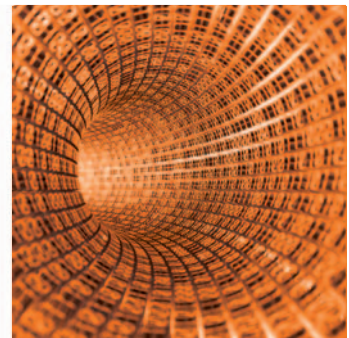


White Paper



Open Access Demands on FTTx Network Technology

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1 The purpose of this white paper

This white paper is aimed primarily at people and businesses dealing with the commercial and technical planning of FTTx networks.

Both aspects will be looked at and different models compared. The environment and the demands on FTTx networks will be described.

2 Why open access?

Rising demands for broadband, IPTV and increases in revenue from new services are some of the many reasons for pushing expansion of the fibre optic network to end customers.

From today's standpoint the bandwidth of fibre optics for data transmission is virtually unlimited. Therefore, laying fibre optics in households is considered a future-proof investment. But laying fibre optics requires very high initial investment. And it is not possible to recoup this investment from telecommunications operators' operational business within the usual depreciation periods. Therefore, partners are sought whose business models allow investments in infrastructure, making high network utilisation and therefore higher revenues possible.

Experience with marketing ADSL and mobile telephony through resellers indicates that network infrastructure operators could be a lot more successful due to the opening up of networks to other market providers. Consequently, most players on the telecommunications market agree that opening up the access networks (open access networks, OANs) is a win-win situation for operators and service providers alike.

In addition to FTTH networks, this also applies to expanding FTTC (Fibre-to-the-Curb) with VDSL2 particularly in less densely populated regions.

Due to the limited range of VDSL2 at high levels of bandwidth and therefore the low number of subscribers near feeder distribution interfaces, it is not worthwhile for many operators to install active technology in their own feeder distribution interface. Currently, major network operators, including Deutsche Telekom, are holding talks to outline a partnership on FTTC networks.

The opening of a network can take place in many different ways. Due to the number, origin and variety of business models, both where operators and service providers are concerned, it is likely that interests will differ. In order to minimise the complexity and therefore the costs in this market environment for all those involved, standardisation of the commercial and technical interfaces for an open access network would therefore be welcomed without stifling the market environment by imposing too many regulations.

The access network is the key point in network technology. The majority of hardware investments are made there. Therefore, the suitability of devices used in the access network plays a pivotal role in open access working smoothly.

3 What does open access mean?

According to Wikipedia, the term open access network in the telecommunications world means horizontal network architecture, or a business model that separates the passive from the active infrastructure. A distinction is also made between network operation and providing end customer services.

On the other hand, standard network architecture in today's telecommunications networks (and the business models they are based on) is called vertical network architecture. This means that the telecommunications network operators usually have passive technology (fibre optics, distributors, empty conduits) and

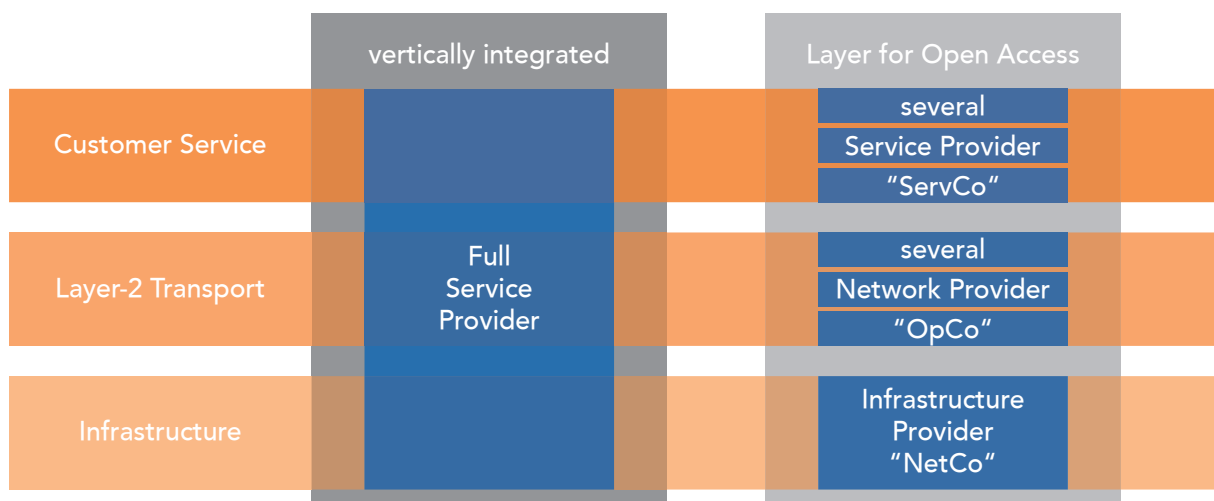
active technology (access network and transmission network equipment) and offer their own product portfolio for generating services (voice, data, Internet).

