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 Officed are equipped with *Main Distribution Frames*, MDF, they are permutators conntecting physically copper twisted pairs of users

628
SGU
10.313
SL
MDF
Utenti
Utenti
140.000
Armadio
SDF
1,5 mln
DF (Box)
Interno
3,9 mln
DF (Box)
Esterno
Rame
Fibra
Rame
pressurizzazione
Rete di giunzione
Rete di distribuzione primaria
200 – 3000 metri
Rete di distribuzione secondaria
100 – 700 metri

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

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pressurizzazione

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3,9 mln
DF (Box) Esterno

Rete di giunzione

Rete di distribuzione primaria
200 – 3000 metri

Rete di distribuzione secondaria
100 – 700 metri

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).

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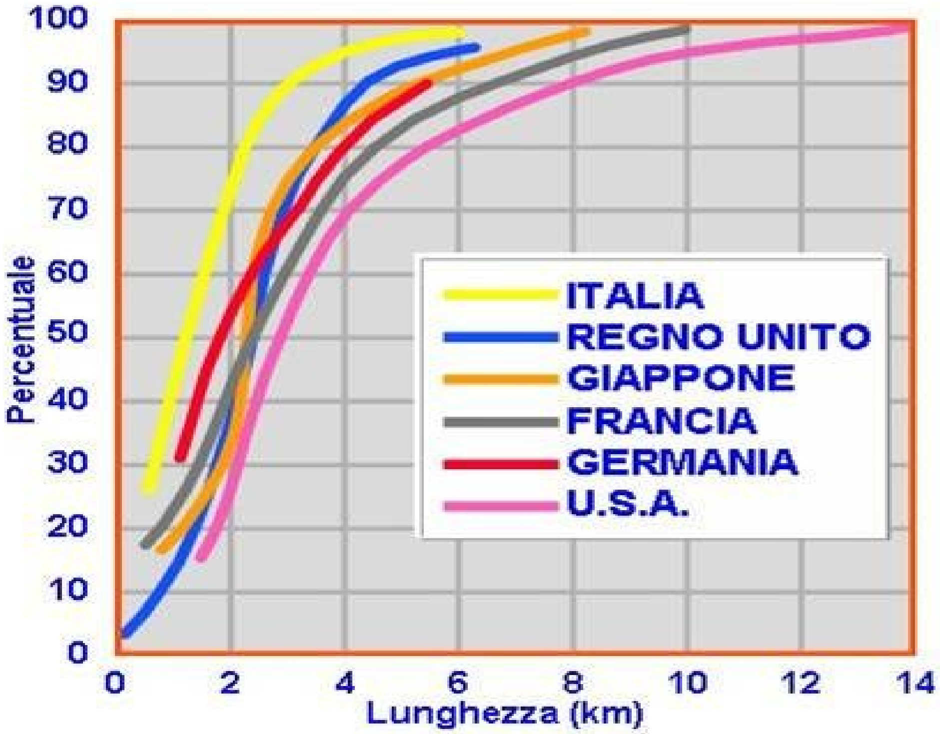
Radius of the copper access network

- The total length of the Italian copper acces 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



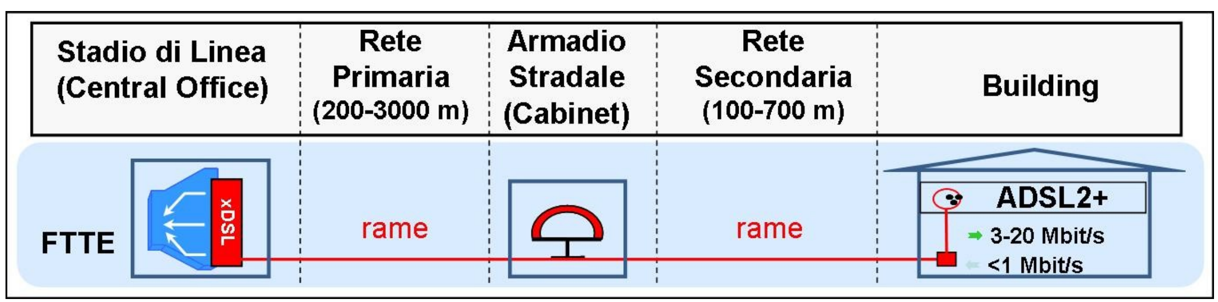
Architectures for Optical Fiber access networks

