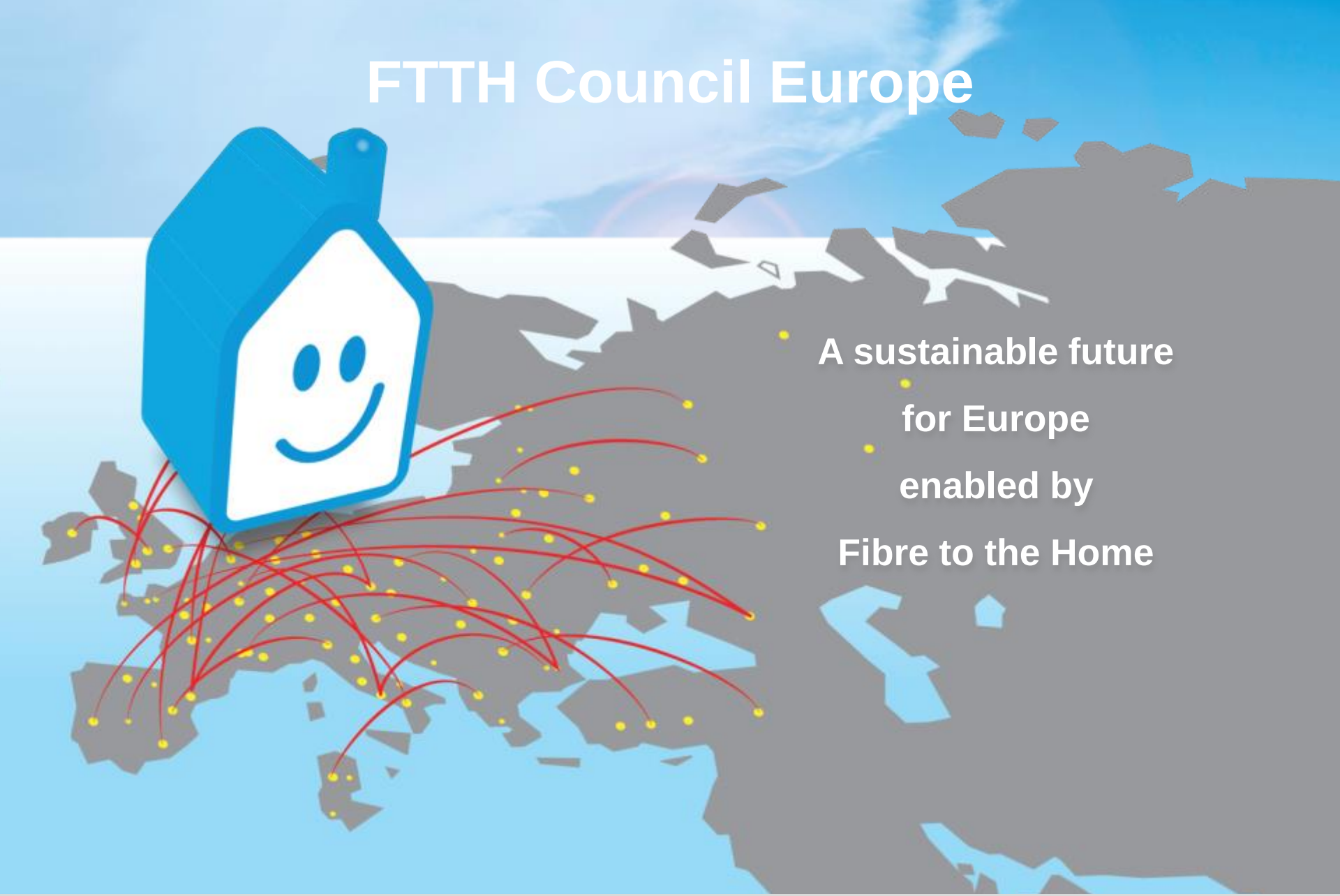
Creating a brighter future

Webinar:

Passive infrastructure of FTTH networks: an overview

Moderator: **Wolfgang Fischer**
Chair Deployment & Operations Committee
FTTH Council Europe

FTTH Council Europe



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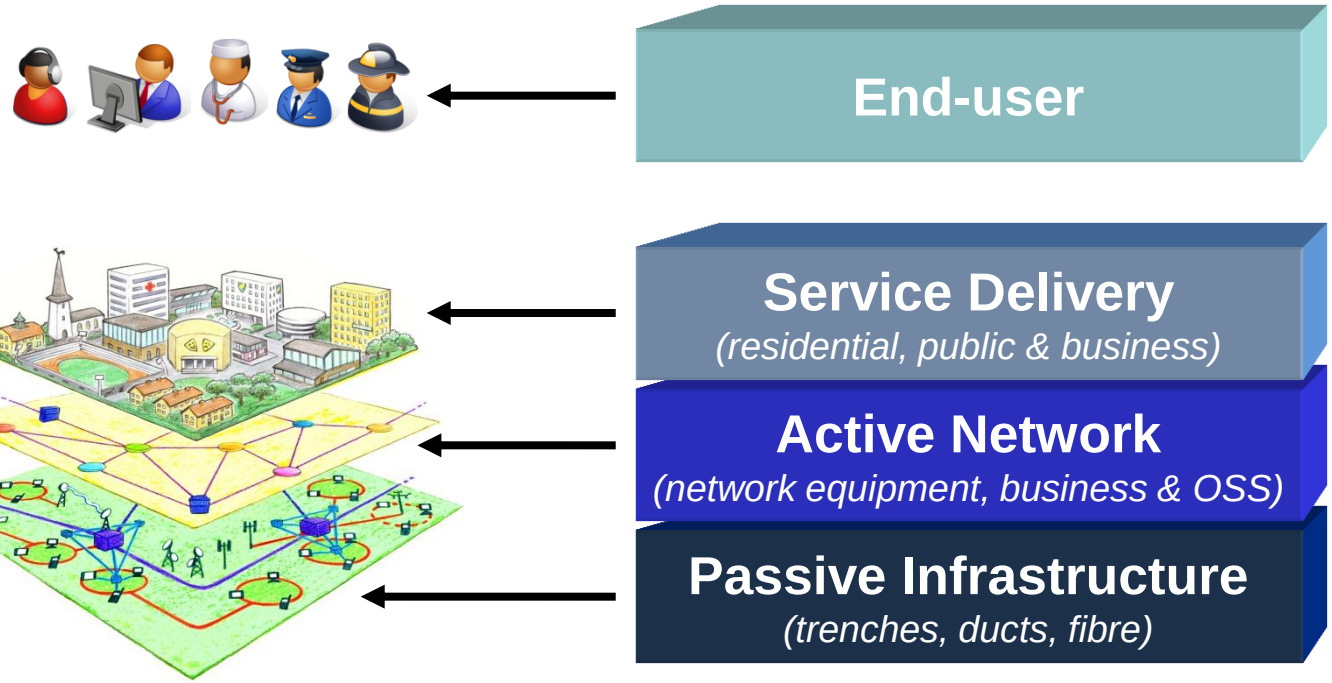
Creating a brighter future

Webinar:

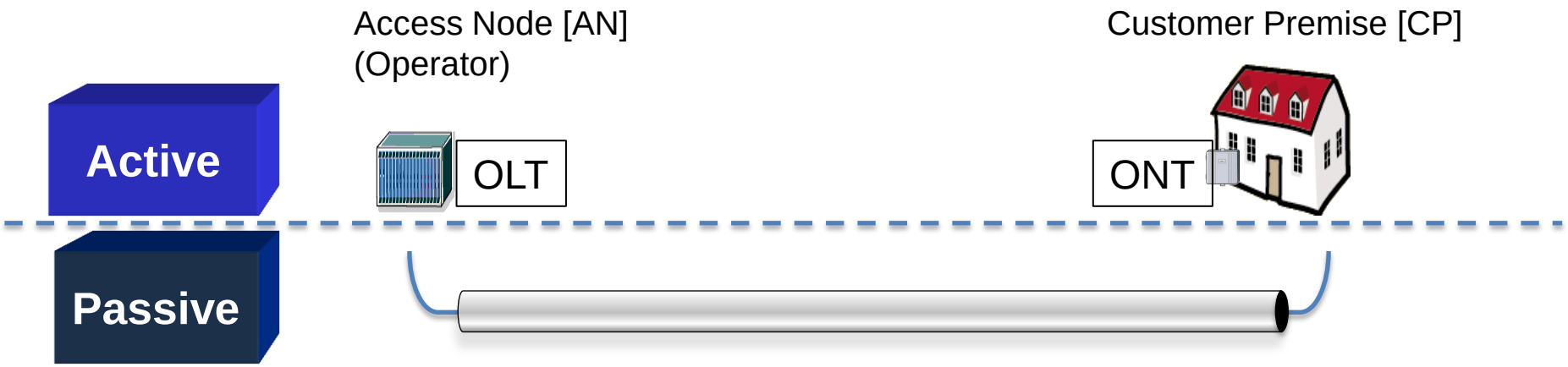
Passive infrastructure of FTTH networks: an overview

Presenter: **Raf Meersman**
CEO Comsof

FTTH
The Layered Model



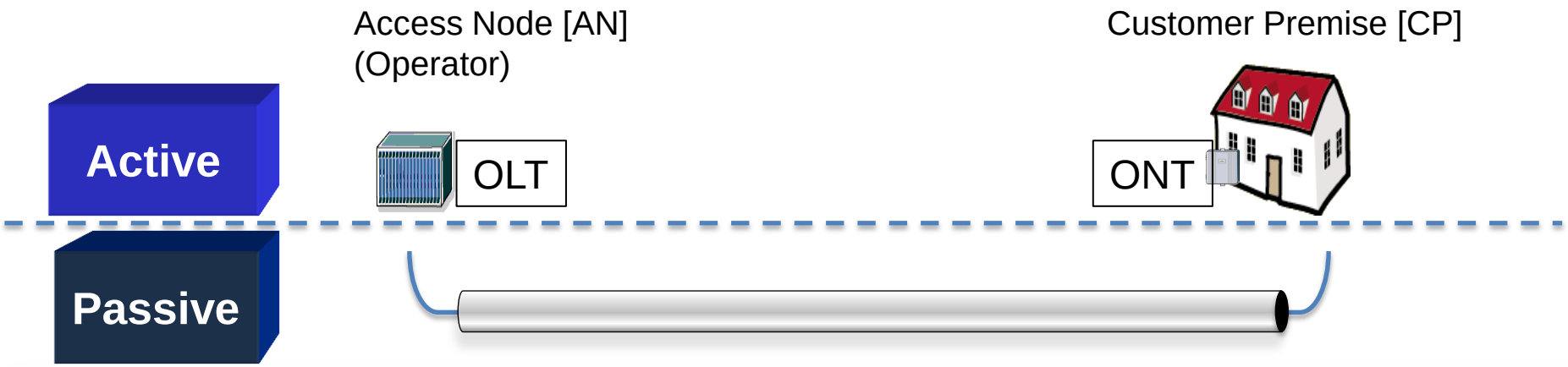
Passive – A simple pipe...



Seen from the active layer, passive layer seems **simple**:

- End-2-end pipe from Operator's AN to Customer's premise
- Transports light between Optical Line Termination (OLT) and Optical Network Termination (ONT)

Passive – A simple pipe...



- **Access Node [AN]: starting point for the optical path to the subscriber. It houses all active equipment from the operator.**
  This is often also referred to as Central Office [CO] or Point of Presence [PoP]
- **Optical Line Termination [OLT]: the active equipment at the operator side that sends and reads optical signals**
- **Optical Network Termination [ONT]: the active equipment at the customer side that sends and reads optical signals**

Passive – ... that is far from simple

Access Node [AN]
(Operator)

Customer Premise [CP]

