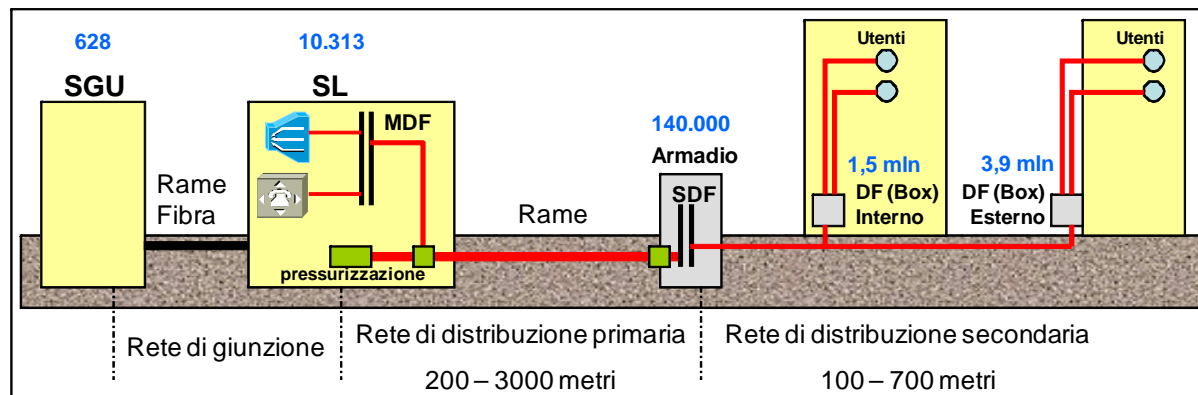


Next Generation Access Network

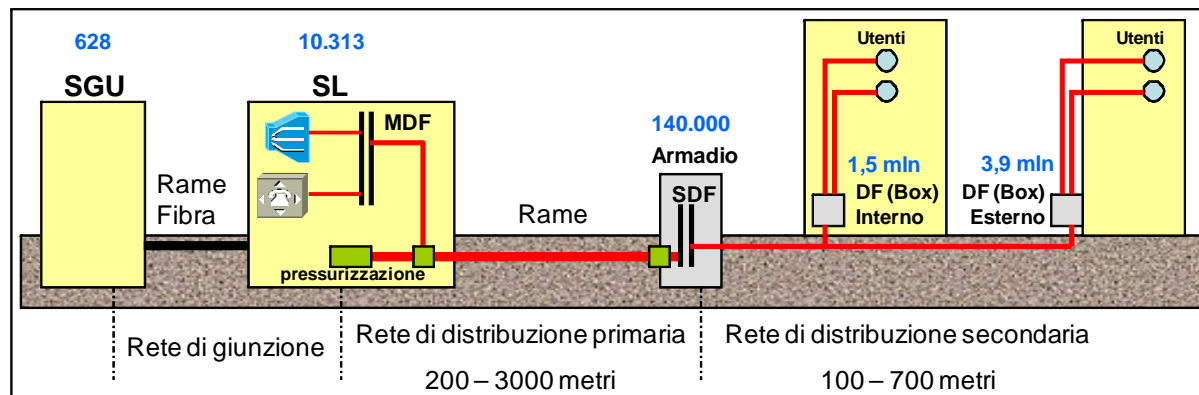
Current Italian Copper Access Network

- The current copper access network in Italy has 10.313 *Central Offices* (CO) connected through the backhaul network to 628 local exchanges (*Stadi di Gruppo Urbano* (SGU))
- Central Offices are equipped with *Main Distribution Frames*, MDF, they are permutators connecting physically copper twisted pairs of users



