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

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[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.

- Ability to support multicast.

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 majority 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.

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	NZ[11]	AU[12]
Ethernet Interfaces								
Flexible CPE								
QoS								
Flexible interconnection								
Multicast								

 Future expected plan No NGA bitstream proposition

[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

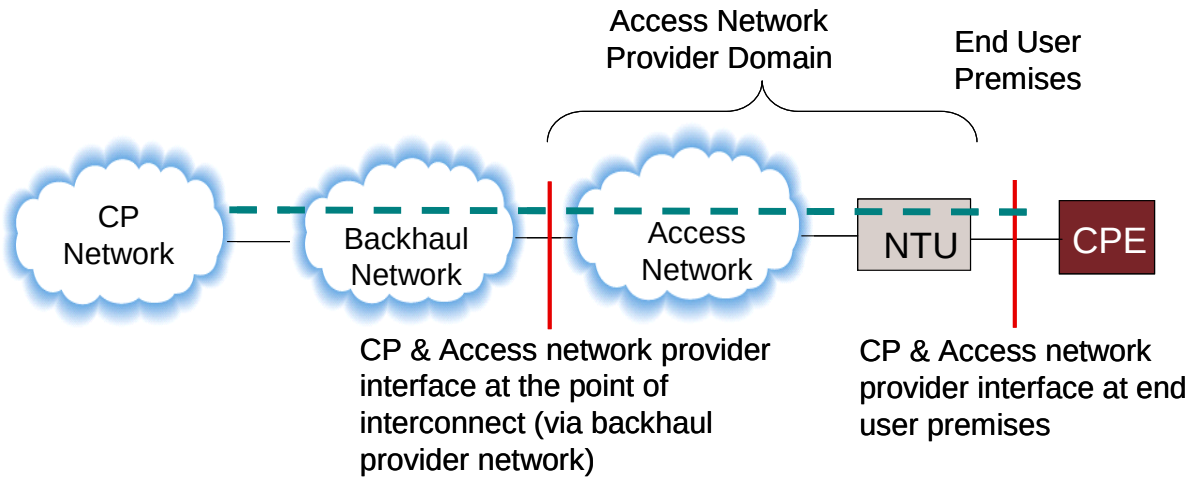
[10] Telecom Italia wholesale service trial proposal 'EasyIP Fibra' for FTTH

[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

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.

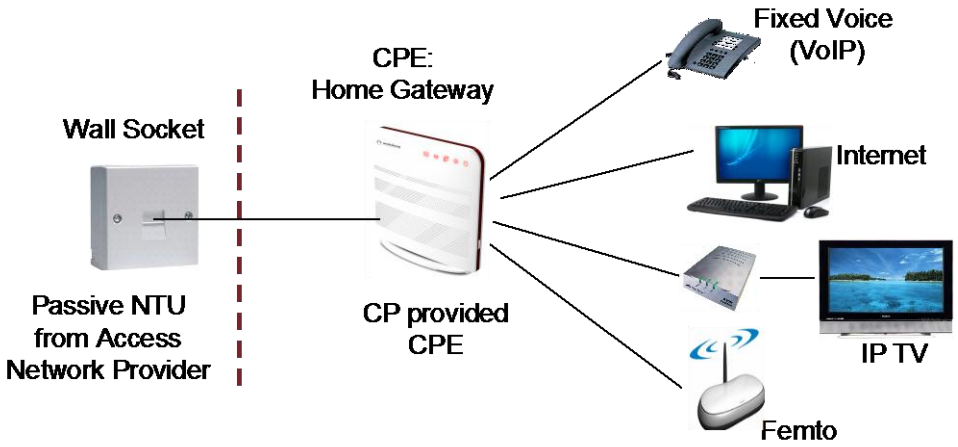


2.1 Flexible Support of CPE

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]:

[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



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.

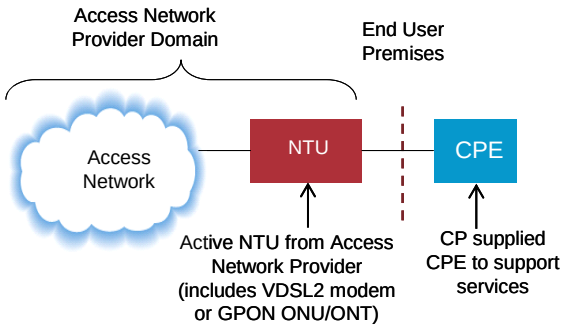
In this case, the access network provider may be given an unfair advantage as it can deploy an integrated NTU+CPE unit:

- 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.

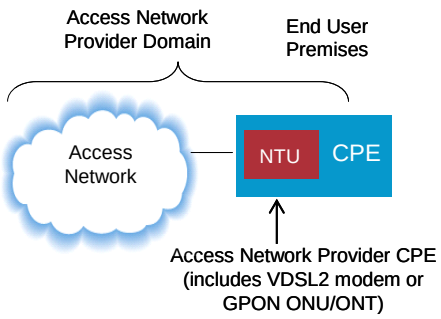
- A one box solution has one and not two points of failures, simplifying the support processes. It also enables a more straightforward innovation as in a two-box solution the CP is dependant on the NTU hardware features and limitations deployed by the access provider.

- 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

[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.



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, 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 CPs, 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 profile 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.[15] 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.[16]

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,

[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).

