Local Loop Unbundling regulation: is it a barrier to FTTH deployment?

DISCUS white paper

Abstract:

This white paper describes how the Local Loop Unbundling regulation of copper pairs in access networks might present a barrier to FTTH deployment, as it inhibits infrastructure providers from developing more efficient optical access architectures that benefit from the closure of many currently active central offices and the early retirement of the copper cable infrastructure.

After introducing the problem, the paper presents three potential solutions to this issue, together with a brief description of their possible implementation by infrastructure providers in the short and medium term.

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1 Problem description

Copper pair local loop unbundling was a very successful strategy for introducing competition into incumbent networks enabling other competing network providers (NPs) and service providers (SPs) to reuse existing copper pair access infrastructure on an annual rental basis rather than having to find the huge capital investment that would be required to build new access infrastructure. However, the question is whether that regulation has now passed its usefulness and has instead become a barrier to the development of FTTH and the novel architectural changes necessary for an economically viable future superfast fibre to the home/premises (FTTH/P) broadband network.

FTTH requires considerable investment into new fibre infrastructure for mass roll out and that large investment requirement has always been a barrier to large scale FTTH deployment in Europe and the US where competitive markets exist and companies need relatively short term returns on capital investment for a viable business case.

The capital investment required for network build can be split into two broad categories: "upfront" investment and "just in time" (JIT) investment see Figure 1 . The nature and proportions of these two types of investment have a significant impact on the business case and the time to positive cash flow for business case evaluation. Upfront investment is capital that is needed to build network to "pass" the potential customers that are targeted for the new network and associated services. This is risk capital as there are no certainties of revenue when this investment is made. The other JIT investment however is that investment required to "connect" customers to the network, it usually includes the last drop, the customer premises termination and the terminating network services unit (i.e., the optical network unit (ONU) for fibre systems e.g. FTTH Passive Optical Network (PON) or point to point fibre systems(PtP). This JIT capital is only incurred when an order for service has been placed and therefore there is a revenue stream associated directly with this expenditure. This capital expenditure is therefore much lower risk with predictable returns on the investment. Thus JIT expenditure has relatively little impact on time to positive cash flow compared to the upfront investment component.

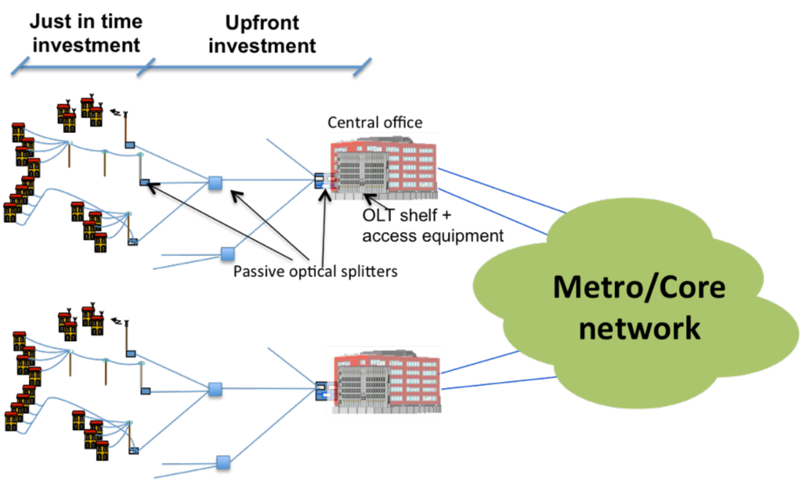

Figure 1 Upfront and JIT cost division for PON developments

We believe future network designs need to change the network architecture to not only minimise total capital investment per unit of network resource but also to redistribute the balance of that capital investment from upfront investment towards JIT investment. This is the basis of the network architecture proposed by the DISCUS project [1-3]. It does this by maximally sharing infrastructure that is provided upfront while also being able to gracefully grow that infrastructure as demand for service increases so that growth in network expenditure is, as far as possible, associated with revenue growth.

