Regulating communications for the future
Review of the Telecommunications Act 2001

A submission to the Ministry of Business, Innovation & Employment Discussion Paper

October 2015

Alcatel-Lucent welcomes the opportunity to respond to the Discussion Paper, *'Review Regulating communications for the future'*. As a leading player in the global communications sector, and contributor to the New Zealand market over many decades, Alcatel-Lucent is well placed to provide insight on market and technology trends, including industry structure and regulatory practice.

As the Discussion Paper points out, technology is becoming more capable, ubiquitous and connected. This trend is producing significant opportunity for productivity, innovation and growth in all sectors of the economy, and also raising new considerations about how to best ensure countries like New Zealand can take advantage.

Having a balanced, flexible and forward thinking regulatory environment and regulator will be key to unlocking these opportunities, and this review is a timely opportunity to consider how New Zealand may appropriately design the future objectives, functions, structure, and governance of its communications regulator.

Most important will be how this review considers the emerging environment of co-dependent players and how a future regulator can enhance this environment for the benefit of industry, consumers and the broader New Zealand national economy.

Alcatel·Lucent

About Alcatel-Lucent

Alcatel-Lucent (Euronext Paris and NYSE: ALU) is the leading IP networking, ultra-broadband access and cloud technology specialist. We are dedicated to making global communications more innovative, sustainable and accessible for people, businesses and governments worldwide. Our mission is to invent and deliver trusted networks to help our customers unleash their value. Every success has its network.

For more information, visit Alcatel-Lucent on: http://www.alcatel-lucent.com, read the latest posts on the Alcatel-Lucent blog http://www.alcatel-lucent.com/blog and follow the Company on Twitter: http://twitter.com/Alcatel_Lucent

Contact Alcatel-Lucent

Tim Marshall, External Affairs Director, Alcatel-Lucent Oceania

tim.marshall@alcatel-lucent.com, +61 (0) 400 00 5373

Table of contents

General Commentary

At a global level the telecommunications sector faces a socio-economical paradox where national regulators and policy makers must balance competing agendas to ensure the best possible outcomes.

One side of the paradox is the dominant national legacy and history of telecommunications as a public monopolistic utility, and the inextricable importance of connectivity to today's world, where ensuring ubiquitous access at the lowest cost possible is increasingly an objective of national governments.

On the other hand, there is a globally accepted desire that fully or partially privatised former incumbents act as rational economic players in a competitive market with the natural objectives of commercial business, such as profitability and return on investment.

Regulation and public policy should always keep in mind both legacy public-good and emerging business objectives to achieve a subtle and effective equilibrium. In New Zealand this has manifested as a strong regulation on access with a clear objective to apply competition law principles when possible. This review may well offer the opportunity for further reform to a more self regulatory approach as new fields of services and application are emerging.

The credibility and effectiveness of a regulatory framework – and hence its ability to facilitate private investment and competition – varies globally according national political and social institutions. Political and social institutions not only impact the ability to restrain administrative action, but they also have an independent impact on the type of regulation that can be implemented, and hence on the appropriate balance between commitment and flexibility, monopoly and competition.

In order to create a dynamic and effective competitive landscape, it is important to strike a balance between consumer benefits, competition and the economical sustainability of the communications industry. A new equilibrium for value chain distribution is needed. It would require a three steps approach:

- Operators should be allowed to monetise the data flow through service differentiation which is key to foster innovation, new services and meet demand for different levels of quality. For instance, in addition to provide best effort delivery, operators should develop their capability of providing end-to-end Quality of Service (QoS) service delivery, in becoming Cloud and Content Delivery Network (CDN) providers as examples.
- New business models should be based on a two-sided market approach driving commercial agreements while preserving openness and non-discrimination rules. It includes provide quality-assured IP interconnection, including cybersecurity features, or trusted parties and business services across multiple networks
- New economic models should enable network operators to increase their revenues either through end-user subscription raise or differentiated data plans. Unlimited data plans have shown their limits when operators are required to heavily invest to maintain high end-user quality of experience.

Alcatel-Lucent does not intend to address all of the issues put forward in the Discussion Paper. Rather, this submission offers some context and insight on the evolving environment, the evolution of fixed access networks, spectrum and mobile broadband, and net neutrality. We also offer as an Appendix a recent Alcatel-Lucent global whitepaper, outlining developments in fixed wholesale products. We trust this contribution is of value to the Ministry as it considers communications regulations for the future.

Evolving Environment

One of the major challenges to designing an optimal future regulator agenda is that the communications environment is constantly evolving, subject to continuous innovation and disruption.

