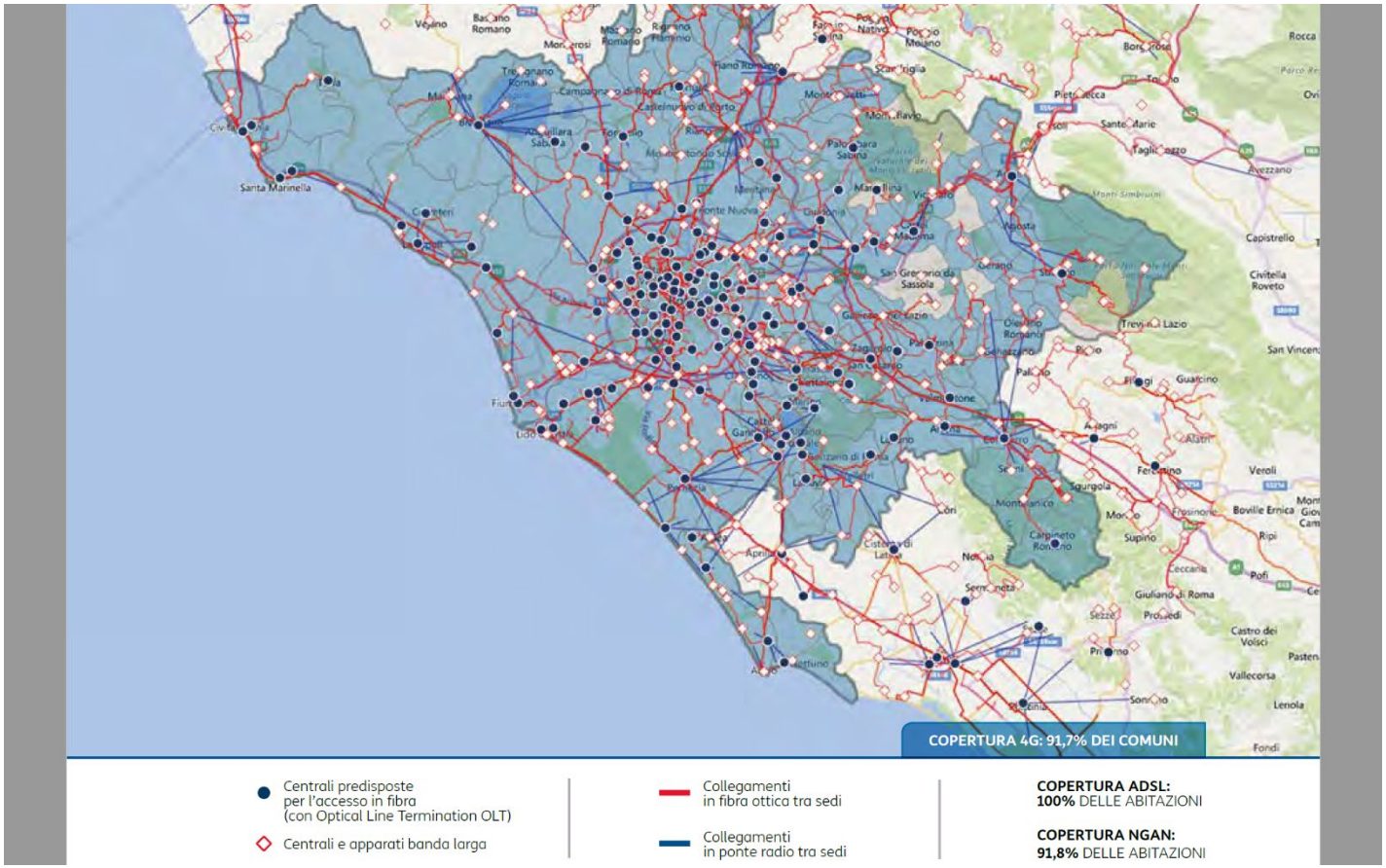
Source:Telecom Italia

Fiber based access network



Numbers today

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

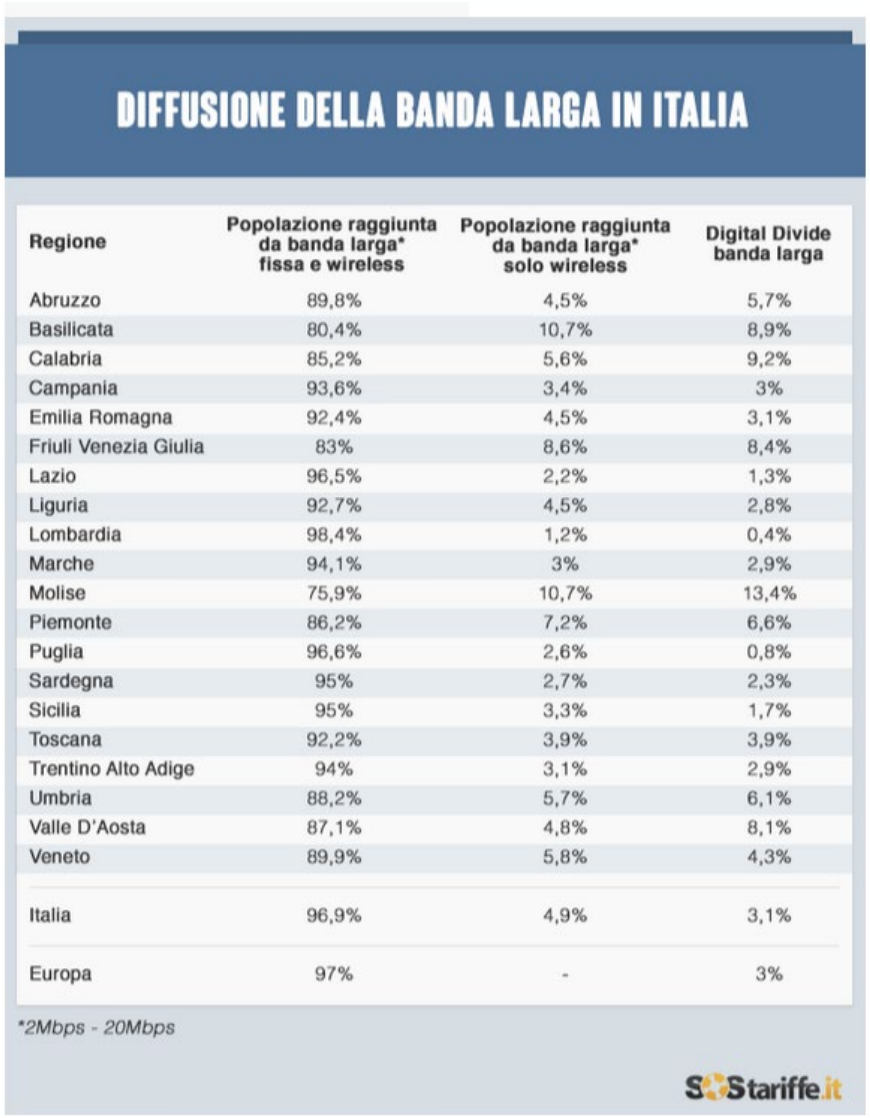


Broadband access Italy 2024

https://www.fibercop.it/en/

https://bandaultralarga.italia.it/

https://rete.gruppotim.it/



DIFFUSIONE DELLA BANDA LARGA IN ITALIA

Regione	Popolazione raggiunta da banda larga* fissa e wireless	Popolazione raggiunta da banda larga* solo wireless	Digital Divide banda larga
Abruzzo	89,8%	4,5%	5,7%
Basilicata	80,4%	10,7%	8,9%
Calabria	85,2%	5,6%	9,2%
Campania	93,6%	3,4%	3%
Emilia Romagna	92,4%	4,5%	3,1%
Friuli Venezia Giulia	83%	8,6%	8,4%
Lazio	96,5%	2,2%	1,3%
Liguria	92,7%	4,5%	2,8%
Lombardia	98,4%	1,2%	0,4%
Marche	94,1%	3%	2,9%
Molise	75,9%	10,7%	13,4%
Piemonte	86,2%	7,2%	6,6%
Puglia	96,6%	2,6%	0,8%
Sardegna	95%	2,7%	2,3%
Sicilia	95%	3,3%	1,7%
Toscana	92,2%	3,9%	3,9%
Trentino Alto Adige	94%	3,1%	2,9%
Umbria	88,2%	5,7%	6,1%
Valle D'Aosta	87,1%	4,8%	8,1%
Veneto	89,9%	5,8%	4,3%
Italia	96,9%	4,9%	3,1%
Europa	97%	-	3%

