Moving the debate forward
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New Thinking on Next Generation Networks

Welcome

This is the thirteenth in our series of Policy Papers. Our aim is to provide a platform for leading experts to write a point of view on issues that are important to us at Vodafone. The opinions expressed are not ours but those of independent experts whose views we respect even if we do not necessarily always agree with them. I would like to thank all those who contributed for their support. I believe these essays will be of interest to anyone concerned with the development of good public policy and hope you enjoy reading them.

Vittorio Colao, Chief Executive, Vodafone Group

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This paper can be seen online at www.vodafone.com/publicpolicyseries

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Introduction

The publication of the Commission's Next Generation Access (NGA) Recommendation in 2010 is far from being the last word on this topic. Although the Recommendation was intended to provide greater regulatory certainty, it has not unlocked the investment that was expected. This has led the Commission to initiate a new round of dialogue within the industry about what more might be done. At the same time, the Commission is soon to propose new guidelines on how prices for various copper and fibre products might be set and is revisiting its rules on the public financing of NGA networks.

Vodafone welcomes this debate and this collection of papers – which summarise longer reports by the authors[1] - is intended to make a small contribution to it.

Vodafone is the largest purchaser of unbundled copper loops in Europe today and we expect to be a significant purchaser of duct and fibre access in future. We might also be an owner or part owner of NGA networks if circumstances allow. We have already written extensively about NGA, mainly when commenting on earlier drafts of the Commission's NGA Recommendation and when considering how any public funds might best be spent. Some of the ideas which we have proposed, such as the need for 'co-investment' in a common network, the rapid switch off of copper or the more strategic use of public funds to influence business models, are still being debated today. Our proposals are generally more radical than anything contained in today's NGA Recommendation, but we continue to believe that Europe needs more radicalism if we are to make further progress.

One example of this is the role of regulators in influencing technology choices for NGA. In the period leading up to the publication of the Recommendation in 2010 Vodafone consistently argued that 'architecture matters' with NGA. We continue to believe that the network technology choices which are made by investors at the outset will determine the prospects of competition for many years to come. As such, regulators should play a more decisive role in influencing these choices.

This did not arise in the past because in the case of copper networks those choices were made many years ago and the job of regulators has simply been to deal with the consequences. However, the transition from copper to fibre allows policymakers to influence network technology, and hence future competition, from the outset. This view challenges a long standing European attachment to 'technology neutrality': the belief that decisions about technology are always best left to the operators themselves. We thought more study was needed to assess what the stakes really were.

We therefore asked WIK to model what different choices of NGA architecture might mean for competition, investment and, ultimately, for welfare. This is exactly the kind of questions which we thought policymakers ought to be asking themselves. WIK's modelling is complex and we enclose only a brief summary of their results in this Paper. The key finding is that, whilst it is not always clear what the best technology will be, the current European attachment to GPON will almost certainly produce the worst outcome in terms of competition and welfare, with only minimal offsetting benefits in terms of investment or coverage.

This is because GPON is the only architecture which cannot be unbundled and for which competitors are therefore always going to depend on an active 'bitstream' product. All of the alternatives – P2P or WDM on GPON – are capable of being 'unbundled' and so promise significantly better prospects for both competition and welfare.

We believe policymakers should act on these results. In particular, they should clearly aim to influence the architecture choices of any networks which are being funded by public money. This would include national Government funding but also loans from the European Investment Bank, 'Infrastructure Project Bonds' or other financial instruments being touted by the Commission. The revision of the Commission guidelines on public financing of broadband networks would be a good place to address this.

Much more effort should also be made to ensure that if GPON networks are to be built they must be capable of being unbundled. This requires the adoption of technical standards for WDM on GPON. The Commission currently has a working group on technical standards where this could be taken forward.

Finally, other policy instruments should be used to influence the technology choices made by operators. Access regulation can be less invasive when the prospects of competition are to be more assured as a result of specific technological choices. Vodafone suggested a similar approach to encourage 'co-investment' ownership models and we regret that the final NGA Recommendation did not adopt it.

We recognise that even if European policymakers were now to follow our recommendations and promote P2P/WDM architectures more aggressively, a significant number of GPON networks will still be built by incumbent operators. Until there is wide-spread adoption of WDM, these will not be capable of being unbundled. This means that the prospects for competition will depend entirely upon how active bitstream products – now known as VULA (Virtual Unbundled Line Access) in European regulatory circles – are offered. We asked Towerhouse Consulting to look at this for us.

VULA is best understood as an intermediate rung on the ladder between an unbundled fibre loop and a fully managed fibre bitstream service. The former allows average costs to fall as the number of loops increases, whilst the latter is generally priced on a fully variable basis. Unbundled loops have been the primary driver of broadband competition in Europe to date.

How is competition to be safeguarded when unbundled loops are not available in a GPON world? The answer, according to Towerhouse, lies in the pricing of the VULA product. Although not a true unbundled product, Towerhouse argue that VULA can and should be priced 'as if' it were. That is, it should be priced to mimic the same economies of density (and the risks) which are available to the owner of the network. They argue that this will allow competitors to access the same (low) marginal costs which facilitate bundling and other forms of retail price differentiation which are going to be critical to building retail demand for NGA services.

Experience from copper unbundling also teaches us that new pricing models for wholesale NGA services are not enough. It is generally the engineers, not the economists, that have the final word and determine whether, or at least how quickly and effectively, new regulatory products can actually be brought to market and whether they allow for effective competition to develop. As with NGA architectures, regulators and policymakers also need to get much more involved in shaping the detailed technical design of wholesale products. The paper by Arul Arulkkumaran and Max Gasparroni, of Vodafone's R&D Group, presents the key issues as being control over CPE, quality of service management, flexible interconnection and multicasting of video. Most national regulators are failing to ensure that the current generation of wholesale NGA services will fulfil these requirements. Here is a task for which, at least in Europe, BEREC seems perfectly suited.

In our fourth paper, by Frontier Economics and Sir Ian Byatt, we wanted to revisit our assumptions about how to price different types of asset. It seems obvious to use modern equivalent asset costing models to set prices for copper loops when there is some prospect of 'replicability'. But it is now clear that some assets are in fact never going to be replicable. Some other approach is then required. The key message from the paper is that the methodology should not depend on whether they are copper or fibre, but on whether they are replicable or not.

These papers all reflect the need to rethink how we are to safeguard and extend competition in an NGA environment which is fundamentally different from what we have today.[2] We believe this will require policymakers to concern themselves with the ownership of the network and the technology choices made by investors, as well as with the regulatory products that are offered over the network. The papers suggest that radical thinking and new approaches will be required on all these topics.

Notes

1 All available at www.vodafone.com/eu

2 These papers do not address the prior question of how investment in NGA is to be funded, nor whether it is in fact wise for policymakers to seek to actively promote such investment if consumers themselves are not willing to pay for it. These are questions which we have begun to tackle elsewhere and to which we intend to return in subsequent papers.

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Architectures and competitive models in fibre networks[1]

Executive summary

With the finalization of the EC's NGA Recommendation there is much debate about how to best deliver the next generation of high-speed broadband networks. Actual FTTH roll-out, however, remains limited in Europe, with most of it based upon GPON technology.

The high capital costs and the long asset life of fibre mean that the technology choices made today will dictate the forms of competition and regulation that develop in these markets for years to come.

This report examines the cost differences and competitive outcomes for different FTTH technologies to determine the impact different technology choices might be expected to have on prices, market entry, penetration and market shares over the long term. Understanding these issues should help policymakers decide whether they should be incentivising particular technology choices today in order to maximize consumer surplus and total welfare in the future.

The various technology scenarios we modelled are:

Technologies suitable for unbundling[2]:

Incumbent	Competitor (Entrant)
Ethernet P2P[3]	Fibre LLU at MPoP
GPON over P2P[4]	Fibre LLU at MPoP
WDM PON	WDM unbundling at Core Nodes

Bitstream-only technologies[5]:

Incumbent	Competitor (Entrant)
GPON	Bitstream access at Core Nodes
GPON	Bitstream access at the MPoP

The modelling approach

Our basic cost modelling relied upon a Greenfield Long Run Incremental Cost approach[6]. We considered both a static model where the relevant FTTH roll-out is completed and the network has (fully) substituted the copper access network and a dynamic approach which considered the time path of investment according to a particular roll-out over time.

For the purpose of this study we created a hypothetical country of approximately 22 million households referred to as "Euroland". We defined 8 areas or clusters, each having typical network parameters derived out of detailed geo-modelling of access networks in several actual European countries. To determine the extent of viable roll-out we then modelled the total cost of providing NGA services in each cluster and assessed its profitability against demand represented by a typical ARPU of €44.25 per customer per month while entrants earned a 5% lower ARPU.[7]

These cost modelling results provide an indication of the competitive conditions we might expect in the NGA market for each technology as the critical market shares for viability indicated the potential number of competitors which could be supported.

We then developed two competition models which show the strategic interaction between the infrastructure provider and its competitors allowing end-user prices, consumer and producer surplus for all technologies to be compared.[8] We considered models both with and without a second vertically integrated broadband infrastructure (representing cable) to which no other firms have access. The "with cable" model is known as "No-Hinterland", while that without cable is the "Hinterland" model. In both types of models the number of entrants is determined endogenously.

Overall results

Our overall results reveal a clear distinction between technologies that can be physically unbundled and those bitstream-only technologies that cannot.

- Scenarios based on networks suitable for unbundling generate greater consumer surplus and total welfare than those based on GPON bitstream access.

While our results are less clear on which technology suitable for unbundling should be preferred, this is an important conclusion for European policymakers because it suggests that the current trend – towards bitstream-only GPON – is clearly inferior to any option that is suitable for unbundling. Such architectures, whether P2P, GPON over P2P or WDM PON would deliver greater consumer surplus and total welfare. P2P architectures are available today, but WDM PON would require the adoption of new standards in Europe.

In addition, we find in our modelling that

- GPON (i.e. closed and not suitable for unbundling) is only about 10% cheaper to roll-out than Ethernet P2P so open technologies can achieve the same coverage as closed GPON. In our basic model, the benefits of Ethernet P2P outweigh the additional investment costs and deliver higher consumer surplus and total welfare.
- Proper pricing for wholesale access is essential, with a particularly strong impact on the unbundling options. Increasing wholesale prices by 10% can have a significant impact on the critical market shares for entrants and their competitive coverage at the given ARPU.
- Under other assumptions, WDM PON would be the best choice if that technology becomes commercially available for the access network.

Networks suitable for unbundling generate greater consumer surplus and total welfare.

The table below summarizes our basic model results for monthly consumer surplus (CS) and total welfare (W) per month.

In terms of total welfare, P2P architectures provide the best results, with GPON over P2P unbundling narrowly beating Ethernet P2P unbundling, while WDM PON ranks consistently third both for total welfare and consumer surplus, usually with a significant margin.[9] The two bitstream scenarios compete for last place.

