Business and ownership model case studies for next generation FTTH deployment

DISCUS white paper

Abstract:

This paper is a review of two previous white papers published by the DISCUS project consortium in November 2013. After discussions with many stakeholders on topics of regulation and business models for next generation fibre access network architectures, we have analysed a number of case studies around the world on both open access and vertically integrated ownership models, and report here our updated view.

DISCLAIMER

Any views or opinions presented in this document are those of the authors and do not necessarily represent those of the individual DISCUS consortium partners.

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Submission date: January, 27th 2016

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1 Introduction and background to the document

This white paper is a follow up of two technical documents [1],[2] proposed by members of the DISCUS [3] consortium in 2013. After evaluating the feedback collected form a number of stakeholders including major operators, vendors, national regulators and government institutions, this new white paper reports an updated view on business and wavelength models for next generation broadband access networks, supported by a number of case studies around the world. We recommend the readers to read the associated project deliverable [4] for more detailed information.

The DISCUS architecture [5], [6], focuses on the idea of node consolidation by adopting a Long-Reach Passive Optical Network (LR-PON) approach which allows bypassing the majority of local exchanges and the associated metro transmission networks, thus directly connecting (i.e., without intermediate packet processing) the access fibre to the Metro-Core (MC) nodes. These MC nodes become the only aggregation and packet processing nodes in the network. It also envisages the idea of a flat optical core where Metro-Core nodes are connected on a full mesh of wavelength links. The concept is visualized in Figure 1.

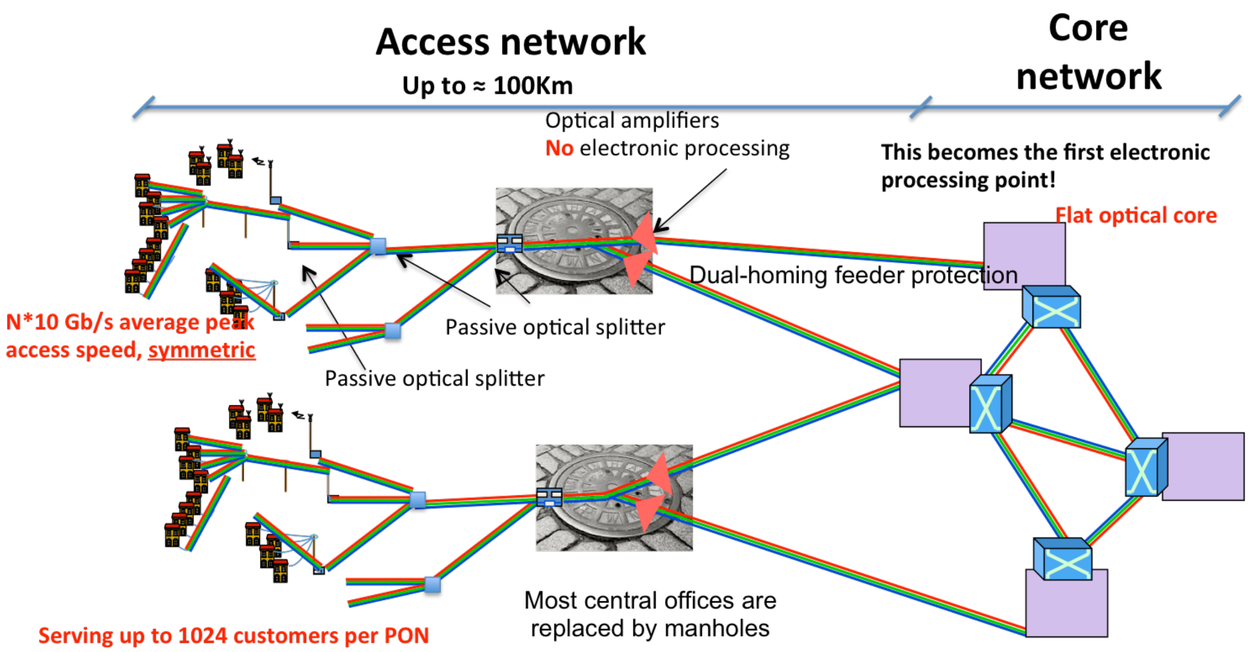

Figure 1 DISCUS Long-Reach access network architecture

The major objective of the DISCUS project is to enable a future network that would address three major problems arising due to the huge growth in network capacity demand. These problems are:

- the cost of network provision and financial viability of the telecoms sector
- the need to avoid a "digital divide" being created between those customers in dense urban areas and those in the sparser rural communities, without the need for massive government subsidies.

- The huge growth in electrical power required if today's telecommunication network architectures are simply scaled to meet the future growth.

Solving these problems has major implications for the regulatory policy, for the distribution and assignment of network resources at all layers to all users of the network, including the service providers, and for the nature of the ownership and business model structures that need to be supported.

1.1 Stakeholder feedback

Our initial white papers [1],[2] produced quite a heterogeneous feedback; we have singled out here the main recurring observations.

- There was a disagreement on the fact that a partial vertical integration at the passive and active layers would be beneficial, even if regulated, as it was believed that it would not promote competition at that layer and would hinder innovation. Also it was mentioned that regulation has often limited power in imposing drastic changes in current business models.
- There was doubt whether a PON infrastructure could truly facilitate open access due to the shared medium and that point-to-point fibre (or at least wavelength) would be a better solution to grant independent access to customers. (We believe this is because the access flexibility of PON architectures is not sufficiently well understood and that both point to point and PON can offer equal flexibility for access to customers with the PON having the advantage of the option of providing that access flexibly and on demand).
- It was argued that competition in fibre access network could reduce incentives for operators to install fibre, especially in rural areas, where the return on investment is very poor and slow.

This white paper revisits the wavelength uses and business models taking into consideration the feedback received and investigation of a number of case studies around the world both in open access and vertical integrated networks. We refer the readers to the associated project deliverable [4] for more detailed information.

2 Case studies

We have considered a number of case studies on both open access and vertically integrated architectures, to help us understand how these different options have developed over the past 10 years in different geographic areas. The cases examined included countries such as Sweden, the Netherlands, Switzerland, France, Italy, Spain, Singapore, Australia, New Zealand and North America. There are some general aspects regarding the success of open access networks which can be learned from the actual deployments. Some of them do not only apply for an open access regime but are applicable for the general acceptance of FTTH networks. Since multiple recurring references were used for case studies, , they are referenced here as a group [7]-[41].

First of all, FTTH (whether it be open access or not) has mainly been successful where there has been no or very limited broadband offering available before. The problem arises if an alternative broadband technology exists, e.g. xDSL (FTTC/N) or cable network. Also, if the price for fibre is significantly higher than the competing technologies then the take rate is generally low. Furthermore, if the FTTH data rates are not competitive, e.g., only 10/1 Mbps DS/US which is still very common in many data plans, the success is also rather limited. So the answer to the question: "*Will the user pay a premium for fibre*?" is usually "*No*" (or very little). To maximize the success operators should charge only prices in the order of usual xDSL or cable offers or at a relatively small premium for a significantly higher speed offering. In some cases operators even offered a bonus to trigger potential customers to sign a contract.

The acceptance of a fibre connection or take rate is one of the fundamental success criteria for FTTH especially for open access networks. Here the available market share for any one operator is a priori smaller than for a vertically integrated operator scenario.

The two approaches of supply-driven deployment and demand-driven deployment strategies need to be distinguished. The supply-driven strategy starts the deployment independently of any guaranteed demand. The large national broadband networks in Singapore, Australia and New Zealand follow this strategy. This strategy is inevitably higher risk as there is no guaranteed revenue and in at least one case (New Zealand) people have been very reluctant to connect to the FTTH network. The main reason for such reluctance seemed to be the higher premium being charged for the service[41].

