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Dostop prek optičnih vlaken do končnega uporabnika - Napotki za gradnjo optičnega omrežja FTTX

Fibre optic access to end-user - A guideline to building of FTTX fibre optic network

Lichtwellenleiter Anschluß beim Endkunden - Leitfaden für die Erstellung von FTTx-Lichtwellenleiternetzen

Accès à l'utilisateur par fibres optiques - Lignes directrices relatives à la construction d'un réseau en fibres optiques de type FttX

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

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Foreword

This document (CLC/TR 50510:2012) has been prepared by CLC/TC 86A, "Optical fibres and optical fibre cables".

This document supersedes CLC/TR 50510:2007.

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Executive summary

The abbreviation FTTx refers to grids using fibres in the terminal area, meaning beyond the last exchange Central Office. “x” thereby denotes different penetration levels, for instance:

- FTTC = Fibre to the Curb, meaning to the street (to the last cabinet);
- FTTB = Fibre to the Building, meaning to the building, normally into the basement;
- FTTH = Fibre to the Home, meaning into the residential area.

Most FTTx networks are designed without any active equipment in the external network and are therefore classified as passive optical networks. The only active equipment is at the central office and the customer premises. FTTH - PON networks can be designed around different architectures.

The purpose of this Technical Report is to be a first guideline for those considering to install a high bandwidth (high bit-rate) FTTx-network. After studying the Technical Report operators, communities, energy companies, installers and others will understand the necessary steps to take to plan and install FTTx-networks with high quality and cost effectiveness, and to secure a uniform structure and a high quality level on such networks.

The main part of this Technical Report describes the FTTx-networks, but Clause 2 also contains more general information to give an understanding as to how these networks fit into the planning of other network infrastructures.

FTTx has for many years been regarded as the most future-proof technique for transmission of broadband multi-media applications. The building of FTTx-networks has previously been prevented by high costs. New investigations show, however, that the cost to install a new fibre based network (100 Mbit/s) is a little less than to install a new copper network. The FTTx-network is also the only structure, which with certainty can offer both the present and the future needs, which broadband access services require. At the same time the technique allows efficient operating maintenance and cost savings.

The networks to be presented are usually called FTTx, but with the strategy described here fibre networks can reach any point in the network. The end-user can be separate homes, houses, office environments, optoelectrical transitions in equipment for alarms, surveillance, monitoring devices etc.

The Technical Report also describes recommendations and gives basic requirements to be fulfilled by an optical fibre installation in an FTTx-network to satisfy present and future requirements on capacity, transmission distance and network quality. As a target, the minimum capacity is set to 1 Gbit/s (1 000 Mbit/s) up to 10 km distance. Relevant types of single-mode optical fibres are specified in EN 60793-2-50. However, in the industry single-mode optical fibre is typically described by the relevant ITU-T recommendations. The physical network should have an expected lifetime of at least 25 years.

The recommendations are written for a general audience, but in particular for people involved in private and public enterprises, people responsible for broadband decisions, planning, training and installations.

The Technical Report is divided into eight clauses:

- Clause 1 introduces the term “broadband” and its background.
- Clause 2 introduces the telecommunications infrastructures and provides an overview of the basic structure for the FTTx network.
- Clause 3 describes system implementations for FTTx including requirements on products and installation techniques.
- Clause 4 provides guidance on how to create a network and gives an overview of applicable network topologies.
- Clause 5 provides basic information in relation to various installation practises and the planning relevant to those practises.

- Clause 6 addresses installation of the FTTx network.
- Clause 7 addresses the testing, documentation and maintenance of the installed network.
- Clause 8 addresses the overall quality.

A number of annexes are included to give deeper knowledge in certain areas. They are broad examples and can be used to give a better view on the principles for installation of FTTx-networks with cables, microduct optical fibre cables, microducts and blown fibre units. To some extent these annexes are company specific, which the reader should be aware of. Annex A (reference [1]) gives a comprehensive list of standards. References [2], [3], [5] and [6] give a good overview of the present status in ITU-T, IEC and the general CENELEC view.