We ran a number of sensitivities in addition to the base-case results reported in the table below. These included the quality of service deliverable by the various architectures, customers' willingness to pay for greater quality and the incumbency advantage. Considering the consistency of rankings for consumer surplus and total welfare across these sensitivities we found:

- WDM PON unbundling always comes up among the best;
- P2P unbundling shows a variable ranking, but is usually in the first tier;
- GPON over P2P unbundling is also quite variable but mostly ahead of P2P;
- GPON with bitstream access at the core is as variable as P2P, but it shows up mostly in the second tier and would rank even worse under weak regulation; and
- GPON with bitstream access at the MPoP is always among the lowest-ranked.

Scenario	Hinterland ("no cable")					No-Hinterland ("with cable")				
	Entrants	CS		W		Entrants	CS		W	
		Mio €	Rank	Mio €	Rank		Mio €	Rank	Mio €	Rank
P2P unbundling	3	243.1	2	279.2	2	4	466.9	1	490.3	2
GPON over P2P unbundling	3	245.6	1	283.6	1	3	434.0	2	493.8	1
WDM PON unbundling	4	240.5	3	270.8	3	4	431.2	3	473.9	3
GPON Bitstream Core	4	216.8	4	247.7	4.5	4	400.5	5	445.7	4.5
GPON Bitstream MPoP	3	208.6	5	245.4	4.5	4	416.0	4	445.1	4.5

In every scenario we modelled, the technologies suitable for unbundling ranked well above the bitstream-only options.

The additional cost involved in rolling out P2P is only about 10% higher than the one associated with closed GPON: technologies suitable for unbundling can achieve nearly the same coverage as closed GPON architectures.

Incumbent coverage of FTTH could reach up to 64% of the population with no noticeable difference between architectures suitable for unbundling and GPON.

We assume that the fixed network can reach a market share of up to 70% of the total potentially addressable market with the remainder representing DOCSIS 3.0, mobile broadband and non-subscribers. On this basis and assuming our ARPU projections, an incumbent operator can profitably cover a significant part of Euroland with FTTH – about 50% of the population could be covered with P2P or WDM PON while about 64% could be covered with GPON over P2P (or closed GPON). If WDM PON customer premises equipment (CPE) costs could be reduced to the level of GPON CPE, this technology could also cover around 64%. If ducts are available for re-use, coverage can generally be extended one additional cluster (Less Suburban) with the greatest impact on the WDM PON case.

The cost comparison of our five scenarios has shown that overall GPON is the cheapest technology, followed by GPON over P2P, WDM PON and P2P.[10] A P2P fibre architecture requires only slightly higher costs than a closed GPON architecture (in the range of 10%), reducing to around 7% if one takes account of the relative timing of investment between architectures. GPON over P2P generates savings compared to an Ethernet P2P architecture further reducing its investment gap with closed GPON.

This result can be understood because the network elements which cause the highest investment requirements, in-house cabling and drop cable, account for around 75% of total investment and these do not differ between any of the architectures.

Cost items like energy and floor space exhibit significant differences among architectures. Ethernet P2P causes nearly double as much energy cost at the MPoP as GPON and nearly 6 times higher energy costs than WDM PON (in terms of present value). P2P has more than 2.5 times higher floor space costs than closed GPON and nearly 90 times more than WDM PON. These apparently huge differences, however, only have a very limited impact on the overall cost performance of different architectures because the cost share of each of these factors is not more than 1%.

Proper pricing for access is essential.

In our basic models we assume that wholesale access charges are determined according to a Greenfield BU-LRIC cost standard. However, as the policy approach to wholesale charges, national specificities, topology, the speed of deployment and copper switch-off will all, of course, influence these wholesale prices, this should not be simplistically interpreted as the 'right' price for fibre access.

Because of information asymmetries between the incumbent and the regulator, identifying the proper level of the LRIC in a newly emerging network may be a difficult task. Furthermore, there is currently a policy debate on explicitly deviating from LRIC to incentivize FTTH investment. Entrants may have to pay a mark-up on the LRIC based wholesale access charge. We have tested the impact of such policies on competition and welfare on the basis of our modelling approaches.

We find that, based on a given ARPU, increasing the wholesale prices moderately by 10% has a significant impact on the critical market shares and the competitive coverage with the strongest effects occurring in the P2P unbundling scenarios at the given ARPU. The competitive business model would become unviable except in the two most urban areas (18% population coverage). In the bitstream access scenarios the viability of competition is removed from the Suburban area- some 11% of the total population. The general increase in critical market shares indicates a lower number of potential competitors and an increase in risk of insufficient market entry.

Under other assumptions WDM PON could be the best choice, if that technology becomes commercially available for the access network.

The ability to consolidate MDF locations should make WDM PON even more attractive to incumbents.

As WDM PON is expected to enable far longer line lengths and much higher splitting ratios, an incumbent rolling out WDM PON will be able to close many MDF locations and greatly aggregate demand in the remaining nodes. The incumbent might then be expected to realise profits when selling former MDF locations. Such profits have been integrated into our analysis by diminishing the discounted total expenses of rolling out WDM PON. With these profits incorporated into the analysis, WDM PON becomes the most attractive architecture in Cluster 1, becomes second in Cluster 2 and generally reduces the difference to GPON significantly. This may, however, strand the assets of entrants who have invested in active equipment at the MDF.

The relative performance of WDM PON is strongly influenced by the cost of customer premises equipment (CPE).

WDM PON viable market shares are actually lower than bitstream across the first 4 clusters but then jump significantly in Cluster 5 (Suburban). Should WDM PON vendors be able to reduce CPE prices to the level of GPON CPE the critical market shares for viability would be significantly reduced and coverage could be extended by one cluster to Cluster 6 - equivalent to the coverage achievable by GPON and at a slightly lower viable market share. Entrants could penetrate to Cluster 5 (Suburban) with viability at only 12% market share compared with 16% or 28% for GPON bitstream access at the core or MPoP respectively. Generally, WDM PON would then rank first as a technology. Getting WDM PON CPE costs down will require activity in the standards arena.

Notwithstanding these potential developments of WDM PON, the relative attractiveness of it against P2P is strongly influenced by assumptions made on consumers' willingness to pay for additional quality, the advantages conferred to the incumbent by its brand (known as the incumbency premium) and the technical performance which may be achieved by

WDM PON. If, by the time the network is fully rolled-out (after about 10 years) consumers ascribe a high value to ultra high speeds and strongly differentiated retail offerings, then the additional cost of P2P is a price worth paying. If, on the other hand, consumers ascribe only a small value to these attributes, or entrants cannot reach the market shares required for viability, then the savings achievable under WDM PON, while still allowing a form of unbundling, make WDM PON the best technology to maximize consumer surplus and total welfare.

Notes

1 This is a shortened version of the paper originally prepared for Vodafone Group. The full paper is available at www.vodafone.com/eu

2 While these technologies have been modelled on the basis of entrant unbundling, this does not preclude, of course, additional bitstream-based entry.

3 P2P – Point-to-Point; PMP – Point-to-Multipoint.

4 This consists of a physical Point-to-Point architecture but with the incumbent using GPON plant "moving the splitters back" to the MPoP with dedicated fibre links in both the drop and feeder segments. Further details are provided in Chapter 2 of the full report.

5 Due to the underlying Point-to-Multipoint fibre plant GPON cannot be unbundled at central sites. Accordingly wholesale access is bitstream-only.

6 As there often is available infrastructure from existing networks which may be reused to generate investment savings we also undertook Brownfield sensitivity calculations.

7 In the dynamic extension of the model we accounted for growing demand over the 20 year period of the model up to a maximum of 70% penetration.

8 In our competitive models, the incumbent owns and invests in an FTTH network to which entrants must obtain access in order to provide NGA services. As we found that infrastructure replication is only theoretically viable in the densest cluster we do not consider it to be of major relevance to FTTH competition so did not consider it further.

9 The margin is narrow for CS in the Hinterland model, because here WDM PON has 4 entrants, while the two P2P scenarios only have 3 entrants.

10 With the exception of the densest urban cluster where WDM PON and GPON over P2P switch ranks, this is consistent over the relevant clusters.

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A new approach to wholesale pricing for next generation access networks[1]

1. Introduction

Towerhouse Consulting LLP has been commissioned by Vodafone to consider the need for a new approach to wholesale pricing for access to next generation access ('NGA') networks. The problem to be addressed is as follows:

- The economics of wholesale network access changes with the introduction of NGA. The result is that passive infrastructure access, equivalent to LLU, will not always provide a viable platform for competition. Therefore, competitors will increasingly need to rely on bitstream services. Unfortunately, to date, competition based on bitstream has been relatively ineffective with the most successful Communications Providers (CPs)[2] using LLU.
- LLU has allowed CPs to offer a much wider range of services, and packages of services, at attractive prices. Part of this is due to the ability to dictate the technical characteristics of the service. However, the flexibility to offer innovative retail tariffs, which has helped to drive the take-up of new services, stems from the fact that LLU creates a relatively low marginal cost for CPs.
- In contrast, bitstream pricing tends to be structured like retail services, with most of the cost to the CP coming in the form of a per line recurring charge. This restricts the range of profitable pricing strategies that a CP can adopt, and ultimately limits the effectiveness of competition based on bitstream.

The solution proposed in this paper is an obvious one: to change the structure of bitstream pricing to reduce per line recurring charges, and to introduce or increase other charges which do not vary directly with the number of lines to ensure the incumbent can recover its efficiently incurred costs. We therefore argue that NGA bitstream[3] services must meet two criteria:

- they must allow CPs to control the technical characteristics of network services; and
- the recurring per line charges should form a relatively small proportion of the total charges to a CP.

Pricing in this manner effectively shifts the bitstream service further upstream, and means that CPs will be able to compete more effectively. As such, it is unlikely that incumbents will introduce this pricing voluntarily. Regulatory pressure will be needed to ensure that this form of pricing is made available.

2. NGA and the need for bitstream

There is little doubt that the introduction of NGA networks is changing the economics of fixed telecoms service provision. And, whilst the prospect of faster broadband and new services is to be welcomed, there is a risk that the effectiveness of competition in this sector will be weakened by the change in cost structure.

Competition will often stimulate innovation. It can be the driving force to encourage the evolution of services to meet the diverse needs of consumers. However, this process is predicated on the ability of competitors to create new services to offer to consumers. This is a well-rehearsed argument in the world of telecoms regulation. It forms one of the principle justifications for local loop unbundling remedies, and for the primacy of physical unbundling remedies to access NGA networks. Equally, it underpins the need for NGA bitstream services to replicate the technical control characteristics of physical unbundling.

The argument we set out in this paper rests on the fact that innovative service differentiation is a function of both technical characteristics *and* price. Fixed telecoms services are increasingly sold in bundles, and in this environment competitive differentiation relates to the manner in which a bundle is priced almost as much as the substance of the constituent services.

Therefore, not only do competitors require the ability to specify technical characteristics, they also need to be able to adopt a range of different retail tariffs. This implies a need for relatively low per-line marginal costs.[4] This cost structure exists for incumbents and other operators who own access network infrastructure, and to a lesser degree for LLU operators. In contrast, it does not tend to exist for competitors using bitstream. This has certainly contributed to the fact that competition based on bitstream has been less effective than LLU. Across the EU, almost three times as many competitor broadband lines are provided using LLU compared to bitstream.[5]

In discussions about wholesale access to NGA networks, regulators have indicated a preference for physical unbundling (or passive access) remedies. Wherever they are viable, we agree that such remedies provide the most robust platform for competition. However, there are always regions in which population density dictates that passive access is uneconomic, and the introduction of NGA networks will tend to increase the number of areas in which this is the case.