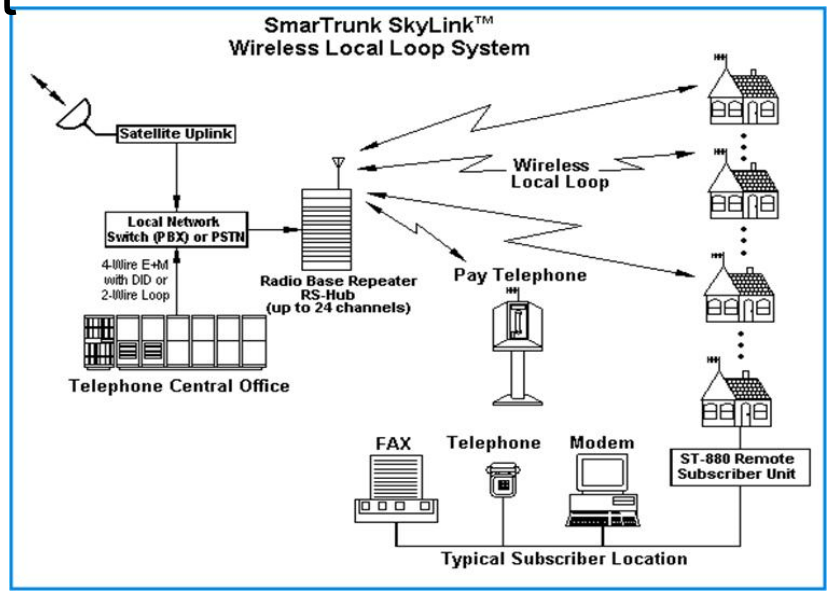
*2Mbps - 20Mbps

SoStariffe.it

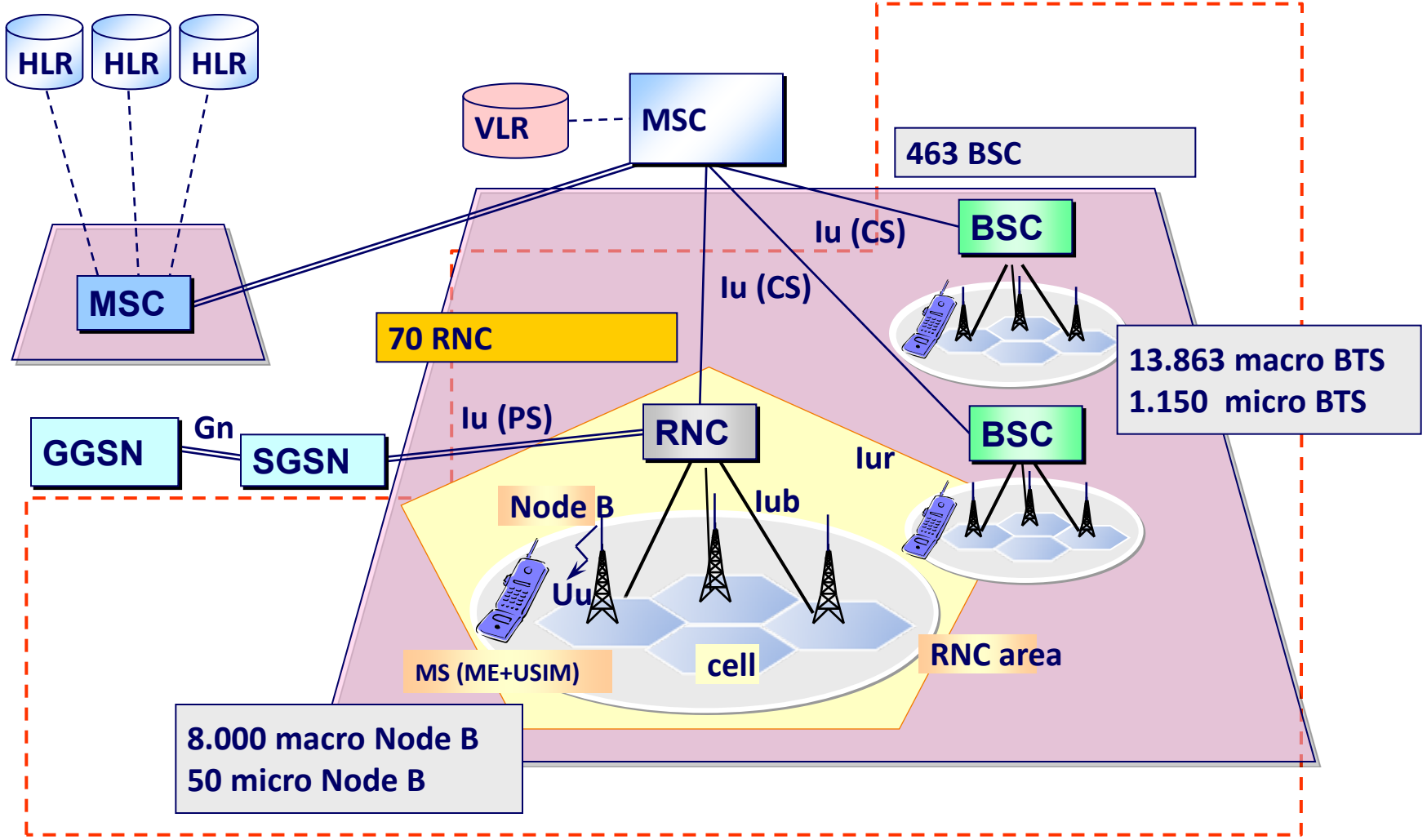
Broadband access Italy 2024

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

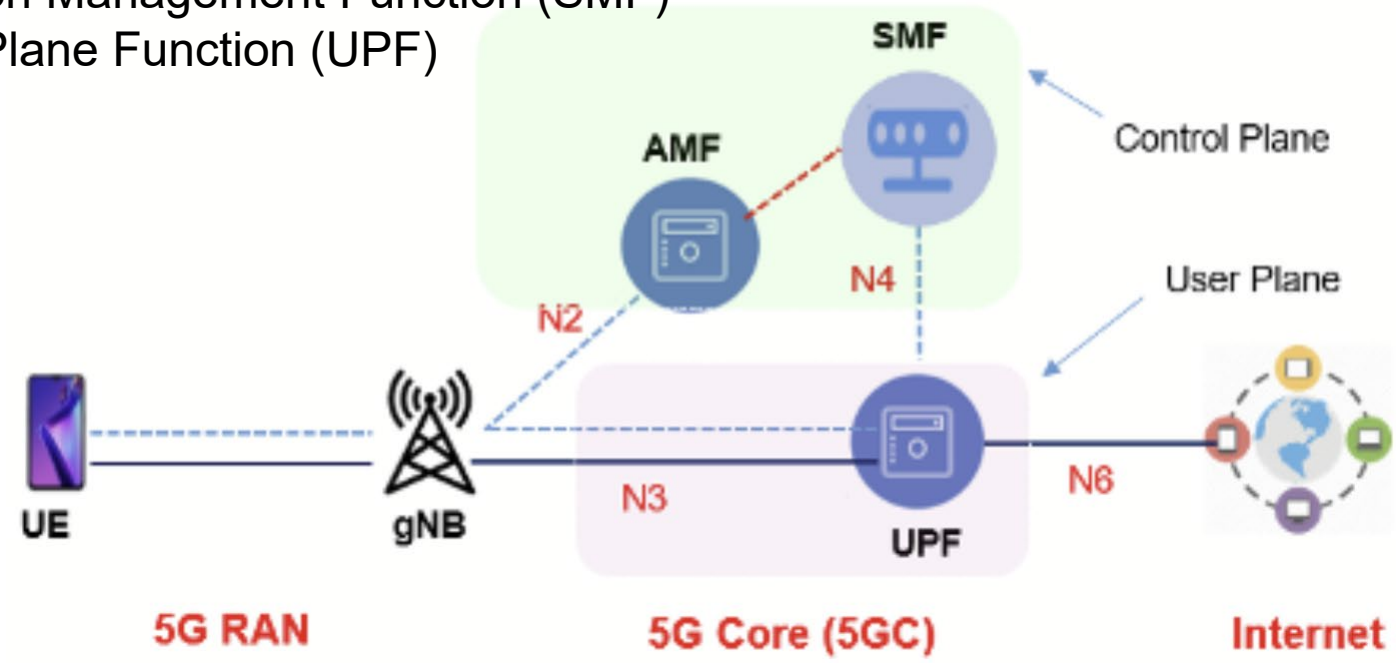


2G and 3G architecture



5G network

- User Equipment (UE)
- Access and Mobility Management Function (AMF)
- Session Management Function (SMF)
