Broadband via Ethernet

Case Study

Investing in the future by working together for a sustainable and competitive region

Content

1. Executive Summary

The ethernet protocol, a computer network technology for local area networks based on frames, is the most popular protocol for networks in enterprises. It is easy to implement, to maintain and very flexible. The ethernet frames can be regarded as carrier services. As a conclusion of

- very broadband intensive applications in the business world as well as
- the migration to the next generation networks (NGN) based firstly on Internet Protocol/Multi Protocol Layer Switching (IP/MPLS) and secondly on ethernet

the consultants „Frost and Sullivan“ expect a market potential for ethernet services in europe of about 4,83 millions of millions euro in 2012 [FROS06].

Ethernet has to be further developed necessarily concerning scalability, service management, standardised services, quality of service and reliability. In addition to the wellknown functions of local area networks (LAN) Ethernet will essential tasks in Metropolitan Area Networks (MAN) and Wide Area Networks (WAN). The user will be offered all functionalities of ethernet services without caring about the carriers networks. If parts of the network consist, for instance, of Synchronous Digital Hierarchy (SDH) or/and MPLS full functionality will be maintained for the user. At its core, we will appoint types of ethernet, ethernet virtual connections and possible realization at the customer.

2. Problem Statement

The passing of the reference IEEE 802.3ae, also called 10 Gigabit Ethernet Standard (10 GE), sets new standards. After ethernet, fast ethernet und gigabit ethernet 10 GE is standard since June 2002. Different from gigabit ethernet 10 GE first was a pure fibre technology. First and foremost 10 GE is intended for linking switch and server or switch to switch. The IEEE 802.3ae reference bases on previous ethernet standards. Hence 10 GE is efficient and easy to implement. Using copper cables at that time was not taken into account but was integrated in the so-called pre-standard. So, fibre as well as copper can be deployed. 10 GE supports seven different fibre types and is appropriate flexible ([METR10]).

The algorithm and technology Carrier Sense Multiple Access with Collision Detection (CSMA/CD) was resigned. Operation takes place exclusively in full duplex mode. Even though ethernet was developed for LAN, the 10 GE standard is discussed and prepared for use in WAN. It directly competes with ATM, Synchronous Optical Network (SONET) und SDH. The improvements in the MAC Layer are especially being mentioned.

The PHY-Layer of 10 GE is divided into the four sublayers PCS, WIS, PMA und PMD. The Physical Coding Sublayer (PCS) is responsible for the coding of the bitstream, which has to be transmitted. Physical Medium Attachment (PMA) and Physical Medium Dependent (PMD) take care for the attachment to the appropriate transmission medium. The WAN Interface Sublayer (WIS) functions as a accomodation to the data rates of SONET/SDH systems if WAN variant are in use.

Two different characteristics can be described at the PHYs on layer 1: The **LAN-PHY** functions as a improvement of bandwidth for pure ethernet systems. Operation happens over passive fibre links (dark fibre). The LAN PHY standards are recognisable at a “R” in their name. The **WAN-PHY** brings together ethernet and SONET/SDH systems. This variant is, from the 10 GE architects point of view, merely a migration solution on the way to a global ethernet. Opposite to the LAN variant the WAN variant owns a WAN Interface Sublayer (WIS, see above). The WAN PHY standards are recognisable at a “W” in their name.

LAN-PHY and WAN-PHY are being used over identically PMD-Layer, both reach the same distance. Hence the distinction refers to the possible use of WAN infrastructure and not to the

transmission distance. "WAN PHY" with 9953,280 Mbit/s is based on SDH and is suitable to provide the ethernet technology for a world wide internet. Remember that 10 GE does not use CSMA/CD, because it defines full duplex traffic and acts as a competitor to SDH with ATM, however it can not supply the necessary functions for th charged area. This technology still works without algorithms for access control and flow control. Equally arbitrary meshing is missing, which can not be solved with spanning tree and link aggregation.

3. Alternatives

New ethernet services are possible, which can be offered by the providers. Ethernet Line (E-Line) as point-to-point connection, or as a point-to-multipoint connection the Ethernet LAN (E-LAN). A broadband access via copper is possible with Long Reach Ethernet (LRE), which creates the conditions for a Ethernet to the Home (ETTH).