The new horizontal network architecture leads to a re-structuring of the traditional telecommunications business model towards three commercially independent business areas:

- The owner of the passive network "NetCo" that provides the passive technology: e.g. empty conduits, fibre optics or copper wires, passive distributors.

- The network operator "OpCo" that provides the active technology, operates the network and conveys the services to the end customer.
- The services provider "ServCo" who supplies and markets the services: telephony, Internet, TV, other added value services ...

In real world conditions NetCo and OpCo partner with one another. However there will be many ServCos that can offer their product portfolio in parallel via the same network access to the end consumer.



Graphic 1: Open access and operator model FTTH/FTTB

Dividing the business model horizontally allows other service providers to give their end customers access to their portfolio. This extends the options open to end customers.

Competition emerges between the service providers and the new network access becomes more attractive to end customers. To the open-access network operator this means that, in comparison to the classical vertical business model, network utilisation is increased significantly and financing is therefore easier and safeguarded.

In the future it is also conceivable that a company could adopt several roles on the open access market. Therefore, in open access business relationships it is important that no discrimination is made as regards access between each of the business areas, or in another words no preferential treatment is accorded.

The purpose of the horizontal structure is to create a new business environment that is as attractive as possible for all those involved and therefore a good basis for growth and new creative services. All market players can focus on the areas they excel in. It is still being debated what the interfaces between the different players should look like.

Because expectations are that in the future there will be a huge number of regional open access networks, it is in the interests of all those involved to reach a standardised regulation with one another. It is unlikely that service providers active worldwide will want to negotiate customised service level agreements (SLAs) with a variety of open access operators.

Open access allows business models to propel the expansion of fibre optics and provide network access to third parties without making any discrimination.

3.1 Residential customer services

Over the past ten years the Internet has undergone massive changes. The medium has gone from pure text which was easy to transmit by modem to include more and more graphics. Flash content, YouTube videos and Facebook with all the pictures require transmission bandwidths that in comparison to ten years ago have to be several times higher in order to make using the Internet an enjoyable experience. And new services that have been, or will be set up, will make demands on data transmission rise even further.

3.1.1 TV and video services: drivers for fibre optic networks (FTTx) and open access

In addition to the intensive usage of fast Internet access, TV and video services play a key role in the growth of broadband in telecommunications networks. To date, many telecommunications operators have struggled to provide television services for a variety of reasons. In addition to all the legal and commercial challenges, the bandwidth in the access network has till now proved to be the bottleneck. Nevertheless these services will in future be a valuable way of creating customer loyalty.

3.1.2 New TV and video services

IPTV (Internet TV) is still one of the new services that is not included in the standard range of all providers. The following IPTV options are further innovations in this environment:

- **Hybrid TV:** is a mixture of different TV transmission types which are usually integrated in a set-top box (STB), or directly in the TV set to become a harmonious unit in varying degrees. Examples are the STBs that have a standard broadcast receiver (DVB-C/-T/-S) and at the same time Internet access for video-on-demand services.
- **Over-the-Top TV:** are IPTV products that are conveyed as a standard data channel via the Internet. A popular example of this is Apple TV. Over-the-Top TV functions are integrated by many television set manufacturers in the set itself. In order to maintain quality, large data volumes are buffered on integrated hard disks or flash memories.