- User Plane Function (UPF)



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

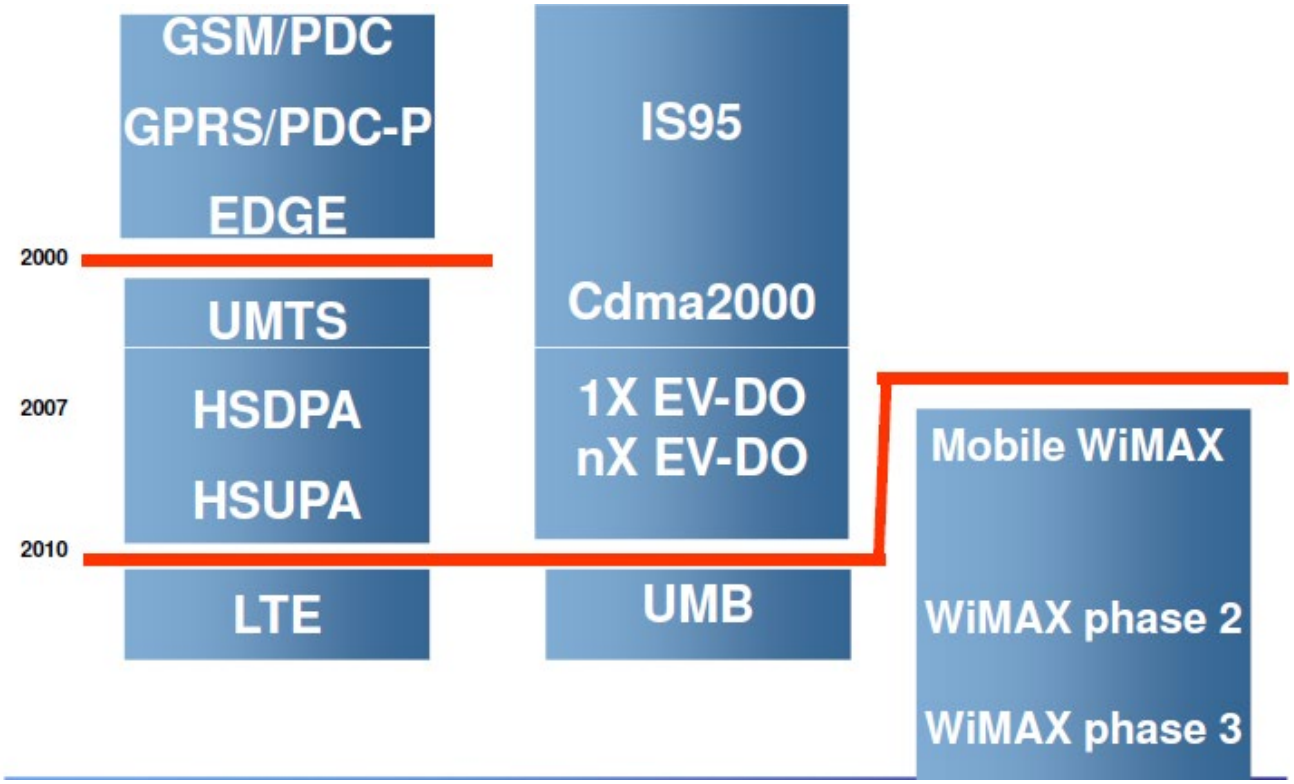
	Quantità	Unità misura
Siti per antenne UMTS	8.030	Siti dei tralicci
Stazioni radio - Nodi B	8.030	Numero stazioni radio
Controllori stazione RNC	70	Numero di RNC
Celle	22.094	Numero di celle
Canali	834.752	Numero di canali
Frequenze	10 (2100 MHz)	MHz