3.1 Applications

3.1.1 Applications for private customers

For private customers the following applications can be listed.

- Access to internet including access to the Next Generation Network (NGN)
- Electronic Services as E-Gaming, E-Health Care, E-Shopping
- IP Telephonie
- Video-Telephonie
- Streaming Video on Demand
- Video Distribution
- Broadcast TV
- B2B
- Triple Play DSL

Triple Play DSL allows customers to use speech, video and data services, which are followed potentially by more services. These are for instance

- Multimedia Mail
- Home Services as Home Security, Home Care, Home Control, Home Entertainment

3.1.2 Applications for business customers

Business customers claim higher requests than most private customers.

- Multipoint-to-multipoint connections
- Serving IP oriented and not IP oriented customers traffic
- Higher Bandwidth
- Video conferences
- Distributed Electronic Services as E-Learning, E-Business

3.2 Types of ethernet

3.2.1 Ethernet over SDH

SDH is able to transmit and multiplex 10 GE. In order to map packet oriented IP data in a SDH container the transmission protocol LAPS (Link Access Procedure SDH) has been developed. Whereas ITU-T X-85 defines IP over SDH, ITU-T X-86 defines ethernet over SDH with LAPS.

To be able to transmit speech and data efficiently over a common platform the Generic Frame Procedure (GFP), the Virtual Concatenation (VCAT) and the granular Link Capacity Adjustment Scheme (LCAS) were defined by ITU..

These extensions of the conventional SDH are called Next Generation SDH (NG-SDH). The NG-SDH is a competitive wide area network technology.

3.2.2 Metro Ethernet and network variants

Metro Ethernet Networks (MEN) are metropolitan area networks, which base on carrier ethernet. They will be inserted incrementally as an alternative to well known WAN. One reason is that there is no longer a length restriction after working full duplex with 1 Gbps and 10 Gbps. Moreover they afford a cost-efficient approach to solution, guarantee high efficiency of the network capacity and support many simple and scalable services ([ITLE10]). Metro ethernet is not a standard, but merely a generic name.

There exist two different network variants for metro ethernet:

- Ethernet Line (see Figure 1)

- Ethernet LAN (see Figure 2)

Ethernet Line

Ethernet Line, often referenced as E-Line, offers a point-to-point connection for the following possible applications:

- Ethernet Internet Access
- Point-to-Point VPN
- Private Line Services

The E-Line Service provides a static connection between two User-to-Network-Interfaces (UNI). These static connection enacts about constant bandwidth and is located between two Customer Equipments (CE) or realizes connection from a CE to a Service Provider Interface (SPI). The CE can be devided in two types.

Though the Customer Premises Equipment (CPE) is located at the customer, it is managed by the provider. The Customer Local Equipment (CLE) is managed by the customer and represents the attachment to his LAN. CPE and CLE are connected via ethernet.

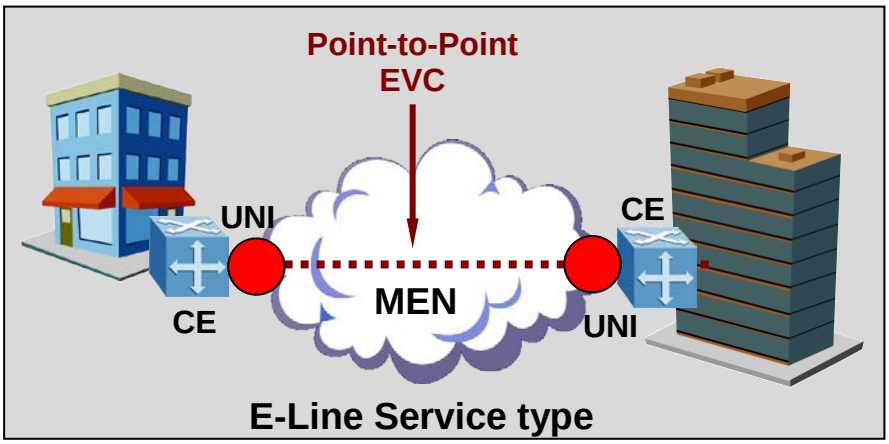


Figure 1: Ethernet Line

Ethernet LAN

E-LAN offers the customer realizing a multipoint-to-multipoint connection also outside the own network. It is possible to establish dedicated connections for the customer, so that he can consider the E-LAN as a transparent LAN. All subcribers are connected in the Metro Ethernet Network as in a LAN.