In the case of video-on-demand this is only noticeable due to a short waiting period before the film starts.

- **Web TV:** online portals have started to become more and more popular for some years. End customers can often access a wide video-on-demand range without incurring extra costs. However, it should be noted that as a unicast service Web TV places huge demands on the access network and the backbone when used intensively.

3.1.3 Further new services and applications in open access networks

Prophets are not required to predict that there will be an increasingly number of broadband-guzzling services that we are not yet aware of today, or consider unimportant. Remember the success of texts in mobile telephony. Texts are sent on a scale that no expert in Europe could ever have predicted.

Because of the increase in the average age of people in our society, services such as eHealth will become ever more crucial. Where this service is concerned, technical characteristics such as real-time transmission in monitoring vital bodily functions, or high resolution and jog-free video connections will be key aspects.

Smart metering is another buzzword and places relatively low demands on network requirements. If we imagine that in the future more and more household appliances are monitored and each has its own IP address, a flood of signalisation traffic is to be expected. These aspects must also be taken into account in open access network planning.

3.2 Corporate customer services

Until now we have looked at the residential customer segment. In the corporate customer segment there is also a growing tendency towards outsourcing business processes and therefore the data. In the telephony environment, these include services such as IP Centrex or hosted office solutions. In the data environment cloud computing is a hot topic. For corporate customers, cloud computing is in its widest sense outsourcing IT services such as storage, webhosting, ERM/CRM systems etc. which are then purchased via fast data connections from a specialised service

provider after a service level agreement (SLA) has been agreed. In this case, fast network access via VDSL2 or fibre optics is essential because in terms of speed users have to perceive that the purchased services work just as fast as if they were on the local hard disk.

■ Benefits for the operator:

- New marketing potentials occur that to date could not (adequately) be tapped into.
- The portfolio becomes more attractive.

■ Demands on the operator:

- The quality of service (QoS) makes high demands on the network as regards its availability, real-time quality and bandwidth.
- If necessary new service level agreements (SLAs) have to be developed and negotiated.

4 Technical implementation of open access networks

Graphic 2 shows a diagram of an open access network. Open access networks can be built as Fiber-to-the-x (FTTx). In this case the x stands either for curb (FTTC), building (FTTB) or home (FTTH).

As regards FTTC and FTTB, the last metres of data transmission to the end customer are implemented with VDSL2 technology via the existing telephone cable in order to minimise the connection and in-house wiring costs. The old copper wire is still used over very short distances. However this does limit the maximum bandwidth available to approx. 100 Mbps per subscriber line.

Today, the widespread roll-out of IP Ethernet network technology in the access and transmission networks allows the convergence of the above-mentioned pillars into a horizontal network layer model. As a consequence, faster roll-outs of new services, savings in running costs and in marketing, as well as an optimisation of overall costs, are just some of the benefits achieved. This development is the basis for new horizontal business models like open access.