Coverage mobile networks Italy

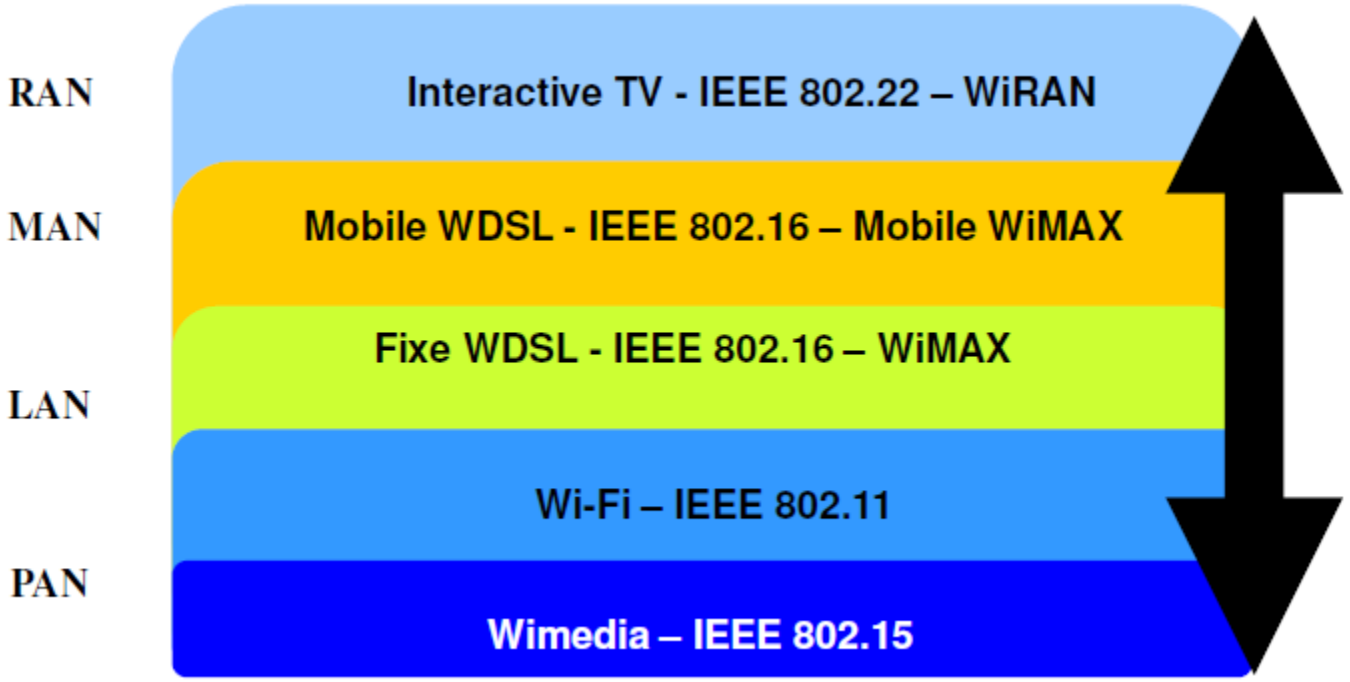
- https://www.tim.it/fisso-e-mobile/mobile/mappa-copertura-mobile

- https://www.opensignal.com/coverage-maps
- (How it works? Try to use with the APP)