In case of a demand-driven strategy the deployment only starts if a certain number of pre-contracts are already signed. This is the case with Reggefiber in the Netherlands where about 30 – 40 % of households must sign such a contract before Reggefiber starts laying fibre at all. The same strategy holds for Deutsche Telekom in Germany in those cities where they planned to establish an FTTH network. This percentage is the minimum which is believed necessary to achieve a positive return on investment according to numerous techno-economic investigations. Stokab in Stockholm had a different but similar strategy as they first connected to public customers (government buildings, schools, hospitals, etc.) and established a secure revenue basis before the extension to private customers. The first private customers were the large housing companies which further secured the revenues. Because this strategy links investment directly to revenues they are much lower financial risk but suffer from the problem of potentially long delays before deployment can commence and maybe losing out to neighbouring areas that deploy earlier.

Related to this question of deployment strategy is the question: *how many network operators can a country or region afford and be run profitably*? Some investigations have studied this aspect and showed that the *number of potential operators is very limited – not more than two or three*.

Other studies investigated the question: *where are the limits of profitable private deployments?* According to them, *infrastructure based competition with several different networks is possible only in the most densely populated areas*. In rural areas with a low population density no private roll-out will ever be cash-flow positive, even more so if the market share is split in an open access regime. These calculations are based on some assumptions: a time frame for return-on-investment of about 5 – 7 years (which is quite a long time for typical business cases), and some assumptions about the achievable ARPU (average revenue per user). The maximum ARPU will be limited (for acceptance reasons and availability of disposable income) but the time horizon can be extended if the infrastructure investor is not a private company but a municipality/utility which has different commercial constraints compared to private enterprises. However unfair competition arguments based on tax payer subsidisation can be levied at such operators and in Europe can fall foul of state aid rules.

However municipalities, especially in rural areas/smaller towns, are often taking the initiative to trigger the deployment of FTTH networks. These municipalities see these networks as a kind of natural monopoly or public infrastructure which should be owned by public authorities. The networks then will be mostly open access based and since the municipalities often don't have enough funds to invest, a lot of the deployments are financed under a private-public partnership (PPP) agreement. Under EU law municipalities are only allowed to invest in telecommunication infrastructure if it is done under identical conditions a private investor would invest in the project. Often EU permission has to be granted (e.g., in the case of Amsterdam's Citynet or the Asturcon network). In the US very often municipalities are not allowed (by state law) to invest in or run telecommunication networks and there have been many legal proceedings against towns that wanted to establish a community network based on complaints of the telecom incumbents or the cable companies.

Utilities which are often owned by municipalities are already familiar with public networks (gas, water, electricity). They have rights of way, own ducts and want to expand their business case. So a lot of them have invested in telecom networks, i.e. fibre networks. This is the case especially in the Nordics, Germany, the US and Switzerland.

One interesting aspect in open access FTTH networks is the choice of network topology, either point-to-point or point-to-multipoint (e.g., GPON). Most of the incumbents worldwide have chosen a PON architecture for their deployments, which is the case also for the open access national broadband networks in Singapore, Australia and New Zealand. But most of the non-incumbent driven networks, especially in Europe, are established using a point-to-point topology. Even the incumbents KPN in the Netherlands and Swisscom are relying on this topology. The reasons for it are named as most future proof and most secure architecture and best-suited for open access, although we believe such arguments are less valid today as NG-PON2 systems already give the ability to use different wavelengths in the same fibre, making the much higher cost of point-to-point fibre systems difficult to justify.