Alcatel-Lucent is supportive of the view put forward in the Discussion Paper that we should consider the sector through a horizontal layer approach. Taking this approach can provide a guide for the behaviour of a regulator in ensuring healthy and sustainable competition at each layer and avoiding gridlocks between any layers that become inter-dependant. Indeed, it may help to guide a statement of objective of future regulatory approach.

As outlined in the Discussion Paper, telecommunications and ICT is becoming increasingly pervasive in sectors across society, including but far from limited to health, education and transport. As this trend continues to develop, cross-sector coordination will become an increasingly important consideration for policy and regulation. Indeed, many current regulatory and policy environments still work in 'silo' approach where decisions are made in isolation and separate communications networks and/or capabilities are built in parallel.

There is a strong opportunity currently available for telecommunications and ICT policy leaders to come together with their counterparts in other sectors to formulate common strategies. Government and the national interest may significantly benefit from work on converging ICT policy that aligns with other sectoral policy objectives in areas such as energy, health, education, in order to maximise impact. It is likely that this opportunity will become more pronounced and action more urgent as growth accelerates in the emerging environments of Machine-To-Machine (M2M) and Internet of Things (IoT).

In this regard, the government should promote more cross sector analysis and recommendations for policy engagements that ensure ongoing positive industry and consumer outcomes.

The Evolution of Fixed Access Networks

In the coming years, fixed access networks will partially or wholly migrate from copper to fibre. In the EU, fixed access networks are generally considered as natural monopolies requiring heavy regulatory intervention and access to the physical layer of networks. Given the technological evolution, this traditional regulatory approach needs to be reviewed as it might be an inhibitor for the adoption of these new technologies and for the openness of new markets[1].

Some broad network trends are evident at a global level.

At the core network level, Network Function Virtualisation (NFV) and Software Defined Networking (SDN) both improve service quality including for specialised services which require guaranteed bandwidth and latency. On a medium term perspective, SDN could be extended to access networks and provide a level of control similar to physical unbundling combined with flexibility similar to bitstream.

At the access network level, FTTx evolution will lead to increased speeds and the reuse of copper network in the terminating segment (FTTdp, G.fast, XG.fast). Unbundling at the terminating segment won't be feasible technically nor economically. Access remedies should be based on virtual unbundling.

Spectrum and Mobile Broadband

Spectrum is the lifeblood of mobile communications and spectrum-related policies, including spectrum management, are critical for the future development of networks, including the evolution to 5G. To enable adoption, operators must be assured that sufficient and affordable spectrum is available in a timely manner. This is required to support the growing mix of data traffic that will be generated by the increasing number of humans and machines that will access 5G networks.

Exclusively licensed spectrum will continue to be a critical element for the developments of 5G because it provides a predictable and stable way to establish the capacity of a deployed network. As such, a forward-looking and investment-friendly policy framework for spectrum management is needed to ensure that the ecosystem develops at a fast pace. Harmonised spectrum, timely and (cross-country) coordinated releases, and longer duration of usage rights are some of the measures that can create certainty in the market and foster the necessary investments in technologies and networks.

Also, spectrum pricing should be balanced against network investments that will be required to ensure the ubiquitous availability of networks and services. An investment-friendly approach to spectrum pricing will ensure that the rising population density and its increasing use of wireless services will be supported by the necessary network infrastructure. Excessive pricing of spectrum can have as effect limited future investments in networks and innovative services and may delay their adoption. As such, it can delay 5G deployments and increase the technology gap between regions. Therefore, spectrum pricing should take into account a number of factors, such as the available bandwidth per operator that will influence technical performance, the required network investments, and the continuous network evolutions that will be required over a licensing period.

A pricing framework that supports balanced ongoing investment in spectrum and networks is an essential step towards a truly mobile and connected society. Moreover, considering that legacy technologies will be switched off eventually to allow operators to re-farm spectrum using more efficient technologies, the existence of a simple secondary market for spectrum trading will allow operators to optimise their spectrum holdings. Likewise, a

[1] See annexe: Fixed wholesale: virtual access and connectivity products

simplification of the regulatory requirements attached to spectrum licenses will benefit operators (eg. a technology neutral approach to spectrum, coverage obligations per technology, etc.).

Finally, accessing new frequency bands already in use by other services implies sharing spectrum and, therefore, an optimised coexistence with other radio technologies and a dynamic use of radio resources. This use of complementary spectrum on a licensed-shared and/or on a license-exempt basis requires equitable access to it through coordination mechanisms. Managing access will be important to maintain high spectrum efficiency and ensure that interference is controlled and managed, as required. This will require revisions to existing regulations and spectrum management practices to encourage and favour the use of shared spectrum resources with other services. Alcatel-Lucent considers that further investigation on spectrum sharing should be considered.