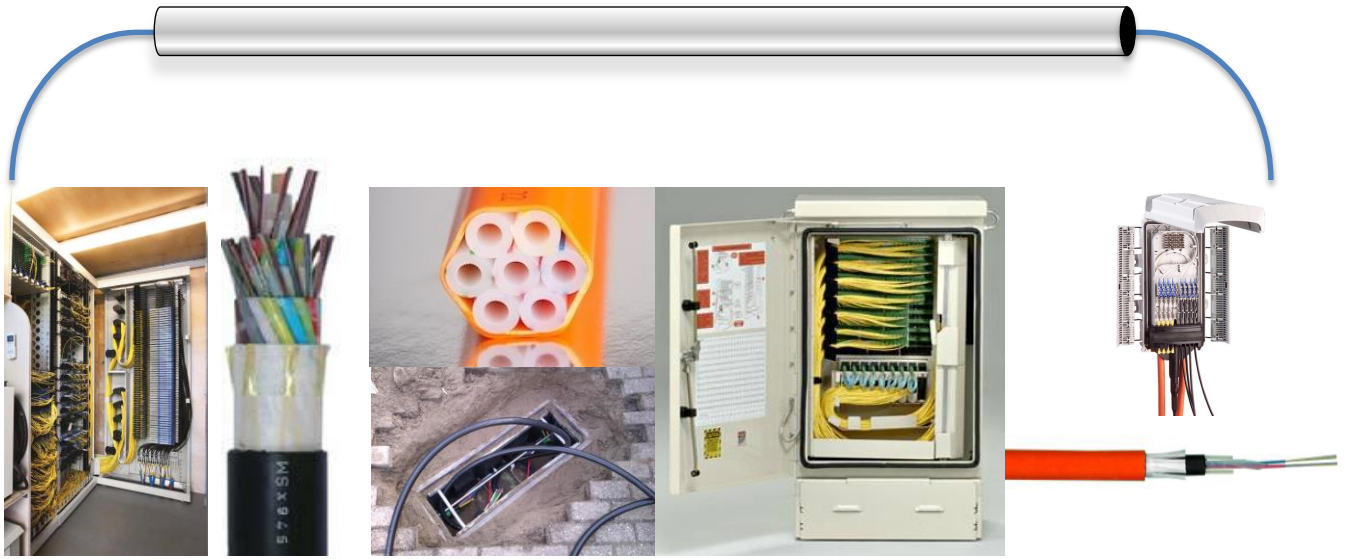
Active

OLT

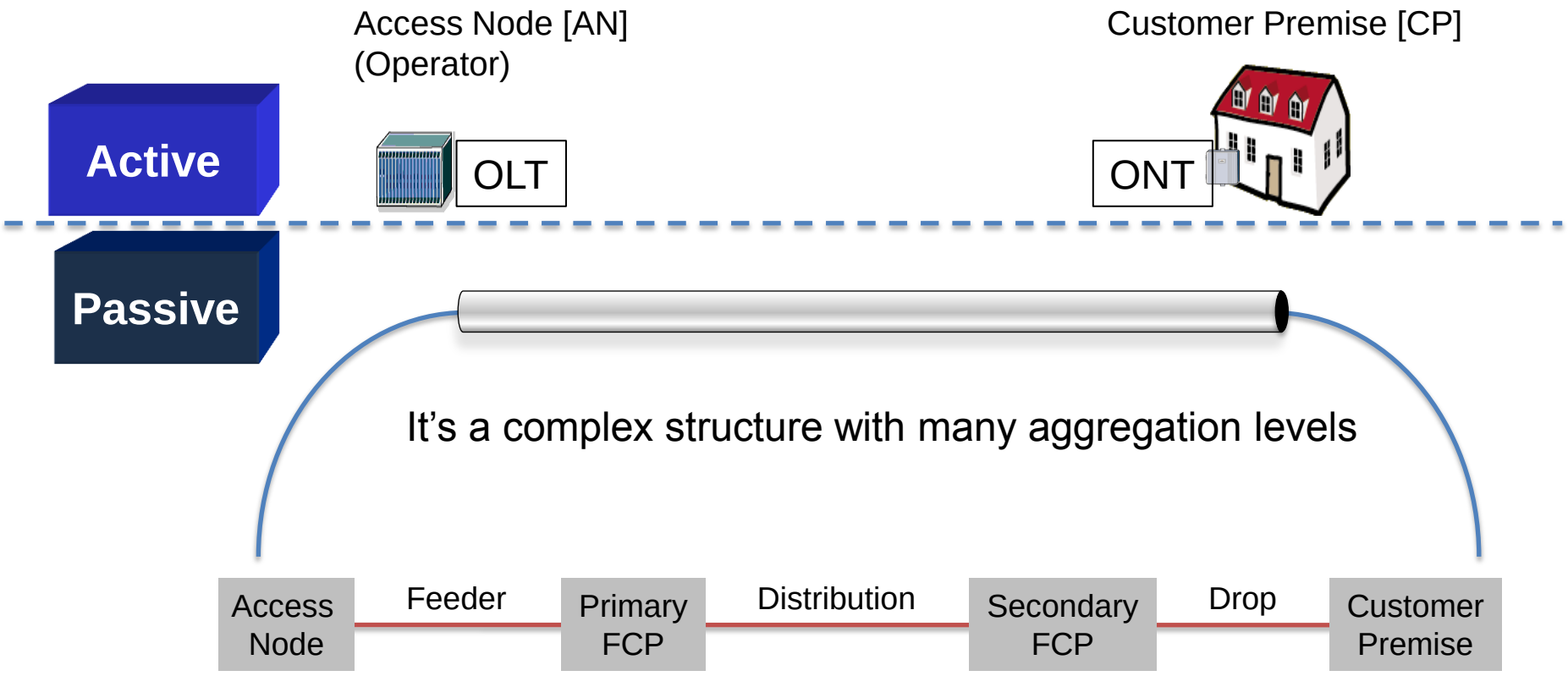
ONT

Passive

But it really consists of many different components



Passive – ... that is far from simple



Passive – ... that is far from simple

Access Node [AN]
(Operator)

Customer Premise [CP]