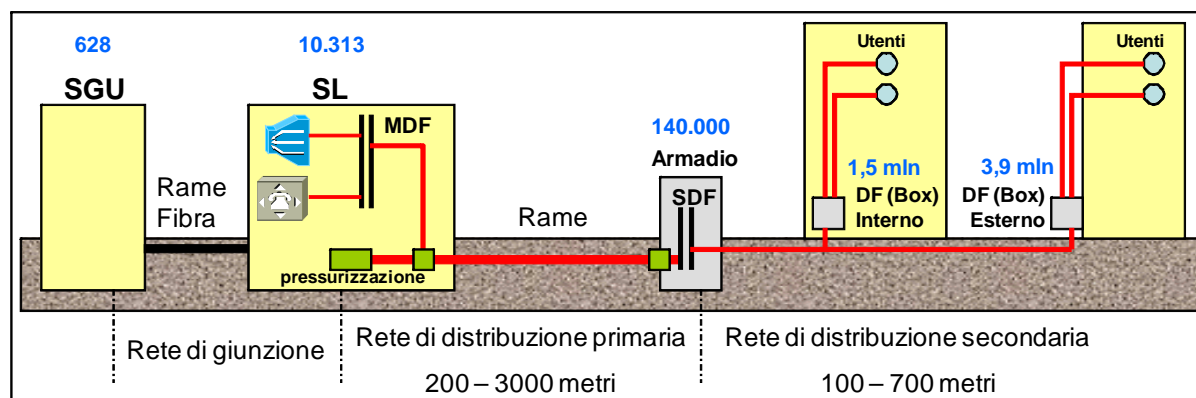
Current Italian Copper Access Network

- The primary network (rete primaria) connectd MDFs to street *cabinets*, containing smaller cable terminations (*Subloop Distribution Frame, SDF*)
- Currently, street cabinets (armadi stradali) are about 140.000. the radius of the primary network ranges between 200 m and 3000 m and usually it is made with high-capacity pressurized cables



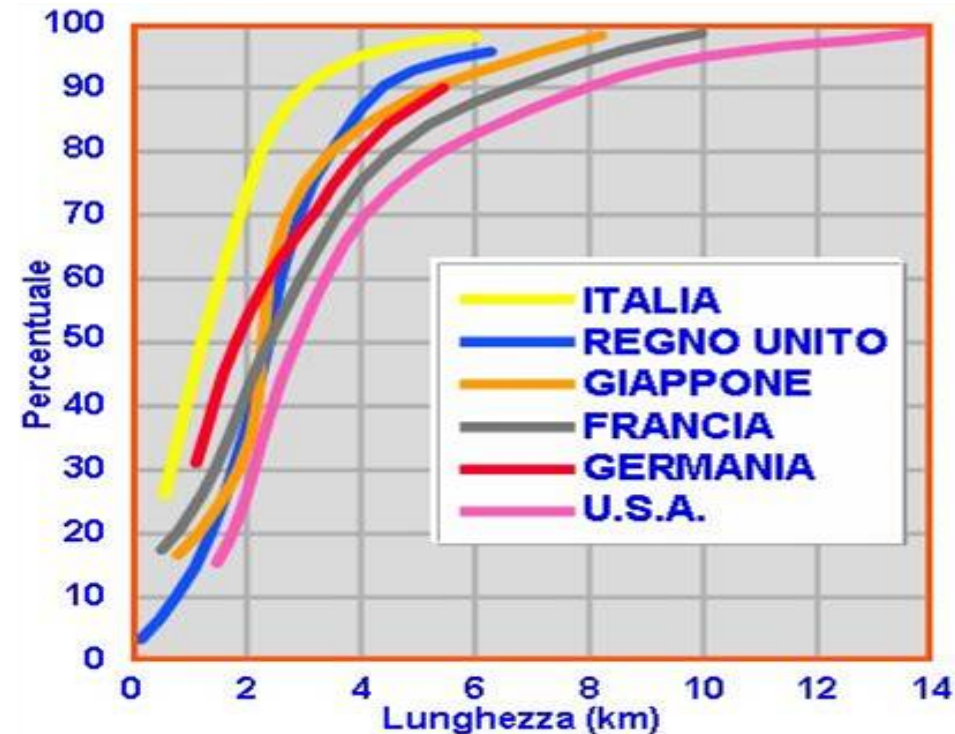
Current Italian Copper Access Network

- The secondary network (*rete secondaria*) connects street cabinets to distribution boxes close to buildings
- This network is usually deployed underground.
- Each distribution box holds several dozed twisted pairs, they are about 1.5 million (inside buildings) and 3.9 million (outside buildings).