In the case of GPON, competitive access to the network is possible today almost only via a bitstream access on layer 2 or 3. This type of access does not allow for significant differentiation in the competitive offer. An alternative would be a kind of sub-loop unbundling (SLU) at the last splitter location. The rest of the way to the customer premise then is practically a point-to-point connection. If the splitter is located in the field near the customer premise a competitor would then have to own his own fibre link to that location. A different scenario, which is also described in the literature, is to push the splitters back into the central office in order to make access to the fibre more convenient. This however this is effectively a point to point fibre infrastructure and increases the cost of FTTH deployment, which needs to be accounted for when considering the economics of deployment strategies.

In addition, recent advances on the use of Software Defined Network (SDN) and Network Function Virtualisation (NFV) approaches for access/metro networks (e.g., the

CORD project by AT&T [42]) could change the scenarios within the next couple of years. Separating control plane and data plane in the access infrastructure, moving the control software in commodity servers through NFV could produce a new virtual OLT that is fully programmable and will allow different operators to take control of virtual slices of the PON. Indeed the use of SDN in the access network has recently been investigated by a number of other projects ([43],[44]).

Generally, the adoption of multiple wavelengths (WDM) into the network is seen as a final solution to all access problems (especially in the case of PONs). In PONs a separate wavelength could for example be assigned to a provider or a customer and create a direct virtual point-to-point link. However only very few discussions or investigations on the use of different wavelengths in such a future network have yet taken place, and the next section provides some updated discussions from a DISCUS project perspective.

3 Revisiting the business models

3.1 Revisiting the wavelength usage models

In consideration of the case studies above, we have reviewed the DISCUS deliverables titled: "Wavelength usage options in access networks" and "Business and ownership models for future broadband networks".

It is expected that the future optical access networks will be based on multi-wavelength transmission over optical fibre to provide the scalable future capacity required. However how wavelengths are used and what they are used for can have a significant impact not only on the costs and efficiency of the future network but also on the opportunities for competition and the service creation environment. In our previous white papers four wavelength usage options were considered. In reference to Figure 2.a these differ mostly on the part of infrastructure in the central office, highlighted with the red circle in the figure.

The proposed wavelength usage models, are:

1) ***Wavelengths assigned to service providers****, visible in Figure 2.b, where different wavelength channels are assigned to different SPs. The users tune to different wavelength to access services from different SPs.*
2) ***Wavelengths assigned to service types***, visible in Figure 2.c, where different wavelength channels are assigned to different service types, and each SP can provider each service on a different wavelength. Similar services from different SPs can be multiplexed into the same wavelength.
3) ***Wavelength used flexibly for bandwidth management****, visible in Figure 2.d, where wavelengths are used to multiplex any provider and any service type. Thus an ONU can receive different service types from different SPs on the same wavelength channel.*
4) ***Wavelength assigned to users****, visible in Figure 2.e, where each user is assigned a dedicated wavelength channel. Thus each ONU is serviced by a dedicated OLT. Notice that this service is typically associated to the use of wavelength multiplexing devices instead of optical power splitters, in which case it requires a different*

architecture in the distribution side of the network (left-hand part of figure Figure 2.a).