Some of the requirements put forward in this Technical Report are unique for an FTTx-network and should not be used in a general sense for optical networks.

1 Introduction to Broadband

Communication today is digital and therefore sound, pictures, voice, data carried by networks are data expressed in terms of bit, bytes and their multiples (kilo (k), mega (M), giga (G), tera (T)). A bit (binary digit) is the smallest digital unit and has only two values: 0 or 1. A byte includes 8 bits and defines the size of a data file. Transmission capacity of networks and terminals is not expressed by using bytes, but using bit per second (Bit/s). When a data file is transferred in a network two supplementary bits are necessary. It means that 10 bits are required for 1 byte.

A subscriber who wants to download or upload a large file must wait for data transfer to be accomplished. This time depends on the file size; say 100 MB, and transmission speed. In most networks, like VDSL or cable, transmission speeds are asymmetrical, with download (data transfer towards the user) being faster than upload (data transfer from the user), e.g. 100 Mbit/s and 4 Mbit/s, respectively commonly offered using DOCSIS 3.0 technology. At these speeds, it takes just 8 s to download a 100 MB file, but as much as 200 s (3 min 20 s) to upload it. In ADSL networks, typical download and upload speeds are 15 Mbit/s and 1 Mbit/s, corresponding file transfer times being 53 s and 800 s (13 min 20 s) respectively.

Actual transmission speed in many networks is lower than advertised and vary with traffic load due to oversubscription of shared system capacity. This problem does not exist in point-to-point (P2P) fibre networks without capacity sharing, where 1 Gbit/s symmetrical transmission speed is currently possible.

While users of passively split FTTx network do share common capacity, it is large, for example 2,5 Gbit/s in a GPON system, so fast and reasonably symmetrical service can be offered, like 100/50 Mbit/s or 100/25 Mbit/s.

The following table gives examples of transmission times for downloading a 6,25 GB file with high quality DVD movie.

Transmission speed	Download time	Access technology
0,128 Mbit/s	5 days, 8 h	Dial-up
10 Mbit/s	8 h	VDSL
100 Mbit/s	48 min	DOCSIS 3.0,GPON, EPON
1 000 Mbit/s	50 s	P2P fibre access

We do not know all future applications, however existing technologies of today, such as video on demand and the exchange of medical data e.g. for Ambient Assisted Living (AAL), offer an outlook on the future usage of broadband networks.

For the purpose of this document the following classifications will be used:

– low bit rate transmission: up to 1 Mbit/s

– medium bit rate transmission: 1 up to 10 Mbit/s

– high bit rate transmission: 10 up to 100 Mbit/s

– Very high bit rate transmission: 1 Gbit/s and more.

2 Network Structure and Nodes

2.1 General

This clause provides an overview of the FTTx networks and provides a foundation for any terminology and references made from subsequent clauses in this Technical Report.

2.2 Network Layers

2.2.1 Overview

For a level-designed view on the components in the build-up of the infrastructure, see Figure 1.