The following table summarises the economic feasibility and the technical and practical feasibility of passive access under different NGA network architectures relative to LLU over the current copper network.

Table 1.1: feasibility of passive access under various network architectures

Architecture/ Technology	Economic feasibility	Technical and/or practical feasibility
Current gen. copper	¾ filled	full
FTTC	¼ filled	½ filled
FTTH: GPON	¼ filled	¼ filled
FTTH: P2P fibre	¾ filled	⅞ filled
FTTH: WDM-PON	⅞ filled	empty

FTTH networks based on point to point fibre have similar characteristics to the current generation network, and therefore would be suitable for unbundling. In contrast, there is little prospect of wide scale adoption of physical unbundling of (or passive access to) FTTC and GPON networks. WDM-PON networks appear to offer considerable potential for highly efficient forms of access which provide excellent levels of technical control. However, this technology is still in the early stages of development, and so cannot currently be relied upon to provide the foundation for competition in the fixed telecoms sector.

In the long term, one of these technologies may start to dominate, but for the foreseeable future a range of different architectures are likely to exist – including substantial areas where the network is yet to be upgraded. This diversity, in conjunction with the costs of passive access, will lead to a growing demand for bitstream services. If competition is to be effective *throughout* national markets, and not just in pockets where passive access is viable, then bitstream services will need to create much greater scope for competitive differentiation than they have in the past. The *structure*, and not just the level, of bitstream prices will play a critical role in determining whether such differentiation will be economically viable.

3. The importance of price structure

Wholesale tariff structure can have a significant impact on the ability of CPs to compete by restricting the range of profitable pricing strategies which they can adopt. The argument is simple:

- Selling at a price below marginal cost results in a loss of money on each sale. In general, therefore, a CP will not sell telecoms services with a monthly recurring charge below its recurring per line wholesale cost.
- If a CP finds that it is selling to some customers at a price below marginal cost, it will clearly try to reverse the situation. This could be by selling additional services, but by far the simplest, cheapest and most certain method will be to either raise the price or terminate the service to these customers.
- As a result, the recurring per line element of wholesale charges sets an effective lower limit on a CP's retail pricing.

On the assumption that wholesale access service prices match the simple rental-per-line structure of retail pricing, then CPs who enter the value-chain further downstream and rely more heavily on the incumbent's infrastructure are restricted in the range of profitable pricing strategies they can adopt. The relatively high recurring per line charges that they face imply a relatively high minimum retail price level.

Competition based on LLU has tended to be more effective than that based on bitstream. It has allowed CPs to create new products, and to offer genuinely new pricing and service bundles. This ability stems from the fact that LLU gives CPs independent control over the technical characteristics of the access service. However, the ability to offer new pricing and service bundles is also a function of the cost structure of relatively low per line recurring charges which LLU generates for CPs. The fact that LLU operators tend to offer more competitive pricing and more comprehensive packages of services in areas where they can use their own network provides some evidence of this effect.[6] For example, the CP 'free' in France sells its basic broadband service for €29.99 per month in LLU and fibre areas, but €35.98 elsewhere.[7] TalkTalk in the UK offers the same broadband packages outside its LLU footprint, but charges £15.32 per month extra.[8]

Figure 1.1: price and cost structure

	Wholesale			Retail
Value chain:	Upstream			Downstream
Production resources:	Raw inputs			Processed inputs
Business model:	Self build	Passive infrastructure unbundling	Bitstream / active access	Resale
Typical cost structure:	Majority costs fixed		Majority costs variable	
Wholesale price structure:	Co-investment	Low % recurring per line charges		High % recurring per line charges

Figure 1.1 above shows part of the fixed telecoms value chain. A CP who self-provides all elements of the service will incur costs according to all the various raw inputs required (civil infrastructure, network equipment, staff costs, IT costs, etc). Many of these will be fixed with respect to the addition of a single new customer in the short run, although not necessarily fixed when considering the addition of large number of customers over a longer period of time.

CPs entering the value chain further downstream use inputs which are less 'raw', having already been processed further upstream. These upstream inputs tend to be priced on a variable basis, and hence the cost structure for CPs operating at this level within the value chain has relatively less fixed, and more variable, cost. In the extreme, we have resale in which the cost structure generally mirrors the retail price structure, and hence is almost entirely variable.

The more that pricing reflects the cost structure of the underlying raw inputs, the further upstream that product will tend to lie. This effect is independent of the ability to control the manner in which the underlying inputs are used.[9] Co-investment takes the idea of matching prices to the underlying cost structure to its logical extreme: where there are fixed costs for the incumbent, a CP pays a one-off upfront fee; wherever the incumbent installs extra equipment, the CP pays a share; etc. As a result, a co-investing CP should benefit from a marginal cost which is very similar to that incurred by the incumbent.

In order to demonstrate the potential impact of this price structure, we consider the following hypothetical example: in a competitive market, a CP can sell a basic broadband service for €10 per month, and can offer a premium TV services as an optional extra for €5 per month. Given this pricing, it will achieve demand of 1 million broadband lines, and 100,000 of these customers will take up the TV service. We consider two cost scenarios shown in table 1.2 below.

	Scenario 1	Scenario 2
Marginal cost of broadband (per month)	€9.80	€10.20
Marginal cost of TV (per month)	€2	€2
Fixed costs (per month)	€400,000	€0
Profit given pricing of €10 and €5 (per month)	€100,000	€100,000

Table 1.2: two cost scenarios

Given the same pricing strategy of €10 for broadband and €5 for TV, a CP would achieve the same volume and would make the same profit under each scenario. However, it is easy to see that scenario 2 is implausible. Even if there is the prospect of profitability in the future through the sale of the high margin TV service, the CP is unlikely to sell the basic broadband service to 900,000 customers at a total loss of €180,000. A simple strategy for increasing profits would be to increase price to these customers, or to terminate their services. In reality, the ease and immediacy of this strategy is likely to outweigh the possibility of gaining higher profits in the future from up-selling the optional TV service to the customer base.

The conclusion is that lower marginal costs create the opportunity to adopt a wider range of profitable pricing strategies – even when total costs remain the same. With this in mind, we should note that our proposed changes to the structure of bitstream tariffs are not equivalent to discounts. The objective of a discount scheme is to reduce total average costs. As we have just seen, there are benefits to having a lower marginal cost even if total average cost remains the same. However, we should also note that in moving to a price structure where CPs pay more upfront, there is a transfer of risk from incumbent to CP. As such, a discount may be justified to reflect the reduction in the incumbent's costs.[10]

4. Virtual LLU pricing

In line with the principle of cost orientation, we propose a structure for NGA[11] bitstream pricing which approximates the use of resources required to produce the service. In matching prices to underlying resource costs, we must decide how far up the value chain should we look to determine cost structure. Given the relative success of copper LLU, we believe that a good starting point is to consider the cost structure faced by an LLU operator. Our suggestion is that bitstream should be priced such that CPs using the service incur costs in roughly the same manner as an operator who uses LLU today. A CP would therefore pay for the following service elements independently:

- service enablement – to create the ability to serve customers in a particular geographic area – through a one-off set up charge and a semi-fixed fee which recurs every few years;[12]
- backhaul rental through a regular recurring charge per unit of backhaul per local exchange area served; and
- rental of customer access lines through a regular recurring charge.

As a result, the line rental element of the bitstream charge would be a much smaller percentage of the total, resulting in a relatively lower marginal cost to the CP.

There are many parallels with the 'virtual unbundling' remedies being discussed by a number of National Regulatory Authorities (NRAs).[13] These have focussed on the technical characteristics of bitstream services, and the ability of CPs to control the network. We fully support these proposals, but add requirements for a price structure which generates a relatively low marginal cost for the CP.[14] In the following subsections we consider the impact of the proposal on CPs, the incumbent and the climate for investment in NGA services.

4.1 Impact on the CP

Greater flexibility over retail pricing will mean that CPs, and the market in general, can serve a greater proportion of potential demand. If a CP can structure its retail packages such that those willing to pay a little more do so, then they can also price slightly lower to attract currently unserved consumers whilst maintaining or increasing their profits. There are a number of strategies which would help achieve this aim, all used in the market today for current generation broadband, and involving some combination of price discrimination and product differentiation. Examples are introductory discounts, and bandwidth or download limits. Product differentiation such as download limits will, in many cases, make little difference to costs, but will allow the CP to vary prices for essentially the same service. For example, many customers would prefer to pay a little extra for a larger download limit than they really need – for peace of mind. Therefore, two customers can make exactly the same use of the network, and so cause the same level of cost, but will pay a different price for the service.

The ability to adopt innovative price structures will be particularly important in the NGA world. The willingness to pay for NGA-based services varies considerably across the population,[15] and will almost certainly change over time. Some consumers with niche demands are prepared to pay a premium today, but the majority appear to be happy to use current generation services.[16] As NGA-based services improve, and as consumer awareness of the benefits of these services increases, it is likely that more people will pay the premium.

We expect that a large number of NGA-based services will be sold as an addition or enhancement to a basic line rental service. This type of bundling already dominates current generation broadband markets. For example, in its most recent consumer research in the UK, Ofcom found that,

> *for many consumers, buying a bundle was a good route to trying out a new service for the first time. This indicates that bundling may well be a driver of take-up of broadband and pay-TV services.*
>
> *[...] 45% of people with pay-TV did not have this service before subscribing to it within a bundle. Similarly, 40% of people with fixed broadband in a bundle did not have this service before.*[17]

Given these circumstances, it will be important for CPs to be able to offer basic access services at a relatively low price, and then 'up-sell' additional and enhanced services to customers. Without the stepping-stone of an attractively priced basic service, it will be difficult to generate the momentum needed to shift the new services from niche interest into the mainstream.[18] Equally, the fact that CPs can attract a wider audience to connect to the network is socially beneficial since this will help to bridge the so-called 'digital divide'.

A caveat to the above argument is that the upfront costs associated with the change in price structure may act as a barrier to entry by creating economies of scale, and therefore prevent some CPs from competing. To some extent this is true, but the upfront investment brings the reward of lower marginal costs and greater competitiveness. The situation is therefore analogous to a CP considering moving up the "ladder of investment".[19]

There are two other points to note in relation to this argument. First, one can make the upfront costs less of a hurdle by ensuring that the relevant charges are sufficiently granular. For example, if the bitstream service offered access on a regional basis, a CP could choose to build up to full national coverage gradually, and therefore would not have to incur all the upfront costs in one go. This would mirror the approach taken by LLU operators in building their networks.

Secondly, given that the effect of the change in price structure is to shift the bitstream service further upstream, it would enable the creation of a secondary wholesale bitstream or resale market. Therefore, if there is demand from smaller scale CPs, the market should create additional downstream wholesale services which can be priced on a traditional per line basis.