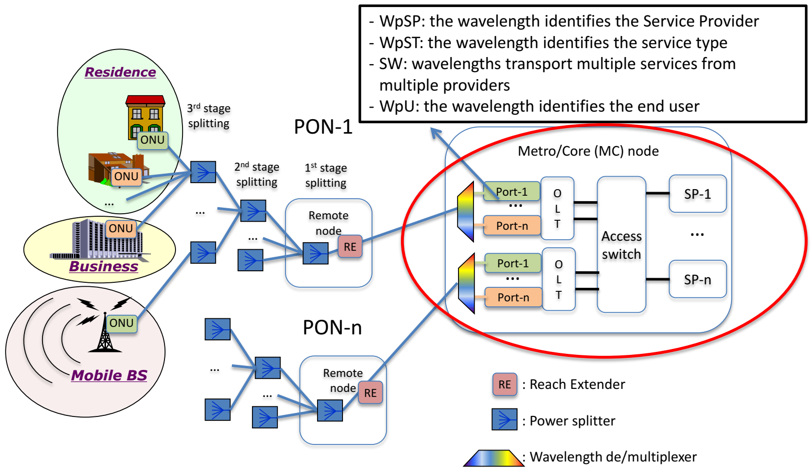

Fig 2.a

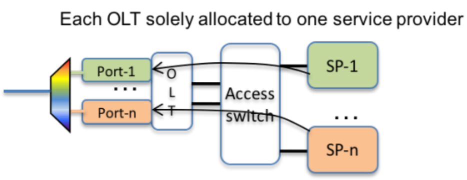

Fig2.b

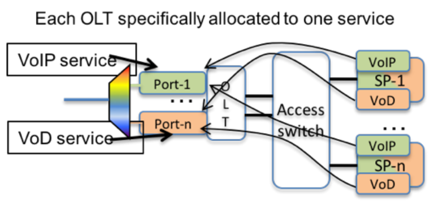

Fig2.c

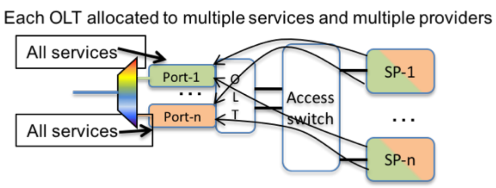

Fig 2.d

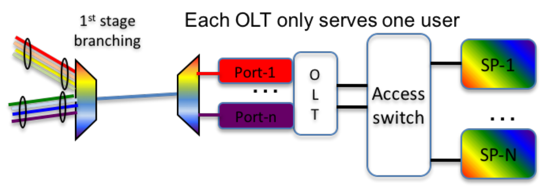

Fig2.e

Figure 2 Different wavelength assignment models for FTTP access architectures. Fig 2.a is the overall reference, while fig 2.b refers to the wavelengths assigned to service providers model; fig 2.c to the wavelengths assigned to services model; fig 2.d to the wavelength used flexibly for bandwidth management model; fig 2.e to the wavelengths assigned to user's model.

We considered that option 2) was likely to be unrealistic as it would require multiple transceivers and protocol implementations per ONU and multiple OLTs at the head-end (the metro-core node for the DISCUS architecture) to terminate the multiple instances of the PON protocol. This is believed not to be cost effective and power hungry as many of the transceivers protocol circuitry and OLTs would have to be operating for large proportions of the time that services are used. Although advances in optics integration means that building integrated laser and photodiode arrays in a common optical module with only a single fibre interface is possible and could enable ultra-fast switching among wavelengths, it remains to be seen if the additional complexity, compared to the limited benefits that such a model would bring, will reach economic viability. But it is a possibility that future ONUs could operate over multiple channels simultaneously.

Option 4) wavelengths assigned to users is the well-known way of implementing a virtual point-to-point topology model over a PON physical layer architecture and could be a way of implementing the point to point architecture that has so far been the preferred options for open access networks. The main drawback is that from an active network perspective it presents higher cost, energy consumption and footprint compared to TWDM PON, and limits the number of users per PON to the number of wavelengths available (i.e., around 40 in post NG-PON2 systems, unless early adoption of coherent technology is evoked). While this is OK considering current GPON split ratio of 32 or 64, it is much less than splits of 256 or higher envisaged by next generation systems and the DISCUS architecture. In addition, this method does not operate statistical multiplexing on the PON, thus wasting capacity that could instead be distributed to other users to deliver additional services. Finally, where the wavelength separation is achieved through passive wavelength filters (which is usually the case in WDM PONS), it will lock wavelength channels and thus capacity to the individual customer access fibres, with a risk of ossifying development of further business models. However, we do envisage that in a PON a number of wavelength will be used as logical point-to-point connections for dedicated services, such as for mobile base stations and ultra-high capacity services for businesses and enterprises customers.