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. [17]

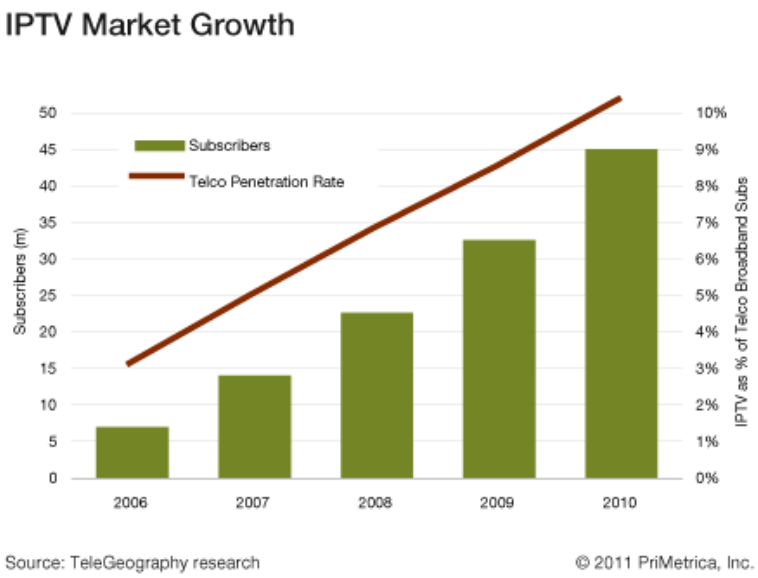
The cost of the inefficiencies cited above impacts the CPs in terms of bandwidth and/or equipment costs. For this reason, without multicast functionality offered at the various interconnection points the CPs may be unable to offer broadcast IP TV economically.

The multicast support of wholesale access should allow the CP to inject multicast traffic into 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[18]

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.

[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



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.

3. Comparison of Wholesale Access Proposals

This section compares the next generation bitstream access offering/proposals of various markets against the key technical requirements set out in this brief. In the sub sections below each market is discussed and the summary is presented at the end.

3.1 Spain

NEBA (Nuevo Servicio Ethernet de Banda Ancha) is the new bitstream service offering by Telefonica which has been approved by the Spanish telecom regulator CMT. The following table summarises the NEBA offering against the key technical requirements:

Key Requirements	NEBA Technical Specifications
Ethernet Interfaces	Wholesale access is based on Ethernet
Security	End user are separated by Virtual LAN per customer The CP defines the security in its network part: how the device authenticates and so on is CPs responsibility
QoS	Supports 3 different QoS Classes (i.e. Realtime, GOLD, Best effort) that will be maintained end to end. QoS implemented using the p-bit of the Ethernet Frame (the p-bit values were agreed with the Incumbent).
Multicast	Not supported (Telefonica, the SMP operator, does not have the obligation to offer multicast).
Flexible CPE	Two-box solution at present for FTTH (GPON). The market is evolving and in the near future the ONT+Router functionalities will be implemented together in only one device. NEBA accounts for this by allowing CPs to ask for a line without ONT. CPs can use the NTU device they prefer, as long as it is compatible with the access provider's network equipment. For VDSL2: wires-only (one box solution) is available. CPs can choose the modem among models compatible with Telefonica DSLAM equipment. For ADSL2+: one-box solution and the CPs have the freedom to select their preferred CPE+modem (wires-only).
Flexible interconnection	Regional interconnection only (50 points); others are possible (local exchange, other levels) but only under commercial agreement between operator and Telefónica. Interconnection points cannot be changed, because they are based on the Telefónica's Ethernet aggregation network. But could be changed under commercial agreements with Telefónica.

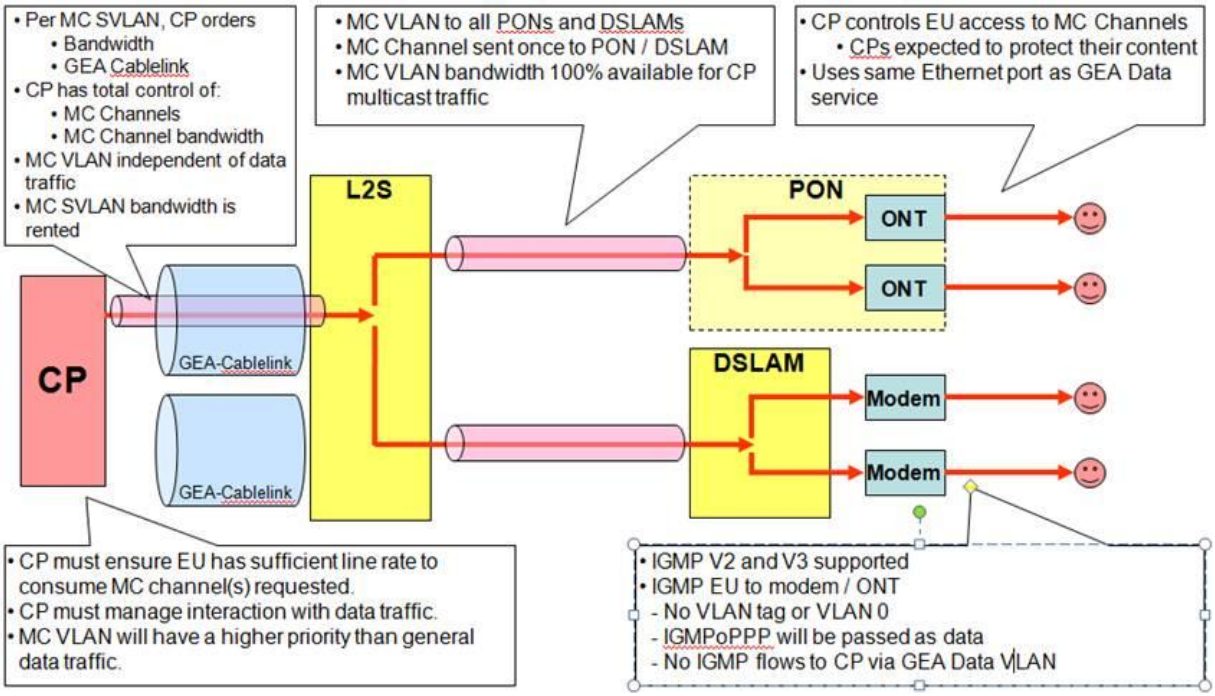
3.2 UK

In the UK incumbent BT has been developing wholesale product called Generic Ethernet Access (GEA) over their NGN based on FTTP and VDSL/FTTC. Information provided related to GEA in this section are based on publically available documents.