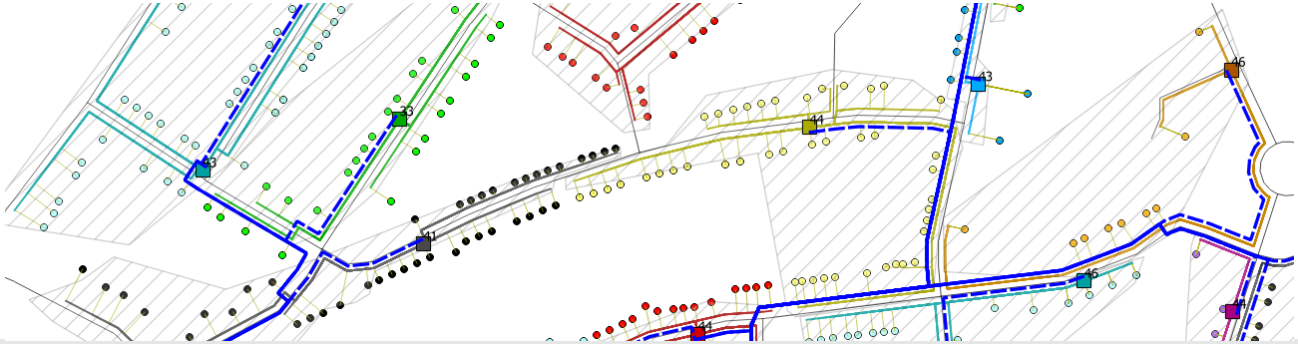
Active

OLT

ONT

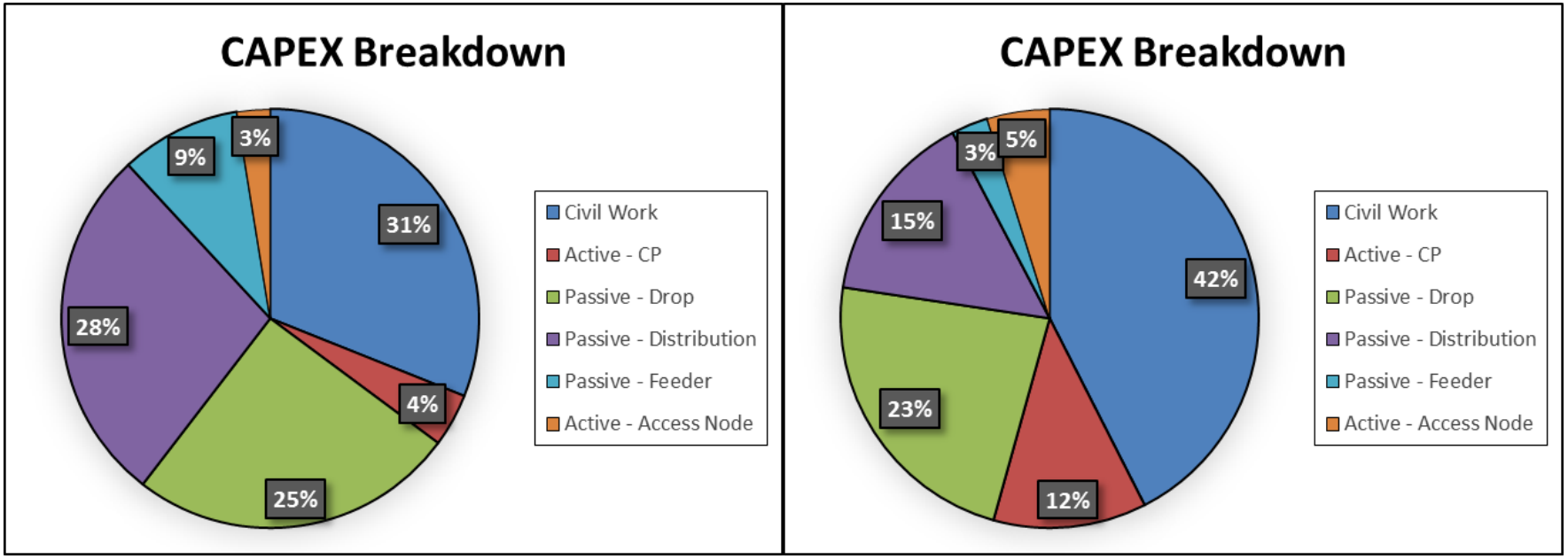
Passive

It’s passing almost every street corner



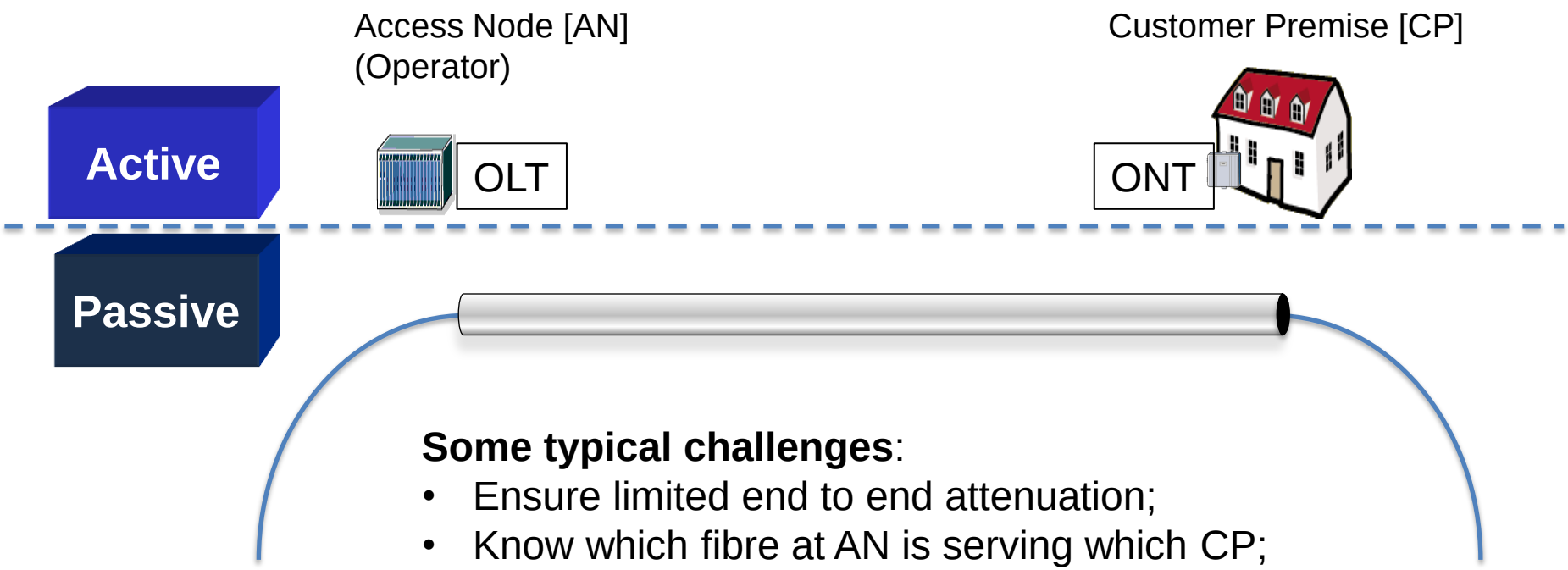
Passive – ... and very expensive

Examples of CAPEX breakdowns in 2 completely different cases



- Differences are linked to labour rates, density of area, type of cable deployment, ...
- But the biggest reason for the difference in ratio Active/Passive between these two cases is take rate!!

Passive – ... and challenging



Some typical challenges:

- Ensure limited end to end attenuation;
- Know which fibre at AN is serving which CP;
- Choose the right topology/technology/components/... to create a network of high quality at lowest cost;

The passive pipe

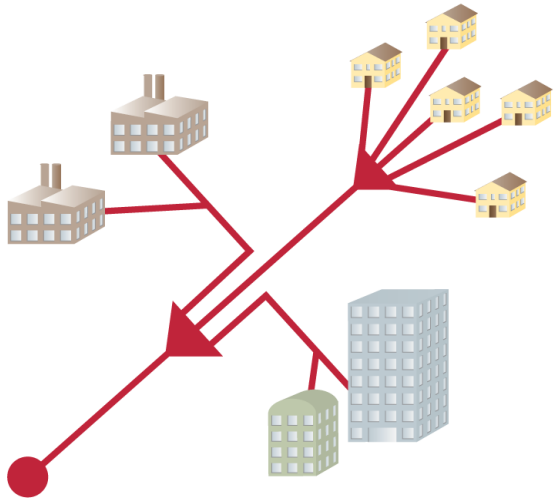
Different aspects / Many variations of the passive pipe

1. Different Topologies
   P2P vs P2MP
2. Different Aggregation Levels
   Feeder – Distribution – Drop – In-House
3. Different Components:
   Fibre – splice – splitter – connector
   Cables – closures – cabinets – manholes
4. Different Cable Deployment Methods:
   Ducts – Microducts – Direct buried – Aerial – Existing Pipes

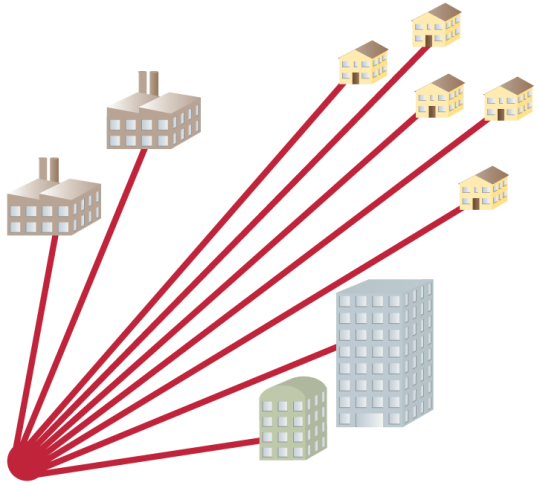
1. FTTH Topologies

Topology

Point to Multi-Point [P2MP]



Point to Point [P2P]



1. FTTH Topologies

Topology

Point to Multi-Point [P2MP]

P2MP:
one fibre leaving the AN will feed a splitter with multiple outgoing fibres. This means the capacity of this feeding fibre is shared between these outgoing fibres. The amount of outgoing fibres determines the split ratio and can vary from 1 by 2 or 1 by 4 up to 1 by 128 or 1 by 256. Splitters can also be deployed in cascade or series, in which case the end to end split ratio is the multiple of the individual split ratios. Since capacity is shared, the higher the end to end split ratio, the lower the maximum bandwidth per customer will be