4.2 Impact on incumbent

In moving from a bitstream service priced on a per line basis to the new price structure, the incumbent's revenue becomes less sensitive to the volume of lines, but much more sensitive to the number of CPs. Small changes in the number of CPs can cause very large changes in revenue. Therefore, the potential variability of the incumbent's revenue increases.

However, risks of over- and under-recovery are an unavoidable feature of the telecoms industry given the largely fixed nature of costs. A variety of volume and timing assumptions are required whenever fixed costs are recovered through simple per line recurring charges. These volume forecasts concern not only the number of customer lines to be served in the future, but the relative amounts of all the various inputs required to produce the service. If any of these volume forecasts turn out to be wrong, then revenue will not match cost. These complexities and uncertainties are intrinsic to the process of setting regulated prices: the regulator must try to verify all these costing assumptions to ensure that future revenues do match costs.

4.3 Impact on competition and investment

A final point to note is that the increased competitive intensity associated with the change in price structure may be seen as damaging to long term investment prospects. In the sense that CPs gain access to lower marginal costs without investing more in physical assets, it may appear as if they are less committed to the long term prospects for the market. The counter argument is that although CPs are not investing in their own physical assets, they are making a similar financial commitment through the upfront payments. In a very real sense, the CPs are investing in the physical assets of the incumbent. Taken to its extreme, this form of pricing equates to co-investment – as noted in figure 1.1 above.

Equally, given that we are proposing to match the structure of payments made by LLU operators today, the risks of short-termism are no different from those based on competition via copper unbundling. Ultimately, a CP must recover its fixed costs to be profitable. The more significant the fixed (and semi-fixed) costs, the greater the risks to a CP of an average price level closer to marginal costs. As a result, we believe that the proposed increases to charges to compensate for lost revenue will tend to offset the risks of short-termism: a very low marginal cost will only be achieved if the CP invests a very significant amount upfront.

5. Conclusions and recommendations

Price regulation of wholesale access serves three potentially conflicting purposes:

(a) to protect against the abuse of monopoly power through excessive pricing;

(b) to promote competition; and

(c) to encourage investment.[20]

In practice, regulated prices are usually set at some measure of average total cost. Assuming these costs are 'efficiently incurred', pricing at this level will ensure that the incumbent cannot make excessive returns, and efficient downstream competitors should be able to run financially viable operations. This covers objectives a and b, and c to the extent that it refers to investment in downstream markets. There is potentially a trade-off between the achievement of these objectives and encouraging investment within the regulated market. If it is difficult to achieve 'efficiency', then it will be difficult to make a return on investment. Hence, one can argue for slightly higher prices in order to fulfil objective c.

We believe that our proposal for a different structure for bitstream pricing can help to balance this trade-off by creating additional options for wholesale access. Pricing structure is more flexible than product design and the location of physical points of access. As a result, it is much easier to create additional rungs on the ladder of investment through changes to pricing than through product design. This helps to generate options which both support effective competition *and* maintain (or even improve) incumbent incentives to invest.

However, the threat to the incumbent of increased, or more effective, competition is likely to mean that they choose not to offer this form of pricing voluntarily. Therefore, we recommend that NRAs include pricing structure as part of the assessment of cost orientation requirements for bitstream services. Ultimately, we believe that where passive access remedies are not viable, NRAs should mandate bitstream access with a price structure that delivers low marginal cost to CPs. The virtual LLU pricing described above would be one option to consider.

We view this as the sole regulatory remedy required in these areas in the access/broadband value chain. That is, no further remedies would be required downstream. Demand for wholesale access services priced on a traditional per line basis would be served by CPs using the regulated bitstream service. This is analogous to areas today where competition based on passive remedies is effective and therefore regulated bitstream access is no longer required.

It should be noted that the proposal is compatible with a retail minus approach to price regulation. However, retail minus tends to imply a wholesale tariff structure which maps onto that found in retail markets – i.e. precisely what we are trying to move away from. It is important to remember that retail minus is simply a method of setting the price *level*, with the 'minus' chosen to reflect the costs of efficient downstream operations. Although it is much simpler, and therefore more transparent, to use retail minus in the context of a wholesale tariff structure which matches the retail price, it is not necessary.

Similarly, one potential concern with the proposed approach is that it would create additional complexity for regulatory bodies trying to prevent margin squeeze since a simple comparison with retail prices is no longer possible. Such simple tests are certainly not possible for the majority of today's upstream remedies such as LLU, and our proposal is ultimately to make bitstream pricing look more like that of an upstream remedy. From this perspective, the design and application of margin squeeze tests will be no more difficult than they are today.

Notes

1 This is an extended summary of a longer paper of the same title. The full paper is available from www.vodafone.com/eu

2 For simplicity, we refer to downstream competitors of the incumbent as CPs throughout the paper.

3 We will use 'bitstream access' as a generic / collective term to refer to both wholesale broadband access services which include shared (and aggregated) backhaul and so-called active access services which tend not to include aggregated backhaul.

4 That is, the change in costs associated with selling a fixed-line service to a new customer.

5 Based on the most recent ECTA broadband scorecard (September 2009), there were 11.4 million broadband lines provided using bitstream or resale, but 30.9 million provided using LLU. See http://www.ectaportal.com/en/REPORTS/Broadband-Scorecards/Broadband-Scorecard-2009/.

6 This is subject to the following caveat. Retail pricing and packages are of course influenced by a variety of factors. In terms of cost, LLU operators specifically target areas where the average total cost of provision is lower. Therefore, one might expect prices to be higher outside LLU footprint areas.

7 Current prices from www.free.fr.

8 See www.talktalk.co.uk for details. For more examples from the UK, see Annex 8 from Ofcom's "Review of the wholesale broadband access markets 2010". See http://stakeholders.ofcom.org.uk/binaries/consultations/wba/summary/wbacondoc.pdf.

9 If a CP also has control over how the raw inputs are used, then the CP is effectively self-providing these inputs.

10 This issue of discounts is discussed in Annex 1 of the recent EC NGA recommendation on regulated access to NGA networks (2010/572/EU).

11 The proposal would apply equally well to bitstream based on the current generation network. However, we focus on NGA bitstream because it is likely to be the only viable option for CPs in many circumstances.

12 The frequency of the charge would be determined by the asset life of the transmission and switching equipment used for the service. So, for example, it might be 5 years for active fibre equipment.

13 Three NRAs, in Austria, Denmark and UK, have now either proposed or implemented wholesale access remedies which are virtual versions of physical unbundling. The basic premise is that physical unbundling provides the greatest level of control for CPs, but that a significant degree of control could be provided using active access products. Therefore, in areas where physical unbundling is

not economically viable, the incumbent should introduce 'virtual unbundling' services which try to replicate the levels of control that a CP would have achieved if they were physically unbundling.

14 In the context of our proposed pricing structure, technical control can be seen as the ability to use the various inputs in different proportions: for example, adopting a different ratio of backhaul bandwidth to lines served.

15 Ofcom recently carried out some consumer research which included an estimate of the willingness to pay for higher speed broadband. It asked consumers how much they would be willing to pay to double their existing broadband speed. The results were a highly skewed distribution. Over half of respondents were either unwilling to pay any extra or were unsure. A very small number were prepared to pay considerably more than their current fee. See, in particular, figure 3.12 in http://stakeholders.ofcom.org.uk/binaries/consultations/wla/annexes/consumer_research.pdf

16 For data on take-up of NGA-based services relative to availability, see chart on page 8 of "Super-fast broadband, Context and summary for Ofcom's consultations on the wholesale local access and wholesale broadband access markets". As the report notes (paras 2.21-2.22), the countries leading on roll-out and take-up of broadband tend to be those with significant government support for NGA networks. See, http://stakeholders.ofcom.org.uk/binaries/consultations/wla/annexes/context.pdf.

17 Page 62, The Communications Market 2010, Ofcom. See http://stakeholders.ofcom.org.uk/market-data-research/market-data/communications-market-reports/cmr10/?a=0

18 One of the reasons for this is network effects: it is important for networked services to reach as wide an audience as possible (including those relatively less willing to pay) since each additional subscriber increases the value of the service to all the existing subscribers.

19 This is not surprising since we have proposed the change in price structure in order to better match the cost structure of the underlying network assets.

20 These three objectives are derived from Article 13 of the Access Directive (2002/19/EC) which concerns a NRA's remit to impose price controls. It states that price controls may be needed where market conditions indicate that lack of competition might allow an operator "to sustain prices at an excessively high level, or apply a price squeeze, to the detriment of end-users." It also notes the importance of investment, stating that NRAs "shall take into account the investment made by the operator and allow him a reasonable rate of return on adequate capital employed, taking into account the risks involved." It goes on to require that any price regulation "serves to promote efficiency and sustainable competition and maximise consumer benefits."

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Key principles for wholesale access over next generation fixed networks

1. Executive Summary

The continuing trend of increasing broadband adoption and utilisation is driving the deployment of technologies with greater capabilities based on fibre deployment and widely referred to as Next Generation Access (NGA). Among the wire-line operators (as opposed to cable or mobile operators), the dominant technologies used for NGA will be VDSL2[1] or Fibre to the Premises (FTTP). FTTP can be via either point-to-point (P2P) fibre or GPON[2]. Both have been deployed in early NGA roll-outs but GPON appears to be dominating, especially among incumbent telecommunications operators.

The wide-spread replication of NGA networks will be economically unviable and the market share required to unbundle P2P networks looks to be more challenging than the current generation of copper networks.[3] GPON networks cannot currently be unbundled and while there exist possible future technologies to address this, such as wave-division multiplexing, they remain unproven and are non-standardised today. Therefore, we can expect that a larger proportion of Communications Providers (CPs)[4] will rely upon active wholesale products to compete in the future.

To compete effectively, CPs require control over key technical parameters of that active wholesale access product so that they may innovate and differentiate their retail offerings from those of other operators, particularly the incumbent. This reasoning has led regulators in countries such as the UK, Austria and Denmark to propose or adopt requirements that the incumbent must offer 'virtual unbundled local access' (VULA) active wholesale products. The UK has gone further than any other European regulator in specifying the technical requirements of this service known as EALA (Ethernet Active Line Access).

This paper describes the most important technical parameters for effective CP competition and then examines whether, in practice, the current NGA active wholesale access products available in selected markets[5] measure up to these principles. We generally find that they do not. We conclude that regulators will need to get more deeply involved in the specification of such products if they are to ensure effective competition in an NGA environment. Addressing such issues *ex post* after the technical specifications have been set will always be a second-best option.

We consider that the most important technical parameters for effective competition are:

- Flexible support of consumer premises equipment (CPE);
- Control over the quality of service delivered to the end customer;
- Flexibility on points of interconnection; and
- Ability to support multicast.