Key Requirements	GEA Technical Specifications

Ethernet Interfaces	Wholesale bitstream access is based on Ethernet interfaces at the customer premises and at the point of interconnect
QoS	For downstream, the network recognise up to 4 different 802.1p markings (i.e. 0, 1, 2, 3 and 4) used by network provider to identify which traffic to discard under congestion conditions. The traffic with marking 3, 2 and 1 are considered 'Should Not Drop' (no drop priority differentiation between these 3 markings) and marking 0 and unmarked are considered as 'Can Drop'. However, these markings have no impact on discard rate for one end-user relative to another (i.e. if two end-users have the same traffic demand and one has all traffic marked as 'should not drop' and the other all traffic marked as 'can drop', they will experience exactly the same level of packet drop). QoS markings are also used to schedule traffic from the DSLAM to the VDSL2 Active NTU. Frames with higher markings are delivered first using strict priority. In the upstream, CPs CPE can mark the traffic using 802.1p markings which effectively allows to select between two priority levels (i.e. high and low). The high priority frames will be sent from the active NTU ahead of low priority traffic.
Multicast	Incumbent recognise the significance of the multicast support and recently outlined the multicast capability for GEA. The GEA multicast design as it is currently proposed supports the basic principles however presents some restriction in terms of encapsulation types used, amongst other things.
Flexible CPE	Two-box solution at present for FTTH (GPON) and VDSL2/FTTC: The incumbent deploys an active NTU at the customer premises and CPs expected to deploy their own CPE in addition to deliver services. Active NTU (ONT and VDSL modem) also supports more than one Ethernet ports. The two telephony ports in the NTU are currently managed by BT Openreach, i.e. telephone calls are routed via BT Openreach telephony system. Main drawbacks for CPs lay in the lack of flexibility in the telephony features they can offer and the revenue for incoming calls termination which is collected by BT Openreach. BT Openreach has publicly mentioned the intention to support open ATA (allowing CPs control of the telephony port) in the future.
Flexible interconnection	Based on the information from the incumbent, CPs could interconnect at the locations where there is an NGN Ethernet switch. Most of the existing Local Exchanges will enable for interconnection. For FTTC/VDSL2 option, interconnection at street cabinet level is not available.

Example Active NTU



GEA Multicast network architecture

3.3 Germany

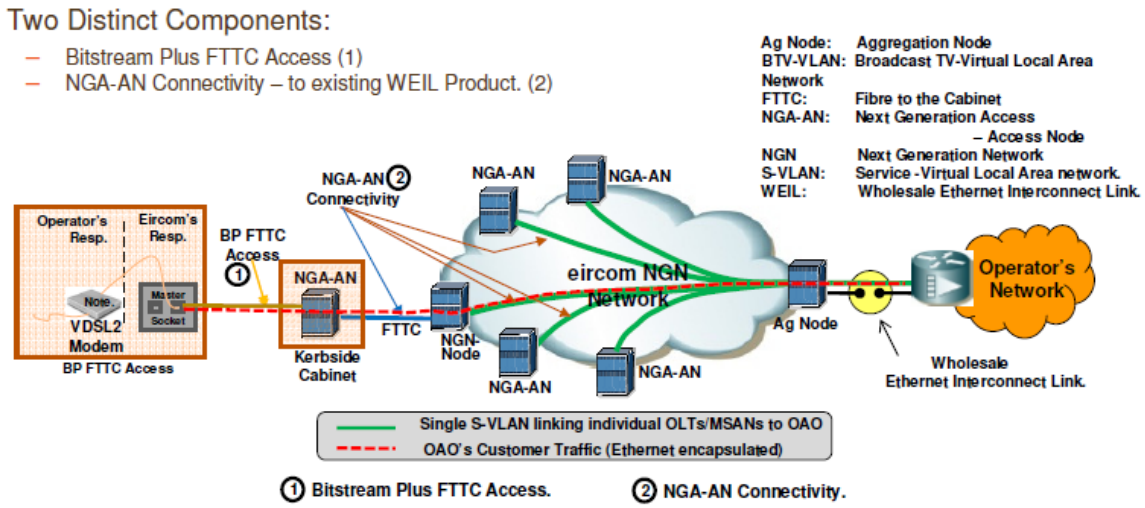
In Germany Vodafone and other CPs tried to push the incumbent Deutsche Telekom (DT) to offer a NGA bitstream product (layer 2), up to now without success. DT was forced by the German regulator Bundesnetzagentur (BNetzA) to do a layer 2 offering, but this has not yet happened. The only product currently available is xDSL "IP bitstream" (=layer 3), so it is not a NGA bitstream in the sense of this document. The traffic is transported via L2TP between the BNG of the access provider and the L2TP network server of the CP. The interconnection is layer 3 (IP) based. Prices are charged per user port (installation and monthly fee), per interconnection (dependent on the physical bandwidth of the link) and per traffic in peak hour. IP bitstream is offered in 2 main flavours: "Shared" which means that POTS is provided by DT whereas DSL is wholesaled to a CP. Second flavour is "standalone" where no POTS is supplied, and can be provided by the CP using VoIP technology over the data connection. This is the variant VF-DE is using. The IP bitstream is available for ADSL2+, SDSL and VDSL (up to 50 Mbit/s downstream and 10 Mbit/s upstream). Key aspects of the DTAG bistream proposition are listed below.