Wireless Access: cont'd

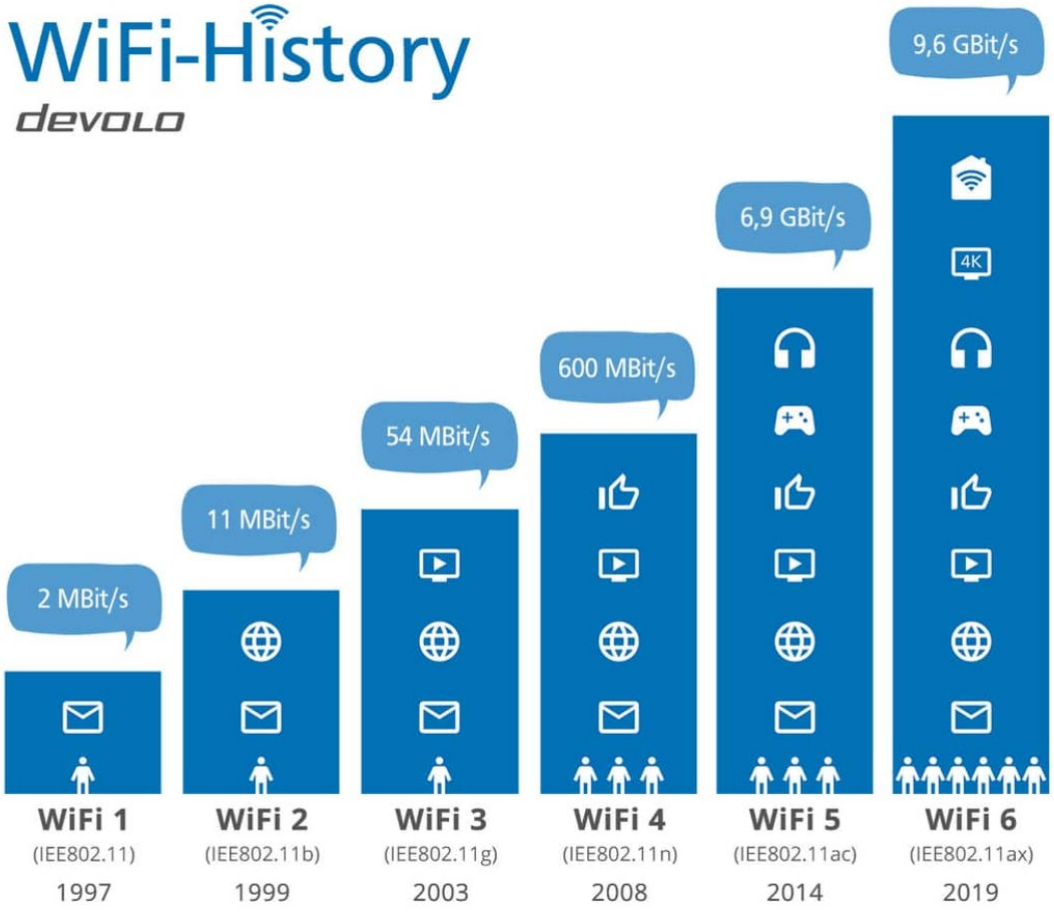


Wireless Access: cont'd



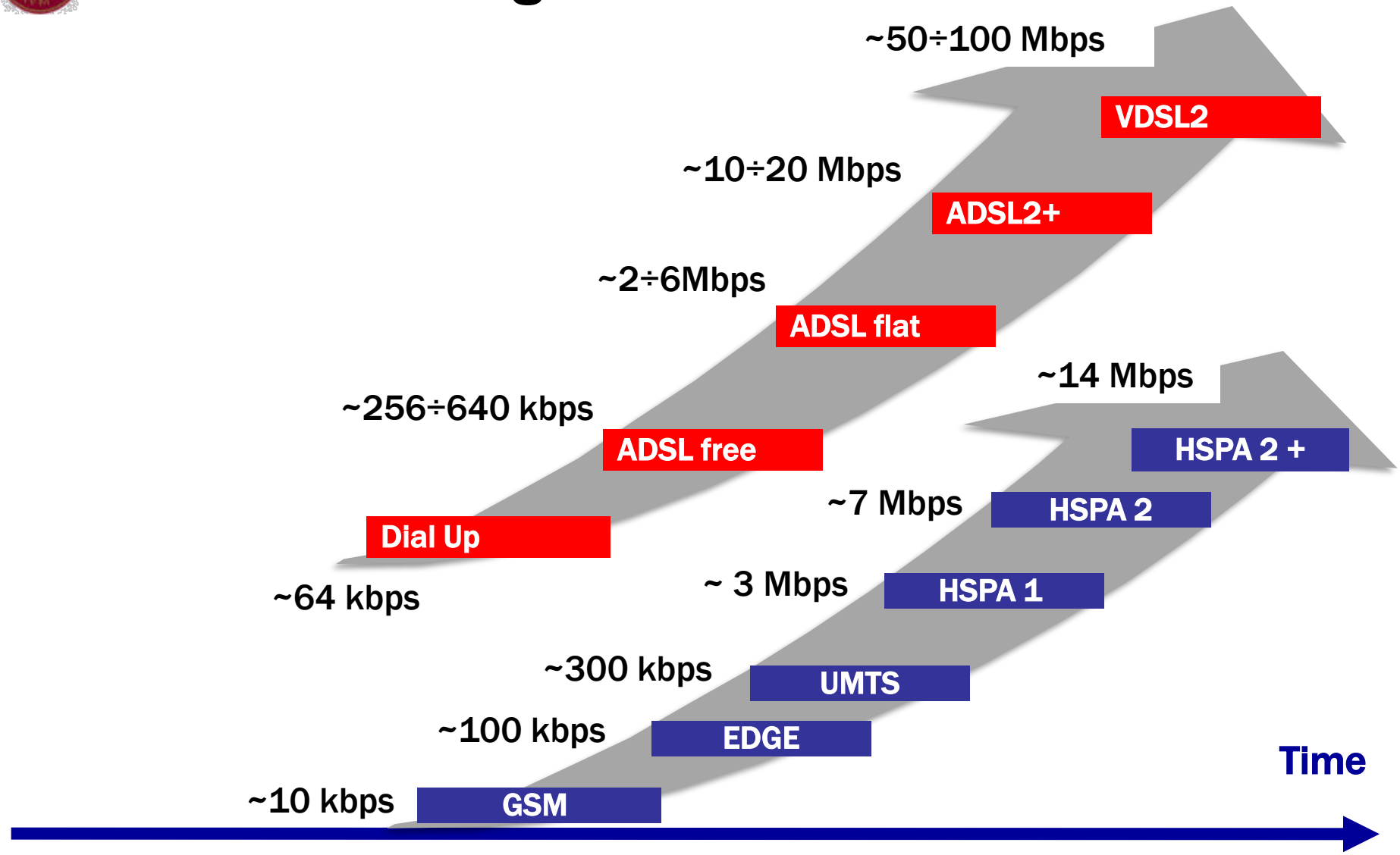
- As ubiquitous service-anytime, anywhere, anyone-becomes the norm, demand for technologies such as conventional cellular phone service and wireless LAN access is being augmented by an increasingly noticeable desire for mobile high-speed broadband service and otherwise seamless communications

Evolution of Wi-Fi



https://www.devolo.co.uk/technology/wifi-6-functions-benefits-ax

Techologies and bandwidths



Backbone: the logical topology

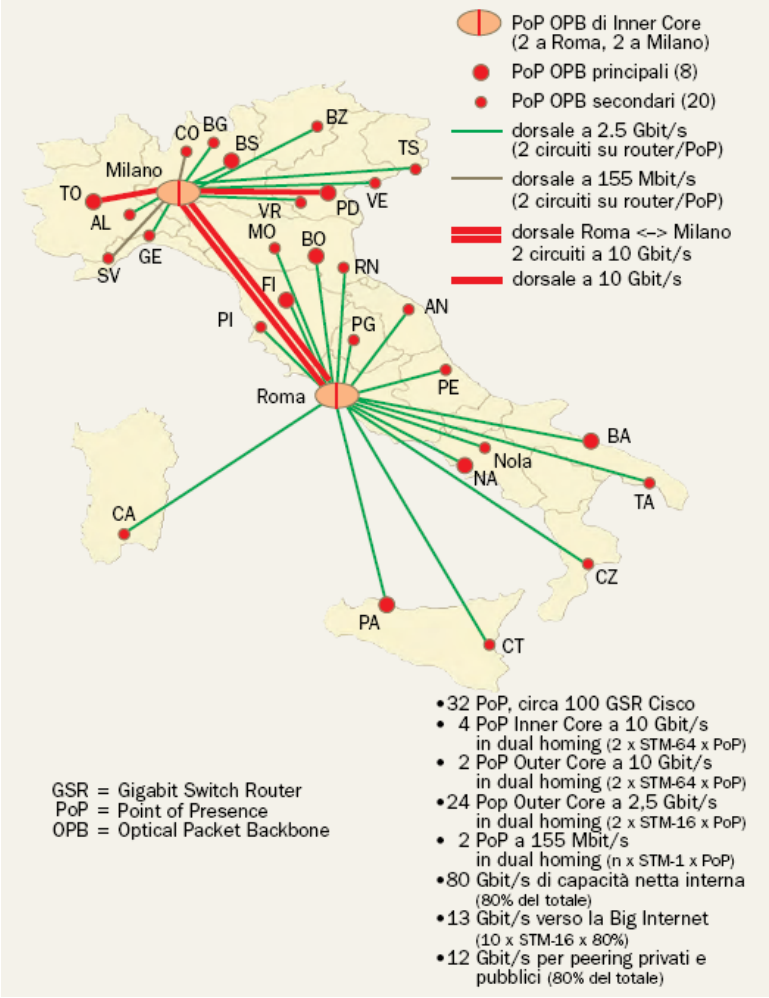
OPB (Optical Packet Backbone)

