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**Conference Paper**

## Modelling the impact of Next Generation Access (NGA) on voice termination cost

21st European Regional Conference of the International Telecommunications Society (ITS): "Telecommunications at New Crossroads: Changing Value Configurations, User Roles, and Regulation", Copenhagen, Denmark, 13th-15th September 2010, No. 17

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**21<sup>st</sup> European Regional ITS Conference**  
**Copenhagen, 13-15 September 2010**

**Jay, Stephan / Plueckebaum, Thomas / Ilic, Dragan (2010)**

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**Abstract**

Termination of a telephone call can only be realized by the network operator of the receiving party. For this reason, the markets for fixed and mobile call termination are regulated ex-ante including price control. To determine the costs of call termination the current regulatory regime considers only those parts of the network where customers compete for jointly used resources (mainly bandwidth). Therefore, the critical border is the “demarcation point” between the end customer dedicated access network and the aggregation network where customers compete for bandwidth.

In addition to the extent of the overall network cost to be considered (depending on the location of the demarcation point) the traffic share of the voice termination service (which determines how much of the relevant cost is borne by voice termination) compared to all the other services sharing the same NGN/ NGA network needs to be taken into account. We analyse the cost effects with a cost model, which considers the part of the access network from the MPoP to the demarcation point, where the dedicated (access) network begins, in detail. This allows us to compare the impact of different demarcation points and service scenarios on the level of voice termination rates for three NGA architectures (FTTH/P2P, FTTH/PON and FTTC). We considered double and triple play service packages and ran sensitivities on data usage. In addition, we calculated termination cost for three different demarcation point locations in the case of FTTH/PON.

**JEL codes:** L96 – Telecommunications, L5 - Regulation and Industrial Policy, L51 – Economics of Regulation

**Key words:** Voice Termination, Next Generation Access, FTTH, price regulation, termination monopoly, cost modelling

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## **Modelling the impact of Next Generation Access (NGA) on voice termination cost**

Jay, Stephan / Plueckebaum, Thomas / Ilic, Dragan<sup>1</sup> (2010)

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## 1 Introduction

Termination of a telephone call can only be realized by the network operator of the receiving party. The caller does not have a choice of operator or price to terminate his call, but has to pay for the termination in the calling party pays system, which is common in all European and many other countries. This position of the terminating operator is frequently referred to as “termination monopoly”. For this reason, the markets for fixed and mobile call termination are regulated ex-ante including price control. To determine the costs of call termination the current regulatory regime considers only those parts of the network where customers compete for jointly used resources (mainly bandwidth). Therefore, the critical border is the “demarcation point” between the end customer dedicated access network and the aggregation network where customers compete for bandwidth.

In its Recommendation on the Treatment of Fixed and Mobile Termination Rates<sup>2</sup> the European Commission acknowledges that the location of this demarcation point may vary depending on the NGA architecture. However, the Commission considers only Fiber to the Curb (FTTC) and no Fiber to the Building / Home variants in its argumentation and states that for the time being “the existing demarcation remains unchanged”. There are sound arguments that speak in favour of a demarcation point closer to the end-user (than in the PSTN) in the case of FTTB and FTTH with PON-technology and farther away from end-user in the case of FTTH with Point-to-Point technology, when the first concentrating equipment is only located in a few MDF locations, and not in all. Yet, so far there has been no specific quantitative assessment of the impact of different NGA architectures on the cost of voice termination under the assumption that the regulatory framework will still focus on the demarcation point. For this reason, we have conducted bottom-up cost modelling to gain insights on the quantitative impact on termination cost that is caused by different demarcation point locations of different NGA architectures. When applying the current regulatory framework for calculation of voice termination rates to Next Generation fixed Access Networks, how is the cost of voice termination affected by different NGA architectures?

## 2 Modelling approach

### 2.1 Terms and definitions

Regarding access network topology we use the terms of the European Commission’s Draft NGA recommendation.<sup>3</sup> It defines the Metropolitan Point of Presence (MPoP) as equivalent to the Main Distribution Frame (MDF)<sup>4</sup>. The MPoP is the last location where, depending on the NGA Architectures and looking from the end user, an Ethernet Switch is located. The Distribution Point is an intermediate node in the NGA, from which fibres from the MPoP can be divided / accessed before running them to the customer building (or in the case of FTTC from which access is realised through copper sub loops). The segment from MPoP to Distribution Point is called Feeder (Cable) Segment. The segment from Distribution Point to the customer location is called Drop (Cable) Segment. There

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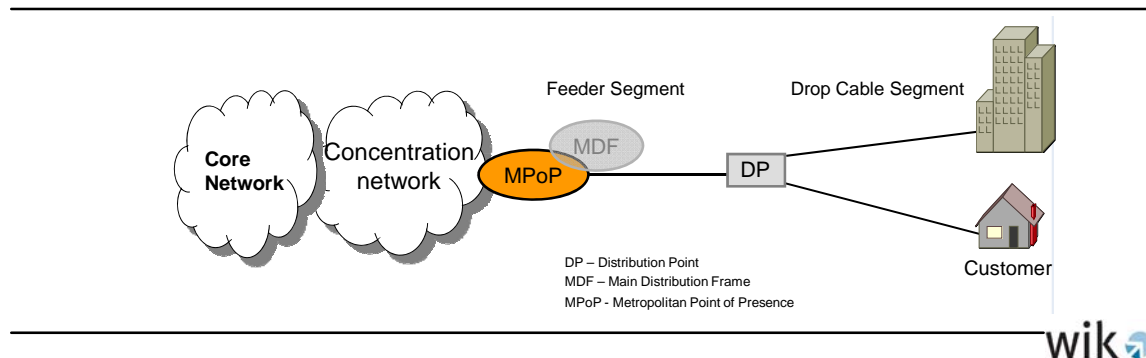
<sup>2</sup> European Commission (2009): Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU - EXPLANATORY NOTE, Brussels, [http://ec.europa.eu/information\\_society/policy/ecomm/doc/library/public\\_consult/termination\\_rates/explanatory.pdf](http://ec.europa.eu/information_society/policy/ecomm/doc/library/public_consult/termination_rates/explanatory.pdf).