We have reviewed the NGA wholesale access products available against these requirements and find:

Requirements	Spain[6]	UK[7]	Germany[8]	Ireland[9]	Italy[10]	Portugal[11]	NZ[12]	AU[13]
Ethernet Interfaces	●	●	○	●	○	● (grey)	●	●
Flexible CPE	◐	◔	◕	◐	◔	● (grey)	●	●
QOS	◕	◔	◔	◕	○	● (grey)	◐	●
Flexible interconnection	◔	◕	◔	◔	◔	● (grey)	◕	◕
Multicast	○	◐	○	●	○	● (grey)	●	● (peach)

Future expected plan (peach) — No NGA bitstream proposition (grey)

In addition, it is generally accepted that these active wholesale access products should be based upon Ethernet technology. Ethernet is well defined, low cost and ubiquitous as it is based on an existing highly competitive ecosystem. The Ethernet packet interface is also highly interoperable, and can be supported by many different types of physical media (e.g. xDSL copper, PTP fibre, PON fibre). Among the other options for a common interface technology, IP interface is considered to provide functionality at too high a level, and therefore there is concern that it would inhibit innovation, while ATM equipment is relatively obsolete and expensive compared to Ethernet. Thus, Ethernet prevails as the preferred interface technology for the NGA wholesale active access which has been implemented in the majority of the markets considered in this paper.

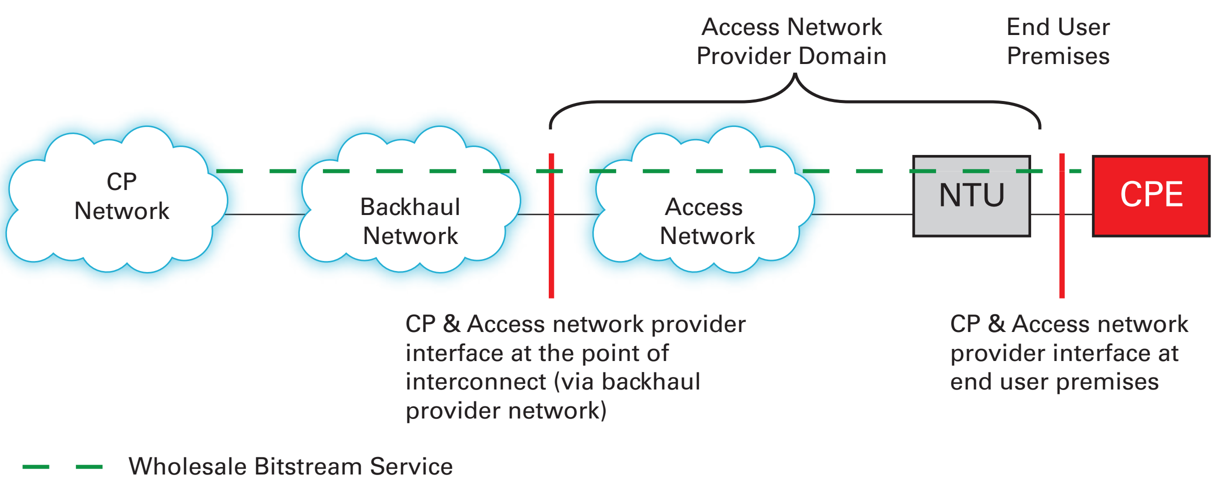
Secure delivery of services is also essential, so any wholesale bitstream access needs to provide basic transport security, allowing the CPs to choose the appropriate higher layer of security to the traffic and be transparent to whatever security procedure the CPs wishes to implement.

2. Key characteristics of wholesale access

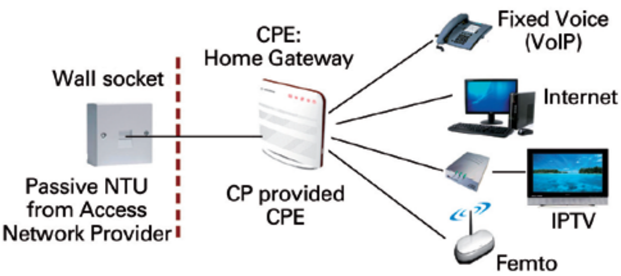
To offer services over a broadband access network, a CP will need to interface with the access network provider both at the customer premises and at the CP's point of interconnect. The demarcation between the access network provider and the CP in the end user premises is called the Network Termination Unit (NTU). In order to provide a wholesale access, an access network provider provides connectivity from the CP's point of interconnect to NTU. Figure below shows the generic architecture of the wholesale access.

2.1 Flexible support of CPE

NGA networks may have different physical interfaces at the end-user premises (e.g. copper vs. fibre) and fulfilment models depending on the technology used. Specifically a given access network may use an active network termination unit (NTU) that is owned and managed by the access network provider or it may support a wires-only delivery to the customer premises. In this context, 'wires-only' means the NTU is a passive device such as a wall socket and the CPE is provided, configured and managed by the CP.



In a wires-only solution, the CP functions will be supported at the CPE which is either provided by the CP to the end user or may be purchased by the end user and configured according to the instructions of the CP. The physical presentation of the customer premises interface is determined by the underlying access provider network technology which the CPE must terminate. The most common example of this is for existing ADSL services where the access network is terminated at a passive device (e.g. NTE5 socket) and CPE includes an ADSL modem that terminates the DSL interface and provides access to an Ethernet interface. See the figure below[13]:



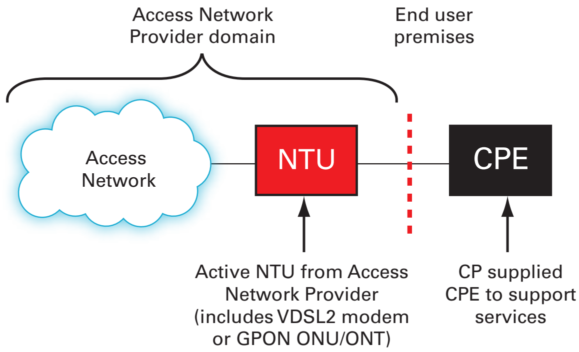
This wires-only solution for ADSL is possible thanks to well established interoperability between all the major vendors of central office equipment and CPE. This level of interoperability has not yet been achieved in VDSL2 and GPON technologies. It is expected to be achieved within 12 months for VDSL2[14] and within 2 years for GPON.

Currently equipment vendors focus first on developing their proprietary systems and generally place less emphasis upon achieving interoperability. However, given the importance of such interoperability for the development of a competitive market, we believe greater efforts in this area will be necessary to improve the timescales above.

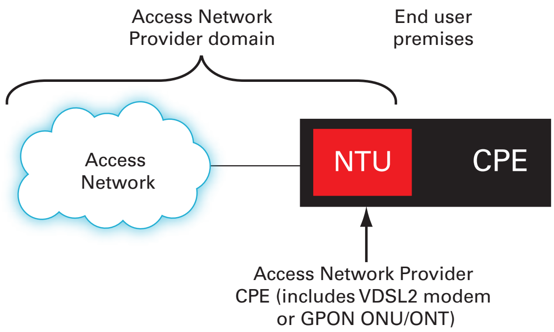
Without the wires-only model, the NTU will be an active device from the access network provider supporting physical line termination for VDSL2 or GPON by accommodating VDSL2 modem or ONU/ONT respectively. This means that to deploy a complete service by a CP, additional functionality such as a router for data/Internet connectivity is required and will need to be provided by the CP by adding a separate box (i.e. CPE) to the customer premises.

In this case, the access network provider may be given an unfair advantage as it can deploy an integrated NTU+CPE unit:

- Unlike the CP, its retail customers do not need to deploy an extra box in the household, which is typically seen as inconvenience by most of customers (See figure below). One box is seen as more environmentally friendly as it consumes less power and space and is generally cheaper than a two box solution.
- A one box solution has one and not two points of failures, simplifying the support processes. It also enables a more straightforward innovation as in a two-box solution the CP is dependant on the NTU hardware features and limitations deployed by the access provider.
- The integrated box may have already POTS and data ports labelled with the access provider's brand, and this may induce customers to connect their devices to these already present ports. This could increase the propensity of the user to choose the access provider over the CP as their voice service provider.



Two-box solution
CP supplying NGN services to end user



One-box solution
Access Network Provider supplying NGN services to end user

The CPE has proven to be a key domain for service differentiation and branding in the largely DSL-based broadband access deployments to date and we can expect this to continue in the NGA environment. A 'wires only solution' creates less cost for the CP and therefore the overall service, takes up less space, power and cabling for the user and allows simpler fault diagnosis. The wires-only interface can also facilitate a more competitive equipment market. In the case of GPON, for example, many vendors have a range of ONU/ONT variants in their product portfolio depending on intended market (e.g. small residential, business or multi tenancy units like office or flats). Hence, a wires-only interface enables the CP to provide the optimum solution for particular end customers.

It is accepted that a wires only solution makes it more complex to have multiple CPs at each user premise, each delivering separate services. However, with the popularity of bundled offers, we consider that few end users will be interested in purchasing services such as voice and broadband access from separate providers. Also, a wires only solution will not prevent non telecommunication service providers such as smart metering, health care, etc., from delivering services to end users as their services could be provided "over the top".

We believe that regulators should consider 'proper' wires-only standards as the first option for delivering services over wholesale bitstream access allowing CP owned CPE integrating physical line termination function (VDSL2 modem or ONU/ONT of GPON) and residential gateway functions at the customer premises. A wires-only implementation of the two technologies (VDSL2 and GPON) should be considered separately as they differ in many respects and the development of GPON is significantly behind VDSL2. VDSL2 is the immediate priority.

If the installation of an active NTU (and hence, the 'two box' solution) is unavoidable then it is recommended that to achieve a good end-user experience:

- The CP should install the active NTU supplied by the access network provider or a compatible NTU purchased by them in the end user premise in an agreed manner along with their CPE. This way, the end-user will see the CP as providing the full installation.
- All active NTUs should support (on a CP's request) an Open ATA (Analogue Terminal Adaptor) so that CPs can supply the customer with an analogue voice service using their voice server if required.
- The NTU should present a single Ethernet port with no branding of the access network provider visible if that provider also competes in the retail market.

2.2 Quality of Service

Quality of Service (QoS) is a broad term used to describe the overall experience a user or application will receive over a network. Network operators achieve end-to-end QoS by ensuring that network elements apply consistent treatment to traffic flows as they traverse the network. Services such as voice, e-mail, browsing video-on-demand (VOD), video broadcast, high speed internet (HIS) and business services have very different requirements in respect of bandwidth, delay, jitter and packet loss.

Therefore, the primary aspects of quality of service concern the ability to define traffic classes and influence the traffic management. For practical purpose operators tend to aggregate these multiple services in to several service classes. We consider that the network access provider needs to offer around five different classes of QoS as shown in the table below to meet the different CP requirements for NGA services today. Of course, these requirements could expand as future services are developed.

Type	Service Category	Services/Traffic
1	Control	Network Control Signalling
2	Real Time	VoIP, video-telephony, Online-Gaming
3	Broadcast	Video broadcast, Internet radio
4	Critical Data	Business data, OAM, billing, Video on demand, Streaming Audio
5	Best Effort	Internet, e-mail

In terms of QoS implementation, each class of service has a service level specification (SLS) that defines the performance objective that must be met for that class. In the context of wholesale access, the SLS specifies the frame delivery performance objectives between the customer premises interface and the network interface. These performance objectives can be specified and measured using service level specification attributes such as delay, jitter, packet loss and availability performance. The SLS for Multicast should also include an attribute for channel change latency, i.e. the length of time to change channel.