Option 1) where wavelengths are assigned to service providers might in principle be an option until the control and management issues with option 3) are resolved (see below). By separating access, giving providers different wavelengths, it can provide reasonable statistical multiplexing of capacity, without limiting the number of users where PONs with high split ratios are deployed. From a physical implementation perspective however it cannot be assumed that different service providers will be able to deploy their own terminal equipment into the same fibre infrastructure through physical wavelength unbundling due to the potential interference between wavelengths when operated independently. Although it is possible to deploy more stable transmitters at the ONU to avoid interference due to wavelength tuning inaccuracies this could increase the cost at the ONU, which is typically a low-cost device for residential usage. However, if the physical layer is controlled by one entity, then different SPs can connect electrically to the OLT and be assigned an entire wavelength channel using today's technology. The main drawback of this approach remains that, besides not being as bandwidth efficient as option 3), it does not allow for multiplexing different providers into one ONU (unless the ONU has more than one transceiver) and therefore restricts simultaneous access to multiple providers.

Option 3) remains the most efficient in terms of capacity utilization and assignment flexibility by dynamically matching network resource to user demand and freely assigning capacity between users and providers. It however requires the presence of an entity owning and controlling the active infrastructure such as an incumbent operator. While this could be operated in conjunction with models such as bitstream and VULA, full open access operation will require more powerful virtualization mechanisms where multiple providers could operate over the same PON and be able to control every aspect of their PON virtual slice as if they were managing a separate physical system. This will require enhancements on the control and management of PONs, which could be provided by developments in the concept of Software Defined Access Networks. When combined with such a virtualization framework, option 3) could in principle give the exact same ability as the point-to-point model in terms of customer management from a provider perspective, with the added value for the end user to multiplex services from different providers at the same time, while being more cost effective and energy efficient.

There are however two intermediate steps that could be adopted in the meantime to enable multi-tenancy in the access [45]. The first is to reuse existing network equipment controlled by the infrastructure provider through their management system: virtual network operators could get access to the network through a standard sharing interface which can provide raw access to the management layer with optional monitoring and diagnostic functionalities (there are however serious network security issues to be addressed for this to become an acceptable solution for network operators). The next step involves the deployment of new hardware in the access node capable of resource virtualisation, so that the virtual network operators/service providers could be assigned a virtual network slice and get full control of the equipment. For this step however the interface might still be into the same network operator management system. The third and final step is the full SDN integration, where the virtual operators get access to their network slice through a flexible SDN framework with standardised APIs.

3.2 Revisiting the ownership models

This section reviews a number of principles concerning the ownership model originally developed in [1].

The proposed design principles were as follow.

1) *There is **no duplication of passive network infrastructure** used to provide basic network services: that is there is only one fibre network for each customer premises for the mass of customers.*

   This principle is still of paramount importance and should be taken into consideration in access network deployment. Indeed open access networks are based on this principle. There are however cases where this principle is not respected, i.e. where an incumbent is not required to open up its network. In a number of such cases this has led competitors to organise and deploy a separate infrastructure from the incumbent. So although not optimal from a network efficiency perspective, market forces can lead to the deployment of overlapping optical access networks.

2) *As much as possible of the **fibre infrastructure (and network equipment) should be shared by as many customers as possible**.*

   What this principle really states is that the number of providers and their mode of operations shouldn't get in the way of maximising sharing of infrastructure among users. While this is achievable with wavelength usage model 3), as stated above it would require full access virtualisation to enable a fully open access model that goes beyond bitstream and VULA overlay models. This requires updating the OLTs as well as the development of an agreed and standardised control and management framework. Until this can be achieved there are possible intermediate steps using virtualisation of current network management systems, and different wavelength assignment mechanisms such as wavelength to service providers.