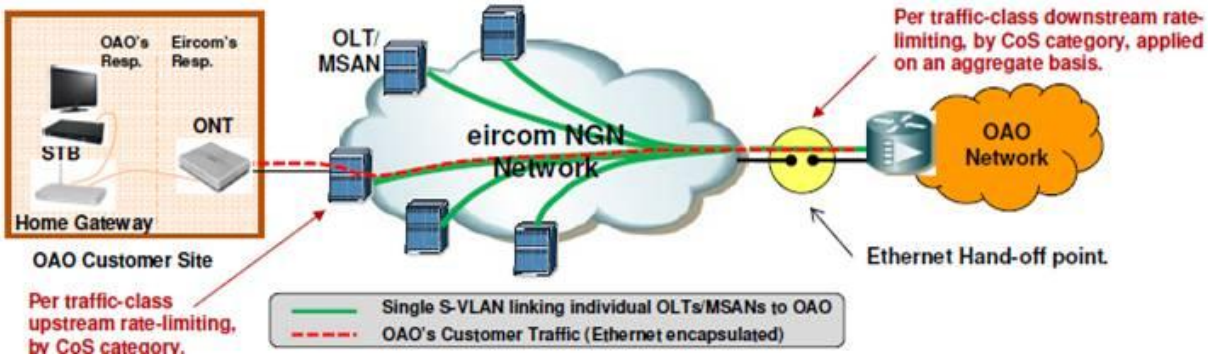
Key Requirements	Current DT Offer Technical Specifications
Ethernet Interface	No, product is layer 3 based (L2TP between BNG of access provider and LNS of CP)
Security	Traffic per UNI is encapsulated in PPPoE, authentication done by CP
QoS	No CoS, but KPIs are defined for the whole traffic which allow the CP to provide VoIP: delay 45 ms, packet loss < 1%, jitter 15 ms, packet error rate < 0.1% accord. to ITU-T Rec. Y.1540
Multicast	Not available
Flexible CPE	xDSL modem is not provided by DT, so CP can use its own CPE. No interoperability testing available.

Flexible interconnection	Regional or national interconnection. Local interconnection is not possible. Interconnections are scalable (from 34 Mbps up to 1GE or POS STM16, 10GE will be available shortly). In case of regional interconnections there is no redundancy between interconnections. Incumbent defined 73 interconnection points in Germany. Each interconnection serves a disjoint region. So if one interconnection breaks, the corresponding region is dark.

3.4 Ireland

In Ireland the incumbent Eircom is proposing bitstream access to CPs (named OAO in the figure below) over their next generation network based on FTTH and VDSL2/FTTC. They propose different demarcation at the customer premises for bitstream access based on the different access networks (i.e. FTTH or VDSL2/FTTC). Figure below shows end to end architecture for bitstream access over both VDSL2/FTTC and FTTH respectively.





Key Requirements	Eircom Bitstream Proposal Technical Specifications
Ethernet Interface	Wholesale bitstream access based on Ethernet
Security	CP traffic is separated using VLAN per MSAN per CP The CP defines the security in its network part: how the device authenticates and so on is CPs responsibility

QoS	Supports 3 different QoS Classes (i.e. Realtime, Business or GOLD, and Standard) that will be maintained end to end. QoS implemented using the p-bit of the Ethernet Frame.
Multicast	Supported (A separate Broadcast TV VLAN per Operator).
Flexible CPE	Two-box solution for FTTH (GPON): Eircom supplies and terminates the access at the ONT at the customer premises and CPs expected to provide additional box to support services. Wholesale voice not supported by Eircom; telephony will be provided by CP using VoIP, which is the preferred option by CPs. One-box solution for VDSL2/FTTC: Eircom terminates the access at the Master Socket in the customer premises and CP supplies the CPE that incorporates the VDSL2 modem and support services (wires-only)
Flexible interconnection	Doesn't offer flexible interconnection for bitstream access

3.5 Italy

In Italy the discussion on NGA is still ongoing and there is not yet a final agreement on the implementation scenario and on infrastructure (discussion currently focussed on financial aspects). Government Bodies, Incumbent Operator TI and CPs are trying to find a common approach for the deployment of NGAN. The CPs are supporting an open P2P network capable of replicating the current ULL ecosystem. The Incumbent is promoting a GPON based network on the basis of increasing their ability to reuse existing assets and passive infrastructure, and hence reduce deployment costs. GPON network would relegate CPs only to NGA bitstream access, seriously impacting (negatively) the vibrant and competitive copper ecosystem.

Whilst the discussion around NGA strategy is ongoing, telecom Italia has setup plans to deploy a new wholesale service called "EasyIP Fibra", applicable to FTTH.

This service is meant to be a provisional offer, to be trialled by the incumbent and CPs until a complete regulation process is finalized.

EasyIP Fibra is very similar to an existing unregulated offer, currently used by Tele2, which mainly is a pure collection of data traffic at IP level. "EasyIP fibra" is characterized by Layer3 interconnection between the incumbent and the CPs. According to the service model, only PPP protocols are supported and the traffic segregation is applied only by the session protocol, PPP.

The PPP is the protocol used for establishing of the user session. The sessions are aggregated into L2TP Tunnel and delivered to the CP at the Point of Interconnection. The access nodes of the CO (LNS), terminate the L2TP tunnels and manages the process of customer authentication, acting as the interface to the Radius System.

"EasyIP Fibra" offer is under evaluation and the Incumbent should define all the QoS, SLA parameters.

Currently "EASY IP Fibra" doesn't match the minimum requirement to support a NGA Bitstream scenario in a Triple Play scenario:

- No QoS support, hence inability to offer VoIP or IP TV services
- Bandwidth constrained to around 200kbps per customer
- CPE provided by access provider (i.e. TI), hence no wires-only

- Not Ethernet based

VF has presented a formal request to the Authority (AGCOM) outlining all the relevant constraints and issues, rejecting the offer and requiring the definition of a complete bitstream offer, similar to the ATM or Ethernet one, with SLA, processes and QoS defined and guaranteed.