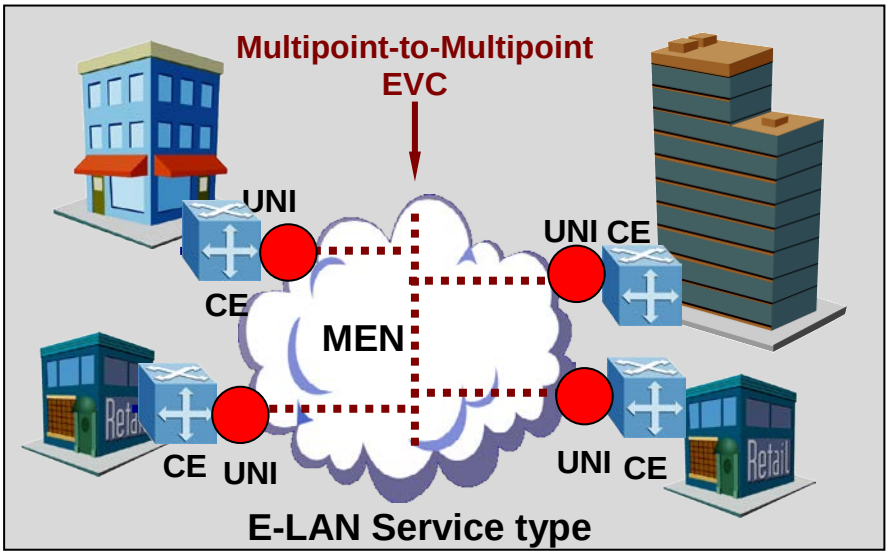


Figure 2: Ethernet LAN

3.3 Ethernet virtual connection

An Ethernet Virtual Connection (EVC) represents a connection of two or more different UNI. There exist realizations as a point-to-point and a multipoint-to-multipoint connection.

EVC allow to build up VLANs through the service provider´s network. For this purpose the so-called VLAN-Stacking is used, which can be implemented in mixed manner due to IEEE802.1ah MinM or IEEE802.1ad QinQ – for details see below (ch. 3.3.1 and ch. 3.3.2).

Two IEEE norms – usable in the environment of MAN and WAN – have been developed to use VLAN structures more and better. Background has been and will be a greater demand for continuous end-to-end ethernet solutions. This technology provides a transparency to the customer and makes conversions of protocols unnecessary.

Figure 3 clarifies the frame construction. There are obvious differences between both standards. 802.1q is as good as a predecessor and in use to equip VLAN.