In order to meet the SLS, the access network provider will need to implement strict priority scheduling at any congestion points in their network such as the following:

- Control traffic gets scheduled first (Strict Priority)
- Real Time (voice) traffic gets scheduled next (Strict Priority)
- Broadcast (video/audio) traffic is scheduled next (Strict Priority)
- Critical Data and Best Effort packets compete for bandwidth in a fair manner (Weighted Fair Queuing, Weighted Round Robin, and Modified Deficit Round Robin). For instance, to provide enough difference in QoS to be noticeable, the CP may assign values of 0.67 to the Critical data queue and 0.33 to the Best Effort queue. However the choice of value will be a commercial decision for each CP, leading to better service differentiation.

At the interfaces with the access network provider i.e. at the customer premises and at a network point of interconnect, each service frame is mapped to a class of service. This class of service in combination with point to point and multicast classification is used to map each service frame to a bandwidth profile. Separate bandwidth profiles must be defined to support asymmetric upstream and downstream bandwidth allocation.

A single set of bandwidth profiles should be shared by a point to point and a multicast service. This supports a concept of 'video bandwidth' allowing a CP to choose whether to send video using multicast or unicast delivery. Finally, the same QoS principles need to be adopted by the backhaul provider and offered to the CPs.

In summary, support for at least 3 - 5 QoS classes will be needed to adequately deliver diverse services using next generation bitstream access. This is certainly achievable as the Ethernet standard IEEE802.1p provides a mechanism for up to 8 distinguished classes.

2.3 Flexible interconnection

A flexible NGN wholesale product should offer CPs a range of options for how and where they interconnect to the access network provider in order to collect the traffic from their end-users. In common with many other products that involve some form of "interconnect", it is possible to conceive of at least three product options: National, Regional and Local.

With a National variant of the product, the CP would be procuring backhaul and core bandwidth from the access network provider who would use their own network to transport the aggregated traffic from all systems anywhere in the country to the interconnect location.

A Regional product variant would enable more distributed interconnection points at a number of regional nodes which act as aggregation points for all NGN systems within a regional geographic area. This enables the CP to leverage their own core network capacity (and hence this Regional product should be cheaper than the National interconnect variant) but the CP is still using backhaul aggregation network capacity (up to regional nodes) from the access network provider.

The Local variant of the product goes a step further and enables the CP to collect the traffic directly at the location where the Access Node (and perhaps an adjunct Ethernet switch) is located. This enables the CP to use their own backhaul or "middle mile" aggregation network capacity or to procure this from a 3rd-party who is not the access network provider. This Local interconnect product option will be of particular interest to LLU operators who could then leverage their existing LLU space, power and fibre backhaul connectivity in case the access node is collocated with existing copper local exchange.

The choice between the three options is determined by two main factors.

- Economics: a local variant allows a CP to provide its own backhaul from the Access Node all the way back to its core. This typically implies investment in transmission infrastructures (e.g. dark fibre), resulting in much higher upfront CAPEX, offset by a lower running cost and greater economies of scale as traffic grows. This choice is typically made by CPs who plan to have a considerable market share to justify higher upfront investments.
- Technical capabilities: local (or regional to a less extent) option allows the CPs to self-build the backhaul infrastructure, or to lease it from a backhaul provider of choice, giving the CPs the freedom to obtain the desired SLA, type of connectivity, ability to deploy intelligence (e.g. caching) at the interconnection points, which in turn will reduce bandwidth requirements.

We believe the CP should have the flexibility to migrate between different points of interconnection, as the demands change on their network, (e.g. due to increased retail customer base and self-provided aggregation network), from interconnection at a national point at the beginning, to the regional or local access point as their traffic grows.

2.4 Multicast

The advantage of NGA is the ability to offer increased access speeds to end-users. Various service offerings can exploit this increased speed but one of the most often cited benefits of an NGA network is its ability to deliver multiple simultaneous HDTV channels. In addition, emerging next generation retail services include broadcast TV and Video on Demand, often cited as the Triple-Play bundle with voice and basic broadband. Multicast is the most efficient means of delivering video services because it sends a single copy of the multimedia stream towards the end customers, replicating it for individual customers as close as possible to the end user, typically at the central office.

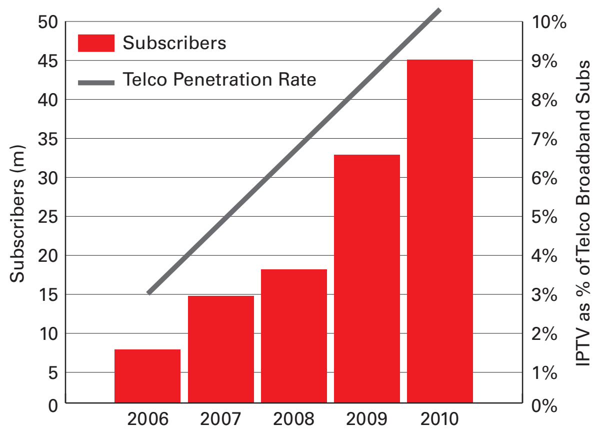
If the NGA product includes the basic hooks to support multicast, then it will be feasible to deliver a single copy of a multicast channel to the access node and have it replicated to all end users. If this basic capability does not exist in the NGA wholesale product offering then the CP may need to deliver multiple copies of the channel to access node (one for each customer wanting to watch it) and then the access node would use unicast techniques to deliver each of these copies to an individual end user. This latter unicast approach is inefficient with respect to the end to end transmission path between multicast 'head-end' and the end-user: In this unicast case, the backhaul network connecting the access node to the multicast head-end would also need to carry multiple unicast copies of the video channel instead of a single copy.

The cost of the inefficiencies cited above impacts the CPs in terms of bandwidth and/or equipment costs. For this reason, without multicast functionality offered at the various interconnection points, the CPs may be unable to offer broadcast IP TV economically.

The multicast support of wholesale access should allow the CP to inject multicast traffic into the access network provider's network at the point of interconnect and have this stream replicated and delivered to appropriate members of the multicast group. Multicast traffic should be delivered downstream either unconditionally (i.e. multicast traffic is forwarded to all the members of the multicast group) or conditionally (i.e. multicast traffic is forwarded to those members of the multicast that have requested the traffic) using an industry standards multicast control protocol (e.g. IGMPv3).

Given that IP-TV has reached 10% penetration worldwide at the end of 2010 (TeleGeography's GlobalComms Pay-TV Research), and grew by 38% in 2010 alone (see picture below), we believe that support of multicast is a fundamental element for bitstream specifications over NGA.

IPTV market growth



Source: Telegeography research

2.5 Policy conclusions

In the past, policy-makers have generally restricted themselves to setting the principles and prices for access without delving too deeply into the technical means taken to achieve that access. Taking just one example from the description above, one might question whether, if NGA access is mandated, it matters whether this is through 'one box' or 'two boxes.' But if, as expected, fault diagnosis, customer satisfaction and take-up are all adversely affected by the 'two box' solution, a technical choice such as this could have a significant effect on the shape of NGA competition.

NRAs in Europe have information-seeking powers under Article 5 of the Framework Directive which include future network or service developments and other regulators have similar provisions. They should use these far more extensively than they have in the past to monitor the technical implementation of their decisions in an NGA environment. Unlike the copper world of the past, the forms of fibre access are being set for the first time now. NRAs should question critically whether the implementations being proposed are optimal in terms of openness, non-discrimination and subsequent competition while always being alert to strategic commercial behaviour in technical standard-setting.

Finally, it is apparent from the analysis above that there is considerable divergence between the approach taken by different NRAs to NGA bitstream implementation. This divergence hinders the emergence, at scale, of precisely those innovative services that are expected to drive the adoption of NGA networks. If, for instance, a service provider today develops an application that relies upon the granularity of 5 QoS traffic levels, they cannot currently count upon such functionality being available across all Member States. Within Europe at least, the technical specification of NGA bitstream may be a valuable topic for BEREC co-ordination.

Notes

1 Very High Speed Digital Subscriber Line 2 which works over the existing copper pairs from a fibre-fed street cabinet.

2 Gigabit capable passive optical network

3 See WIK Consult (2010) Architectures and competitive models in fibre networks" available at www.vodafone.com

4 We refer to NGA access-seekers as CPs throughout this paper, to distinguish them from the incumbent operator which will, we assume, generally be an integrated network provider competing with the CPs at the retail level.

5 Australia, Germany, Ireland, Italy, New Zealand, Spain, UK.

6 NEBA, the new bitstream service offering by Telefonica which has been approved by the Spanish telecom regulator CMT

7 Generic Ethernet Access (GEA), a product currently being developed by BT Openreach for FTTP and VDSL/FTTC.

8 Current Deutsche Telekom bitstream offer

9 Eircom bitstream access proposal to CPs over both VDSL2/FTTC and FTTH

10 Telecom Italia wholesale service trial proposal 'EasyIP Fibra' for FTTH

11 Telecommunication Carrier Forum (TCF) description of Ethernet Access Service over Ultra-Fast Broadband (UFB)

12 National Broadband Network Co Technical Specifications for bitstream access

13 For the GPON wires-only, the physical connecter provided by the access network provider will be a SC/APC (Subscriber Connector or Standard Connector/Angled Physical Contact) connected to GPON physical line termination equipment, the ONT/ONU (Optical Network Unit / Optical Network Termination) integrated to the CP's CPE

14 A wires-only interface of VDSL2 may use the similar arrangement as ADSL where access network is terminated at the passive wall socket and the CPE provided by the CP terminates the VDSL2 interface by accommodating VDSL2 modem.

15 This should not break the access network provider's contracted capacity limit at the interface.

16 There would usually be at least two national interconnection points to provide resilience) selected by the CP, usually at one of the CP's major Points of Presence (PoP).

17 For example, if a CP has 20 users on an NGN who wish to watch the same movie or broadcast sports event encoded at 8 Mbps for HD quality then multicast would require only 8 Mbps of bandwidth to be used across the core and backhaul networks. However, without multicast functionality being available to the CP, use of parallel unicast channels would require 160 Mbps.

18 IGMP = Internet Group Multicast Protocol

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Martin Duckworth has worked in telecommunications regulation since 1995, first as an employee of Oftel, the then regulator in the UK, and since 1998 as a consultant in Belgium and Spain. Martin has worked extensively in the field of telecommunications regulatory costing advising regulators and operators on the appropriate valuation and cost attribution approaches for interconnection, access and retail price control.

Co-authored by: Jay Batchelor, Frontier Economics

Access network costing: proposals for NGA networks[1]

1. Introduction and summary

The roll out of next generation access (NGA) networks in Europe and internationally has re-ignited interest in the issue of the appropriate approach to the costing of fixed access networks for regulatory purposes. In this context, Vodafone asked Frontier Economics and Sir Ian Byatt, to consider the appropriate approach to the costing of the underlying network access elements, taking into account experience not only from the communications industry, but also other industries that have been subject to access regulation.

The largest element of the cost of access to fixed access networks relates to network assets. This is an area where there is the greatest scope for differences in allowable revenues[2] under a price control in a given period. Decisions need to be made about the timing as well as the level of cost recovery. In contrast, operational expenditure can be directly included in allowable revenues in the year it is incurred. In this report, we consider both the economic case for different approaches as well as the practical implications.