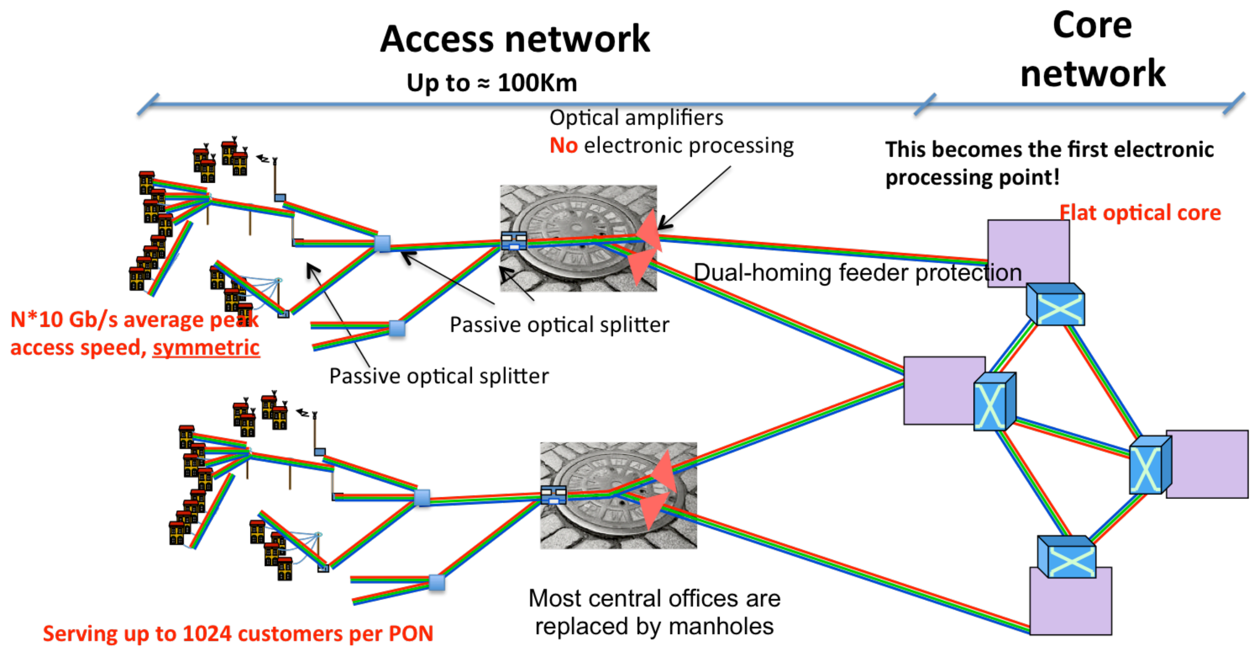

Figure 2 DISCUS Long-Reach access network architecture

The architectural features of DISCUS that enable this change in investment expenditure is the closure of as many network nodes (local exchanges or central offices) as possible and the use of Long-Reach access technology that connect directly to a relatively small number of core exchanges, see Figure 2. These core exchanges are interconnected via a flat optical core network which has been shown by the DISCUS project to be the lowest cost and lowest power consumption network beyond a certain user bandwidth requirement. This results in a much simpler network, which for European-sized countries leads to a two-hop network topology, thus also enabling simpler protocols and network operations in the future (although this aspect was beyond the scope of the DISCUS project).

The question we want to address in this white paper is: *how does LLU regulation affect FTTH deployment in general and this architectural solution in particular?*

The basic problem arises from the physical characteristics of the copper network infrastructure that LLU regulation was applied to. Copper cables have very limited reach due to the poor transmission properties (compared to fibre). This reach problem is even worse as higher speed broadband technologies are operated over the copper infrastructure forcing electronic nodes ever closer to the customers, which also increases cost and the upfront investment required. The reason is that multi-customer electronic equipment has to be installed before service can be offered, thus increasing the upfront investment component, and hence the risk and the time to a positive return on investment. FTTH on the other hand can have very long reach: by using simple optical amplifiers DISCUS is proposing over 100km reach, with actual distance depending on the geotype under consideration (i.e., the longest reach might only be used for less densely populated areas).

There are two problems that LLU creates that produce a barrier to the transition from a copper local loop to full FTTH deployment and to the implementation of the architectural changes required to ensure its economic viability into the future.