•32 PoP

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

•Outer Core: 28 PoP

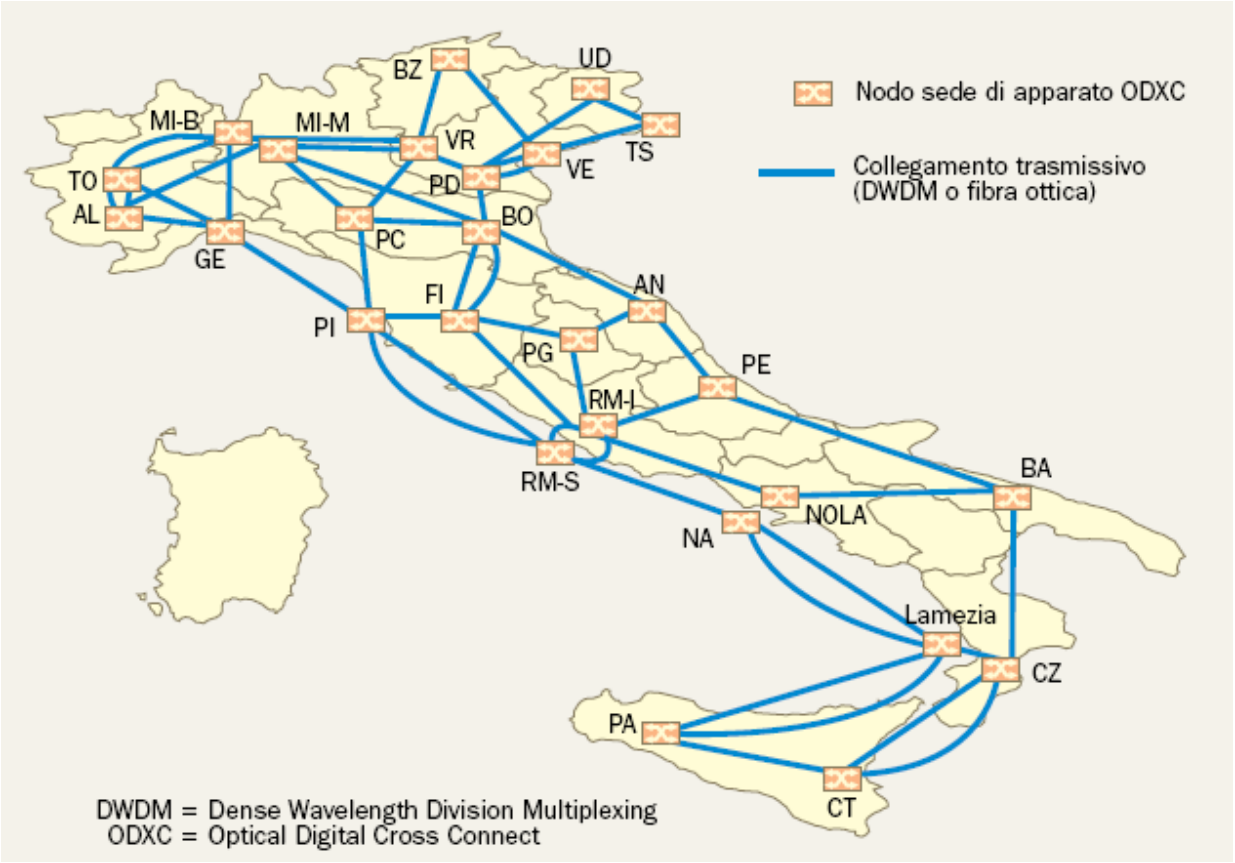
•Inner Core: 10 Gbit/s (STM-
•64)
•Outer Core: 10 Gbit/s (STM-64),
•2,5 Gbit/s (STM-16) and 155 Mbit/s (STM-1)
• Link used at 50%