<sup>3</sup> European Commission (2009): Draft Commission Recommendation on regulated access to Next Generation Access Networks (NGA) - 2nd public consultation, Brussels

<sup>4</sup> A definition, which we do not unconditionally share.

may be fewer MPoPs as MDFs, since fibre overcomes the line length restrictions of broadband connections. Thus MPoPs may be a subset of the existing MDFs.

**Figure 2-1 Network topology: Terms and definitions**

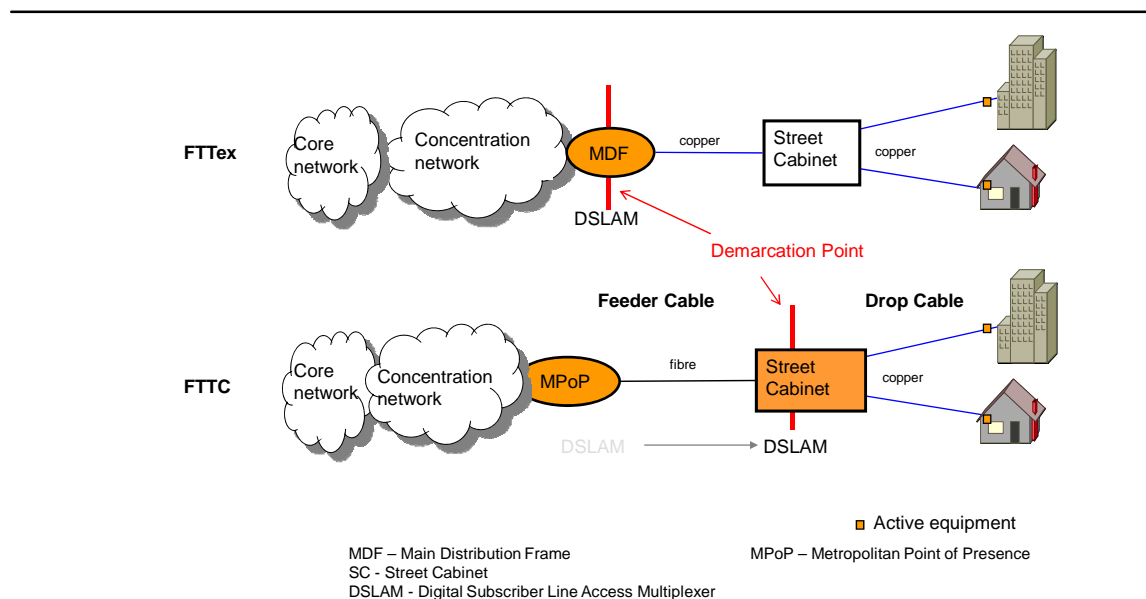


## 2.2 Determining the location of the demarcation point

The level of voice termination cost is dependent on the extent of the overall network cost to be considered (depending on the location of the demarcation point) and the traffic share of the voice termination service (which determines how much of the relevant cost is borne by voice termination) compared to all the other services sharing the same NGN/ NGA network. We analyse the cost effects with a cost model, which considers the part of the network from the MPoP to the demarcation point, where the dedicated (access) network begins, in detail.

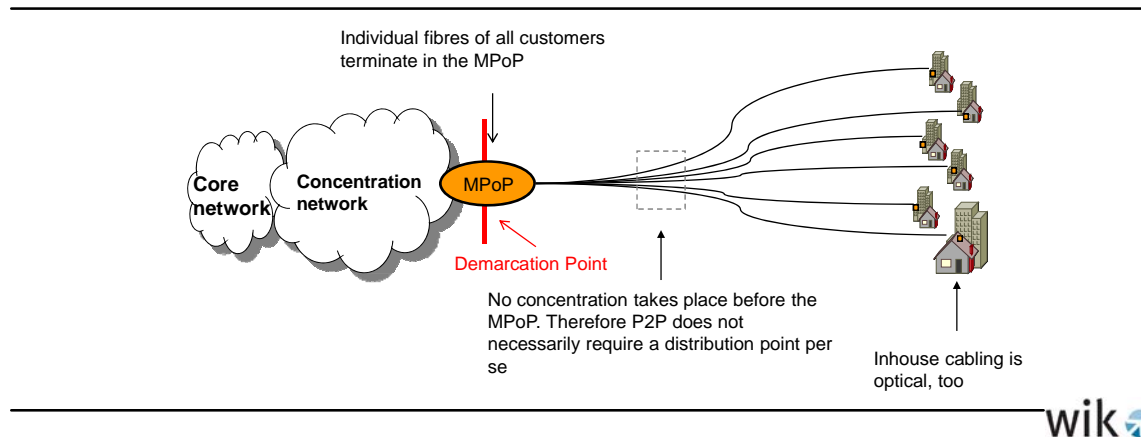
In current Fibre to the Exchange ADSL architectures the demarcation point is located at the DSLAM in the exchange. In Fibre to the Curb (FTTC) architectures the demarcation shifts with the DSLAM to the street cabinet (see Figure 2-2).

**Figure 2-2: Fiber to the Exchange (PSTN) and Fiber to the Curb architecture**



In case of FTTH/P2P (Point to Point) the demarcation point location already is the Ethernet Switch in the Metropolitan Point of Presence itself.

**Figure 2-3: FTTH/P2P architecture**



PON (Passive Optical Network) is a technology where the end customers are connected with fibres, which are concentrated in intermediate points onto one single fibre connecting to the MPoP. The connecting element is a splitter, which branches the signal from the central site (MPoP) to all connected end customers, and vice versa couples the signals from the end customers into the single upstream fibre. In order to prevent signal collisions an OLT (Optical Line Terminal) at the MPoP administers upstream transmission rights (who of the users is allowed to send data at a given time). The OLT broadcasts downstream data to all users interacting with the end user modem (the ONT - Optical Network Terminal) to ensure that every user can only access his own downstream traffic. In PON deployments with this kind of dynamic bandwidth allocation the end customers therefore compete for common bandwidth, which is administered by the OLT. Another administration scheme, dedicates an equal share of fixed capacity to each of the end customers by allocating a fixed timeslot to send and receive messages to every customer. In such cases which are implemented rarely– if at all –, the demarcation point will remain at the MPoP, since the access infrastructure is dedicated to the end customer.