1. The first problem is the increasing cost per working copper pair as customers move from the copper network to the fibre network. Copper cables are installed in a physical tree and branch network with thinner cables (fewer copper pairs) near to the customer and much larger cables with thousands of copper pairs) entering Local Exchanges/Central Offices. The cable owner (usually the incumbent operator) must maintain these cables while there are any remaining customers connected. Also, in general, the cost of maintaining those cables is largely independent of the number of working pairs and does not decrease as customers taking up FTTH move off the copper cable to fibre cables, thus the larger and most expensive cables to maintain will be the last few standing with only a handful of customers still connected. This means that the operational cost per copper pair per customer connected is increasing as customers transfer across to fibre cables.
   The regulatory question is: how can that cost be absorbed by the remaining operators that still use those copper cables to access their customers? The current regulatory process usually involves negotiations between the regulator and the largest owner of the cables (usually the old incumbent operator) about the costs to maintain and expand the copper network and to agree a fair annual rental which then becomes the upper price limit imposed on the infrastructure owner that can be charged to the LLU operator. If those annual charges cannot be flexibly increased and shared across all the remaining LLU users, then the cable owner has increasing operational costs per customer as they deploy FTTH. If this cost cannot be passed on to the copper pair users and has to be absorbed by the FTTH deployment then the payback period for that FTTH deployment will be extended, possibly to untenable time scales. However, the dilemma for the regulator is that if those copper pair costs are passed on fairly to the LLU operators then those LLU operator's costs will increase to possibly unsustainable levels, making them less competitive. In addition, from the LLU operator perspective, this is not due to any internal inefficiency, but to an external action taken by the regulator/incumbent operator over which they would have no control. The end result of an FTTH migration process could easily be that the only customers remaining on the copper pair network are those belonging to the LLU operators.
2. The second problem is the closure of local exchanges that have LLU operator's equipment within them. The DISCUS project is showing that the lowest cost and lowest power consumption future broadband network is one where most of today's Local Exchanges/Central Offices are closed down and customer traffic is transported deep into the network to a small number of large Metro-Core nodes. However, if Local Exchanges cannot be bypassed and closed down because there are LLU operators within them then the lowest cost network cannot be realised and customers will either have to pay more than necessary for FTTH or the FTTH network will not be deployed, or at best be deployed much more slowly.
   There is real evidence that this is indeed occurring as operators such as BT are contemplating networks with over 1000 nodes. Although this is a significant reduction compared with the 5600 nodes in the UK network today, it is still significantly greater than the minimum proposed by DISCUS (i.e., on the order of 70 to 100 nodes) and will result in a more costly solution. Also, a core architecture with 1000 nodes requires a fairly conventional hierarchical core network where the core is structured into at least two and possibly three hierarchical layers. This is necessary for networks with a large number of nodes because the number of light paths required to interconnect a flat network, as proposed by DISCUS, scales as the square of the number of nodes and becomes untenable with large node count. However, DISCUS has shown

the flat core to be the lowest cost and lowest energy consumption transmission architecture for future networks, if the number of nodes can be reduced to much lower values, as the DISCUS architecture enables. However, this will require closure of Local Exchanges where LLU operators have equipment installed. The regulatory problem is how can these exchanges be closed in a fair and equitable manner while maintaining competition that benefits the customer base rather than just for servicing a political agenda?

Again the dilemma from a regulatory perspective is the following: if the full costs of maintaining those buildings, which would be closed by the incumbent owner, are passed on to the LLU operators they would have significantly increased costs, which would make them uncompetitive. However, if the incumbent absorbs these costs then they are effectively subsidising the LLU operators and would need to pass those cost onto the FTTH deployment potentially making that uneconomic and therefore at best delaying FTTH roll out or possibly making it non-viable indefinitely.

1.1 Summary of LLU problems

The two problems with copper LLU unbundling for wide scale transition to full FTTH deployment can therefore be summarised as:

1. The increasing cost per working copper line per customer as customers take up FTTH delivered services.
2. The problem of LLU operators in existing Local Exchanges inhibiting closure of those exchanges and preventing necessary architectural change.

If effective regulatory solutions are not found these problems could inhibit wide scale roll out of FTTH for a significant time if not indefinitely. This could put Europe at a severe disadvantage compared to regions of the world where FTTH does have significant deployment.