Radius of the copper access network

- The total length of the Italian copper access network is about 530,000 km
- The total number of copper twisted pairs is 110 million
- The figure shows the distribution of the length of user connections is a number of countries
- The length is smaller for Italy
- This allows a better exploitation of xDSL techniques

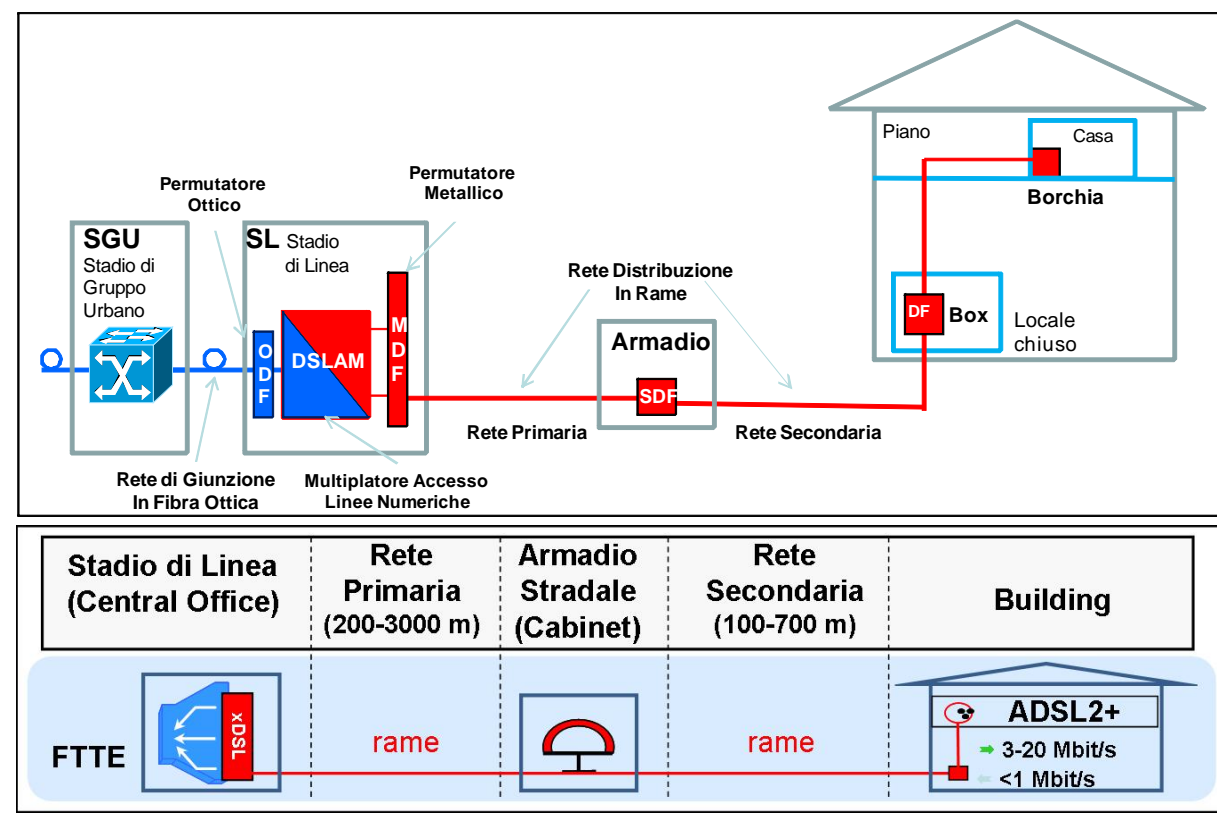


Architectures for Optical Fiber access networks