For FTTH/PON<sup>5</sup> with dynamic bandwidth allocation we have considered three different demarcation point locations (Distribution Point between Metropolitan Point of Presence and Customer, basement of the customer's building, apartment of the customer). Considering just the physical layer each customer has a dedicated fibre from his home up to the first splitter (splitters may be cascaded). If the splitter is located in the basement of the building then the dedicated physical fibre only encompasses the inhouse fibre cabling from the splitter to the customer's apartment. The splitter could also be in a distribution point between the home and the Metropolitan Point of Presence. Then the dedicated physical fibre part also consists of the drop cable segment between the splitter and the customer's home.

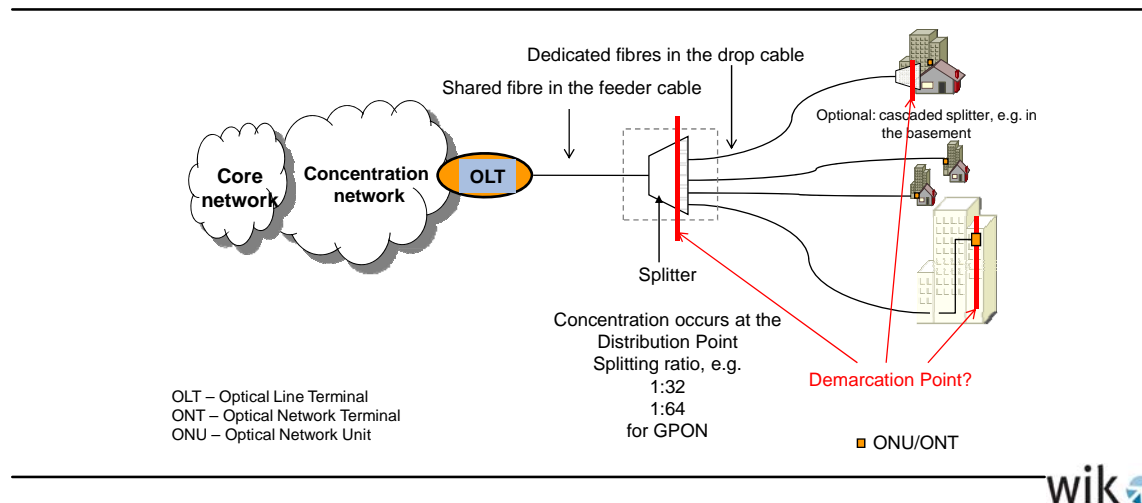
However, due to the shared medium character of GPON, customers compete for bandwidth throughout all of the PON, from the Optical Line Terminal (OLT) in the Metropolitan Point of Presence right to up to each individual user's apartment. In fact the OLT controls which of the customers may transmit data upstream at any given time. Downstream data for a given user is

<sup>5</sup> We refer to the Gigabit PON (GPON) standard in this text, using dynamic bandwidth allocation.

broadcast to all users thereby also limiting the available bandwidth. This means that the bandwidth available to one user is dependent on the current usage of the network by other users in the same GPON. Therefore one can also argue that the complete PON access (not only the feeder segment from MPoP to splitter, but also the drop cable segment from the splitter in the distribution point to the customer's home) should be considered in the cost for voice termination because it does not act as a dedicated line.

We have modelled the cost of voice termination in a FTTH/PON network based on a standard architecture with a single splitter located in the distribution point in the street including the cost of inhouse fibre cabling. By discarding the cost of inhouse cabling we *approximate* the cost of a demarcation point inside the building (e.g. for an architecture that has the first splitter inside the customer's building). By additionally discarding the cost of the drop cable segment we can approximate the cost for a demarcation point located at the splitter in the distribution point. This way we can also economically judge the impact of these different argumentations towards the demarcation point in PONs.

**Figure 2-4: FTTH/PON architecture**



## 2.3 The modelling philosophy

We have used a bottom-up cost model<sup>6</sup> to calculate the cost of rolling out FTTC, FTTH/PON and FTTH/P2P in the denser populated regions of Germany by a stand-alone competitor. The network is dimensioned according to the customers' bandwidth demand at the busy hour with the following conditions: The deployment passes all homes; in case of FTTC all street cabinets are passed and have DSLAMs installed, sub loops are then unbundled according to demand. The operator realizes a penetration of 50% with all access technologies (this enables comparison across the architectures). All telephony is realized as VoIP. A Weighted Average Cost of Capital of 10% was equally applied to all architectures (again to focus on the impact of the demarcation point in different architectures).

<sup>6</sup> We have expanded our WIK NGA cost model in order to approximate the termination cost for Fiber-to-the-Curb and Fiber-to-the-Home networks of a hypothetical German network operator. The WIK NGA model was originally developed in our economic analysis for the ECTA (European Competitive Telecoms Association). Elixmann, D. / Ilic, D. / Neumann, K.-H. / Plückebaum, T. (2008): The Economics of Next Generation Access. Study for the ECTA, Bad Honnef, [http://www.wik.org/content\\_e/ecta/ECTA%20NGA\\_masterfile\\_2008\\_09\\_15\\_V1.pdf](http://www.wik.org/content_e/ecta/ECTA%20NGA_masterfile_2008_09_15_V1.pdf).

Total cost is then distributed over all services according to the services' share of the total usage of a given network element level (e.g. drop cable segment, MPoP, etc.). At the demarcation point there are some cost elements that belong to the dedicated part of the network (e.g. customer sided ports of the DSLAM) which have accordingly not been considered for voice termination cost determination. The remaining element's cost (e.g. the rest of the DSLAM) has been considered for allocation to the different services among which is the voice termination service for inbound calls. Other cost elements that are not directly accountable (e.g. floorspace, air condition, etc.) have been divided between the dedicated and the jointly used part.

For the core and concentration network (see Figure 2-1) we have derived costs from a separate bottom up model. These costs are approximated through a representative price per 10kbps of network capacity and therefore evolve linearly. Dimensioning of the core and concentration network in the base scenario is based on an assumption of ~65kbps average busy hour data capacity per user (10kbps associated to voice, so the core network was dimensioned with ~75kbps per user). This value is for an average user, i.e. the average user demand includes the low bandwidth demand by single play voice only customers (assumed at 18% of all subscribers).