2 Possible solutions

These are not trivial problems and there seems to be no easy solutions but some possible approaches are:

1. **Force the physical layer infrastructure owners (usually the incumbent operator) to absorb the increasing costs.** This is the "do nothing" approach and is effectively the current default approach that Europe is taking. The problem is that it inhibits those infrastructure owners from investing in FTTH, and therefore does not solve the problems facing future broadband networks that are: the digital divide which requires an FTTH solution; the economic problems of future bandwidth growth, which will eventually impact the ability of network operators to invest in network build; and the power consumption problems facing future communications networks. All these problems require an architectural change that simplifies the network by reducing nodes and packet processing electronics and also provides the lowest cost FTTH solution.
2. **Let the market take its course and allow costs to rise as they occur and be passed on to the organisations in proportion to their use.** This will inevitably lead to many of the LLU operators going out of business if they insist on staying with copper pair technology;

however, it may be very difficult for such operators to adopt fibre due to the high upfront costs. Even a dark fibre leasing model would put significant financial strain on such operators. Coper pair LLU was introduced to encourage competition in the telecoms service business: in order to maintain competition for the benefit of customers there could be a move from the physical layer competition of current LLU to much broader competition at the service provider layer enabled for example via access network virtualisation. However, a structure for the infrastructure and network operations layers would need to be setup and that might mean greater regulation of those layers while leaving the service provision layer largely unregulated. Such access network virtualisation could provide the competitive service provision market for the benefit of customers on FTTH networks without the service providers having to provide the huge investment for access network infrastructure, in the same way LLU provided that capability for the copper access network.

3. **Restructure the telecoms network business so that retail and wholesale service provision is separated from the network provision and operations business.** The simplest form of this and potentially one of the most efficient options is to have an infrastructure (physical cables and transmission systems) and network operations (traffic/packet processing and network OA&M and control etc.) businesses as an integrated but regulated entity with separated and largely unregulated retail and wholesale service industries. This enables the economies of scale from a large infrastructure and network operations business while also enabling restructuring of the new network architecture required for low cost and energy efficient broadband networks. The wholesale, retail, service provision and content industries can then be largely left as separated and unregulated free market companies where competition for customers is the norm.

These suggestions are just some of many other possible options and combinations but the basic regulatory problems that need to be urgently addressed are those described in the earlier sections and summarised in the "Summary of LLU problems" section.

3 Implementation

We believe a favoured solution to be the combination of the option 3 in the section above with some strategy such as that suggested in option 2 so that the physical layer competition gets replaced by a more regulated network business framework. The network business would sell connectivity services to provide access to the customer base to the services businesses on an equal access basis and indeed should set up those network access services so that customer contractual lock-in cannot be enforced and would enable customers to access multiple service providers at all times. Or at minimum let different users of a network terminal, e.g. an ONU, set up different and independent service contracts. This would enable a free market approach for LLU evolution to occur with costs falling on those using the copper network but with an opportunity for LLU operators to migrate to the FTTH platform with differentiated service offerings.

A key to this is the requirement for some form of access network virtualisation and sharing of the capacity provided by future FTTH networks. In the DISCUS white paper titled "**Business model case studies for next generation FTTH deployment**" [4] we provide additional details of different possible methods that could be implemented to divide the capacity between providers and users in next generation FTTH networks, which are briefly summarised here:

1. assign wavelengths to service providers, so that a user can move between different SPs by changing the operating wavelength of the ONU. In this scheme each SP is assigned (at least) one wavelength channel over a shared fibre, physical layer, infrastructure. We find that this option requires implementation of costly ONU transmitters if the unbundling is carried out at the wavelength level, with SPs providing their own independent network equipment operating over the assigned wavelengths. This issue is solved if the optical layer is controlled by one active network equipment provider (who could also be the physical layer infrastructure provider), which offers dedicated electrical interface connections to the other SPs.
2. assign wavelengths to service type requires multiple transceivers at the ONU in order to receive simultaneously different service types (e.g., IPTV, VoD, Internet,…). While in the medium to long term future integrated transmitters and receivers array could reduce technology costs to affordable levels, it needs to be seen whether the advantages brought about by this solution will justify the additional complexity and energy consumption required.
3. assign wavelengths to individual users, which means each ONUs receives connectivity by operating on a different wavelength. While potentially feasible today, this option is very inefficient for delivering mass market residential broadband due to poor statistical multiplexing, and overall high energy consumption and footprint. It also requires some additional form of bit stream access in situations where multiple users share an ONU. However, it is envisaged such logical point-to-point connections will be used for low volume, targeted services such as mobile base stations and business and enterprise services.
4. assign wavelengths flexibly for capacity management: this option implies that the physical infrastructure layer and traffic processing equipment layers are operated by a network operator that assigns capacity to SPs using some form of access network virtualisation for service providers to differentiate their competing products and services. This remains our preferred option, and is discussed further below.