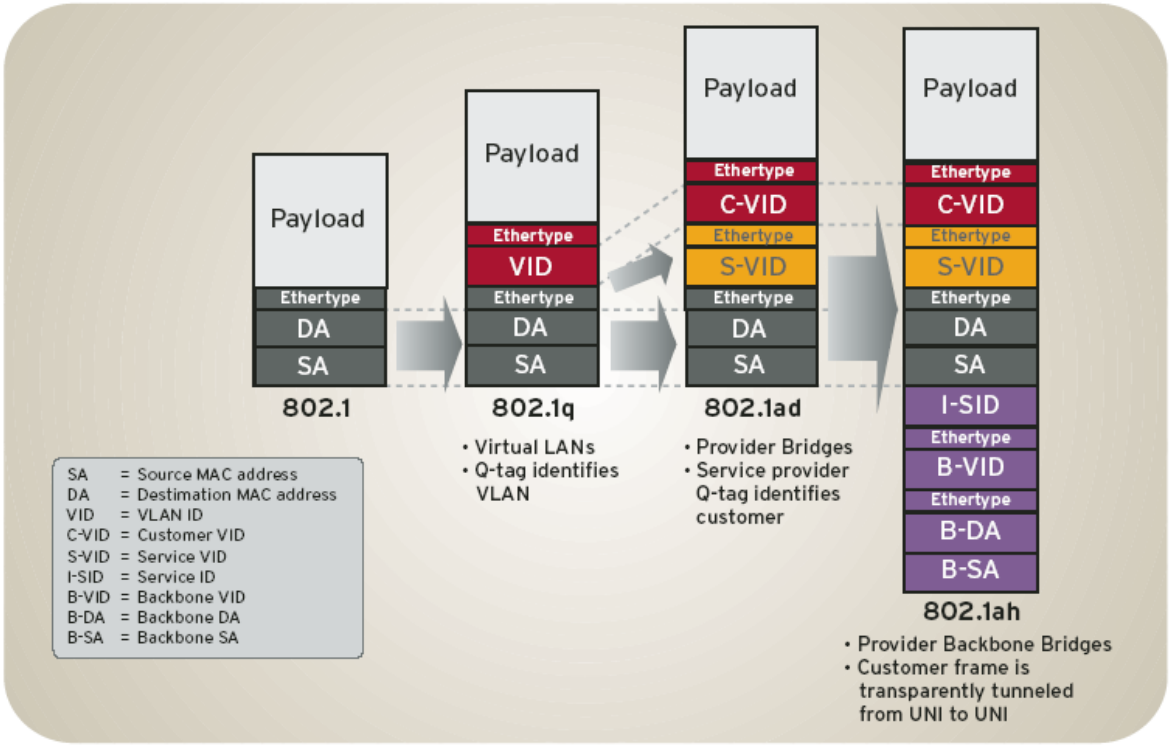


Figure 3: Frame construction IEEE standards IEEE802.1x

3.3.1 IEEE802.1ah MinM (Mac in Mac or Provider Backbone Transport)

802.1ah bases on the simple tagout of some ethernet functionalities. After this tagout the same hardware is able to use new methods for connection oriented forwarding. The switched-off methods are MAC learning, broadcast unknown and spanning tree. At the moment ethernet switches send packets by means of 60 bit, 12 bit of which are used by the VLAN-Tag whereas 48 bit are used by the MAC address of the receiver (see figure 4).