Core and concentration network costs are also identical for all considered access architectures because we have considered the same user behaviour (demand for telephony, broadband capacity and TV) for all architectures. Even though this hypothesis regarding broadband usage is doubtable, it is entirely acceptable for our purposes because our goal is to compare the impact of Next Generation Access on the cost of voice termination. We strive to identify the impact of higher investments into architecture and the relocation of the demarcation point towards the end-user. In any case our sensitivity analysis on broadband usage also enables cross examining higher broadband demand on FTTH architectures.

## 3 Modelling results

### 3.1 Double Play analysis: Voice & Broadband base case

We have assumed a call volume of ~1000 minutes per month for inbound, outbound and on-net calls in total. We have initially assumed that an average user consumes ~7.5GB of broadband data per month (derived from the 65kbps busy hour bandwidth per average user).

Voice minutes were converted into GB per month taking account of the different routing for inbound, outbound and on-net calls. A capacity of 100kbps was assumed for the voice service which was doubled to approximate the necessary network capacity for adequate quality of service.<sup>7</sup> We have therefore assumed a monthly voice usage per user of about 1.7GB.<sup>8</sup>

No TV service is considered in this first calculation. The share of voice in the total volume is about 20% (note that this is the total voice traffic and not the sole voice termination share).

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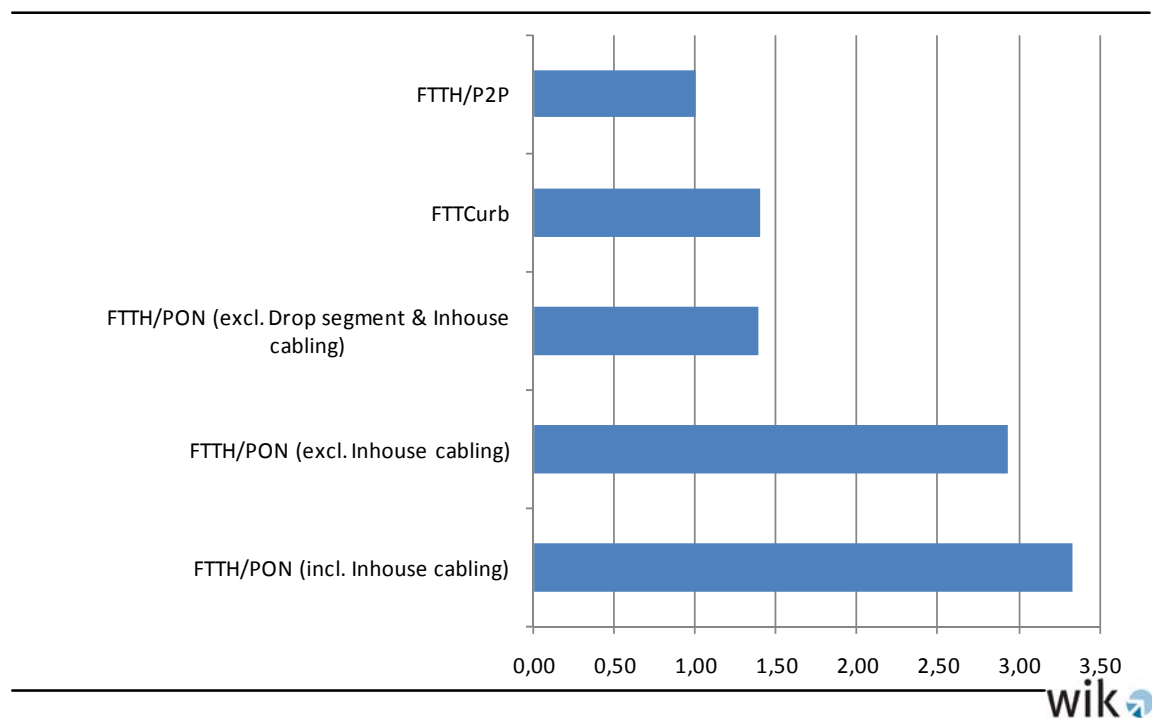
<sup>7</sup> This rule of thumb is explained in Evans / Filsfils (2007): Deploying IP and MPLS QoS for Multiservice Networks. p.250.

<sup>8</sup> Due to different routing of inbound, outbound and on-net calls the result is not the mere conversion of minutes into GB per month.



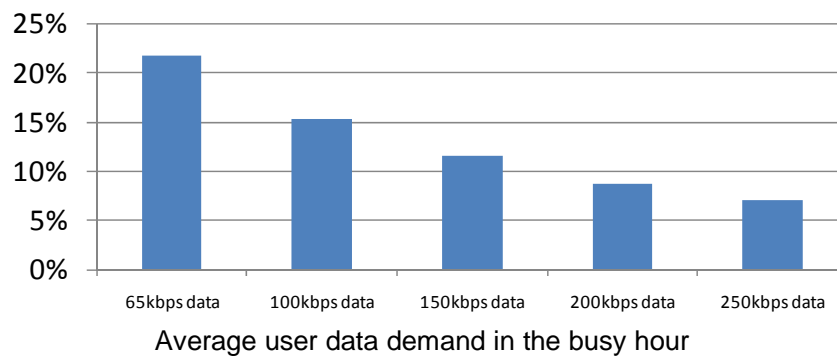
The results of this base scenario are shown in Figure 3-1 in which the cost of voice termination is reported as index value. The cost of FTTH/P2P in this double play base case is used as default index 1.0. All successive figures are relative towards the FTTH/P2P result in this base case and therefore all diagrams are directly comparable with each other. The figure shows how moving the demarcation point closer to the customer – i.e. shortening of the dedicated access line – leads to an increase of voice termination cost because more network elements need to be taken into account. Interestingly the cost of FTTH/PON with demarcation at the distribution is slightly below that of FTTC. The reason is that the DSLAM is more expensive than the splitter and – being an active electronic device – is depreciated over just a few years. The drop cable segment accounts for the majority of investments in FTTH due to the civil works necessary to deploy the fibre to every building. Because the VoIP share is still relevant in the base case it was expected that the termination cost increases compared to FTTH/P2P. The calculations confirm that FTTH/PON including drop cable leads to voice termination cost that are about 3 times higher than in an FTTH/P2P architecture.