- The architectures for optical access networks are named Fiber-To-The-x (FTTx)
- The four main categories are:
 - Fiber-to-the-Exchange (FTTE)
 - Fiber-to-the-Cabinet (FTTC)
 - Fiber-to-the-Building (FTTB)
 - Fiber-to-the-Home (FTTH)
- FTTE is the architecture already adopted in Italy to achieve basic broadband access (standard ADSL rates)
- The other three architectures are designed for ultra-broadband access

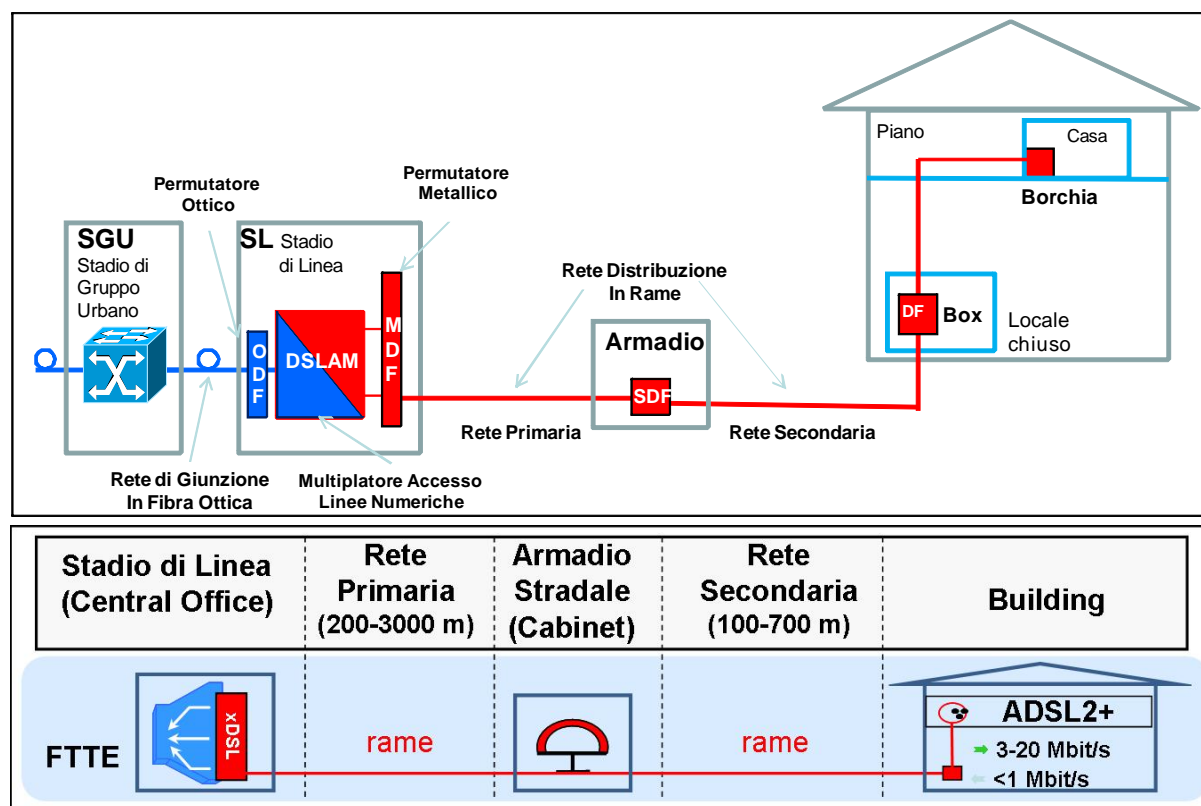
Fiber to the Exchange (FTTE)