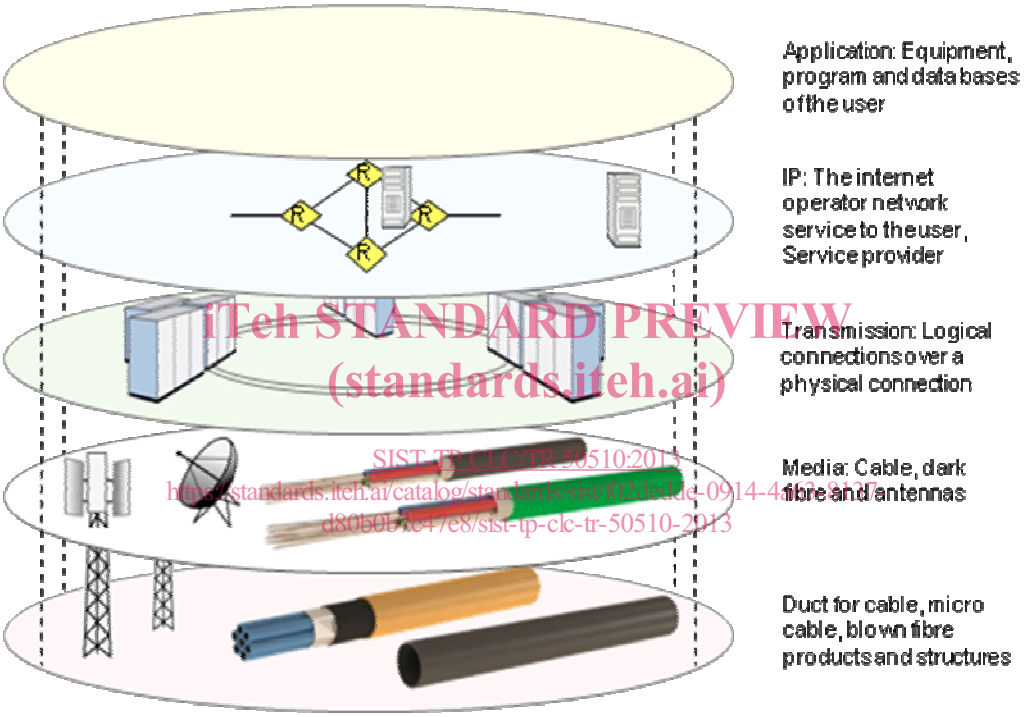

Figure 1 – Network layers

From the bottom up, Figure 1 shows the following network layers:

- Physical routing: Duct for cables, for microduct optical fibre cables, and for microduct fibre unit cables (blown fibre products) and for structures for antennas
- Passive transmission and interconnecting media: optical fibre cable, connectors, antennas, boxes, closures and their physical interconnections
- Active transmission systems: Logical connections over a physical connection
- IP: The internet operator network service to the user
- Application: Equipment, program and data bases of the user

Designing the infrastructure in layers makes it possible for different ownership of individual layers. This creates possibilities for open networks and competition, but also presents risks regarding responsibilities and long-term interaction.

2.2.2 Physical routing

The lowest layer in the physical network is the physical routing. It consists of ducts in standard dimensions, antenna structures, network components and microducts among others. Also existing infrastructure tubing such as sewer-, gas-, and drinking water tubes may be used. The physical routing should have an expected lifetime of 25 years.

This Technical Report describes the physical routing as applied to FTTx infrastructures. Most of the cost for a broadband network is in the planning and installation of the routing layer. It is therefore important to be accurate in planning, installation and documentation, and that the material of the parts used is of high quality. Applying an advanced Network Software Suite for the design, deployment and registration of the passive network, as readily available today, is essential to optimize the network design and to reduce costs. Normally the network owner owns this level.

2.2.3 Passive transmission media

This layer contains optical fibres (cable, microcable, indoor- and outdoor-cable, blown fibre units etc.), interconnecting devices (connectors, splices, closures etc.), copper cables (not treated here) and antennas for wireless access (FWA, WLAN, 2G, 3G, 4G, LMDS, LTE) as well not treated here.

This Technical Report describes the passive transmission media as applied to FTTx infrastructures.

The installation of single-mode optical fibres within FTTx-networks provides the longest operational lifetime due to its transmission performance. Cables containing those optical fibres are expected to have design lifetimes consistent with those of the physical routing components of 2.2.2.

Cables should be installed in ducts to minimise costs where network growth requires additional cables to be installed and when cables need to repaired or replaced.

The network owner typically owns the cables and the optical fibres.

2.2.4 Transmission-, IP- and application layer

The transmission-, IP- and application layer will not be described in this Technical Report.

2.2.5 Ownership, operating and maintenance

When all parts in the infrastructure fulfil specified quality requirements regarding transmission and installation, different ownerships could be possible. Ownership and operation could be split by different governmental or community companies, jointly owned companies between different communities, energy companies, building enterprises. Housing co-operatives, house-owner associations, private persons and landowners may also own the local network closest to the end-users.

Considering operation and maintenance the network level owners have to specify acceptable downtimes.

2.3 Network topology – Terminology

2.3.1 Overview on Infrastructure

To get an overall picture of optical fibre networks it is necessary to explain some of the terminology and concepts used.