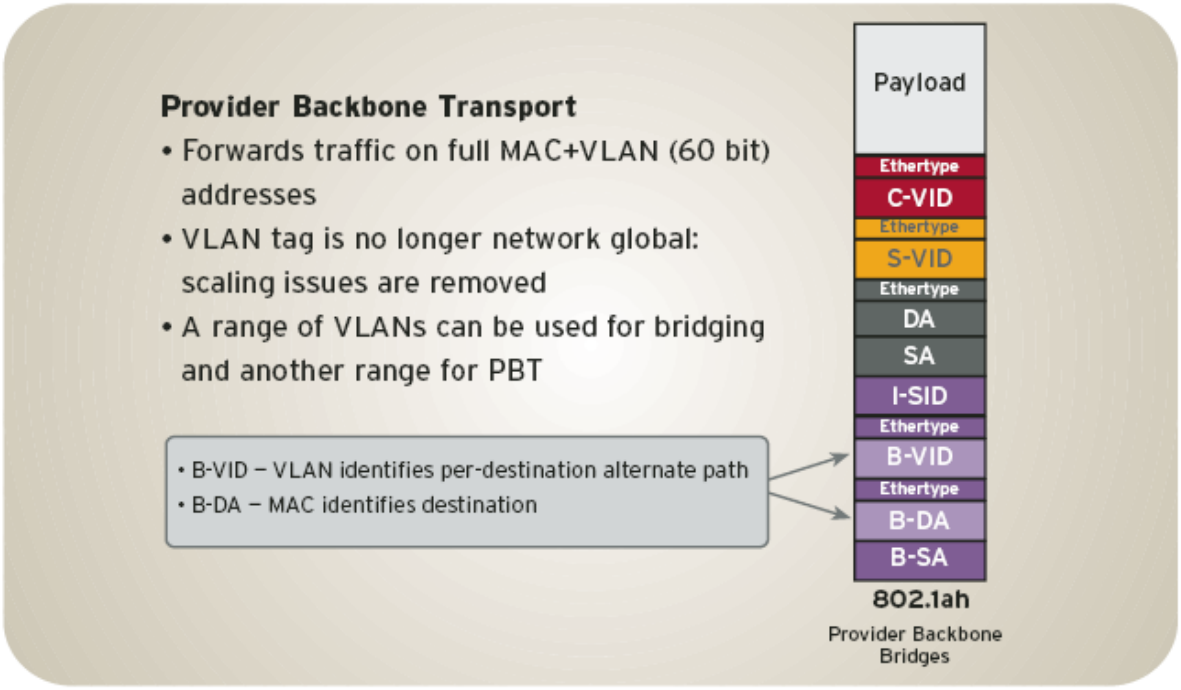


Figure 4: IEEE standard 802.1ah

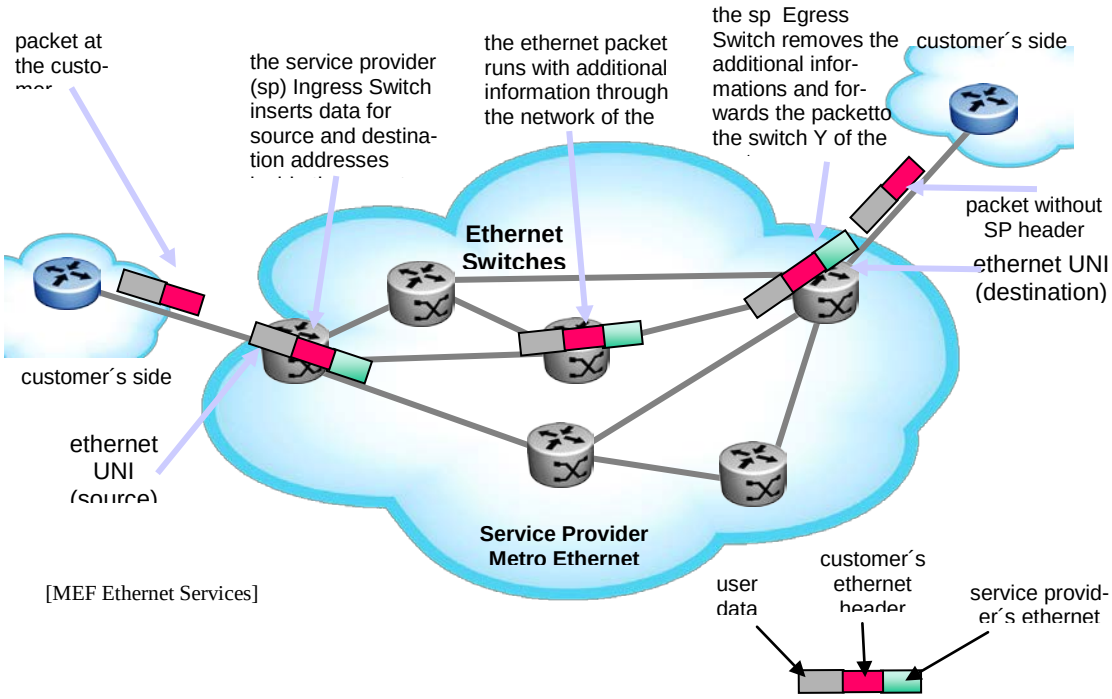
The switches are going to be managed and every VLAN-Tag represents a predicted path through the network, so that the target address is stated. There is no longer a self-learning environment as in the origin ethernet but the execution of demands of the provider´s backbone. The spanning tree protocol is no longer used and unnecessary; every path, taken by a frame, is a combination of demand of the provider and the VLAN-ID. If the fixed path (working path) is not available, it is possible to fall back onto a secure path (protection path).

IEEE802.1ag (Connectivity Fault Management) controls the process of recognizing a faulty path. Connectivity check frames are sent from both sides in between a time interval, for instance 10 ms. When three frames of the other station do not arrive, the working path is switched off and the protection path will work. At the starting point the VLAN-ID must be changed and set to the protection path. It is possible to react within 50 ms on changed network relations; this is comparable to SONET/SDH.

The advantage is, that only very small routing tables exist, only actual routes must be known. A sharp segregation exists between the network of the provider and the network of the customer. None of them has to know the structure of the other network, which guarantees a greater security.

The network provider plans his network without knowing of VLAN-Tags or address conflicts outside his range. The network load is smaller for the provider, because broadcasts are passed through and do not stress his own network.

The computer power and the memories of the switches may be smaller and therewith cheaper as in a solution where information about the customer´s network must be known. Figure 5 demonstrates the way, when a packet runs through the network of the service provider.