Again, we invite the readers to read white paper [4] for a more comprehensive discussion on capacity assignment options in future PONs.

The reason we favour the last option is that we believe it is the most efficient for delivering residential broadband services (as well as other services that do not require the use of a full wavelength, such as small cell backhaul) as it allows better statistical multiplexing among services, users and providers and reduces the total number of wavelengths required and therefore optical line terminations (OLTs) and network switch/router ports for terminating those OLTs. It should be stressed though that the flexible capacity on offer in our proposal goes far beyond that currently provided by bit-stream services. Following up on latest development on access network virtualisation through Software Defined Networking and Network Function Virtualisation, we envisage a fully programmable platform, where service providers can request capacity dynamically and on-demand to the underlying network at the required granularity, and select the appropriate quality of service and network protection type. A network access hypervisor is in charge of pooling all available capacity, both at the wavelength level, and within each PON wavelength using the time division multiplexing level.

Indeed, recently operators have started considering the adoption of SDN in their networks as a strategic upgrade to lower capital and operational spending, while reducing service provisioning time. SDN will allow "driving up to 95% improvement in our provisioning cycle times..." stated AT&T senior executive VP of technology and senior operations, and added "...what is our network of the future? It's a multi-service, multi-tenant platform where equipment is more flexible and able to perform many functions and, it will be open, simple and scalable" [5].

Additional efforts have focused more specifically in the access part of the network, with projects such as CORD (Central Office Reimagined as a Datacentre) [6], based on the ONOS SDN controller, which aims at virtualising most of the functionalities of OLT and CPE through a NFV framework, running them on commodity servers. White box switches are envisaged for basic CPE operations, where required, and for the MAC layer of the OLT.

From here, the step towards a sliceable virtual access network is small, as this framework can easily embed multi-tenancy functionalities, giving the ability to external providers to seamlessly control virtual OLTs across multiple PONs. Such ideas have already been picked up by standardisation bodies such as the Broadband Forum, and other companies and research projects around the globe [7], [8].

It is however recognised that the fully-virtualised SDN solution might take time to be developed and deployed, and in the short term two intermediate steps could be adopted to enable multi-tenancy in the access [9]. 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 although its network security implications need to be further investigated. The next step involves the deployment of new hardware/software in the access node capable of resource virtualisation, so that the virtual operators could be assigned a virtual network slice and get full control of the equipment. For this step however the interface might still be the same Infrastructure provider 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.

4 Conclusions

The LLU regulation for the copper pair access network could be a barrier to mass market FTTH deployment either causing delay and/or increased costs for FTTH customers. The main reasons for this are the increasing operational costs per working copper pair as customers leave the copper access network to get services from the FTTH network and the difficulty of closing down local exchange buildings where LLU operators connect to their customers and potentially have equipment installed.

These are difficult problems for the regulating bodies to solve without damaging the competitive environment that LLU has successfully produced. However, the favoured solution proposed in this white paper is to let free market forces evolve the LLU landscape allowing costs to fall on the users of the copper network but at the same time allowing those LLU operators to transition to a shared access FTTH network using access network virtualisation approaches to offer differentiated competing services to their end user customers.

Acknowledgments

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Abbreviations

API	Application programming interface
CPE	Customer premises equipment
CORD	Central office reimagined as a datacentre
FTTH	Fibre to the home
FTTP	Fibre to the premises
JIT	Just in time
LLU	Local loop unbundling
MAC	Medium access control
NP	Network provider or operator
NFV	Network function virtualization
OLT	Optical line terminal
ONU	Optical network unit
PON	Passive optical network
PtP	Point to point
SDN	Software defined networks
SP	Service provider
VoD	Video on demand