3) ***Customers should have the option to access multiple providers simultaneously*** *and be able to change providers "on the fly".*

4) *Customers should have the option of bundled and fixed term contracts or have all* ***services provided from any provider at any time on a pay as you go basis*** *if desired*

   Option 3) and 4) are both variants of a fully accessible or "open access" scenario service provisioning market. While this is the preferred option to achieve full competition at the service level, it works with wavelength usage model 3), but not with usage model 1), which might be used for expediency in the near term. A few stakeholders believe that the benefits that could occur from such a high degree of flexibility in the service provisioning is over-rated, as they believe that service bundling provides a better option for both users and providers. We believe this is still debatable and cannot be tested until such flexible service level architecture is made available in the market. There are certainly significant limitations in the service bundling models used today such as: most bundles are pre-structured and customers may need to buy into bundles that have services they do not use, or they do not get the all the services they would prefer because they are in a different bundle package, or possible all the services they want are not available from a single supplier. The customer cannot get access to best of breed for all the services he/she uses but will have to compromise on some of the services within the bundled package. The customer gets locked into a contract for a fixed term and there is often a penalty for leaving the contract early (at best not all of the remaining term will be refunded).

   If wavelength option 1) is to be considered however, there is still the option for a new category of brokers to emerge in the market, offering bundles that are a selected mix from the services offered by different SPs. However, whether SPs would enable brokers access to such service bundles without regulation to force them into "open access" remains to be seen.

5) *There should be* ***no lock-in to single providers****.*

   From a technical perspective there is no reason why change of providers could not be done on demand, although in many cases, where part of the installation cost is subsidised by the provider (e.g., for the fibre connection or for the ONU), temporary lock-in might be required.

6) *There should be* ***no physical hardware reconfiguration of network equipment, or infrastructure, required to change service provider -*** *all reconfiguration would be via software control of network equipment.*

   From a technological perspective there are no major issues. With wavelength option 1) this could be done by tuning the ONU to a different channel, while with option 3) only network PseudoWire rearrangement might be required. The requirement is that of a standardized network control and management framework (e.g., a Software Defined Access Network) allowing infrastructure, network and service providers to coordinate their actions following a user request. This type of interaction is what DISCUS has implemented in its control plane deliverables and demonstrations and is a key feature of the DISCUS architecture proposal.

4 Conclusions

This paper has presented a discussion on broadband access network ownership and business models, considering a number of case studies on both vertical integrated and open access networks. Indeed, many options are available both for wavelength use and network ownership in next generation fibre access network. However, the favoured solution presented in this paper is that of using wavelengths flexibly for bandwidth management without artificially restricting their use to a specific service provider, service type or user, except for few specific high-capacity services that justify the use of dedicated wavelength channels. From an ownership model perspective, the favoured solution remains that of open access, as it allows sharing of costly fibre infrastructure among multiple market players, which could otherwise lead to a monopolised broadband market. Finally, it is believed that access network virtualisation and software defined network, by adding open programmability and flexibility to the network management infrastructure, will play an increasing role in facilitating such open market solutions.

Acknowledgments

This material is based upon work supported by the European Union seventh Framework Programme (FP7/2007-2013) under grant agreement N. 318137 (Collaborative project "DISCUS"). The authors would like to thank Werner Graudszus for is invaluable contribution to the investigation of the case studies presented in this paper.

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Abbreviations

API	Application programming interface
ARPU	Average revenue per user
CORD	Central office reimagined as a datacentre
DSL	Digital subscriber line
FTTC	Fibre to the cabinet
FTTH	Fibre to the home
FTTN	Fibre to the node
FTTP	Fibre to the premises
GPON	Gigabit PON
LR-PON	Long-reach passive optical network
NFV	Network function virtualization
NG-PON2	Next-generation PON2
OLT	Optical line terminal
ONU	Optical network unit
PON	Passive optical network
PPP	Private-public partnership
SDN	Software defined networks
SLU	Sub-loop unbundling
SP	Service provider
VULA	Virtual unbundled local access
WDM	Wavelength division multiplexing