Net Neutrality

Alcatel-Lucent, like the vast majority of the telecommunications sector, is committed to an open Internet where consumers and business customers are able to access the content, the applications and services of their choice in line with their individual preferences.

As the Discussion Paper points out, this consultation takes place at a time where we witness an Internet traffic explosion. Net neutrality has to be considered in a pragmatic way. In fact, with the explosion in data volumes, actively managing network traffic (without blocking services or constraining innovation) is becoming ever more integral to ensuring the best internet experience for end-users.

Prioritisation should be allowed for specific data flows. While ensuring non-discrimination between services and between providers, the new digital economy will require the development of 'specialised' services with the highest quality, speed or priority. The appropriate functioning of products such as automated cars, industries such as the aircraft industry and vital services such as health services, will heavily depend on a network with prioritised data flows.

Net neutrality should be addressed with a flexible legislative toolkit. Regulators should limit intervention to the setting of general principles, without fixing strict binding rules that could hinder innovation and hamper the possibility for operators to introduce and differentiate new services in the future.

Alongside best-effort Internet connectivity, there has to be room for innovation and for the delivery of content, applications and services that require an enhanced quality of service and appropriate end-to-end Service Level Agreements (SLAs).

Such services are already delivered today and will become more and more sought after as technological innovations permits more and more devices to be connected for new benefits, eg. e-health, industry 4.0, smart grids. It is also because of such innovations that the network can continuously evolve to meet the demanding application/content/service mix (NFV/SDN, eHealth, M2M, IoT, mobile backhaul, IPTV & VoD, web traffic, voice and gaming…) – capacity and traffic quality requirements – in an economically sustainable way. Additionally, while the delivery of services other than Internet access services do require resource management tools, these develop with new and better techniques being constantly developed. Regulation should therefore not mandate specific technologies or ways in which these services should be delivered.

<u>The nature of traffic management</u>

Trafic management is essential at the Internet access level, and must be applied:

- o to mitigate congestion which may occur; including

   - enabling operators to optimise (peer–to-peer) applications
   - enabling modification of network parameters to combat chatty applications, and thereby improve service quality for the benefit of all users

- o to ensure QoS delivery of the service levels expected by users in terms of bandwidth, jitter, delay, availability, security and reliability beyond best effort (unpredictability);
- o to ensure fairness among all end-users connected to the same access equipment
- o to provide network security, including improving protection against malicious services and applications (spam, malware, etc.)
- o to meet the Quality of Experience (QoE) expectations that the end-user wants to get for the applications he chooses.

These traffic management functions cannot be replaced by investment in network overcapacity.

Finally, Alcatel-Lucent is not aware of any difficulties related to network management practices. The vast majority of concerns raised in the context of net neutrality are purely theoretical and have not manifested themselves in the marketplace. Furthermore, industry information suggests markets are sufficiently competitive to deter any harmful conduct. Legislation should avoid specifying the technical means used to manage networks and congestion, and to offer specialised services, given the fast pace of the evolution of networking technologies. The rules should leave regulators free to tackle breaches of those principles, as the circumstances require.

Appendix

Alcatel-Lucent paper, 2015

Fixed wholesale: virtual access and connectivity products

Fixed wholesale: virtual access and connectivity products

INTRODUCTION

This paper examines wholesaling in fixed networks. Wholesale access products play a leading role in the development of competition as the telecommunications markets were liberalised. A variety of wholesale products which will be described here enable different levels of investment and possibilities for technological independence and service differentiation for new entrants. While the price level of this regulated access has often been and is still being contested in some countries, many of them have achieved a far higher degree of competition than would have been the case if they had not intervened to assist in the development of market access. Passive wholesale access products, such as dark fibre services, access to ducts or access to in-building wiring were not included as the focus of the paper is voluntarily on the active infrastructure layer.

A few scenarios will be reviewed to understand the importance of wholesale in fixed access. After describing the different products, we will focus on the requirements and obligations to create them. Then Alcatel-Lucent position on fixed wholesale will be outlined.