- The architectures for optical access networks are namedFiber-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

Piano
Casa
Permutatore Ottico
Permutatore Metallico
Borchia
SGU Stadio di Gruppo Urbano
SL Stadio di Linea
Rete Distribuzione In Rame
Box
Locale chiuso
Armadio
Rete Primaria
Rete Secondaria
Rete di Giunzione In Fibra Ottica
Multiplatore Accesso Linee Numeriche



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

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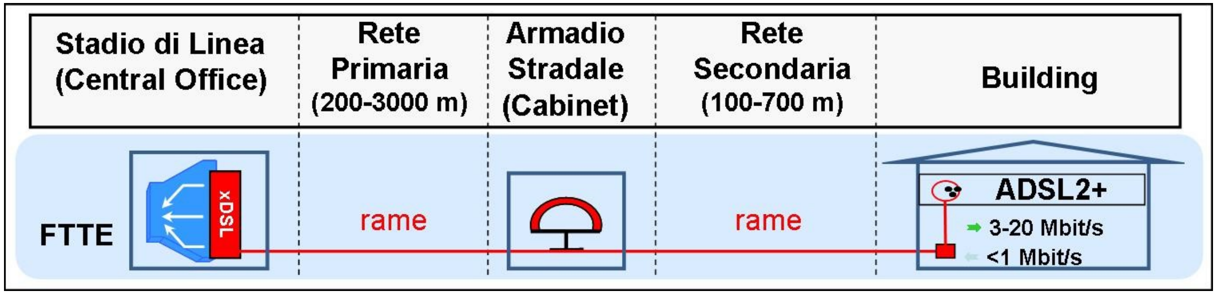
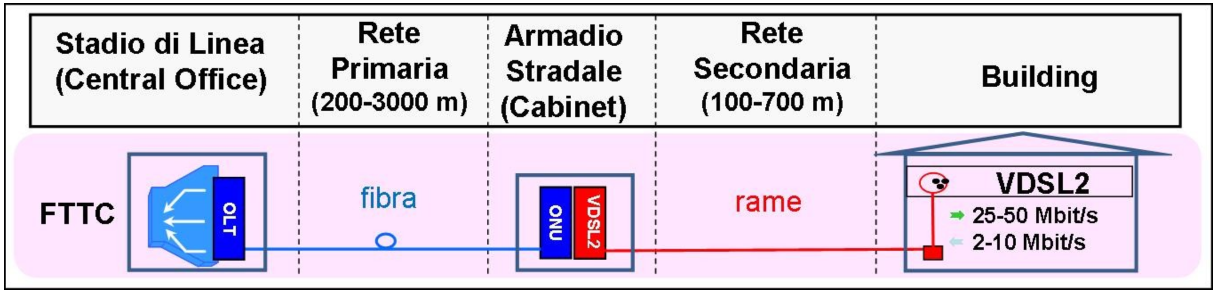
Rete di Giunzione In Fibra Ottica
Multiplatore Accesso Linee Numeriche



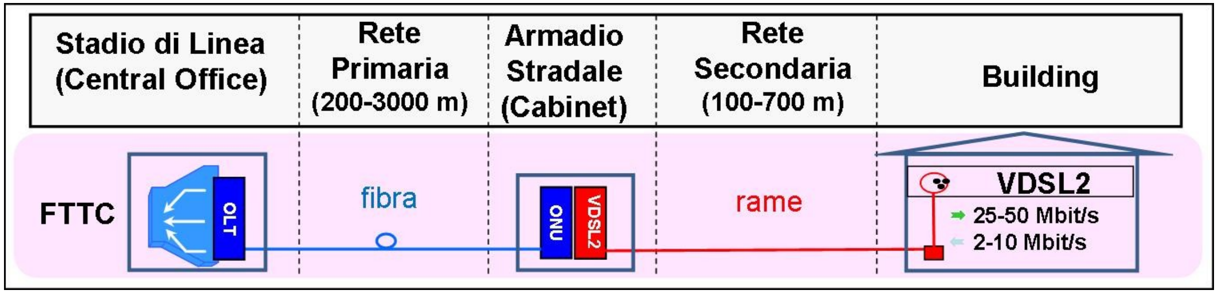
Fiber to the Cabinet (FTTC)

- To deploy the future ultra broadband access network using the existing copper infrastructure is not enough (ultra boroadband 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 (SL) 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