Key Requirements	TI's Easy IP Fibra' Technical Specifications
Ethernet Interface	No, product is layer 3 based
Security	No Vlan per customer, no segregation of traffic
QOS	No
Multicast	No
Flexible CPE	No - The ONT is provided by the Incumbent
Flexible interconnection	To be defined – expected to be restricted to national or regional level

3.6 Portugal

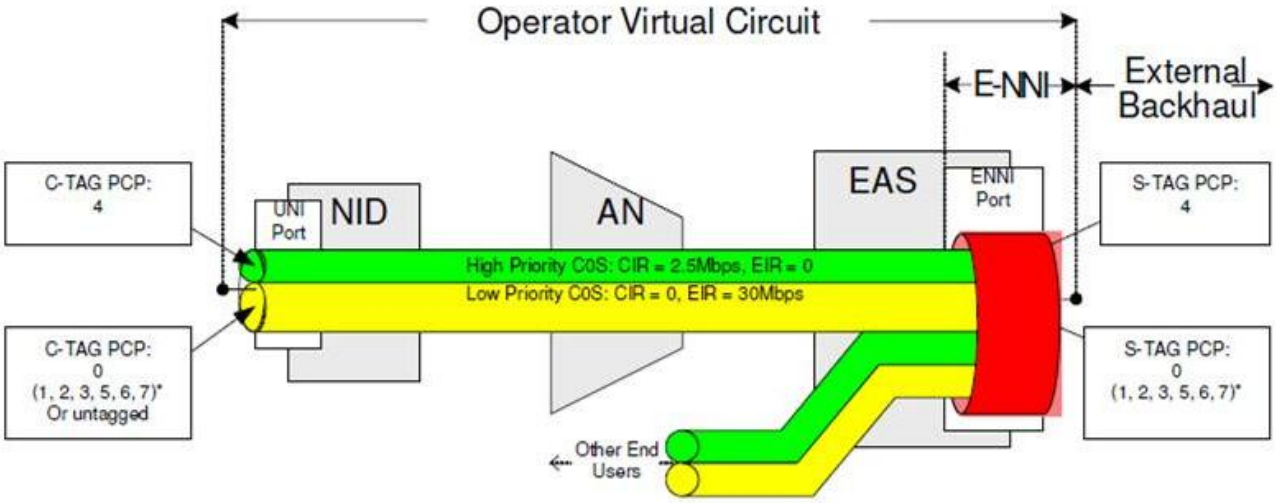
No NGA Bitstream proposition is currently offered by the incumbent Portugal Telecom on its 1m FTTH GPON premises. The national regulatory authority ANACOM has so far regulated duct access as regulatory remedy to stimulate competition, leaving Portugal telecom without any obligations to offer Bitstream service over its fibre access infrastructure.

3.7 New Zealand

In order to accelerate the roll-out of Ultra-Fast Broadband (UFB) the New Zealand government is investing in next generation infrastructure and to manage the investment, Crown Fibre Holdings (CFH) has been established. The Telecommunication Carrier Forum (TCF) Working Party, in which CFH, incumbent telecom network providers and CPs are member of, has recently published a minimum set of requirements that should be met to deliver Ethernet Access Services over UFB infrastructure. The Ethernet Access Service Description provides the framework for Ethernet Access Services, the Layer 2 services to be provided to Access Seekers under the Government's UFB initiative.

Key Requirements	TCF description of Ethernet Access Service over UFB
Ethernet Interface	Wholesale access service is based on Ethernet
Security	End user are separated by Virtual LAN per customer The CP defines the security in its network part: how the device authenticates and so on is CPs responsibility
QoS	802.1p marking is used to separate the traffic in to high priority (drop ineligible) and low priority (drop eligible). The access provider should support guaranteed (i.e. Committed Information Rate) bandwidth for high priority traffic which also guarantee performance attributes such as frame loss, frame delay and frame delay variation. The low priority traffic supports only shared (i.e. Excess Information Rate) bandwidth profile. Multicast service is defined as high priority. Different approach also recommended to support business services.

Multicast	The description of the multicast support is very generic however, consideration is give to key aspects such as separate multicast VLAN, use of same interfaces for both multicast and other data services, industry standard for multicast control protocol (i.e. IGMP v2, v3) etc.
Flexible CPE	A multi-service solution in which end-user can subscribe to services supplied by more than one CP will require an active NTU from the access network provider. Two-box solution at present, which does not have detrimental consequences for CP given the requirements of the ultra-fast broadband tender prohibits Local Fibre Companies from offering retail services.
Flexible interconnection	Under UFB no flexibility for interconnect. Only Local Interconnect is specified. Backhaul from the Local Interconnect to CP's network will either be over CP's own infrastructure or via a 3rd party Backhaul provider.



QoS Architecture

3.8 Australia

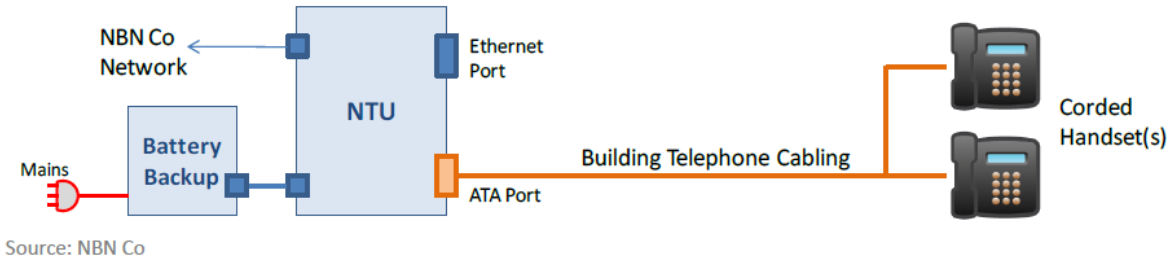
The Australian government has setup plans to structurally separate the incumbent Telstra and roll out an NGA covering all the Australian households, 93% HHs on fibre and remaining with wireless. The NBN (National Broadband Network) will be deployed and operated by a new entity called NBN Co.