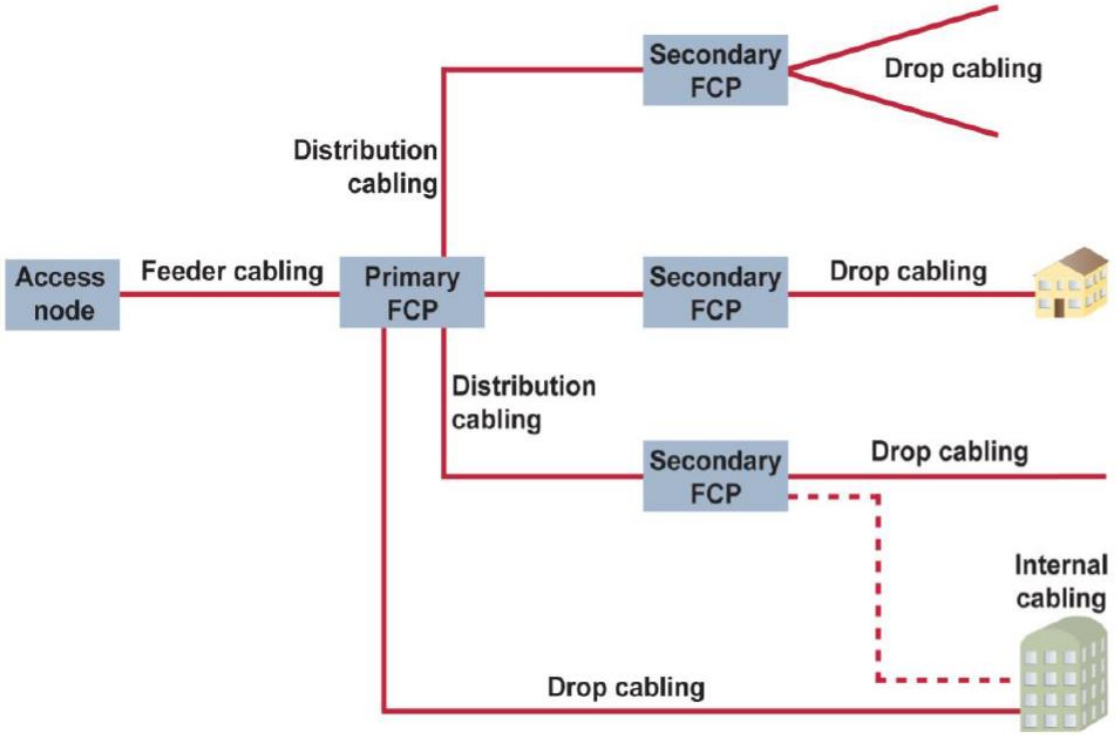
Point to Point [P2P]

P2P:
when a dedicated fibre is available from AN into each Customer premise. No capacity is shared, but high fibre counts are entering the AN, requiring also large amounts of active equipment in the AN.

2. FTTH Network Structure

From Access Node to customer premise: different aggregation levels

- Access Node
- Feeder
- Primary FCP
- Distribution
- Secondary FCP
- Drop
- In-House



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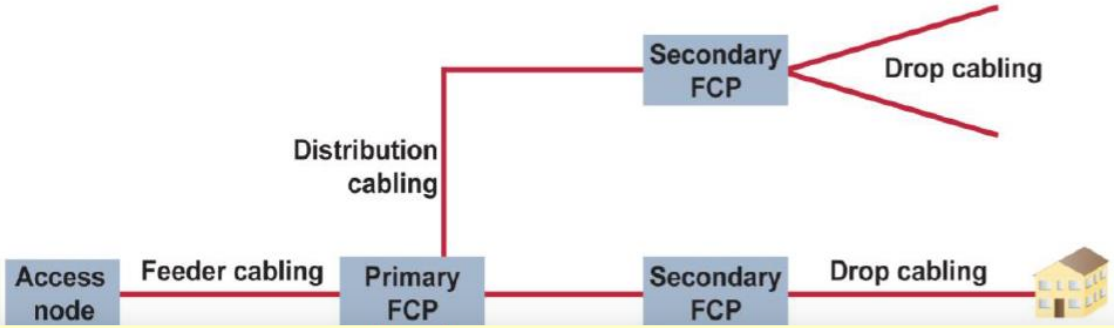
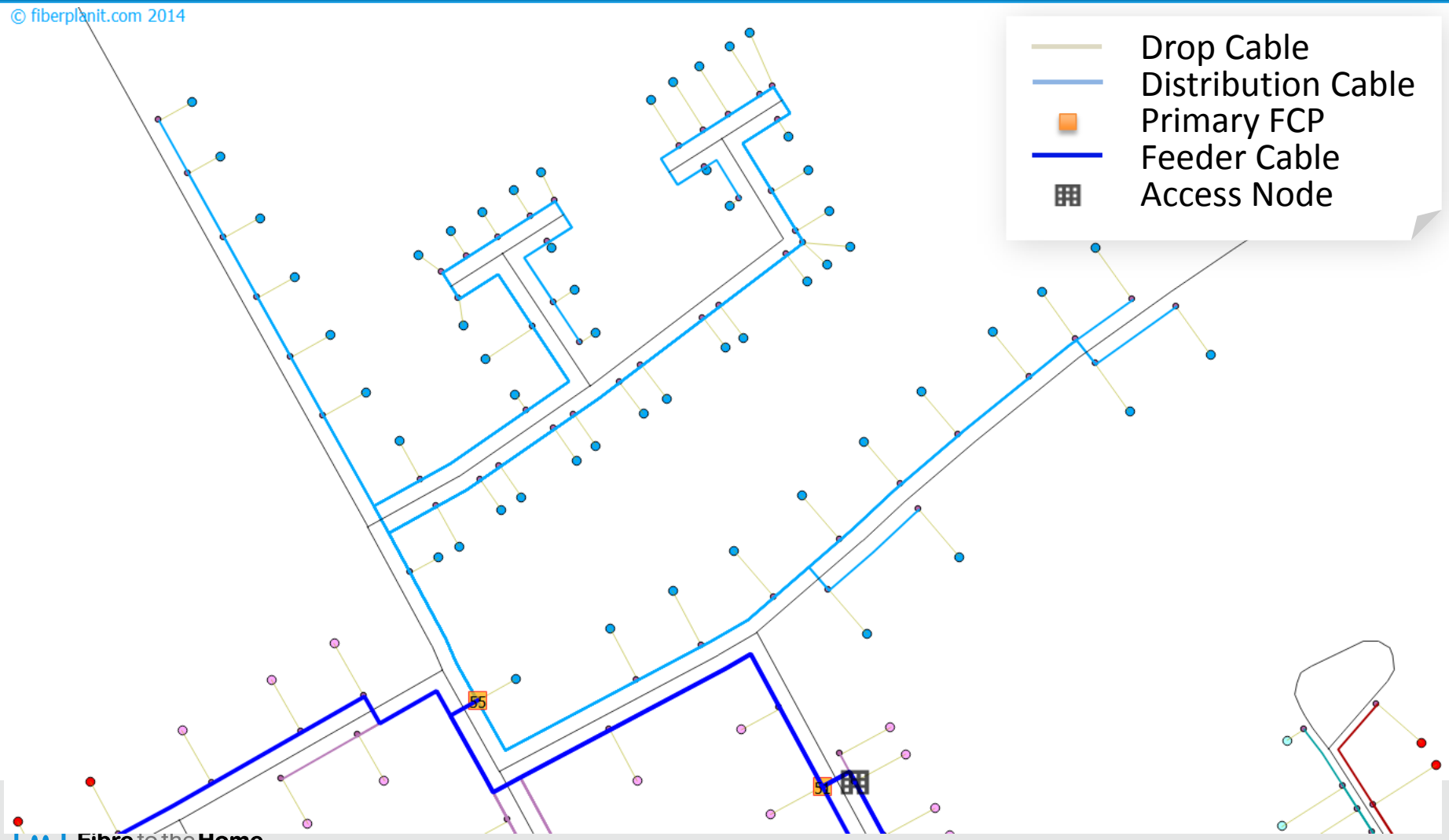


Fibre Concentration Point [FCP]: a point in the network where cables of different types or sizes are typically joint, in a way that may include flexibility or splitting functionality.

- Typically networks will use FCPs at different aggregation levels in the network. Primary FCP is often also referred to as Distribution Point (DP). Secondary FCP is often referred to as Drop Point.
- FCPs can be realised in the form of a street cabinet, a manhole or a smaller handhole.