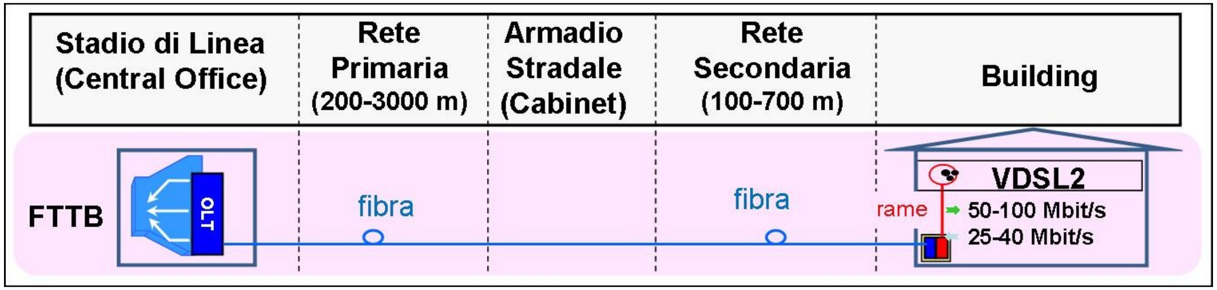
Fiber to the Cabinet (FTTC)

- 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



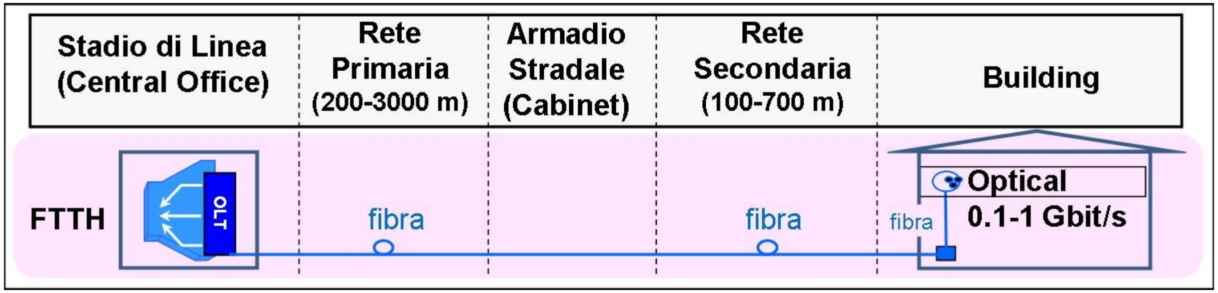
Fiber to the Building (FTTB)

- 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 electircal convertion 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 archuitecture is FTTH (unfortunately it is the most expensive)
- The optical fiber reached the user's house
- Both vertical and horizontal cablings are made with optical ficer
- 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

Elements of the NGAN

- *Optical Line Termination* (OLT), it is the terminating device of optical cables and it can be positioned both in SLs and in SGUs.
- *Optical Network Unit* (ONU): the optical device positioned close to the user: it can be connected, on the user side, to a copper network termination (NT) dello stesso. Multiple ONUs are connected to one OLT. In the FTTC case, the ONU is in the street cabinet. In the FTTB case, the ONU is placed close to the building.
- *Optical Network Termination* (ONT): it it the user’s optical termination, in the FTTH architecture
- *Optical Distribution Frame* (ODF): it is the optical permutator, in the exchange, which substitutes the electric wire permutator (MDF). Peripheral devices placed in street cabinets or underground are the SDFs, while, if they are placed inside buildings, they are called DFs.