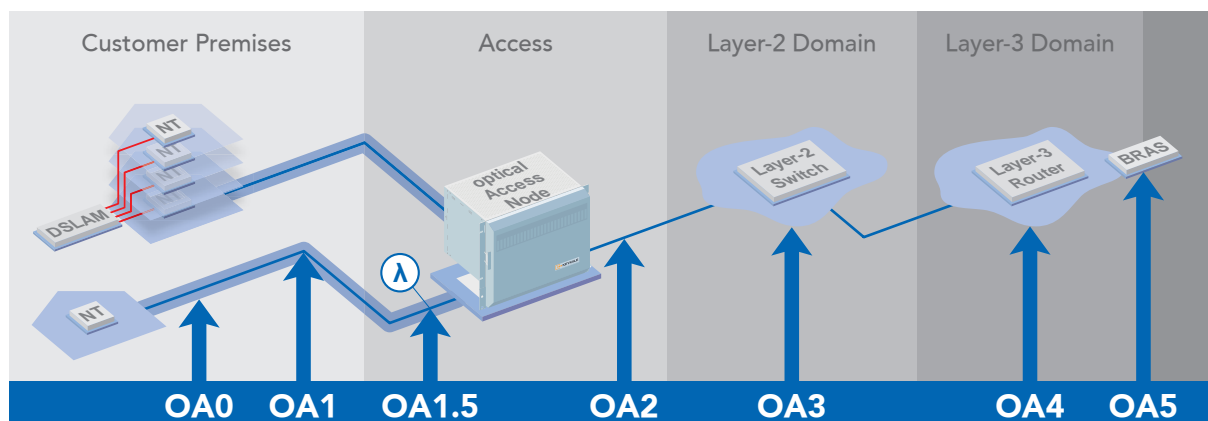


Figure 1: Access points for open access

4.1 Access points for open access

Different network nodes are conceivable as interfaces for feeding in services from more network operators. As defined in graphic 2 as OA0 to OA5 there are advantages and disadvantages in the different feed-in points:

- OA0 – empty conduits:
In an existing empty conduit infrastructure, further network operators can use existing empty conduits for an additional fibre optic network.
 - Advantage: it offers the provider a free choice of network topology and medium.
 - Disadvantage: high initial costs due to own infrastructure and active technology in the field, a lot of discussion required at the planning stage.
- OA1 – Dark fibre:
Competitors receive access to the end customer's fibre optics.
 - Advantage: works like copper unbundling, each supplier has a free choice of the active components.
 - Disadvantage: requires a lot of space on the optical distributor, as each supplier has to set up their own equipment. High investment costs. Not suitable for PON topology.
- OA1.5 – Wavelength:
Competitors receive a dedicated wavelength
 - Advantage: theoretically less complex than dark fibre. Needs much less space.
 - Disadvantage: No affordable equipment currently available. Strong dependence on one manufacturer due to a lack of standardisation.
- OA2 – Access Node Layer 2:
Competitors receive access to the access equipment of the network operator.
 - Advantage: affordable because access technology is used jointly.
 - Disadvantage: the variety of services might be restricted by the access equipment. Access regulations need to be established (service level agreement).
- OA3 – Aggregation Node (Layer 2):
Competitors gain access to the network operator's aggregation node (layer 2 domain).
 - Advantage: affordable because access and transmission technology are used jointly.

- Disadvantage: the variety of services might be restricted by the access equipment. Access regulations need to be established (service level agreement).
- OA4 – Layer 3 domain:
Competitors gain access to the network operator's layer 3 domain.
 - Advantage: affordable because network components are used jointly, possible simple subscriber provisioning.
 - Disadvantage: restricted variety of services. IPTV feed-in may not be possible. QoS and SLA parameters have to be laid down.
- OA5 – BRAS:
Competitors gain access to the network operator's BRAS (is already used today as wholesale bit stream access).
 - Advantage: affordable because all of the network operator's network is used.
 - Disadvantage: not suitable for IPTV services. Service offering is determined by the network operator.

Each country has a different approach to choosing the suitable feed-in point for open access networks. In practice of course different feed-in points could be used, but network interconnection is made a lot easier by jointly establishing technical and commercial rules. Future partnerships between network operators and service providers do not have to be renegotiated for every project. Currently, in Germany and England interconnection at the aggregation node of the network operator (OA3) is favoured. Specifications are at the moment being created in both countries to regulate the technical and commercial parameters – unfortunately however with national differences.

4.2 Demands placed on the interconnection of open access networks

Joint usage does of course place special demands on the systems in the access area that did not exist before the introduction of open access.