**Figure 3-1 Voice termination cost base case (Double Play, 65kbps data usage)**



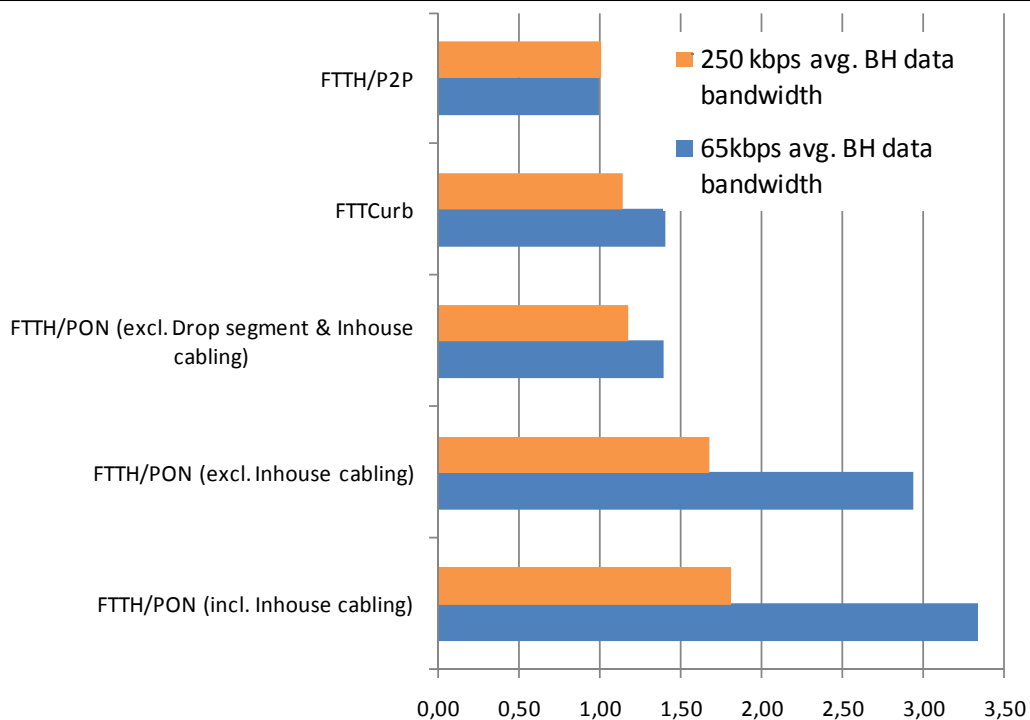
### 3.2 Double Play analysis: Impact of increasing broadband usage

In the future broadband data volume will increase also because NGA enables higher bandwidth for customers to make use of. The increase of data volume in this consideration is not driven by IPTV, but by all other services, since this scenario is double play (voice, data) only. This means that – assuming telephony usage remains at the same level - the share of voice traffic decreases. We have calculated the share of voice traffic for successive increases of data volume represented as an increase in average user busy hour bandwidth. The results are shown in Figure 3-2.

**Figure 3-2 Sensitivity analysis: Voice traffic share at the Distribution Point (FTTC, Double Play)**

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We have then calculated voice termination cost with 250kbps of data per user in the busy hour. The results are shown in Figure 3-3. The reduction of voice share leads to strong decreases in termination cost for the two last FTTH/PON options. With a lower voice share fewer costs are accounted to the voice service. While the reduction for FTTC and FTTH/PON with demarcation point at the distribution point is not as strong it still shows how termination cost starts converging towards Index 1.0.

**Figure 3-3 Voice termination cost (Double Play with 65kbps and 250kbps busy hour data bandwidth)**

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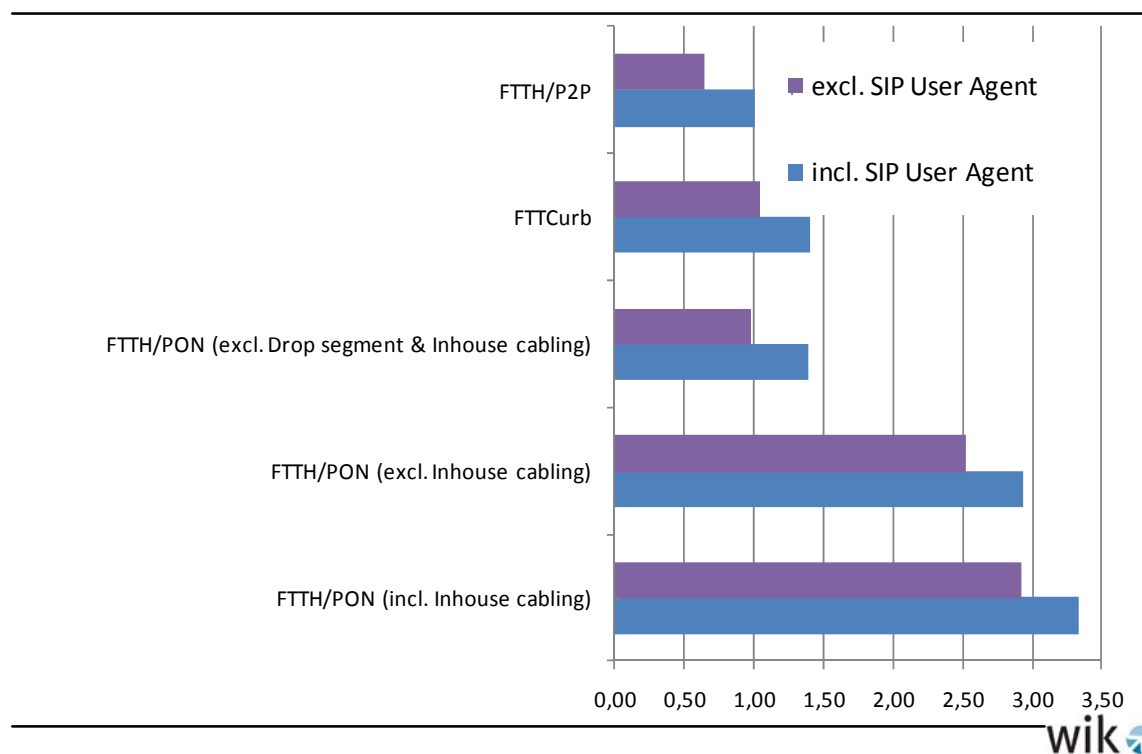
### 3.3 Double Play analysis: Treatment of the SIP-user agent in the CPE