Elements of the NGAN

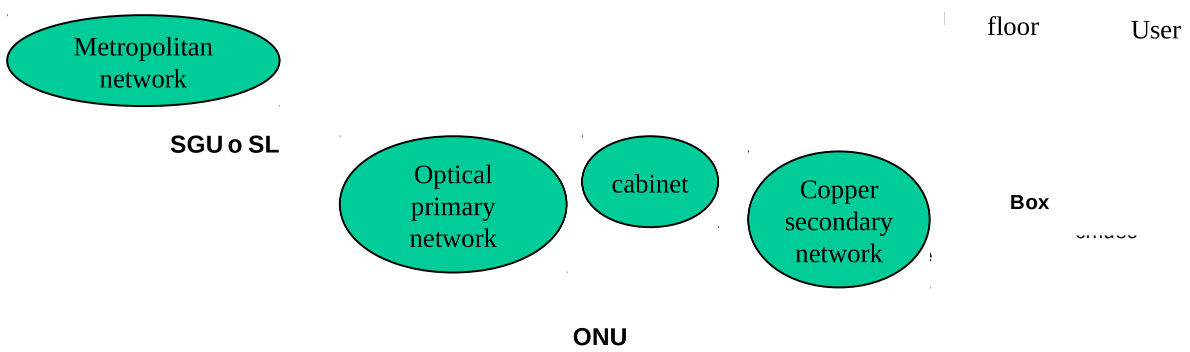
- In some cases optical connections among OLT, ONU and ONT are single-fiber, thus bidirectional transmission is obtained by wavelength division.
- OLT-ONU connections frequently adopt 2 fibers (no neel of wavelength division)
- In other less frequent cases, optical connections are made with two fibers, one active and one spare.

Point-to-Point systems (Point-to-Point, P2P)

- In P2P systems there is a dedicated optical connection from OLT to ONU/ONT, used with Fast Ethernet (100 Mbit/s) or Gigabit Ethernet (1 Gbit/s) technologies
- Generally the access network has a star topology, which is common also in the classic copper access network
- The optical transmission cable is dedicated, thus the transmission capacity is the highest possible
- The P2P architecture has comparatively higher costs
- PON techniques provide an alternative tradeoff trading in performance for cost

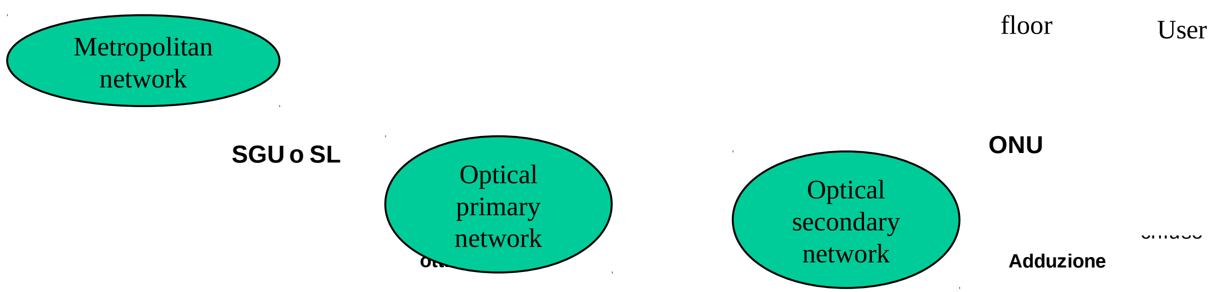
Point-to-Point systems (Point-to-Point, P2P)

- The Figure shows a P2P-FTTC system
- The connection between the SGU/SL to the street cabinet (*armadio*) is optical
- The street cabinet accommodates the ONU to terminate and connect optical fibers and copper lines
- On the copper network, transmission is frequently done through VDSL2



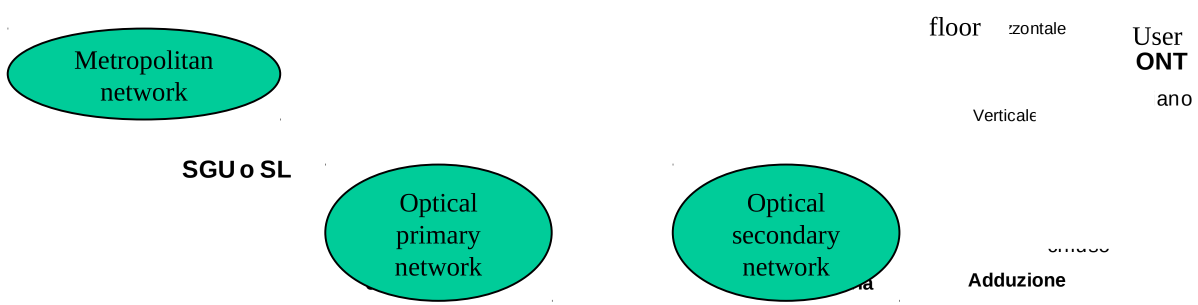
Point-to-Point systems (Point-to-Point, P2P)

- The Figure shows a P2P-FTTB system
- The optical connection reaches the building, then the vertical copper cabling connects the user
- The ONU is placed at the basement of the building, and it is where optical/electrical conversion occurs