We find that different elements of the network required to offer fixed access services each have sufficiently different characteristics to justify a different costing approach. Such an approach is consistent with the EU NGA Recommendation[3] which provides for the costing approach to vary between assets.[4] Our views, in terms of the most appropriate cost based approach for each of the assets, are summarised in Figure 3 below.

These recommendations are based on the principle of cost orientation and exclude the impact of any potential externalities which might justify a departure from these principles.

2. Asset costing and regulatory objectives

2.1 Regulatory objectives

Choosing the methodology to determine costs requires typically striking an appropriate balance between competing objectives.[5] The range of different decisions that need to be taken when determining regulation is summarised in Figure 1.

Figure 1. Objectives of access regulation

Valuation	Should values reflect historic purchase costs of assets, current replacement costs or prices paid by investors?
Cost recovery over time	How should the cost of assets be recovered over the life of the asset?
Capital maintenance	Should prices ensure investors achieve payback or reflect the spend needed to maintain the network?
Investor returns	Do investors have an expectation they will earn a reasonable return?
Efficiency	Do prices reflect and incentivise efficient investment?

Source: Frontier Economics

Table 1. Approaches to asset valuation and determining allowable revenues

Approach	Valuation	Determining allowable revenues
Historic cost accounting	Valuation based on acquisition costs of individual assets used to provide regulated services	Allowable revenues consist of depreciation (typically straight line) and the cost of capital Constant depreciation charge and falling cost of capital leads to "front loading" of cost recovery
Current cost accounting (replacement costs)	Valuation based on replacement costs of individual assets used to provide regulated services	Allowable revenues consist of depreciation (typically straight line calculated as a percentage of the changing asset price), holding gain (loss) to reflect changing asset prices and the cost of capital Shifts cost recovery forwards (if asset prices are falling) or back (if asset prices are rising) compared to HCA
Annuities	Not required to estimate allowable revenues For an individual asset, derived using discounted future allowable revenues	Allowable revenues are constant over time in nominal or real terms
Economic depreciation	As for annuities	Allowable revenues may take account of the volume of output of assets in addition to changes in asset prices
Renewals accounting (regulatory asset base)	Changes in value calculated as capital expenditure less capital charges. Initial valuation may be exogenously determined, for example as price paid at acquisition	Allowable revenues reflect capital expenditure required to maintain the asset base plus cost of capital employed

Source: Frontier Economics

The primary regulatory objective when costing methodologies were initially developed was to encourage the eventual deployment of competing fixed access infrastructures, where efficient for them to be deployed, with the ultimate aim of encouraging competition at the deepest level possible. In general, the most commonly used approach was a current cost accounting fully allocated costs (CCA-FAC) method, which places weight on ensuring that prices match the regulator's current view of the 'competitive' level of prices, based on replacement costs, in order to provide suitable entry signals. This was generally the case even where there was/is little prospect of the assets being duplicated by competitors.

Furthermore, regulatory costing in relation to access networks has commonly sought to use a 'one size fits all' approach. This meant that all relevant assets were costed using a similar approach, with limited variations to reflect the underlying characteristics of the assets themselves, including their replicability.

As a result of developments in Next Generation Access technologies, and the need to consider expanding the capability of the fixed access network through the deployment of such technologies, there has now been a renewed interest in the appropriate approach to the costing of access network costs. This means considering not only the appropriate approach to the costing of the NGA assets, but also the 'legacy' copper access network assets.

The overall regulatory objective of encouraging competition at the deepest level of the network possible, to deliver long-term benefits to consumers, appears to continue to be an important objective. However, the consideration of the appropriate approach to costing needs to take into account two key developments.

- First, the deployment of NGA networks requires significant investment, which is expected to have a more risky profile than the past investment in the legacy networks of today.
- Second, there is experience of the deployment of alternative fixed access infrastructures, which has led to a better understanding of the conditions under which fixed access infrastructures are replicable.

The need for significant new investment, and the improved understanding of replicability, suggests that a more refined approach to costing may now be desirable, with greater emphasis placed on the following objectives:

- The need to provide greater regulatory certainty to *investors*, to enable efficient investment in next generation access networks by both incumbents and competitors; and
- The need to ensure that *consumers* are not paying more than necessary for the use of legacy networks and do not disconnect or inefficiently switch to alternatives.

Table 2. Strengths and weaknesses of approaches

Approach	Strengths	Weaknesses
Historic cost accounting	Costs can be precisely and objectively determined	Resulting prices do not reflect the changing costs of assets. Front loaded cost recovery may not be appropriate
Current cost accounting (replacement costs)	Costs reflect changes in underlying asset prices	Determining the replacement cost of assets introduces subjectivity and unpredictability Front loaded cost recovery may not be efficient
Annuities	No front loading of cost recovery Tilted annuities simple to implement in bottom up models	Allowable revenues are constant over time in nominal or real terms
Economic depreciation	Flexibility to profile cost recovery to reflect demand	High degree of subjectivity Valuations of existing assets may be highly sensitive to assumptions about future developments
Renewals accounting/regulatory asset base	Provides high certainty to investors that they will recover future investments	May be uncertainty over the correct level of maintenance expenditure Requires an initial valuation of existing assets

Source: Frontier Economics

2.2 Potential methodologies

A wide range of potential methodologies have been used and developed for determining the annual costs of assets in a regulatory context. These methodologies can be broadly classified into four groups:

1. Approaches consistent with statutory accounting standards used by the regulated operator;
2. Current cost accounting approaches that attempt to set prices that reflect the cost base of potential new entrant operators in order to ensure efficient entry;
3. Economic depreciation approaches which attempt to set the the profile of cost recovery over time to reflect demand for services; and
4. Regulatory asset valuation (RAV) approaches which focus on ensuring cost recovery over time.

Table 1 summarises the range of methodologies that have been used by regulators to determine costs for price control purposes with the most commonly used methodologies (in both telecommunications and other regulated sectors).

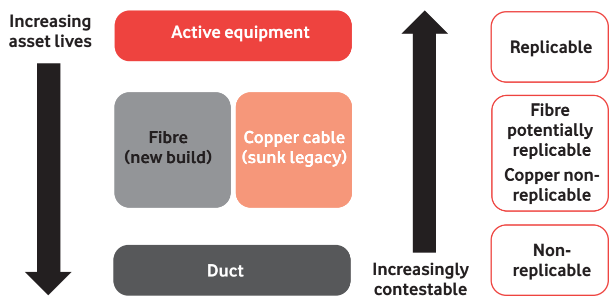
Each of these approaches has strengths and weaknesses which may make them more or less applicable to a given set of assets, as set out in Table 2. We consider these in the next section, where we provide our recommendations on the appropriate approaches to costing of fixed access networks.

3. Recommendations

The review of different methodologies available highlights that there is no single methodology that will necessarily achieve the best balance of the differing objectives for all assets. Thus the choice of methodology should follow an analysis of both the characteristics of the assets themselves and the regulatory and market context.

In this respect, it is useful to consider the 'supply chain' of the network access services, and analyse the factors that will affect the choice of methodology for each of the different groups of assets, as illustrated in Figure 2 below.

Figure 2. Network access asset groups – with NGA



Source: Frontier Economics

Our view is that different elements of the fixed access network have sufficiently different characteristics to justify a different costing approach. Regulation based on differential approaches reflecting the characteristics of each class of asset are widely used in both fixed telecommunications and other sectors[6], with the EU explicitly recognising this possibility in Annex I of the NGA Recommendation.

With the increasing complexity of regulated wholesale access in the EU, assets such as duct are inputs for a range of regulated services using different technologies, (for example fibre or copper), and for wholesale services in different parts of the value chain, such as active and passive services. Using different costing approaches for different assets should not lead to arbitrage opportunities between the prices set for those services, provided regulators ensure consistency

Figure 3. Summary of recommendations

	Duct	Copper	Fibre	Active equipment
Nature of assets	Long and unpredictable asset lives Single asset that needs to be maintained in the long run	Predictable asset lives Discrete assets Assets largely sunk with little continuing investment	Unpredictable asset lives Discrete assets Network at beginning of life cycle	Short predictable asset lives Discrete assets High level of innovation and price reductions
Regulatory objectives	Provide certainty on cost recovery of future capex Maintain downstream prices at a low level	Ensure assets appropriately used Insulate downstream prices from copper price fluctuations	Provide certainty for investment Promote super-fast broadband penetration	Provide correct build or buy signals for competitors Provide correct investment incentives for incumbent
Potential approach	Renewals accounting	HCA based valuation	Determine prices based on economic depreciation Create RAB by rolling forward value based on incurred capex less econ. depreciation	CCA based approaches Ensure allowable revenues reflect demand profile

Source: Frontier Economics

between services, in both the determination of costs and the recovery of fixed and common costs.[7]

A summary of our recommendations on the most appropriate cost based approach for each of the assets is summarised in Figure 3 and explained in more detail in sections 3.1 to 3.4. These recommendations are based on the principle of cost orientation and therefore exclude the impact of any potential externalities on pricing. Section 3.5 discusses how externalities may be taken into account by policy makers.

3.1 Duct

3.1.1 Nature of the assets

Duct assets are typically the longest lived assets in the telecommunications network, with asset lives typically determined by regulators to be of the order of 40 years (although there is considerable variation in assumptions). The asset base is also not a collection of discrete assets as ducts are by their nature a continuous network. For example, when a section of duct is replaced, it is not immediately obvious which, if any, part of the existing duct asset has been retired.

The asset valuation largely relates to the capitalised labour costs involved in installing and maintaining the duct network, rather than the underlying physical inputs. This also increases the difficultly of assigning value to individual assets. A single entry in the asset register for capitalised costs may related to a installation and maintenance activities across a range of duct assets.

3.1.2 Regulatory objectives

Given the very long life of access assets, the risk of setting allowable revenues which result in over- or under-recovery of efficient costs is considerable. This is accentuated by the difficulties of accurately measuring the installed asset base or accurately modelling the assets required for a hypothetical efficient operator through a model.

In addition, the roll out of NGA may require significant forward expenditure in upgrading the existing duct network to allow fibre rollout. Ensuring these investments are made will require providing investors with certainty on the future recovery of these asset costs.

As duct will be used for both current broadband services and NGA services, keeping prices as low as possible consistent with efficient investment, and providing a smooth and predictable profile of allowable revenues appears to be the more important objective.

To the extent that ducts are largely non-replicable, setting prices to reflect the competitive level of prices based on replacement cost should not be one of the objectives.

3.1.3 Potential approach

A renewals accounting based approach seems consistent with both the nature of the asset and the need to provide regulatory certainty. Such an approach raises some challenges in terms of:

- Determining the opening valuation;
- Determining the operational capital maintenance based depreciation charge; and
- Ensuring that additions to the asset base are efficient and justified.

The most contentious issue is likely to be the opening valuation. A book value (HCA) based approach may be appropriate in many jurisdictions for a number of reasons.

First, there seems little reason to base an initial valuation on an estimate of net replacement cost for competition reasons if the network is assessed to be largely non-replicable.