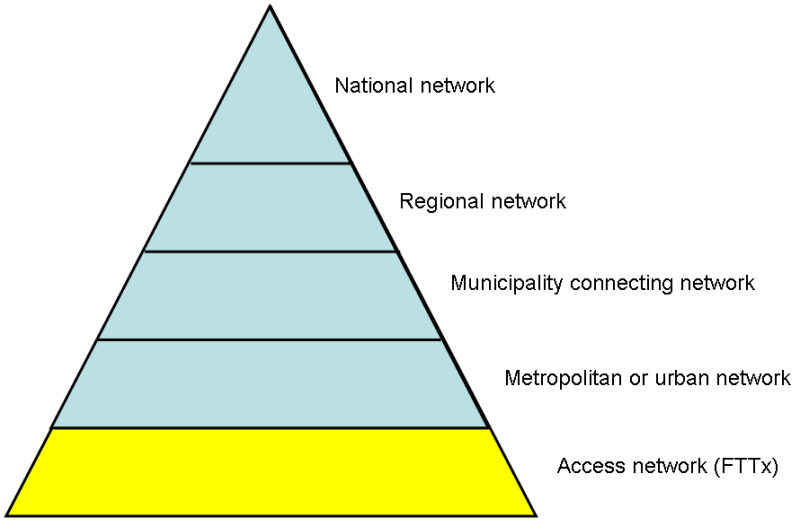

Figure 2 – The network is hierarchically built up

The traffic volumes and requirements for capacity, functionality and availability increase with the network level. Therefore the strategic significance and requirements for protection and security also increase in the higher network levels. All IP-traffic can be distributed, which means that this hierarchy may be flattened in a few years. The present network is a combination of a traditional telephone- and a future IP-network, which can be described as in Figures 2 to 7. This means that the information can find the best route when alternative routes are available.

The highest level is the national network, see Figure 2 and the lowest (colour-marked) is the network for connecting end-users or subscribers and is focussed on in this Technical Report.

2.3.2 National network

The national network connects all regions in the country and is connected to international networks. This type of network has a very high security level. A national network has normally few owners.

2.3.3 Regional network

A regional network or a community-connecting network connects networks within a region. Networks within a region often consist of municipality-connecting networks from different communities. A regional network is then connected to the national network.

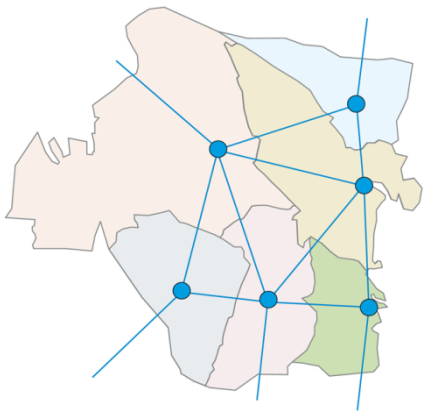

Figure 3 – A regional network, e.g. in a county

Some of the municipality-connecting networks can be connected to nearby regions (Figure 3).

2.3.4 Municipality connecting network

Municipality-connecting networks connect different municipalities (places) within a community. These networks are in turn connected upwards to regional networks or community-connecting networks and downwards to access networks. The connection is made through the community main node.

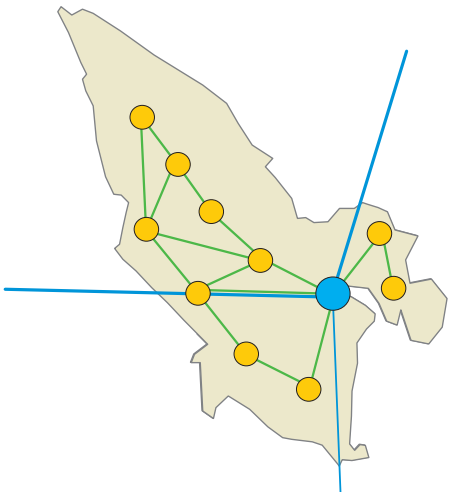

Figure 4 – The municipality-connecting network connects the larger places within a community

In each place there are one or more nodes, access nodes (possibly also distribution nodes), which connects the end-user – the subscriber (Figure 4).