So far calculations have been made under the hypothesis that the cost of the SIP-user agent in the Customer Premises Equipment (CPE) should be taken into account. The reasoning for this approach lies in the migration of call set-up and signalling from PSTN to NGN: In the PSTN there is a separate

signalling protocol (SS7) which organises the switching in the network; the circuit switching function is controlled entirely by elements that reside in the operator's network. In an all-IP network based on the Session Initiation Protocol (SIP) the SIP takes care not only of signalling but also is relevant for routing the call to the final destination. Parts of the PSTN switching function are transferred from the network to the customer where a SIP User Agent is required in the CPE to establish, address and terminate calls. In fact, users can make calls entirely without signalling functions residing in the network if they know each other's IP address. The network's SIP Server technically is a matter of convenience because it – among other things - relieves participants of the necessity to let each other know their IP addresses. The SIP User Agent therefore is a critical element of call switching which is why its cost was considered in the previous calculations. 33% of the CPE cost has been taken to approximate the cost of the SIP User Agent, an approach taken from a reported recent rate decision by Italian regulator AGCOM.

However, there are also sound arguments that speak against this approach. The cost driver of the SIP User Agent is the number of customers. In fact, there is no rivalry in consumption of an individual user's SIP User Agent. While there is still competition for switching resources, these contested resources are the SIP Servers that reside in the core of the network. Accordingly one can argue that the SIP User Agent is part of the customer dedicated access network and should not be accounted for when calculating voice termination cost. To judge the impact of SIP User Agent treatment we have excluded the SIP User Agent from the cost calculation. Results are shown in Figure 3-4 and prove the relevance of this cost position. Since FTTH CPE is more expensive than FTTC CPE the reduction is lower for FTTC. Broadband data usage has been reset to the base scenario value in this calculation.

**Figure 3-4 Voice termination cost (Double Play, with and without SIP User Agent cost)**



### 3.4 Triple Play analysis: Inclusion of IPTV in the traffic volume

IPTV transmission could be facilitated in a broadcast manner in which all programs are broadcast once throughout the network from a central source to all users. Considering a TV bouquet of 100 channels at 5Mbps each (advanced HD or a mix of HD/SD programs) this yields a 500Mbps broadcast. ADSL and VDSL technology does not even come close to enabling such a bandwidth in the access network. Instead of broadcasting, channels are therefore multicast to the DSLAM from which only a smaller number of the multicast channels are transmitted over the copper bottleneck of the access network “on demand”. FTTH/P2P and FTTH/PON (with restrictions) principally allow transmission of all channels to the customer.

Keeping in mind that we are only interested in those parts of the network that are not dedicated to the customer we have compared the location of the demarcation point and our assumptions for the multicast of IPTV in the following table.

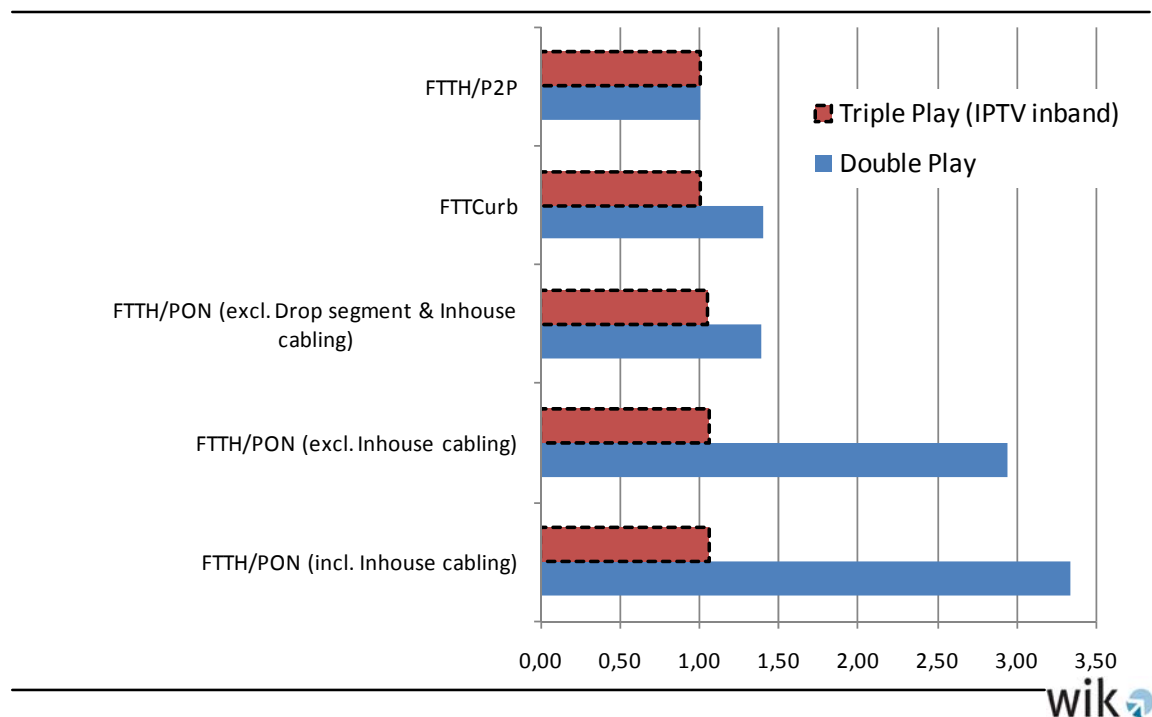
**Table 1**      **Multicast TV assumptions**

| Architecture | Location of the demarcation point   | IPTV transmission<br>(relevant network cost for voice termination cost calculation)  |
|--------------|---|--|
| FTTC         | DSLAM in the street cabinet<br>(distribution point)   | Multicast of 100 channels to the DSLAM in the street cabinet   |
| FTTH/PON     | Different options discussed<br>1) Distribution Point,<br>2) Building basement,<br>3) Customer | Multicast of 100 channels to the MPoP<br>Reduced multicast of 50 programs from MPoP to customer.<br>Assumption: At a splitting ratio of 1:64 there are a maximum of 64 customers per PON so with statistic considerations there is no need to carry the full multicast |
| FTTH/P2P     | MPoP  | Multicast of 100 channels to the MPoP  |