Therefore, the above-mentioned specifications for network interconnection also entail new functionalities for the devices to be used in the access network. For example, these are just some of the demands:

Layer 2 functionalities:

- Transmission of single- or double-tagged VLAN services
- Using the entire VLAD address area
- Parallel operation of n:1 and 1:1 services

QoS service functionalities:

- Establishing service classes for voice, data and TV services
- Mapping of provider-specific service classes used

Traffic engineering functionalities:

- Bandwidth restriction of data streams upstream and downstream
- Broadband management for service classes – particularly for IPTV services
- Colour marking in combination with QoS classes to prevent blocking

Enhanced safety requirements:

- Separating the data between subscribers (basic demand)
- Additional separation of the data between providers

Enhanced multi-cast capabilities:

- Support of several multi-cast bodies by different providers
- Superior demands on the number of multi-cast streams possible
- Parallel operation of unicast and multicast
- Traffic engineering of multicast groups

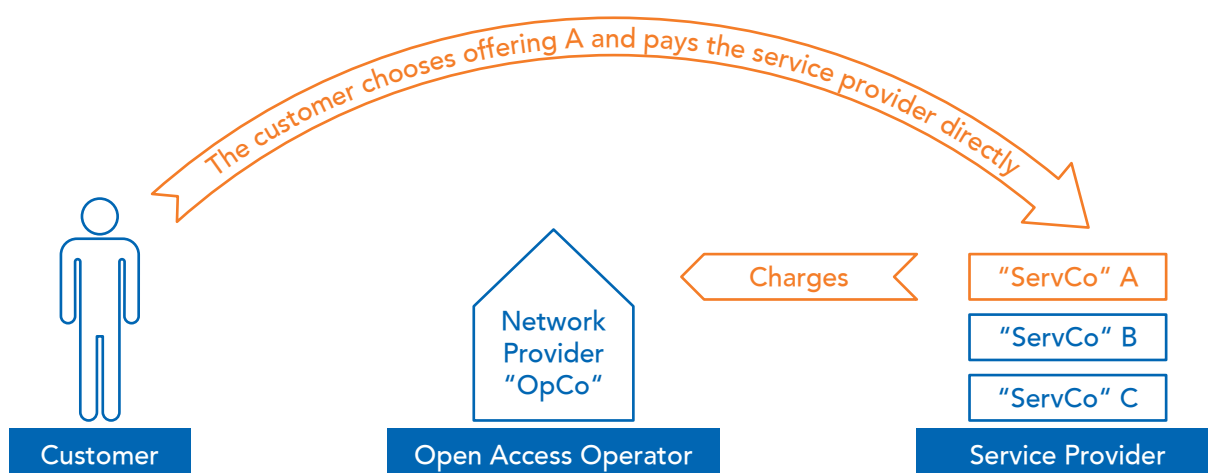
These high demands should always be borne in mind when selecting the devices in the access network, so that in the long term smooth operation in the open access environment can be guaranteed.

5 Commercial standpoint regarding open access networks

To assess business models in the open access environment, it is important to examine payment streams in addition to the aspects looked at to date. These have a permanent impact on the success, or lack of it, on long-term fibre optic expansion.

Based on the technical aspects mentioned in the previous chapter, depending on where they are interconnected (OA2 and OA3 or OA4 and OA5) payment flows are also different. These differences will be shown in a highly simplified way below.