Second, even where regulated prices are currently set based upon CCA, this move from CCA to HCA is likely to have been made relatively recently. Thus any holding loss in moving from a CCA valuation to a HCA valuation will, to a large extent, be a reversal of the holding gain made when regulation moved to CCA.

Third, HCA based approaches are likely to result in relatively low prices in the future which is consistent with the objectives of ensuring high penetration of broadband services and ensuring productive efficiency by making full use of sunk assets.

Where evidence suggests that the book value of the network is overstated due to previous inefficiencies, additional downwards efficiency adjustments could be considered to the valuation.[8]

In theory, if the duct network is in a steady state, the average capital expenditure required to maintain the network should be approximately equal to a depreciation charge based on replacement costs. Thus, a move to a renewals accounting approach should not significantly alter the level of prices. In practical terms, basing prices on the directly observable level of capital expenditure, rather than a series of highly uncertain estimates of duct asset lives and the replacement cost of the complete network, is likely to provide far greater certainty to both regulators and to investors.[9]

3.2 Copper cable

3.2.1 Nature of the assets

The asset life of copper cable is typically determined to be of the order of 20 years, reflecting degradation in the cable over time. While the cable network forms an end-to-end network, it can be broken down into individual assets in a way that is not possible with duct, for example. This is because the physical materials are a high proportion of the costs of copper cable and each cable will generally be replaced in its entirety at the end of its useful life.

3.2.2 Regulatory objectives

Copper cable is no longer likely to be the Modern Equivalent Asset (MEA). This can be observed by the increasing use of fibre only networks in new build property developments. Setting regulated prices based on the replacement cost of copper cable would not seem therefore to provide appropriate price signals for future investments by potential entrants or existing competitors to the incumbent network. Indeed, using replacement costs could mean that wholesale access prices would be driven by volatility in the prices of copper in commodity markets. This could lead to a disincentive to invest in downstream markets as future profitability would be dependent on the price of copper. Linking regulated prices to volatile copper prices may also lead to significant under or over recovery of costs, compared to the valuation of existing assets.

Where the likelihood of future investment in copper cables is limited, incentivising future investment in copper is not likely to be a primary consideration. A more important consideration is likely to be maximising overall productive efficiency by ensuring that this existing asset is adequately utilised.

In areas where fibre is either already rolled out or could be rolled out, the level of prices determined for copper based services will have an effect both on the incentives for fibre investment and the penetration of fibre. The exact relationships will be complex, depending on current and future parameters (such as cross-price elasticities of demand between copper and fibre based products) which cannot be determined with any level of certainty at present.

In the absence of significant externalities, the regulator may not need to directly address issues of fibre investment when setting prices for copper based prices. If the regulator commits to setting prices that reflect forward looking costs for both copper and fibre based products, investors can internalise the decision as to whether a given fibre based investment is efficient or not. This case is addressed further below.

If NGA generates significant positive externalities, regulators may choose to set prices in a way to realise these gains by incentivising investment in NGA above a level that would occur when prices are set to solely reflect costs. This is addressed further in section 3.5 below

3.2.3 Potential approach

In the absence of any externalities, productive and allocative efficiency would suggest setting prices at a level that reflects the forward looking costs of operating and maintaining the copper cable.

In terms of allocative efficiency, setting prices at this level would ensure that the existing sunk asset was efficiently utilised, avoiding the risk that demand that could be met went unserved, for example broadband customers leaving the network. In terms of productive efficiency, it would incentivise future investment in substitute networks where such alternative networks offered some combination of lower forward looking costs and increased capability.

However, setting prices to only reflect forward looking costs, if leading to an implicit writing off of the remaining value of past investments, would set a precedent which could discourage future investment. Thus, some account must be taken of the value of the existing assets. An HCA valuation of the existing network may be a reasonable opening RAV (Regulatory Asset Value), where this allows the operator to make a reasonable return on its past investment, without pricing copper based services significantly above forward looking cost.

3.3 Access fibre

3.3.1 Nature of the assets

Given the limited experience of operating mass market fibre access networks, the economic and engineering life of fibre cables may not be readily determined. Regulatory precedent for core transmission fibre and fibre serving large enterprises suggest an asset life similar to copper cable.

Similarly to copper cable, it should be possible to easily identify individual components of a fibre network. Given the availability of geographic information systems, as the fibre network is being rolled out, operators should have an accurate inventory of the network.

3.3.2 Regulatory objectives

The Commission has dual objectives of ensuring widespread availability of NGA and encouraging take up. This requires a balance between investment incentives for efficient roll out and maintaining prices at a level that allows for rapid take up.

There is potential for competition for fibre based wholesale services, both from alternative networks and from operators using regulated access to the duct network. However, given the nascent stage of the market and the long pay back periods for competing networks, competitors' investment decisions may be less dependent on the level of prices in the period of network roll out and more dependent on certainty on the regulatory regime going forwards.

3.3.3 Potential approach

While the nature of the asset base means that it would be relatively straightforward to develop CCA estimates for fibre networks, on a straight line basis or a tilted annuity basis, the relatively low utilisation of networks in the early years of roll out may result in achievable revenues being below the calculated allowable revenues based on a CCA straight line or annuity approach initially. This may lead to under-recovery over the longer term as the operator would never be able to recover the allowable revenues 'foregone' in the initial period.

An economic depreciation approach could be used initially to set allowable revenues to reflect the limited demand during the phase when the network was being rolled out.

The main weakness of an economic depreciation approach, which is dependent on judgemental assumptions about future developments, is the increased regulatory risk to investors. Under many economic depreciation approaches both the forward looking allowable revenues and the (implied) opening valuation of assets in each price control period will differ from the closing value from the previous control. This could result in significant holding gains and losses at the beginning of each price control period as new data and revised forecasts of future market developments are included in the valuation. These holding gains or losses could in turn lead to under- or over-recovery of investments.

The regulatory risk due to resetting the valuation at the beginning of each price control period could be significantly reduced by using a RAV approach. Rather than independently setting the opening valuation for each price control, the opening regulatory valuation for successive price control periods would be calculated by rolling forwards the previously determined opening valuation adding the capital expenditure incurred and subtracting the determined depreciation charges in the previous period. This would remove the risk of significant holding gains or losses.

Such an approach would require three elements to be determined by the regulator:

- The opening RAV when the price control is first introduced;
- The depreciation charges used to set the allowable revenues; and
- The level of capital expenditure to include when the RAV is rolled forwards to the next period.

As investment in Next Generation Access networks has been relatively recent and to date has been limited, setting the opening RAV may not be critical as the valuation should be relatively close to the expenditure to date less an allowance for the costs already recovered.

Depreciation charges can be determined according to an economic depreciation calculation, similar to that used in mobile termination rate determinations in many jurisdictions. This would be a two stage process:

- Setting the profile of future allowable revenues for existing assets to reflect expected changes in asset prices and demand; and
- Scaling this profile so that the net present value of the future allowable revenues equals the current RAV for the asset.

Setting forward looking prices controls will require some forecasting of future capital expenditure. In some regulated industries, for example UK water, forecasts have been included as an input when setting the RAV in order to provide incentives for the regulated company to ensure capital expenditure is efficiently incurred. However given the uncertainties surrounding investments in NGA, any regulatory forecasts are likely to be subject to a high degree of uncertainty and the incentive effects of giving weight to such forecasts is likely to be small. Thus it is likely to be appropriate to include actually incurred capital expenditure in the RAV.

Including actual capital expenditure would provide both investor certainty and protect consumers from over-recovery. Using an economic depreciation approach would set prices at a level that reflected the need to increase penetration in the medium term.

3.4 Active assets

3.4.1 Nature of the assets

Active assets used for providing broadband and/or narrowband services over the fixed access networks typically have relatively short economic lives, driven by technological developments making existing assets obsolete. Equipment may be in service for say 10 years, but for some of the operational life, the equipment may be used to provide support for legacy services in parallel with the latest generation of equipment. Thus some allowance may need to be made for the fact the equipment is not fully utilised for the whole of its operational life. Technological development typically results in comparable equipment either falling in price in real terms over time, or increasing in capability (on a MEA basis resulting in falling unit costs).

Compared to the passive elements of the access network, the number of active components is relatively small and the components are discrete, rather than continuous.

3.4.2 Regulatory objectives

Many active components may be considered to be replicable. For these components the regulator's objectives will need to balance allocative and productive efficiency with the benefits resulting from greater competition.

3.4.3 Recommendation

Given that assets are likely to be determined to be replicable a CCA based approach reflecting replacement costs is likely to be appropriate. The exact choice of methodology will need to take into account a number of factors including:

- Whether the network is in a "steady state' with an even mix of asset lives and steady demand or whether the allowable revenue profile needs to take account of rapidly changing utilisation; and
- The need to allow for the additional costs of dual running technologies.

3.5 Setting copper and fibre prices to account for externalities

If there are significant externalities associated with NGA roll out, then setting regulated prices on the basis of forward looking costs alone could lead to welfare enhancing investment not being undertaken. This is because investors would only take account of the potential increase in revenues due to the availability of fibre based services relative to the increase in cost of rolling out fibre. Thus there may be cases where the increase in revenues due to fibre is not sufficient, even where overall economic welfare would be enhanced by the investment being made. In these circumstances an efficient outcome may require the policymaker to provide a subsidy to the operator for rolling out fibre in these areas to reflect identified externalities. These subsidies could be funded from outside the industry, for example through general taxation, or within the industry if a direct subsidy from government was not available. Any subsidies would need to be directly linked to increased roll out, rather than simply increasing the revenues of fixed access operators.

Notes

1 This is a shortened version of the paper originally prepared for Vodafone Group. The full paper is available at www.vodafone.com/eu

2 In this report we use the term 'allowable revenues' to refer to the cost oriented target level of revenues that a regulated company is allowed to earn under a price control. We make the distinction between 'allowable revenues' and 'cost' to emphasise that there is no single unique measure of cost.

3 COMMISSION RECOMMENDATION of 20 September 2010 on regulated access to Next Generation Access Networks (NGA)

4 Annex I of the NGA Recommendation provides that a consistent regulatory approach may "imply that NRAs use different cost bases for the calculation of cost-oriented prices for replicable and non-replicable assets, or at least adjust the parameters underpinning their cost methodologies in the latter case." Where there are relevant differences in the character of assets, those differences can and should be taken into account in the regulatory approach.

5 A more extensive discussion of the objectives is provided in Annexe 1 of the full report.

6 For example in the UK water industry 'underground' assets are accounted for on a renewals accounting basis while 'above ground' assets are accounted for on a CCA basis.

7 We note for instance that the NGA Recommendation provides that IT and system costs fixed and common to different services should be allocated on a 'proportionate' basis across all access seekers including the downstream arm of the SMP operator. It also provides that costs for civil infrastructure access should be 'consistent' with the methodology used for pricing access to the copper loop. However, as noted in footnote [3] above, consistency does not imply an identical treatment particularly if there are relevant differences in the nature of the assets.

8 Such evidence may come from, for example, bottom-up cost models.

9 This should help achieve the objective of the NGA Recommendation which provides that access prices reflect the costs effectively borne by the SMP operator taking account of actual asset lifetimes.

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