NBN Co will be providing Bitstream access to all CPs (called Retail Service Providers) at equal terms. Given that the access provider (NBN Co) will not operate in the retail area, some of the bitstream product features will not have discriminatory impact as they would be in other countries where the access provider is a retail ISP as well.

NBN Co will install an NTU in each premise passed. The NTU will feature 4 Ethernet data ports (GbE) and 2 telephony ATA ports (see picture below). Each port is subjected to pricing depending on data rates and SLAs.

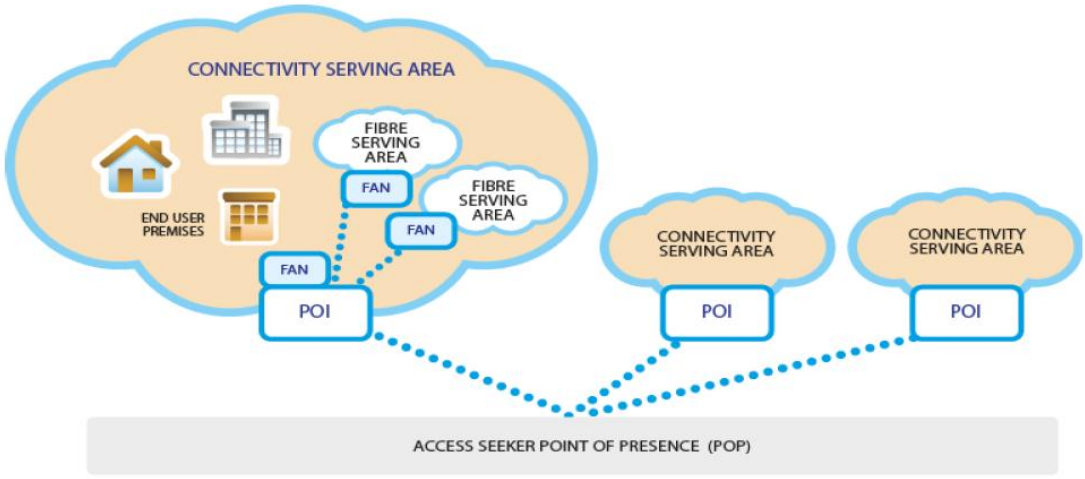
Each CP will provide the customer with a CPE connecting to one (or multiple) Ethernet port of the NBN Co NTU. Telephony could be provided with a VoIp service via the CPE or via the

native ATA ports provided by the NTU. In both cases, call control features will be the responsibility of the CP. SIP is the call control protocol to be used.



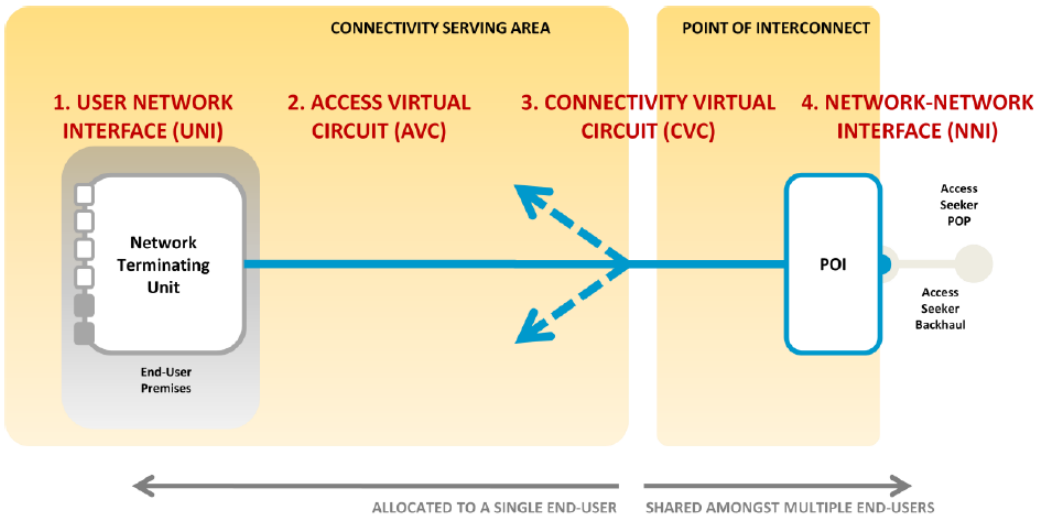
Source: NBN Co

Points of Interconnect (PoI) are the nodes where the traffic can be picked up by the CPs. A PoI serves an area called CSA (Connectivity Serving Area), composed by multiple FSAs (Fibre Serving Area). A FSA is an area served by a central office (fibre exchange). The figure below (from NBN Co) illustrates the logical architecture.



The bitstream service is divided in two pieces (see figure below):

- Access virtual circuit, related to the connection between the fibre exchange and the user
- Connectivity Virtual Circuit, effectively a backhaul connectivity service from the fibre exchanges to the PoIs



The number & location of PoIs was selected to provide a level plain field to all players. The PoIs are situated in points where competitive backhaul infrastructures can reach, so that each CP has a choice of backhaul provider to backhaul the traffic from PoIs to its core. Giving the opportunity to interconnect at FSA level (local level) would provide players like Telstra, who have exclusive fibre to the majority of FSAs, an unfair advantage over the remaining CPs.