TABLE OF CONTENTS

SCENARIOS

There are a number of reasons why wholesaling fixed networks is happening or required. These can range from public investment, commercial or voluntary arrangements through regulatory intervention. Let's review a few cases for which sharing telecommunications infrastructures is fundamental:

- Some access remedies that are available to regulators for traditional and next-generation access broadband are no longer technically or less and less economically viable (scenarios 1 and 2)
- When service-based competition is the result of insufficient competition at the physical layer or is promoted by public initiatives (scenario 3)
- Promote competition between all types of service providers (over the access network – scenarios 3 and 4 – and at the Internet Exchange Points named IXPs, i.e. over the access, backhaul and core networks – scenario 5)

Scenario 1 – When unbundling is not technically feasible at an economically viable point

When physical unbundling is not technically feasible at an economically viable point, the National Regulatory Authority may impose a wholesale bitstream access product. In UK, physical unbundling of the fibre loop at the Metropolitan Point of Presence (MPoP) is not technically feasible at an economically viable point, as is currently the case with GPON.

Or when physical unbundling has limited economic viability. In Belgium, the last market analysis has shown that there is no business case or investment identified at the street cabinet for sub-loop unbundling for alternative operators.

Apart from going straight with fibre to private properties (FTTH), with fibre being deployed deeper in the network (FTTx: FTTN, FTTCurb, FTTdp$_{1\rightarrow n}$, FTTB…), moving closer to premises, there is an increase of the number of nodes to access to a reduced number of copper pairs. This will make the physical unbundling scenario even more difficult to achieve.

Scenario 2 – When unbundling renders access technologies ineffective

When physical unbundling is detrimental to performance of access technologies (VDSL2 + Vectoring 1.0 or G.fast + Vectoring 2.0 in the future), the National Regulatory Authorities (NRA) may impose a wholesale bitstream access product.

The noise-cancellation technology called vectoring addresses the gap between the theoretical maximum rate and the speeds that service providers can deliver in typical field conditions. Not only can it boost the downstream and upstream bandwidth but it also delivers consistent and predictable performance across all lines (of similar length).

In order not to impair the performances described above, vectoring requires full coordination of all the copper pairs in the cable binder. Physical unbundling is therefore withdrawn at the condition that the network operator deploys effectively in a timely manner for service providers to benefit also from these new technologies (access, differentiation, fair pricing).

Scenario 3 – When service-based competition is the objective

Some national broadband plans retain only or in addition to infrastructure based-competition the service based-competition one: one network for multiple service providers and/or access seekers (shared common active infrastructure operated by one infrastructure provider).

Examples at national level are from Australia, Singapore and countries where the historical operator has been separated (structurally or functionally).

One example at regional level is France with Open Public Initiative Networks – a complimentary model for broadband deployment to incumbents and alternative telcos. Since 2004, public authorities are able to build infrastructures, establish networks and offer access to operators and, in some limited cases to end-users. The latter applies in case where the private market is unable or unwilling to deliver sufficient services for end-users, if it is established (via a formal process) that there is insufficient supply from independent operators.

At local level, some authorities in Sweden for example opt for a business model that relies on local, publicly-owned utilities which are given the responsibility of deploying the networks using their existing infrastructure, which means a less costly and a faster rollout.

Scenario 4 – EU Digital Single Market proposal for virtual access products

The European Commission is to propose a new set of regulatory measures aiming to spur investment in new infrastructures and facilitate the provision of innovative services in the EU.

At Member State level, National Regulatory Authorities (NRAs) are developing responses raised by the transition from copper to fibre-based networks, built on the analysis of relevant ex-ante markets, as shown in the table below: the wholesale network infrastructure access (market 4), the wholesale broadband access (market 5) and the wholesale leased lines (market 6).

Market	Definition	Remedies
Market 4	Wholesale Local Access (WLA): access network infrastructure (including shared or fully unbundled access) at a fixed location	Grant access to the physical path of the network (copper, fibre) of the Significant Market Player (SMP)
Market 5	Wholesale Broadband Access (WBA)	A range of possible remedies including different levels of bitstream access, different pricing mechanisms, etc. applied to the SMP
Market 6	Wholesale Leased Lines (WLL) for providing business connectivity services (including trunk segments, terminating segments and backhaul market)	Grant access to a dedicated transmission capacity between two termination points, at least one of which must be a point of connection with the SMP provider's network

Table 1: Market 4, 5 and 6 definitions and remedies

But to promote competition, investment and innovation in new and enhanced networks and services by fostering market integration and cross-border service offerings, the Commission would like to define certain key virtual access products with minimum parameters: "(…) Virtual broadband access products (…) should be made available where an operator with significant market power has been required under the terms of the Framework Directive and the Access Directive to provide access on regulated terms at a specific point in its network."