2. FTTH Network Structure



3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- Closures
- Cabinets
- Manholes

3. FTTH Network Components

In each layer: different components

- **ODF/ODR**
- Fibre/Cable
- Splitter
- Splice
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- Manholes

3. FTTH Network Components

In each layer: different components

- **ODF/ODR**
- Fibre/Cable
- Splitter
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Optical Distribution Rack [ODR] :
Rack that houses the ODFs. A good fibre guiding system is crucial to keep high amount of fibres entering the ODR well organised

Optical Distribution Frame [ODF]:
A frame enabling the fibres from the outdoor cables to become available on an individual fibre level for flexible patching with the active transmission equipment (OLT Ports)

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- **Fibre/Cable**
- Splitter
- Splice
- Connector
- Closures
- Cabinets
- Manholes

Low-fibre Count (drop)

High-fibre Count (feeder)

3. FTTH Network Components

In each layer:

- ODF/ODR
- **Fibre/Cable**
- Splitter
- Splice
- Connector
- Closures
- Cabinets
- Manholes

Optical fibre

- individual “light pipe” able to carry pulses of light over a long distance, because the light is captured in the core by the surrounding cladding.
- Different fibre types exist, for example single-mode versus multi-mode fibre

Optical fibre cable

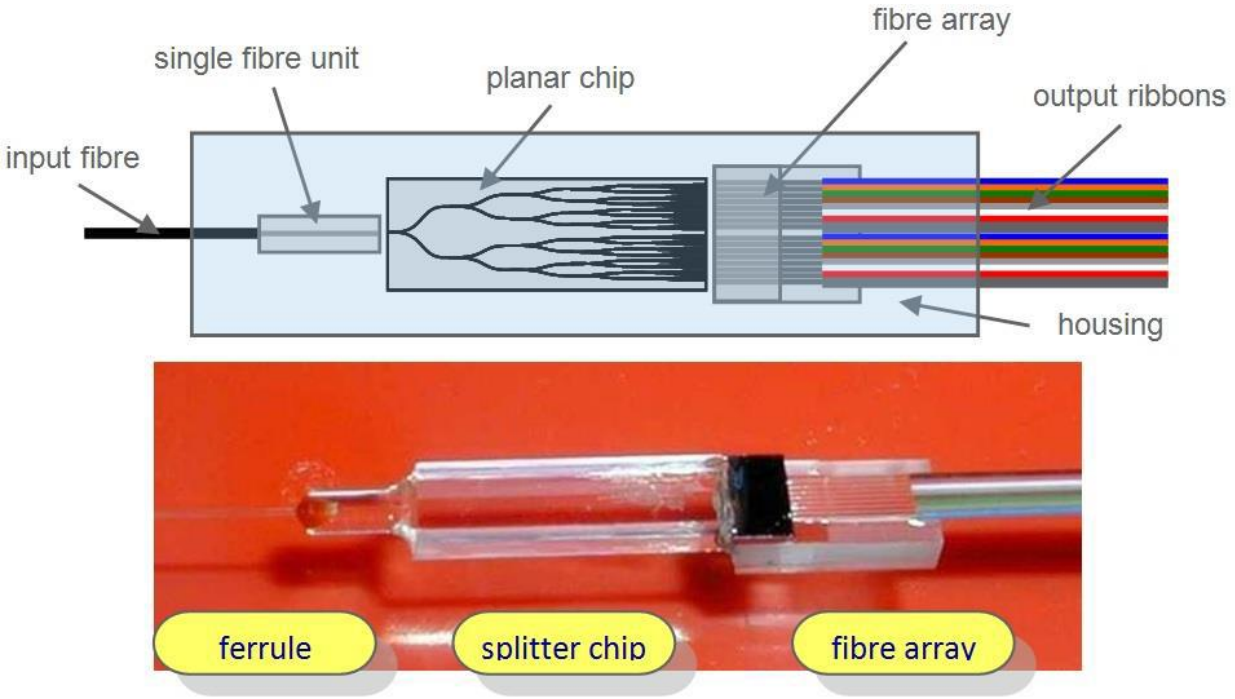
- groups several fibres into one cable for easy deployment. Amount of fibres in one cable can go from 1 or 2 up to 288 or even 864. Internally the fibres can be organised in different ways, for example in fibre bundles of 12 or 24 fibres. This is needed to allow for an easier identification of individual fibres within a cable, for example where fibres need to be spliced onto each other.
- The cable is responsible for protecting the individual fibres, but also to enable specific deployment techniques: for example for an aerial network the cable needs to be able to resist a certain tensile load, while a blown cable needs to minimize fraction within the tube it is deployed in.

More info about this in section 4 of this presentation.

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- **Splitter**
- Splice
- Connector
- Closures
- Cabinets
- Manholes



3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- **Splitter**
- Splice
- Connector
- Closures
- Cabinets
- Manholes

- Splitters allow to feed multiple output fibres by 1 input fibre.
- **Typical split ratios** are 1:2, 1:4 1:8, 1:16, 1:32 or 1:64, but can also go up to 1:128 or 1:256
- Splitters can be deployed in the **AN** (centralised split), in one of the **FCPs** (decentralised split), or within the **building** of the customer (typically for MDUs) or in a **combination** of these different locations, in which case we speak about **cascaded splitting**
- Splitters can either be firmly spliced into the fibre infrastructure or be connectorized, so that they can be flexibly inserted in a FCP.
- Splits can be **symmetric** and **asymmetric**
- Splitters introduce a considerable **insertion loss** depending on the split ratio. This insertion loss is **bidirectional**

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- **Splice**
- Connector
- Closures
- Cabinets
- Manholes

Fusion Splice Machine

Mechanical splice

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- **Splice**
- Connector
- Closures
- Cabinets
- Manholes

- Splices **are used to connect** 2 fibres to each other.
- Splices introduce extra **optical losses**, depending on quality of alignment.
- **Two technologies:** fusion (melted together) and mechanical (aligned and fixed)
  - **Fusion:**
    - Less optical loss (<0,1dB)
    - More expensive (skills, tools) to realise
  - **Mechanical**:
    - More optical loss (<0,5dB)
    - Less expensive (skills, tools) to realise

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- **Connector**
- Closures
- Cabinets
- Manholes

3. FTTH Network Components

In each layer: different components

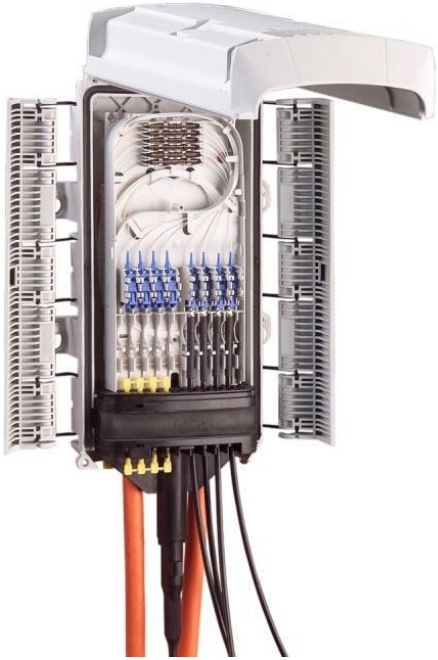
- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- **Connector**
- Closures
- Cabinets
- Manholes

- **Connectors** are installed at end of fibre to allow a flexible connection with another connectorised fibre
- Typically used where **flexibility** is needed, for example in the Access Node or Customer Premise for connection to the active equipment, in combination with patch cords or pigtails
- **Many types and standards** (ST, SC, MU, MPO, FC, LSH, MT-RJ, SC-RJ, LC, LX, ...)
- **Introduces losses** of the light signal – due to reflection *(return loss (RL)* or insertion *(insertion loss (IL)* – depending on the alignment of fibre cores (angular pointing error, concentricity)
    - Connectors are typically **graded** to indicate their quality (mean/max attenuation)
    - Careful with difference between *theoretic* loss values (ideal circumstances) and *real usage* values

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- **Closures**
- Cabinets
- Manholes



3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- **Closures**
- Cabinets
- Manholes

- **Cable joint closures** are installed where different cables are connected/spliced onto each other. They are used to organise the joints (including overlength), and to protect the joints (against water, dust, ...). The closures must be accessible in order to add or adjust fibre connections, or to test and repair connections.