Key Requirements	NBN Co Technical Specifications
Ethernet Interface	Wholesale access is based on Ethernet
Security	End user are separated by Virtual LAN per customer The CP defines the security in its network part: how the device authenticates and so on is CPs responsibility
QoS	Supports 4 different Class of service (i.e. Real time/mission critical, interactive, transactional and best-effort) QoS implemented using the p-bit of the Ethernet Frame (the p-bit values were agreed with the Incumbent)
Multicast	In roadmap
Flexible CPE	Two-box solution at present, which does not have detrimental consequences for CP given access provider is not a retail operator. In the long run NBN Co is committed to support unbundable PON, which would enable CPs to unbundle the optical wavelength of each customer and implement the 'wires-only' solution
Flexible interconnection	No, done on purpose in order not to give Telstra an unfair advantage

4.9 Summary of comparison

The following table summarises the NGA bitstream current propositions across the 8 markets analysed.

Requirements	Spain[19]	UK[20]	Germany[21]	Ireland[22]	Italy[23]	Portugal	NZ[24]	AU[25]
Ethernet Interfaces								
Flexible CPE								

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

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

[21] Current Deutsche Telekom bitstream offer

[22] Eircom bitstream access proposal to CPs over both VDSL2/FTTC and FTTH

[23] Telecom Italia wholesale service trial proposal 'EasyIP Fibra' for FTTH

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

[25] National Broadband Network Co Technical Specifications for bitstream access

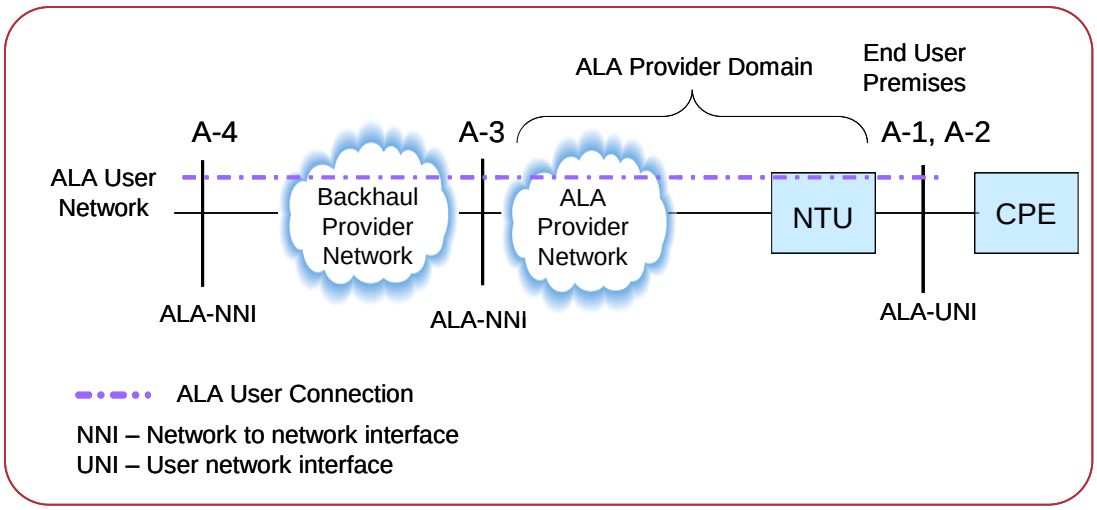
QoS								
Flexible interconnection								
Multicast								

Annexes

A. Ethernet Active Line Access (EALA)

In 2009, Ofcom, the UK telecoms regulator agreed headline technical requirements via a series of workshops to guide the creation of standards for wholesale bitstream product over fibre access infrastructures that will support the competitive delivery of services to end-users. The initiative is called Ethernet Active Line Access (EALA). Although the core functionality of EALA was to deliver residential services, the delivery of business services by adding additional functionality was not precluded. Since then, the Ethernet WG within Network Interoperability Consultative Committee (NICC) in the UK has been producing technical specifications for EALA based on requirements provided by Ofcom. In December 2010 the first set of specifications, the service definition, user network interface, network to network interface and the overall architecture were published by the WG. NICC ALA specifications describe the service and the interfaces between the access network operator providing the ALA service and the CP using the ALA service. Ofcom and NICC specifications use the terms ALA provider and ALA user respectively for the access network provider and the CP. It is worth noting that NICC ALA specifications leverage the industry standards defined by the Broadband Forum, the Metro Ethernet Forum and IEEE 802.

Figure below shows the end to end reference architecture for ALA where ALA user connects to the ALA provider network using the service of a 3rd party backhaul network provider. According to NICC specification, ALA provider network may use a number of technologies (e.g. GPON, GEPON, WDM-PON, VDSL2, ADSL2+, or Gigabit Ethernet direct fibre) to transport the ALA service.



In the following sub sections technical features of EALA is evaluated against the desired characteristics of wholesale bitstream discussed earlier.

A.1 Ethernet Access

Since a number technical issues associated with ALA would be difficult to address on a generic basis, following an industry consultation Ethernet was recommended by Ofcom as the interface technology for ALA.

A.2 Flexible Support of CPE

EALA supports both wires-only interfaces and Ethernet based interfaces as required by the Ofcom.

For the Ethernet based UNI type, the ALA provider supplies the equipment terminating the ALA physical network medium in the customer environment (e.g. VDSL2 modem or GPON ONU/ONT), and offers Ethernet presentation to the ALA user. This UNI uses the reference point A-1 as defined in the ALA architecture shown above.