[MEF Ethernet Services]

Figure 5: Standard IEEE802.1ah, Frame tracing

3.3.2 IEEE802.1ad QinQ (VLAN Stacking)

This standard deals with the so-called Virtual Local Area Network (VLAN). One can say, it is the assignment of a logical network to a physical network. The assignment takes place when a subdivision on physical level is not possible. A VLAN-Tag will be inserted into the header; there are 4096 explicit possibilities, thus the same number of creating logical networks.

The VLAN-Tag, defined in IEEE802.1q, permits a distinction of the different VLANs on layer 2. This allows a database oriented network management, so that a removal out of a subscriber to another hub or switch is possible without physical changing of the network. The

connected equipment will be recognized at its MAC address based on the database and the port will be configured. Such VLANs are dynamic and adaptive.

One aim was avoiding distributing broadcasts throughout the whole network. So it is allowed to stack the VLANs (stacking). Service providers profit, because they rent their network at different ISPs and can depart network elements, which is physically very difficult or impossible. With VLAN-Tags routers are also feasible to choose miscellaneous routes in order to manage the traffic of two ISPs over different paths and, if necessary, sell with its own quality of service.

3.4 Realization at the customer

The wide spreading of ethernet hardware concedes the service providers to build up on existing infrastructure. The customer can use his existing equipment and saves enormous costs. There are two different physical possibilities of linking, first is copper cable, the second is fibre. Meanwhile fibre is laid also to the customer (fibre to the home). Both connection types are described below.

The term „First Mile“ used for instance by IEEE means the same as „Last Mile“, which is used by the service providers seeing the network and at last the last mile to the customer.

3.4.1 Ethernet over the First Mile via copper

Copper cables are present in many households and companies. With the aid of Long Reach Ethernet (LRE) this technology can be used to tap to a metro ethernet. With LRE it is possible to extend a IEEE 802.3 conform ethernet in order to connect directly to the network of the service provider without laying new cables. The greatest range between customer and service provider is of vital importance for the data rate. Age and quality of the cable have additional influence and can harm data communication due to increased attenuation.

LRE was developed by Cisco in order to guarantee a connection with a bifilar copper cable. The line has symmetrical bandwidth for up- and downlink. This technology is comparable with a symmetrical DSL. Due to different used frequency bands it is possible to transmit data as well as speech over one link simultaneously.

The ethernet access at the customers is certified after IEE802.3 so that not changes must be made at an existing network. The data rate can reach up to 1060 meters 15 Mbps over copper

cable in half duplex and in full duplex. Up to a range of 1220 meters the data rate is specified with 10 Mbps and at more than 1520 meters with 5 Mbps.

The existing structures at the service provider respectively at the network owner remain. That means that the customer can use ISDN, an analog line or a private branch exchange (pbx) as usual. As transmission method Quadrature Amplitude Modulation (QAM) is applied, therewith the usable frequency band between 300 Hz und 3.4 kHz is used. LRE also uses Frequency Division Duplex (FDD) in order to separate data from ISDN, analog access and pbx; even the asymmetric DSL is possible with LRE.

3.4.2 Ethernet over the First Mile via Fibre (EFMF)

EFMF (see Figure 6) is striking for use of single mode fibre in the first mile. Copper is in use only in the customer´s premises. A converter, a so-called optical network terminator (ont), ensures for transposition from fibre onto copper. Every user is able to use the whole bandwidth, whereas data rate is dedicated scalable.