- Can be installed in manholes, cabinets or on poles, each with different requirements (for example UV protection for pole mounted)

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- Closures
- **Cabinets**
- Manholes

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- Closures
- **Cabinets**
- Manholes

- **Cabinets** are installed at **flexibility points** in order to allow easy access to the fibres, cables and ducts, while offering protection against environment (wheather, vandalism, ...)
- Mostly above ground, but sometimes in manhole
- If above ground, need to find locations with sufficient room for accessing, not too vulnarable, permitted by authorities, ... while minimising costs

3. FTTH Network Components

In each layer: different components

- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- Closures
- Cabinets
- **Manholes**

Big Manhole
(typically on big branching points in network)

Small Handhole
(typically near Customer Premise)

3. FTTH Network Components

In each layer: different components

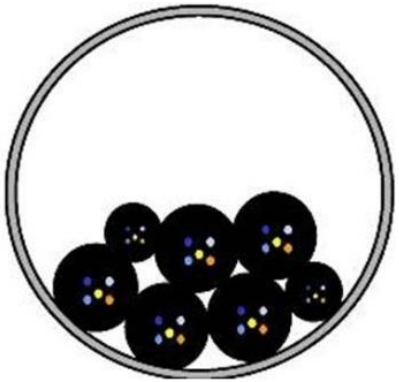
- ODF/ODR
- Fibre/Cable
- Splitter
- Splice
- Connector
- Closures
- Cabinets
- **Manholes**

- **Manholes** are typically concrete chambers that are covered by a metal lid, and are intermediate locations in the network that allow access to ducts and/or cables. They can also host closures.
- Small manholes are sometimes also called **handholes**
- They are typically introduced at locations where **access to ducts or cables** is required, for example for blowing or pushing extra cables through ducts

4. FTTH Cable Deployment Methods

Cables can be installed in different manners

- **Ducts**
- Subducts
- Direct buried
- Aerial
- Existing Pipes



110mm duct with cables

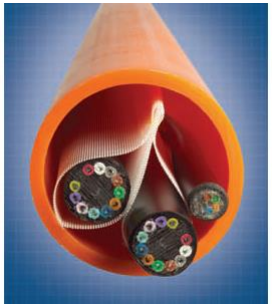
- **Cable installation** in duct via pulling, pushing, blowing or floating
- **Duct size** depends on cables (amount, type, diameter): 25mm, 50mm, 110mm, ...
- **Challenges:** cable entaglement, bends, friction on cable, installation equipment

4. FTTH Cable Deployment Methods

Cables can be installed in different manners

- Ducts
- **Subducts**
- Direct buried
- Aerial
- Existing Pipes

Microduct bundle



Flexible inner ducts

Micro cable

- Cable installation in microduct typically via **blowing** (easier, lighter than in convential ducts); in flexible ducts via **pulling**
- **MicroDuct size** depends on cables (type, diameter): 16mm, 10mm, 5mm, ...
- **Flexible ducts** can be used to increase occupation of existing ducts

4. FTTH Cable Deployment Methods

Cables can be installed in different manners

- Ducts
- Subducts
- **Direct buried**
- Aerial
- Existing Pipes

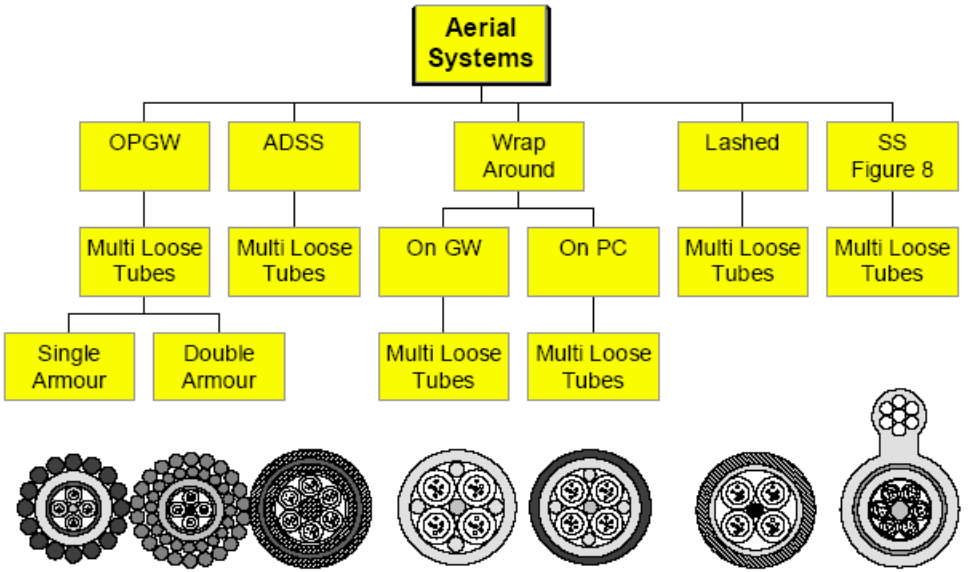
Direct Buried cable with Steel protection

- **Cable installation** directly into open trench (ploughing, slotting, mini trenching, micro trenching) or via excavation made with drilling
- **Challenges:** crush protection, termite protection, no flexibility

4. FTTH Cable Deployment Methods

Cables can be installed in different manners

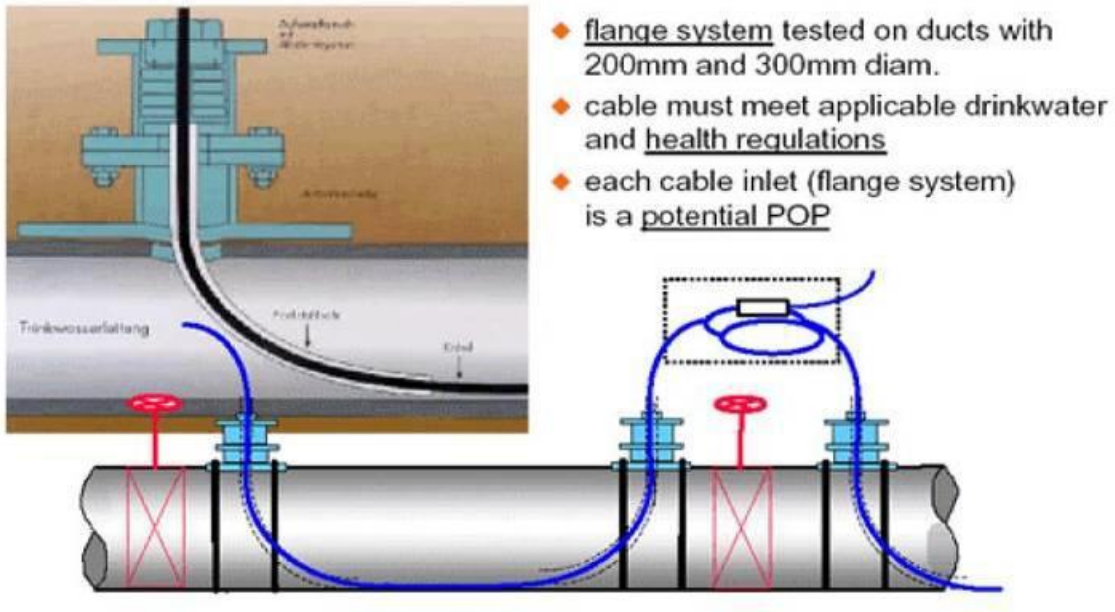
- Ducts
- Subducts
- Direct buried
- **Aerial**
- Existing Pipes