- FTTE uses the already available copper access network and xDSL technologies, such as ADSL, ADSL2 and ADSL2+
- With ADSL2+ di the available user rate is about 20 Mbit/s downstream and 1 Mbit/s upstream



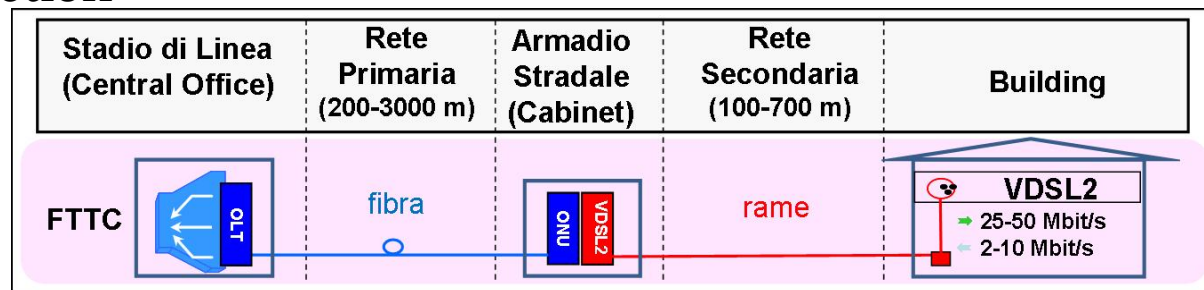
Fiber to the Exchange (FTTE)

- Performance depends on the length of the twisted pair, and on the quality of the physical connection (including noise)
- In the legacy Italian system, SLs and Digital Subscriber Line Access Multiplexers (DSLAM) are connected to the core network with Asynchronous Transfer Mode (ATM) or Ethernet technologies
- For short connections (about 400 m) it is possible to provide fast VDSL2 access



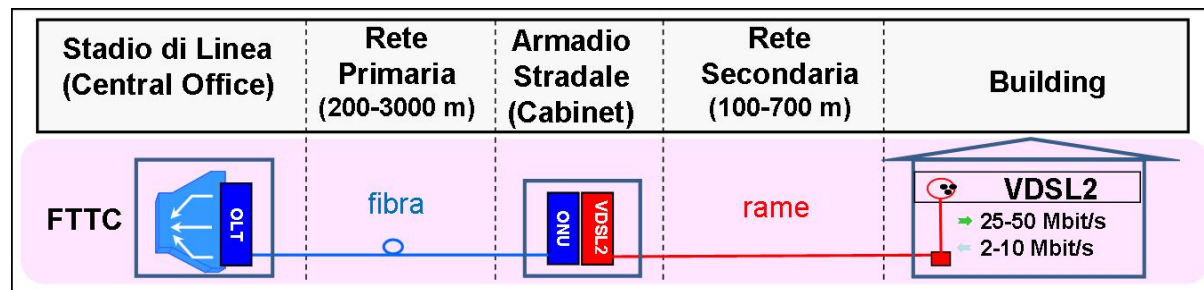
Fiber to the Cabinet (FTTC)

- To deploy the future ultra broadband access network using the existing copper infrastructure is not enough (ultra broadband access requires at least 30 Mbit/s per user, downstream)
- Optical fiber must be used also in the final part of the user's connection, as close as possible to the user
- A first step is to substitute copper with optical fiber from Central Offices (SO) to street cabinets
- Street cabinet must become active devices, doing electro-optical translation, among other functions
- In this case, with the VDSL2 technology, it is possible to obtain a downstream rate of 50 Mbit/s and 10 Mbit/s in the upstream direction