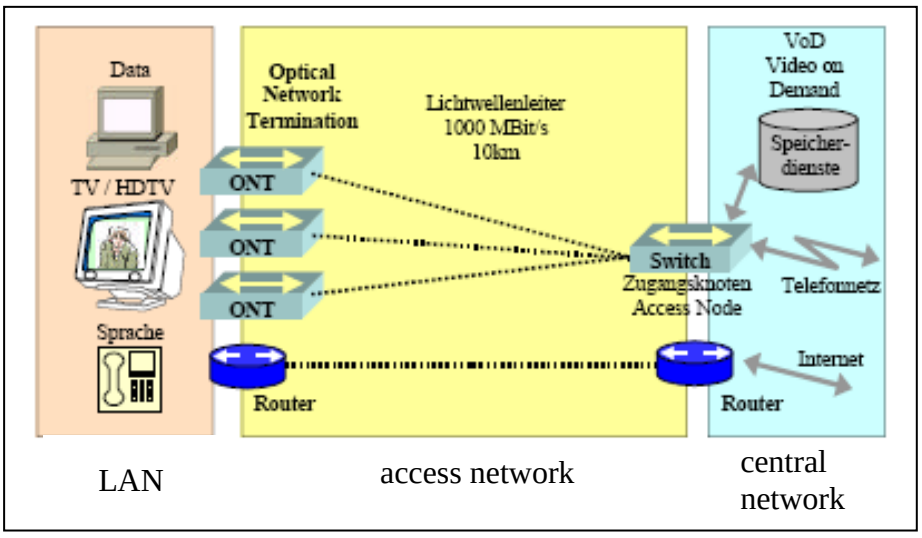


Figure 6: Ethernet in the first mile via fibre

3.4.3 Ethernet over the First Mile via passive Optical Network (EFM PON)

If EFM PON (see Figure 7) is in use the customers have to share the bandwidth. According to demand the bandwidth will be divided by the optical distributor. The signal will also be re-

generated, so that the length between Switch of the provider and the ont can be longer than 10 km.

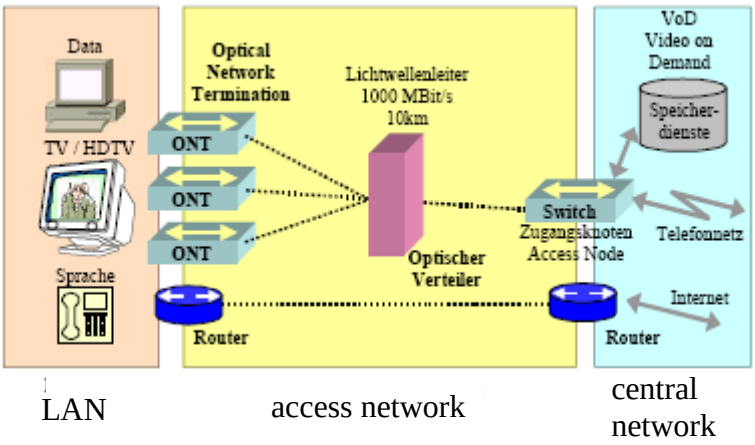


Figure 7: Ethernet in the first mile via passive optical network

4. Conclusion

Metro Ethernet is forging ahead. Ethernet is often said to provide the „lowest cost per bit“. The terminal equipments are nearly everywhere available, most personal computer own an ethernet interface and most industrial buildings are wired convenient.

More and more applications need higher data rates in the LAN and companies often are spread over some locations. A fast transmission technology is requested to take advantage of modern applications and to distribute data fast and as well as in real-time. Some software developers see the future of computers in the range of terminals, which are equipped on low level and work over a network with software from a server.

As mentioned not only companies are potential customers, the end user also want to take fast data and voice communication to a good account. VoIP, online gaming, video on demand in high definition quality and a fast approach to information are customer wish.

In Germany the companies Colt and the Deutsche Telekom have already products which base on metro ethernet in their portfolio. In past new techniques often had first to be used by potent firms, after that end customers got the new techniques step by step (see DSL for instance). The technique is sophisticated, standardized products are on the market and in action.

It seems to be a question of time, when households get entrance to internet via ethernet. Ethernet got a great market penetration in the last years. The acceptance is very high and the costs for a changeover are low.

5. Implementation

With the use of EFM conversions of protocols are not longer necessary. Ethernet can be used native on the whole transmission way. This new standard is not penetrated to most customers and moreover internet provider are still upgrading their DSL network.

EFM via copper is the way we prefer to realize in wide areas of the Weser-Ems district. Copper cables are present.

As mentioned in chapter 3.4 LRE is another possible solution for implementation in order to use copper cables. On the other hand it is bounded to the company Cisco.

At this time (autumn 2010) fibre glass is laid in some cities but not throughout the district. The technology is in comparison to ATM or SDH favorable in operation and offers ranges up to 10 kilometers with transmission rates of 1 Gbps. Fibre glass technology will not be laid comprehensive. Developing areas are able to be provided fast and advantageous EFMPON.

After all it is not possible for us to give a complete advice for a region with very different structures as small and medium cities as well as rural areas.

List of references

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