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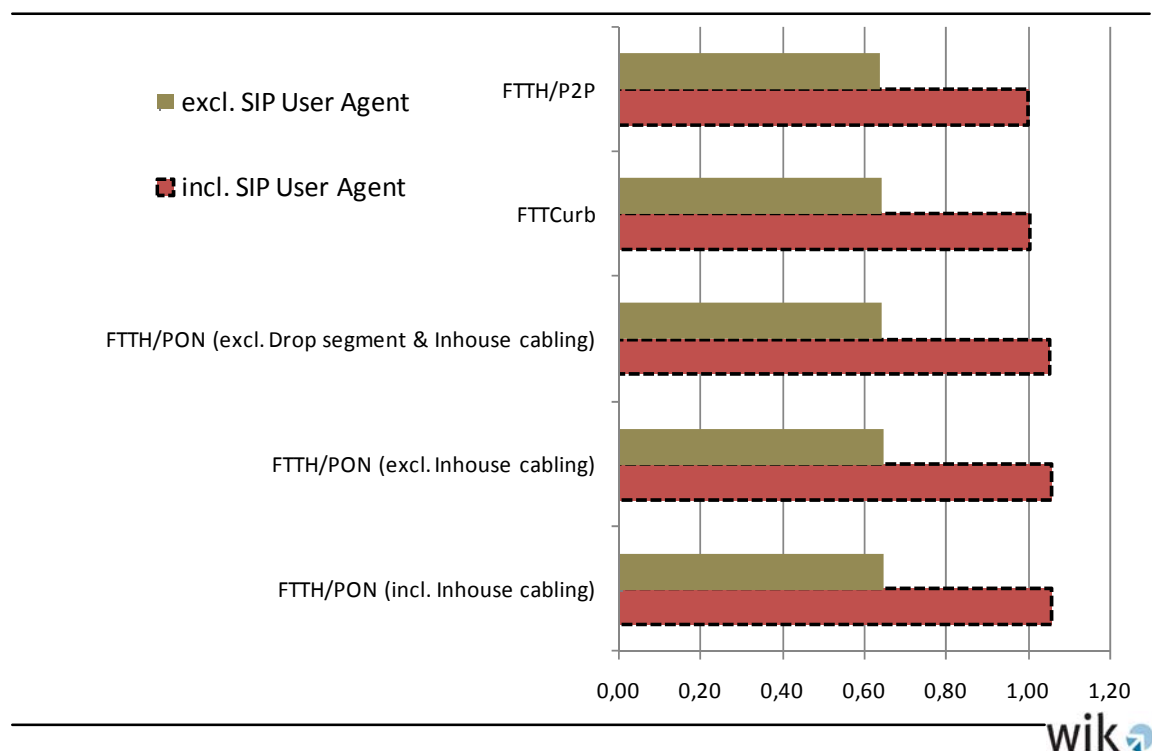
IPTV is hence transmitted fundamentally different than voice and data which are unicast communications between two designated partners. So while monthly voice volume per user is directly comparable to data volume (taking account of different routing for inbound, outbound and on-net traffic) it cannot easily be compared to the multicast volume. The voice volume of a given user will be the same in the drop cable segment, at the distribution point, in the feeder segment and at the MPoP. The multicast TV signal is transmitted once on every network level. So when looking at a specific network node such as a specific MPoP there is voice traffic from e.g. 10.000 customers and one multicast TV group of 500Mbps. At a specific distribution point, e.g. a VDSLAM location there could be voice traffic from 100 users and still one multicast group of 500Mbps. This easily shows how the share of TV traffic volume increases when looking at network levels closer to the end-user.

Accordingly, the IPTV traffic share is highest where network costs are highest also, i.e. in the network segments close to the end-user, especially in the drop cable segment. This is reflected in Figure 3-5 which shows that due to the low voice traffic share in the feeder and drop segment, termination cost is practically equalized at the level of the MPoP.

**Figure 3-5 Voice termination cost (Triple Play)**

### 3.5 Triple Play analysis: IPTV base case without SIP User Agent

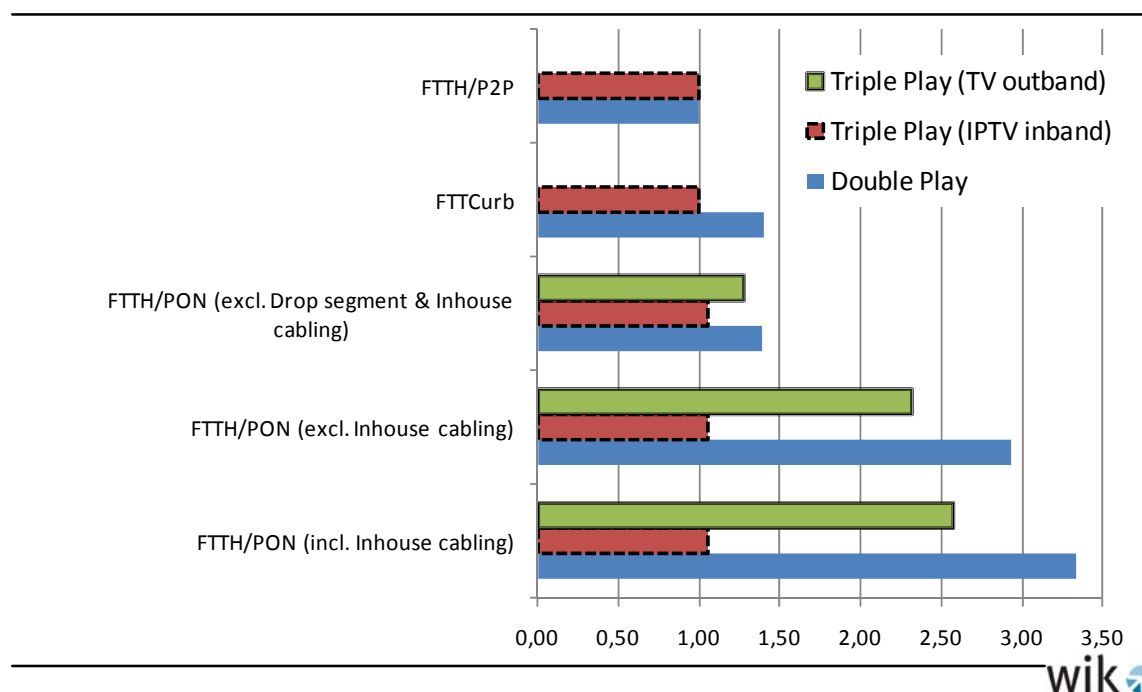
For purposes of comparison we have also run a calculation of this triple play case excluding the cost of the SIP User Agent. This reinforces the observation that the IPTV load leads to a very small voice share which in return makes termination cost more or less the same for all discussed architectures.