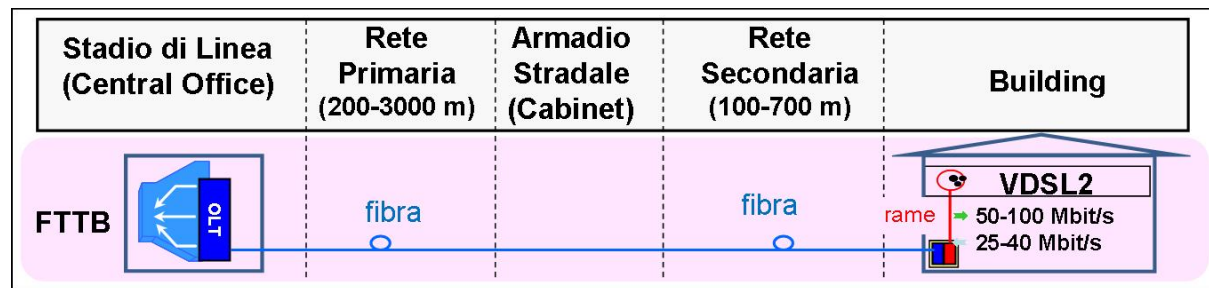
Fiber to the Cabinet (FTTC)

- The FTTC architecture allows us to limit the initial investment costs, as it impacts only on the primary access network
- The main disadvantage is that the remaining copper network is a bottleneck
- Another disadvantage is that space inside street cabinets becomes a scarce resource
- Moreover, in order to allow colocation and unbundling, cabinets must be very large



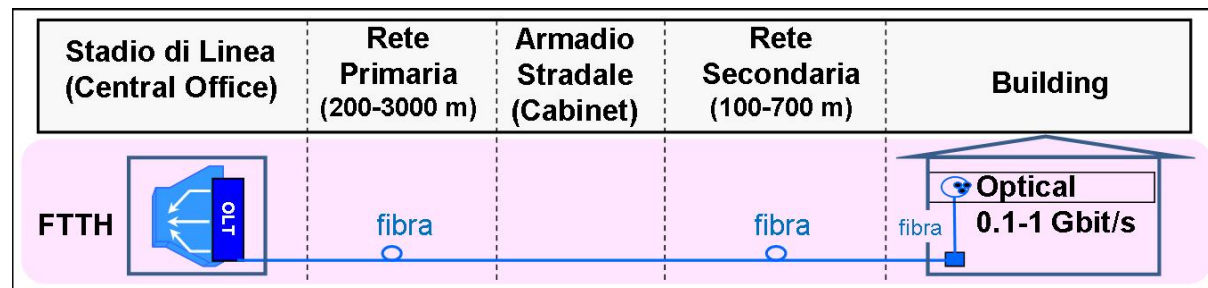
Fiber to the Building (FTTB)

- With the FTTB architecture, the optical fiber reaches the building where the user lives, this optical connection spans from the central office to the building, thus eliminating street cabinets
- Optical to electrical conversion takes place in devices usually placed inside buildings
- Then, the connection to the final user proceeds with copper cables (very short) used with VDSL2 transmission (100 Mbit/s downstream and 40 Mbit/s upstream)
- This architecture saves the cost of street cabinets and is more economic than FTTH, as far as the final connection to the user is concerned (copper instead of optical fiber)



Fiber to the Home (FFTH)

- The most performing architecture is FTTH (unfortunately it is the most expensive)
- The optical fiber reached the user's house
- Both vertical and horizontal cabling are made with optical fiber
- It is possible to deploy symmetric user connections with rate ranging from 100 Mbit/s to 1 Gbit/s



Access systems

- For FTTC, FTTB, and FTTH, two main access systems are possible:
 - Point-to-Point systems, (P2P): dedicated optical fiber connections with Fast Ethernet (100 Mbit/s) or Gigabit Ethernet (1 Gbit/s) transmission technologies
 - Passive Optical Network, (PON): they are tree-like structures where from an optical fiber root multiple users are reached; the capacity of the fiber is shared among the user accessing to the network though it