4. FTTH Cable Deployment Methods

Cables can be installed in different manners

- Ducts
- Subducts
- Direct buried
- Aerial
- **Existing Pipes**
  - Sewer
  - Water
  - Gas



Many choices for the passive infrastructure

- **Important to compare different options and decide before you build**
  - **Overhead vs underground cable deployment**
  - Greenfield vs brownfield (reuse existing ducts/pipes)
    - Pull vs Blow
  - Duct vs microducts vs direct buried
  - **Level of Accessibility/Flexibility**
    - Splices vs connectors vs retract
  - **Splitters: centralised vs decentralised**; cascaded (multi staged)
- **Comparing options based on**
  - CAPEX Costs: typical breakdowns in labour, equipment, installation
  - OPEX Costs: impact on failures, repair, power consumption, ...
  - Life time/Future proofness: expanding/upgrading network

Examples

1. Overhead vs. underground
2. Level of accessibility/flexibility in FCP
3. Optimised location of PON splitters

Example 1: overhead vs underground

Cost may increase:
- if poles are rented: recurring OPEX;
- if poles need reinforcement: extra CAPEX;

Overhead	Underground
+ low CAPEX, particularly when reusing existing poles	– High CAPEX, particularly with traditional trenching (> 50cm deep)
+ Easy and cheap customer connection and repair	– Expensive and difficult customer connections and repair
– Lifetime of the network (damage from storm, accidents, ...)	+ Longer lifetime due to higher protection from environment
– Local regulations: no permissions for estical reasons – rather trend towards putting existing overhead infrastructure underground	– Longer, more disturbing installation process can be negative for people/government

Example 1: overhead vs underground

Cost may decrease:
- if existing ducts can be reused
- if micro-/mini-trenching is allowed
- if trench sharing with other utilities

Overhead	Underground
+ low CAPEX, particularly when reusing existing poles	– High CAPEX, particularly with traditional trenching (> 50cm deep)
+ Easy and cheap customer connection and repair	– Expensive and difficult customer connections and repair
– Lifetime of the network (damage from storm, accidents, ...)	+ Longer lifetime due to higher protection from environment
– Local regulations: no permissions for estical reasons – rather trend towards putting existing overhead infrastructure underground	– Longer, more disturbing installation process can be negative for people/government

Example 2: level of accessibility/flexibility in FCP

For example:
Street cabinets with Patch panel and connectors

For example:
Manholes with Splice closures and spliced fibres

High flexibility FCP	Low flexibility FCP
+ can save on feeder cables, splitters, PON cards, power, ...	– Need all splitters and fibres installed and ready from day 1
– Customer Activation requires access to FCP for configuration	+ Customer Activation requires no intervention in FCP
– Challenge to keep Documentation up to date	+ No changes to documentation needed

Can be option to save initial costs if take rate is low

Can be easier and safer on long term while extra cost is limited if take rate is high

Example 3: optimised location of PON splitters

For example:
splitters in Access Node

For example: splitters in Primary FCP and/or secondary FCP and/or basement of MDU

Centralised splitters	Decentralised splitters
– High nr of fibres needed in feeder network	+ Save fibres in feeder network
+ Less PON splitters needed (better occupation of PON splitters), lower amount of PON cards	– More PON Splitters and cards needed (less occupied)
+ Easy to upgrade the network (for example change split ratio)	– Changing splitters requires to visit many places
– Large fibre count into MDU	+ For MDU, splitters can also be placed inside the building

The FTTH Handbook

Written by the D&O Committee of the FTTH Council Europe

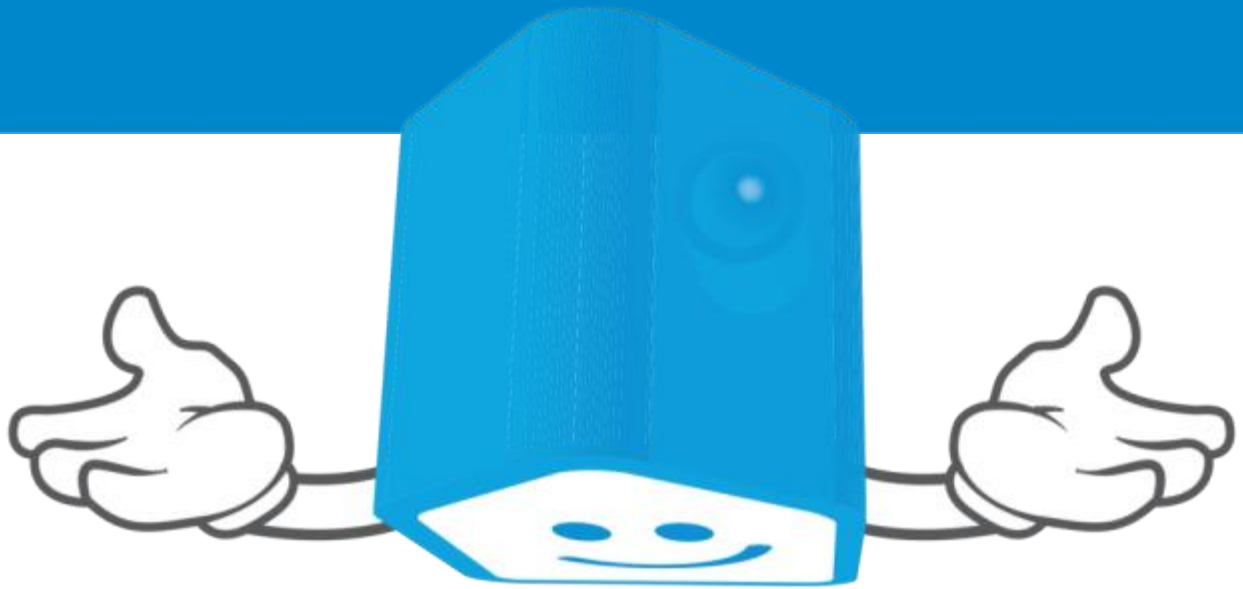
What is its purpose?

- **Explain all elements** associated with FTTH deployments
- List details of **deployment options** when planning and building FTTH

Two main parts

- **Active Infrastructure**
  Active Network Components & Technologies
- **Passive infrastructure**
  Infrastructure Components, Cabling, OSP

Current version, released in Feb 2014
(FTTH Conference in Stockholm)



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