Source: Telecom Italia

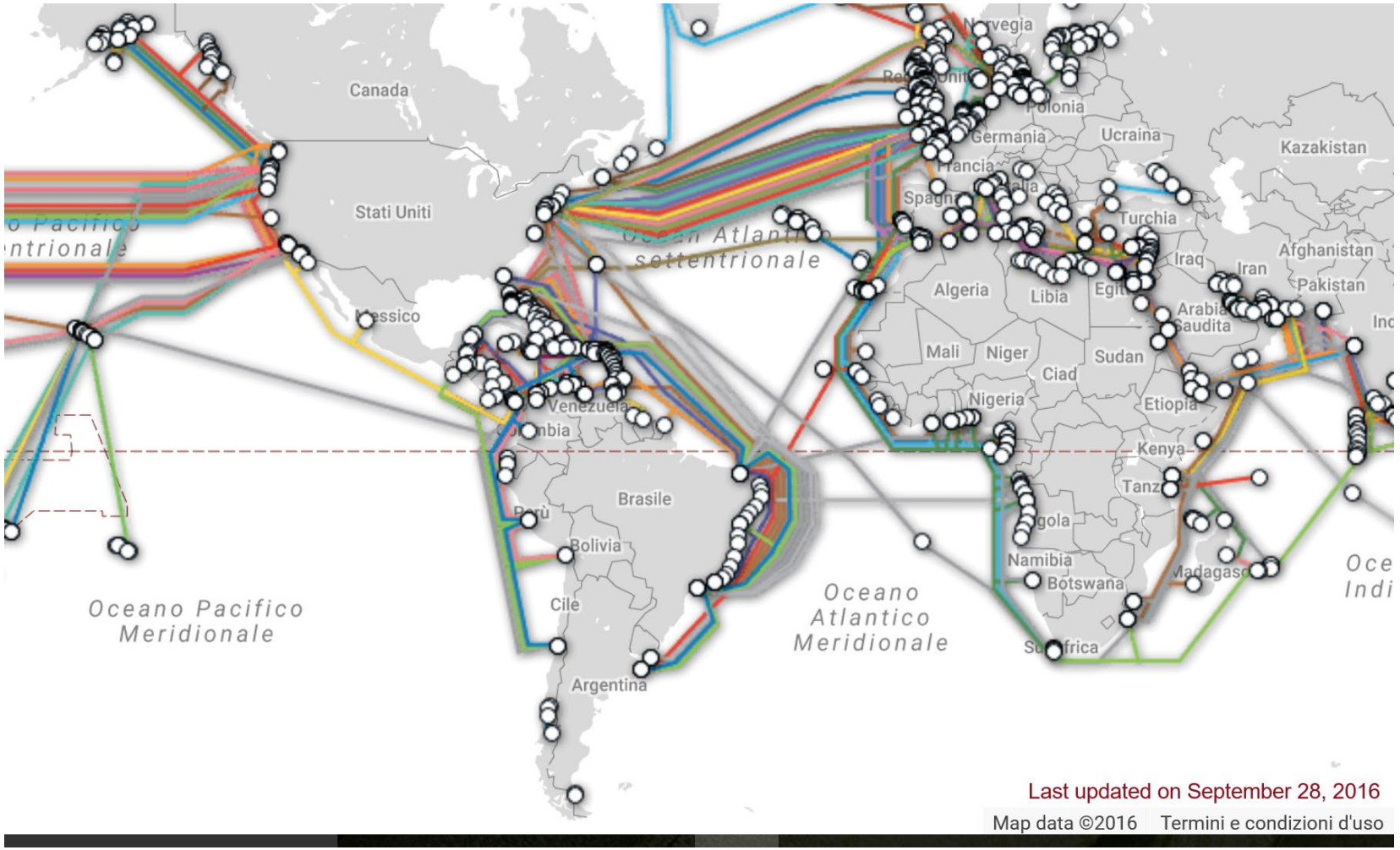
Backbone: the physical topology

Physical network build up on the Optical Transport Network

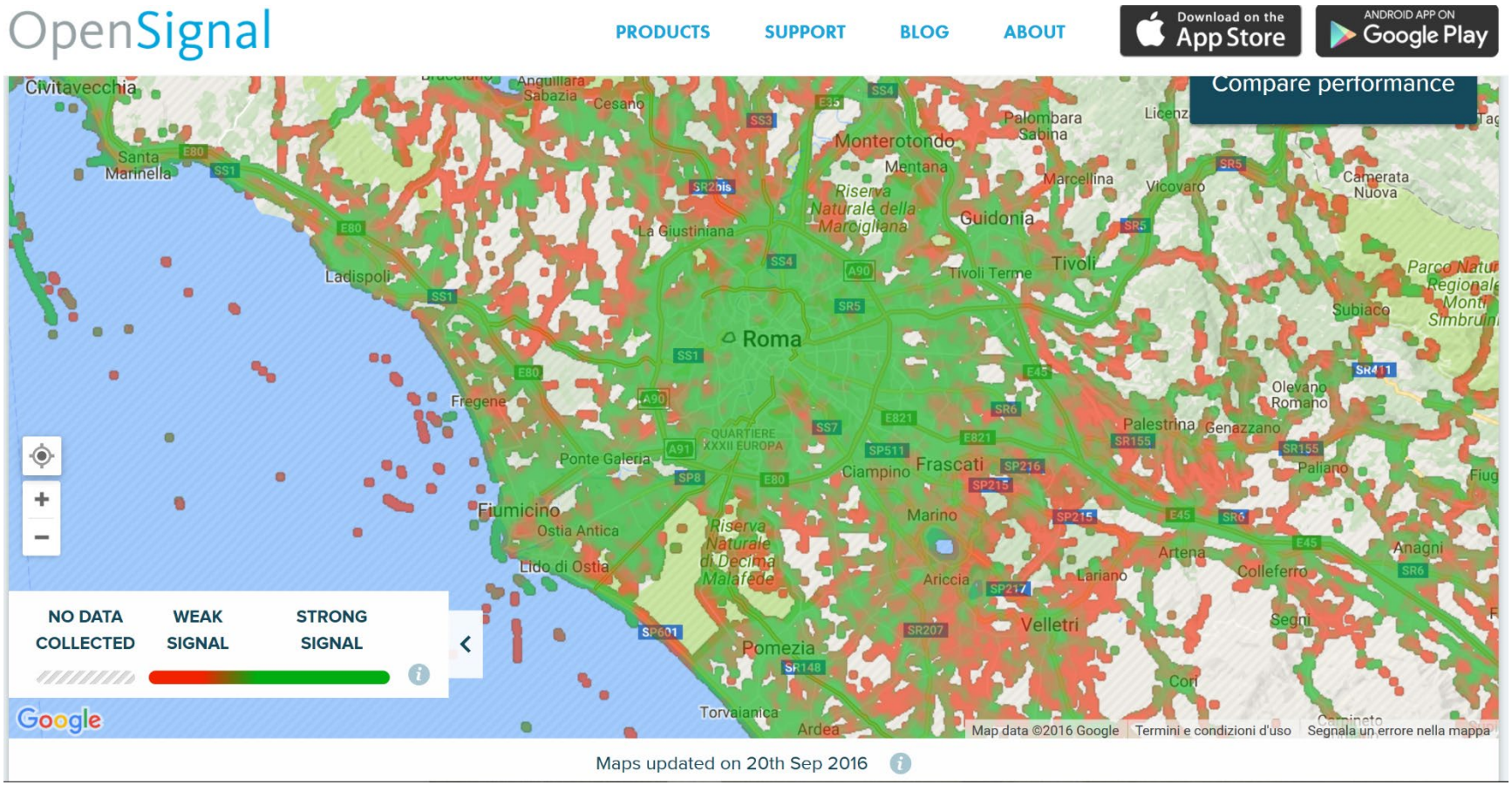


Source: Telecom Italia

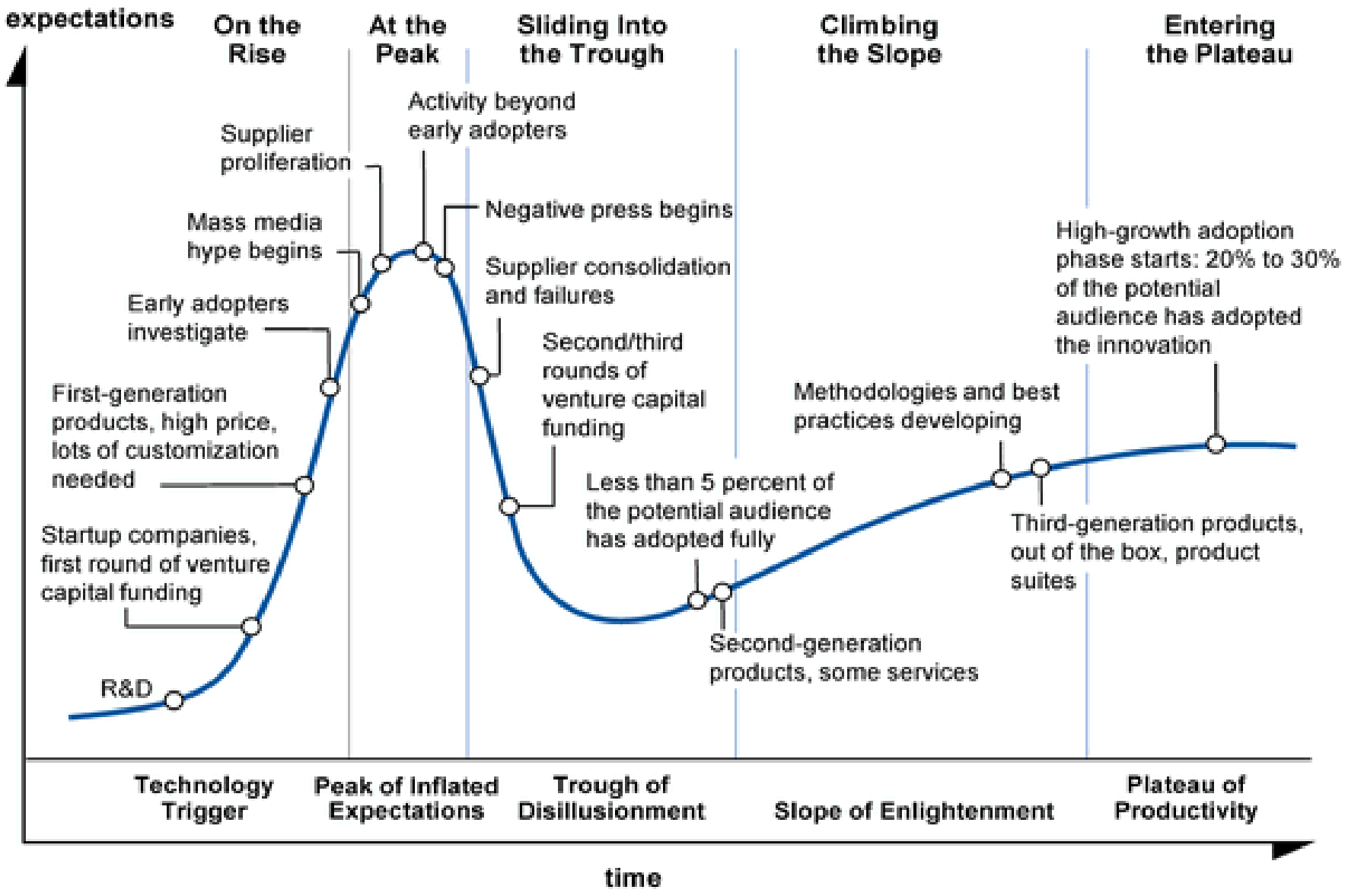