**Figure 3-6 Voice termination cost (Triple Play, with and without SIP User Agent cost)**

### 3.6 Triple Play analysis: Running TV on a separate wavelength in PON

The GPON standard already foresees a third wavelength suitable for RF-TV transmission (RF – Radio Frequency). If TV is delivered this way then one could consider this an “outband” TV transmission because it is not included in the IP-stream and it does not limit the bandwidth available for voice and data. The question is how such architectures should be treated with regard to voice termination cost calculation and cost allocation to TV. The approach we have used is to base on the number of wavelengths used for the triple play service delivery. As two wavelengths are used for voice and data and one wavelength for broadcast TV we have shifted 1/3 of the total cost between MPoP and customer to the TV service. The remaining 2/3 of costs has then been accounted depending on the traffic share of voice and data just as in the base scenario. The results are shown in Figure 3-7 which also includes the previous triple play case (“IPTV inband”). As expected the results lie between the double play base case and the IPTV inband scenario. Such an outband TV strategy is also frequently used in FTTB deployments, where the TV signal is fed into the buildings’ existing coax TV cables.

**Figure 3-7 Voice termination cost (Triple Play Inband/Outband vs Double Play)**



## 4 Conclusions

There are a variety of architecture options for NGA deployment of which we have only discussed some. Very likely the issue of efficiency, i.e. which architecture should be considered efficient in the sense of determining costs of efficient service provision, is a matter of national, regional and local circumstances and path dependency. Accordingly it is still open whether it will be possible to designate a few “efficient” architectures. The issue of efficiency also strongly depends on the requirements for bandwidth and Quality of Service. In this study we have modelled only FTTC, FTTH/PON and FTTH/P2P but not e.g. FTTB or Active Ethernet.

We have assumed that the regulatory framework for voice termination rate calculation is carried over into the NGA networks and have determined that the demarcation point differs between the architectures. Using a bottom up cost model we then considered different service scenarios, namely double play (voice & broadband data), triple play with IPTV (voice, broadband data, IPTV inband) and

for FTTH/PON also a triple play case with outband TV (voice, broadband data, TV on a separate wavelength). In addition we analysed the impact of rising average data bandwidth per user in the busy hour on voice termination cost (leaving voice volume at the previous level). We also calculated results with or without taking the SIP User Agent in the end-user device into account.

It was shown that a number of issues exist that need to be decided when modelling voice termination cost, among them

- The location of demarcation point in GPONs
- The treatment of outband TV on a separate wavelength (or on a separate fibre as it is frequently done in the case of FTTB P2P architectures)
- The treatment of the SIP User Agent
- And in addition the correct user demand for data

These issues will surely have to be debated. However, we believe that contrary to the European Commission's recommendation it is not immediately evident that a uniform demarcation point should be applied to all architectures. Instead, the double play scenarios show that there are strong differences between architectures. Yet, we also found that when taking IPTV provisioning into account these differences can be neutralized because of the dominant traffic volume of the TV service. If one perceives the triple play scenario as the likely future commercial scenario then the modelling results may serve as an argument to treat all architectures the same and apply a common demarcation point at the MPoP.

However, in reality there will likely be a mix of NGA architectures deployed by a given network operator due to the limits of economic operation (FTTH requires a higher penetration to be profitable than FTTC). This means that some areas in the same city could be favourable for e.g. FTTH/PON and other areas for FTTC only. This brings up the issue whether termination rates should be network specific or operator specific. Another element is relevant here: Determining voice termination cost according to the principle of the demarcation point also means that revenues from call termination are higher in FTTC and FTTH/PON architectures and lowest in FTTH/P2P. However, clearly the latter architecture is considered the most future-proof because of its ability to provide a dedicated fibre connection to each customer (scalability, ability to unbundle a customer). Now, focusing just on the issue of revenues from call termination, network operators would have higher incentives to invest into architectures that are less future-proof. This means that network specific termination rates would provide different incentives for NGA deployment - potentially not preferred by policy makers.

As long as the costs for voice transmission are not driven by the demand for voice communication, e.g. are invariant for traffic variations like the termination traffic, the determination of termination cost according to the new pure LRIC approach of the European commission will not be affected by the cost of NGA, because no cost increment for the terminating traffic can be identified. Identifying such increments cannot be achieved with modelling on the base of average access network assumptions but only by modelling the access network and the capacity dimensioning e.g. of the VDSL DSLAM backhaul interfaces in detail, line per line.

There is also another message that can be deduced from these calculations. Under the applied cost allocation scheme IPTV carries the majority of costs. The costs of distributing IPTV are largely

independent of the number of customers. If IPTV is only used by a fraction of the customers, the deployment of NGA is financed by a service whose costs per user will be very high. If sold at cost, the retail price will likely be prohibitively high. Therefore, network operators should maximize their TV customer base.

This study only focused on the determination of termination cost. The customer dedicated part of the network (client-sided of the demarcation point) was not analyzed. This is especially relevant with regard to questions of NGA wholesale services such as unbundled access. For example, in an FTTC network where the demarcation point is at the distribution point, operators can provide a dedicated dark fibre between the MPoP and the distribution point to wholesale customers while at the same time the demarcation point for voice termination remains at the distribution point. Hence there can be an overlap between (parts of) the dedicated local loop and the concentration network relevant for determining voice termination cost. The cost of duct access and dark fibre would therefore need to be extracted before distributing costs on the services of the network. This means that it could be necessary to revisit the strong separation of dedicated access network and contested concentration network which are the basis of current termination rate regulation.