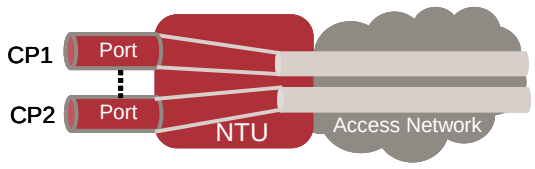
For a wires-only type UNI, the interface describes the demarcation between the ALA provider domain and ALA user domain, whereby the ALA user provides the equipment that terminates the ALA physical network medium in the customer environment. This UNI uses reference point A-2 as show in the ALA architecture shown above. It is worth noting that the NICC UNI specification explicitly states that this interface is defined to meet the Ofcom's 'Flexible choice of CPE' requirement. As mentioned in the previous sections, wires-only solution implies that the NTU is a passive device and the CPE, which is provided, configured and managed by the CP, implements the physical line termination functionality (i.e. the active functions of the NTU).

The UNI specification mandates the use of OAM based on Ethernet standard for both wires-only and Ethernet based customer premises interface.

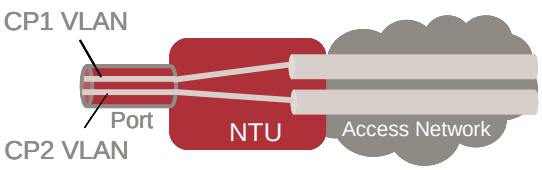
A.3 Multiple connectivity providers per households

Based on the Ofcom requirement, ALA supports multiple parallel CPs (i.e. ALA users) providing services to a single end user. Ofcom argued that NGN would be used not just by the competing CPs but also be used by the civil societies and utility companies (e.g. smart metering) to access homes in the future that may want to provide this service independent of broadband access.

To enable connectivity of multiple CPs via a single NTU, a CP's traffic may be presented on a dedicated physical port, or alternatively a physical port may be used to present multiple CPs differentiated by virtual LAN (VLAN) mechanism available in Ethernet (See figure below). In the latter case VLAN-aware equipment will need to be attached to the port to separate the traffic belongs to different CPs.



Multiple CPs per end user via multiple ports in the NTU



Multiple CPs per end user via single port in the NTU

It is recognised by NICC WG and the Ofcom that although it may be technically feasible, support for multiple CPs to a single end user could make the implementation of a wires-only presentation more difficult. However, market dynamics will probably drive the ecosystem towards a single CP per household; regulations will have to make sure the CP serving a HH

gives access to any service provider. The adequate level of service (e.g. QoS differentiation, bandwidth, etc.) required by each individual service provider can be guaranteed by the CP on commercial basis.

A.4 Quality of Service

EALA specifies QoS mechanisms that enable ALA users to offer services that require a defined Ethernet performance. On entering the ALA provider network at the UNI or NNI each service frame is mapped to 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. Each service has a service level specification that enables ALA user to define the performance objectives that must be met for packets of that class.

EALA supports four classes of service as in the table below.

Class	Typical UseTypical use
A	To support applications which have the most stringent delay and jitter requirements (Realtime, delay sensitive applications e.g. voice)
B	To support applications that are less jitter sensitive than Class A e.g. Streaming applications (video)
C	Internet data
D	Guest or 3rd party access[26]

According to the EALA architecture specification, typical use case for Class C and D would be to support (wireless) guest access at the end user premises or to limit the bandwidth of a background application such as push video. Among the four classes of service, the specification only mandates ALA provider to support Class A and C.

Following table shows the service level specification attributes that can be used to define separate performance for each supported class.

Class	One-way Frame Delay	Inter-frame Delay Variation	Frame Loss Ratio	Availability
A	M	M	M	M
B	O	M	M	M
C + D	O	O	M	O

M – RequiredO – Optional

The specification also recommends strict priority scheduling by ALA provider at any congestion points in their network to prioritise transmission of Class A traffic over Class B traffic, which in turn would be prioritised over Class C and D traffic. Class C and D are scheduled for example using a weighted round robin algorithm where weighting between the two traffics is set by the ALA user or the end user. Class A and B support only committed bandwidth while Classes C and D support both committed and excess bandwidth.

[26] Guest access is highly questionable from a legal point of view, because the owner of the internet connection (end user) is responsible for anything what is done with his IP in the internet

If multiple ALA users are supported by the ALA provider at a single customer premises then the total bandwidth available at the customer premises will be shared between the ALA users. The EALA specification discusses this scenario and recommends several implementation options in terms of number of queues and policing.

A.5 Flexible Interconnection

EALA recognises that different network interconnection points will be suited to different operators (e.g. due to different number of end users and level of traffic) and supports interconnect at any local, regional, or national active points, either directly or via a backhaul product.

A.6 Multicast

An ALA multicast connection allows an ALA user to inject multicast traffic into an ALA provider's network at the NNI and have this stream replicated and delivered to appropriate members of the multicast connection. The multicast ALA user connection has a defined bandwidth profile as for a point to point ALA user connection, defined forwarding behaviour (conditional or unconditional forwarding) and a service level specification.

At the ALA NNI the multicast connection has a bandwidth profile that defines the total bandwidth for all multicast traffic in each direction that the ALA provider will accept. The bandwidth profile at the UNI defines the total bandwidth downstream and upstream for multicast traffic that will be passes over the UNI.

EALA multicast service allows end users to request individual multicast streams using a widely accepted multicast group membership protocol, Internet Group Management Protocol (IGMP).

In order to support the multicast service over EALA, CPE need to be multicast aware need to act as a multicast router at the boundary of the end user network and the ALA provider network. The ALA user is responsible for providing connection admission control required to prevent and end user from exceeding their available bandwidth and thus disrupting their own service.

A.7 Security

EALA requirement specification recognises various security requirements related to wholesale access. It is believed that various mechanisms available for Ethernet will enable EALA user to achieve the required security. EALA also considers security issues arising in network architecture where routing of traffic to the end user involves ALA provider processing end-user device identity (i.e. MAC address).