Examples of network infrastructures (http://www.submarinecablemap.com/)



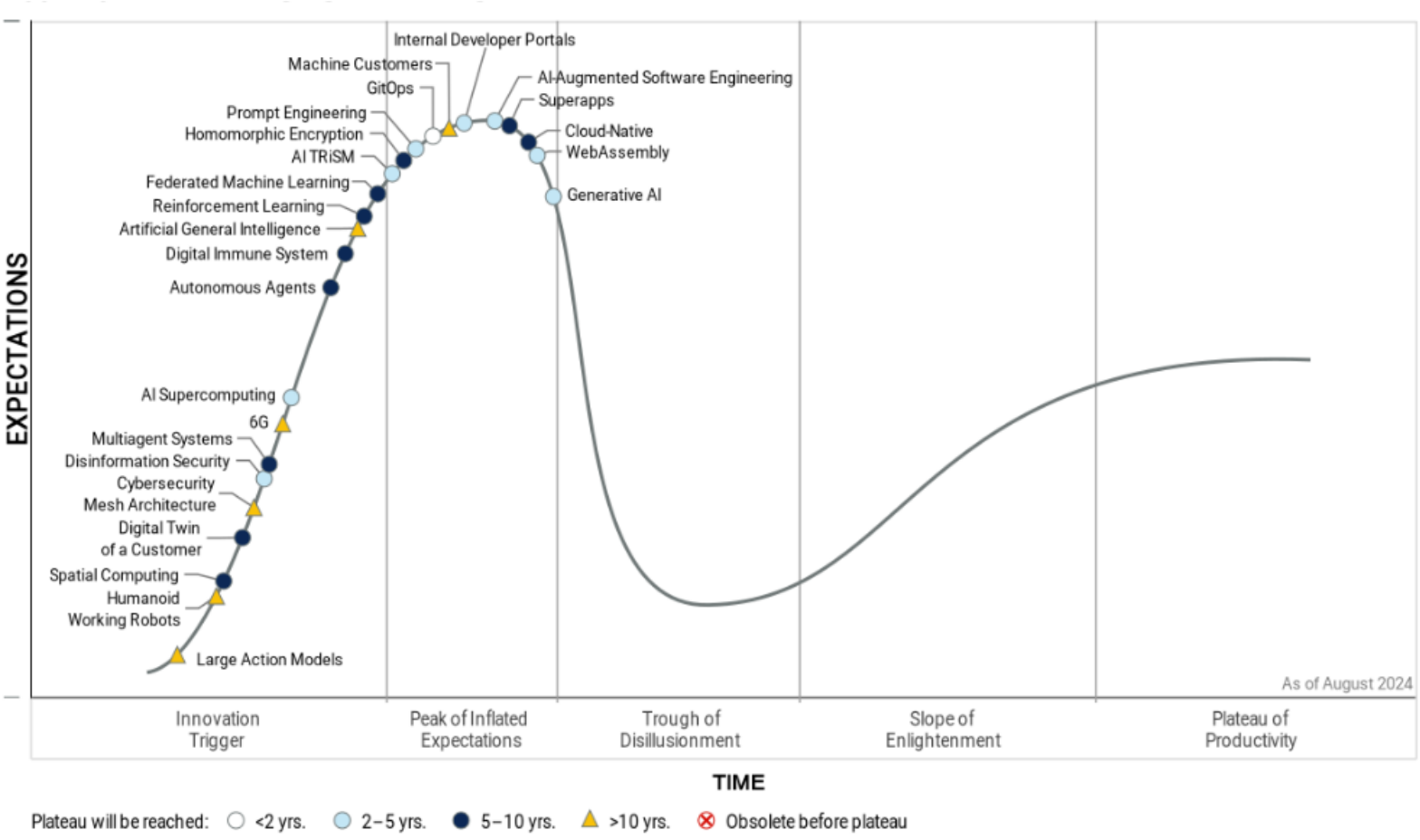
Examples of network infrastructures (http://opensignal.com/coverage-maps/Italy/



Gartner hype cycle



Gartner 2024 Hype Cycle for Emerging Technologies



Gartner