5.1 Bit stream access to OA2 and OA3



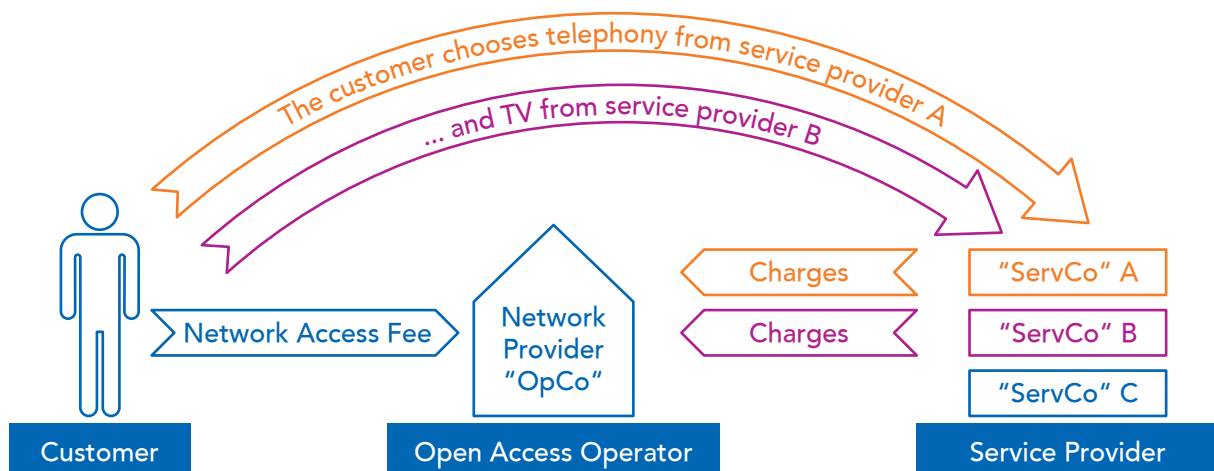
With this option, in the future it is likely (similarly to the standard practice with DSL connection in many countries) that the end customer will be able to choose a service package from a service provider. From a commercial standpoint, in this model the end customer pays a selected service provider directly ("ServCo A" in the graphic here).

ServCo A on the other hand then pays a charge (usually per subscriber and month) to

the open access provider who delivers the network access. This charge can be regardless of the services offered, or depend on the bandwidth required, or for example quality parameters.

In this case typical service providers could be for example Vodafone, T-Home, 1&1, O2.

5.2 Bit stream access to OA4 and OA5



In this case the open access provider leaves it up to the end customers which service provider they choose for the service concerned (e.g. telephony, Internet access, television, online banking, telemedicine, video-on-demand, home security, storage etc.).

The end customers pay the open access provider a network access fee, like the basic charge for a standard telephone line. They also pay a fee to each individual service provider (per usage frequency, per month etc.). In this case typical service providers could be companies without their own telecommunications infrastructures.

To summarise, it should be said that the canvas is not just black and white, but that in the future there will probably be no lack of grey shades. Hybrid forms of both models might also emerge. Whether and which model will permanently win through depends on factors such as the previously mentioned practicability, competition between the market suppliers, as well as regulation and standardisation.

5.3 Advantages and disadvantages for the open access providers and users

Advantages:

- For the infrastructure owner (NetCo): Owners of fibre optic networks hand over the running of their passive network infrastructures to various OpCos. The risk of setting up their own active networks and teams therefore no longer exists. With the exception of conurbations, as it is very likely that in the foreseeable future no second company will invest in a parallel fibre optic infrastructure, entry into the market as a NetCo is considered a very secure investment.
- For the open access operator (OpCo): He can on the one hand fully, or at least partially, hand over the investments in the network infrastructure to local government, or a utility, and therefore reduce the initial investment and consequently the entrepreneurial risk. On the other hand, by leasing

the access network to third parties – Internet Service Providers (ISPs) or other (larger) network operators – the network is more attractive to the end customer.

- For the service provider (ServCo):
He can set himself apart from the competition by offering new service packages which were previously impossible due to the lack of bandwidth. The same applies to addressing whole market segments (e.g. corporate customer services). A ServCo can also extend its value chain by entering into direct contracts, e.g. for a triple-play package with the end customer.
- For the end customer:
He receives high-speed Internet access that gives him a wider range of services and the choice between different service providers. Previous analyses have shown that the resale value of the property is increased significantly.

6 Summary

Since the networks on the telecommunications market were opened up in the 1990s and many small and large network providers sprang up as a result, network interconnections today are no longer a big problem – in fact quite the opposite. Due to the wide availability of Ethernet, the replacement of ATM and other antiquated protocols, network interconnections have become much easier in comparison with the situation ten or 20 years ago.