Point-to-Point systems (Point-to-Point, P2P)

- The Figure shows a P2P-FTTH system
- Both horizontal and vertical cabling inside the building are made with optical fibers
- Optical terminations in DFs are placed both at the building basement and at each floor
- For a transmission speed of 100 Mbit/s a single fiber is used;
- For 1 to 10 Gbit/s and long distance from building to SGU/SL, two fibers are used, one for uplink and one for downlink



The content of this presentation includes parts drawn from: Progetto ISBUL, WP1.1: Infrastruttura di rete fissa, Autori: M. Decina, S.Bregni, R.Casale, G.Cerquozzi, P.Giacomazzi, G.Maier, R.Melen, A.Pattavina. URL: http://www.progettoisbul.net/Home/work-packages/wp-1-1--infrastruttura-di-rete-fissa

Passive Optical Network, PON

- A PON network used only passive devices between OLT and ONU/ONT
- The capacity of optical fibers is shared among groups of users
- Passive devices can be splitters; a splitter divides the capacity of one optical fibers among a number n of optical fibers at its output
- Conversely, it multiplexes the signal from multiple fibers onto a single fiber, in the opposite direction

Passive Optical Network, PON

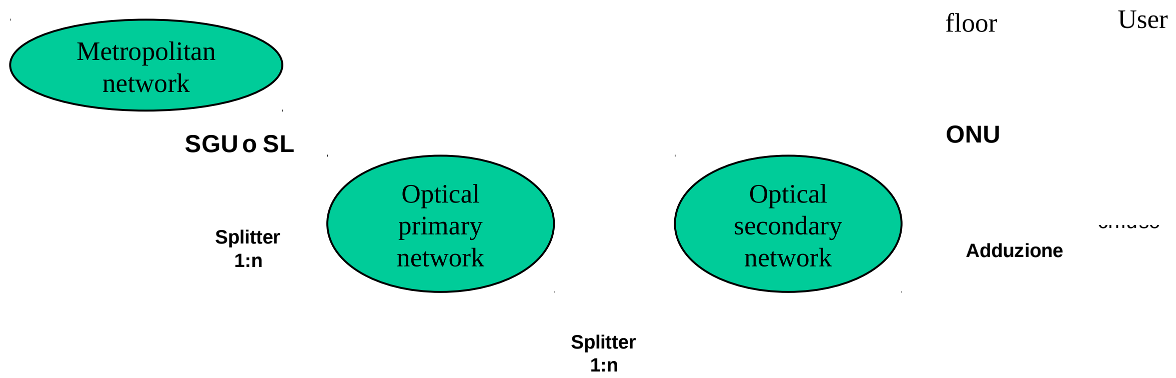
- A splitter is characterized by its split ratio (1:*n*), o split ratio, where *n* is the number of optical fibers at its output (in the downlink direction)
- *n* can vary, typical values are 32, 64, and 128
- The signal at the input of the splitter (in the downlink direction) is broadcasted on the *n* output optical fibers
- Privacy is thus an issue and it can be coped with through encryption
- In the upstream direction, n signals converge into one optical fiber, thus a multiple access method to share the capacity of this single physical resource is needed

Passive Optical Network, PON

- PON systems require comparatively less optical fibers to reach a given number of users, thus, costs are smaller than with P2P systems
- However, sharing the capacity of one fiber among *n* users degrades

Passive Optical Network, PON

- The Figure shows a FTTB-PON system
- Splitters are frewquently placed in small underground cabinets
- Splitting can be performed multiple times, as shown in the figure
- The purpose of the splitter in the SGU/SL is to divide the bandwidth of the PON network among a set of branches departing from the ODF
- The Figure shows one of these n branches
- The purpose of the second splitter is to reduce the number of optical fibers in the secondary access network and thus reduce costs
- If the SGU splitter has ratio 2 and the other splitter has ratio 4, a PON rooted at the OLT reaches 8 ONUs at the building



Passive Optical Network, PON

- The Figure shows a PON-FTTH system
- Usually splitters are placed in small street undergroud cabinets and inside the building
- The ratio of the street splittere is frequently 1:2 - 1:4, and for the in-building splitter the ratio is 1:8 - 1:32
- This adds up to a total split ratio ranging from 1:16 to 1:128 (typical values in practice)