2.3.5 Metropolitan or urban network

City (metropolitan) or urban networks are networks within a city or in a sparsely populated area. The function is to give a broadband infrastructure, which meets a long-term need using cost-effective solutions enabling the access networks to reach subscribers. This can be achieved by using existing or planned networks of different kinds. These networks are directly connected to the main node or to a distribution node (redundancy). Access nodes are connected along the ring structure (Figure 5).

Figure 5 – The metropolitan or urban network, the red lines, connects areas in a thinly populated area

2.3.6 Access network

The network levels described in 2.3.2 to 2.3.5 are normally installed on public land. In contrast, parts of the access network may be installed on private properties or land. Subscribers from houses, terraced houses, blocks of flats, companies, hospitals and authorities can be connected to the access network. Also masts for FWA (Fixed Wireless Access) or WLAN (Wireless LAN) and antennas for the mobile network can be connected. Furthermore equipment for security, surveillance, fire-alarms and control equipment can be connected.

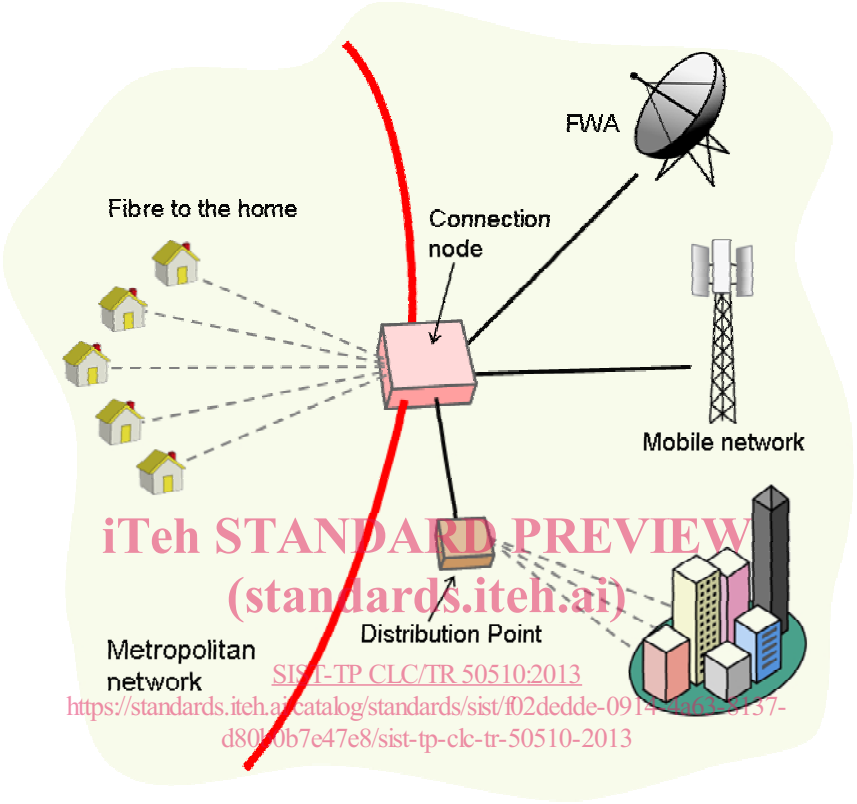

Figure 6 – The access network connects a large number of end-users

2.4 Nodes – Topology and Terminology

2.4.1 Overview

There are a number of junctions (also known as nodes) in a broadband network, where single traffic flows are mixed, multiplexed and de-multiplexed to create an efficient flow through the network. In the nodes the routing and switching of the data packages is performed. Joint traffic between different network owners or operators is also possible. The largest number of nodes will be used for the connection of the end-customers.

The nodes are spaces filled with transmission equipment, ODFs (Optical Distribution Frames), cross-connect devices, splice boxes, uninterruptible power supplies and equipment for climate control.

The design of the access node will be briefly described in the following but other types of nodes will not be discussed, except for a few comments.