But appearances are deceptive if we look at tomorrow's open access networks. Depending on the demands of the service provider, or open access operator (see chapter 4), technical show-stoppers can occur that suddenly put the entire business case in a dubious light. The wrong choice of access network, provisioning system, VoIP platform etc. could lead to insurmountable differences in the service level agreements required by the service provider and supplied by the open access operator. In the worst case scenario this could mean that a wholesale contract between the open access operator and service provider could be prevented. This can mean the end of the business case in some cases.

The access network should be especially carefully chosen because it takes up a large

Disadvantages:

- Initial investments for the NetCo, OpCo and provider are high.
- The depreciation periods are much longer than usual in the ICT industry (> 10 years).
- The market price obtainable for ICT services is limited because the price level for high bit rate products has taken a huge tumble over the past few years.

Today, the first encouraging examples of successful open access projects are primarily found in the Middle East and Scandinavian countries. Basically we can assume that an open access business case will need several years to get going before it is really up and running. The reasons lie in the speed of network expansion, often drawn-out negotiations with partners, and the time taken for marketing the services to take effect.

share of the investment costs in the active network technology. Here in particular, taking the decision should not primarily be CAPEX driven for the following reasons:

- Sustainability:
The fibre optic infrastructure has depreciation periods of at least ten years. During this time no or very few refurbishment or even upgrade measures should be carried out. In this case the emphasis when choosing the systems technology should be placed on whether it is future proof, i.e. upgradeable. Proprietary interfaces, both for the data interfaces and in the network management and provisioning are to be avoided. Standardised and open interfaces are a must.
- Interoperability to network terminations:
Experience in the past has shown that in the medium to long term proprietary network technology always ends up in a technological and commercial dead end. Examples of this can be found for example with Centrex or the first generation passive optical networks. The usage of standard Ethernet in the FTTH environment is not just more beneficial because of interoperability, but in the long term for commercial reasons because the dynamism of the global Ethernet terminal

equipment market can be harnessed. Over time this definitely leads to a colourful mixture of optical Ethernet network terminations, as well as falling prices similar to the ADSL-NTs.

■ Future proof:

The way that user behaviour in FTTH networks changes compared with DSL networks does of course depend on future new applications. New findings from already operational FTTH networks in Scandinavia and Holland clearly point to one trend: broadband usage by the average FTTH subscriber is more symmetrical than was previously the case, i.e. the upload capacity of the network is becoming more and more important. In the DSL world, due to the strong restriction on bandwidth in the uplink channel, usage behaviour is more asymmetrical, i.e. a lot more data is downloaded and uploaded.

However if more uplink bandwidth is available users tend to upload more photos, back up more files on virtual disks and swap more data etc. These factors could be used as a sales pitch. The disk on the Web is complemented by new offerings such as cloud computing, so that in the long term user behaviour will be practically symmetrical.

One thing is clear, despite all the current challenges open access networks face, the fact is that end customers will benefit from the increase in competition and services.

7 List of abbreviations

IP	Internet Protocol
ADSL	Asymmetric Digital Subscriber Line
VDSL2	Very high-speed Digital Subscriber Line, Version 2
TC	Telecommunication
FTTx	Fiber-to-the-Home/Building/Curb
OAN	Open Access Network
SLA	Service Level Agreement
OpCo	Operator of an open access network
NetCo	Owner of the network infrastructures
LTE	Long-Term Evolution

About KEYMILE

KEYMILE is a manufacturer of multi-service access platforms for NGN-/FTTx applications. They allow operators of telecommunications networks to offer a variety of voice and data services through copper and fibre optic lines. KEYMILE's focus lies on network solutions that support future services and at the same time protect sales from traditional services. KEYMILE systems are used for reliable data transmission in mission-critical areas of telecommunications networks used by railway companies and energy suppliers. The company has major business bases in Germany and Switzerland, as well as subsidiaries and partners worldwide. It has installed systems in more than 100 countries.

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