The three virtual broadband access products mentioned are:

- Virtual unbundling (not named as such but with "equivalent functionalities to physical unbundling") with Points of Interconnects (PoIs) close to end-user premises
- Next-Generation IP level bitstream with PoIs at regional and/or national level.
- Ethernet leased line-like wholesale product for business services providing permanent and uncontended symmetric capacity

Scenario 5 – EU Digital Single Market proposal for Assurance Service Quality connectivity product

In order to stimulate the provision of cross-border services especially to business users, all operators upon reasonable request should provide an assured service quality connectivity product at IXPs which enables end-to-end quality of service to offer “high-quality” products anywhere in Europe for service providers to meet the needs of their customers.

Internet Exchange points are almost wholly driven by market players with no regulatory intervention. They band together with a certain set of policies and practises. The Commission would like to setup an effective wholesale access to all network infrastructures with a certain degree of openness for all types of service providers to compete. Any service provider (application provider, content provider, Internet provider, etc…) could rely on such connectivity product from network operators to deliver high-grade products and services (examples: minimum set of QoS parameters for cloud and video services, ensure that SLAs are met in delivering services to end-users, businesses and the public sector, etc…).

All the scenarios above underline the importance of wholesale in fixed access. Let’s now review the main wholesale products.

DESCRIPTION OF WHOLESALE ACCESS PRODUCTS

Bitstream access covers a range of products from close to physical unbundling up to close resale depending on access point, used technology and product characteristics.

Before digging into each bitstream access product feature, let’s highlight the way access seekers are going to assess remedies in terms of dependency: technical dependency, operational dependency, economical dependency and strategic dependency.

- Technically wise, the access seeker is looking for access products on which it can develop its own differentiated retail products. So the important criteria are technical restrictions and limitations, architectural choices and network equipment restrictions (maximum packet length, number of simultaneous communications, …).
- Operationally, the access seeker is looking for self-controlled provisioning, commissioning and maintenance of each user access line. Products come with SLAs (Service Level Agreements), including for example information on mean time to repair (MTTR).
- Economically, the access seeker is looking for service catalogue and pricing. The structure should allow the access seeker to differentiate at the retail level with profit margins.
- Lastly, strategically, the access seeker is looking at how financial and cash flows are going to be structured with the network provider and what sustainable business models are possible to be developed over time.

Ethernet-level Bitstream access products

Virtual Unbundling and Next-Generation Bitstream provide both to access seekers wholesale access at Ethernet level protocol (layer 2), with a greater degree of flexibility than legacy bitstream offered on copper based broadband networks.

Legacy bitstream has already been applied for quite a while but is only a basic and limited form of wholesaling (Best Effort High-Speed Internet). Next-Generation Bitstream on the other hand represents a much more complete and flexible solution: multicast, triple-play services with their associated QoS requirements (by differentiating traffic into classes) and subscription to multiple access seekers for multiple services at the same time, to obtain optimal service mix.

Virtual unbundling

The outcome of Market 4 analysis in some countries led to substitute physical unbundling as a remedy by Virtual Unbundling. ***It consists of an active access link to the customer premises (over copper or fibre)***. Consequently, handover takes place at local exchange level, similar as LLU. The access seekers have either their backhaul networks reaching the local exchanges or are dependant of backhaul services from other providers. Virtual unbundling is not expressly required in the NGA Recommendation if physical unbundling at the MPoP is not technically feasible, but its use has been accepted in the Article 7 practice.

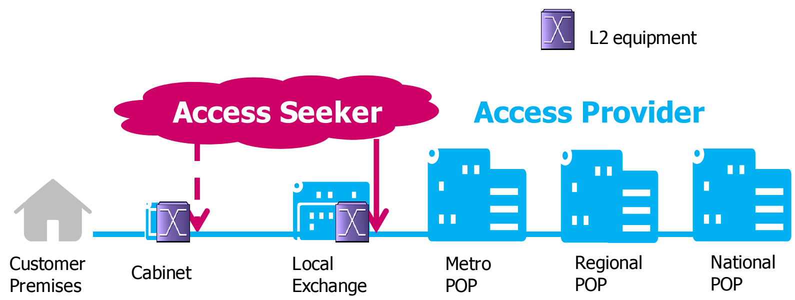


Figure 1: Virtual Unbundling

Virtual Unbundling is compatible with any physical technology in the first-mile, and shields its specificities from the access seeker. It allows a maximum degree of freedom for the access seeker to define the parameters of its retail products and is priced in a similar way as passive infrastructure. An optional non-blocking switching stage helps in reducing the amount of Points of Interconnect (PoIs).

Its main features render it similar to products included in market 4 as shown below:

- Point of interconnection or handover point: local exchange (similar to LLU) (note that although regulators may consider also cabinet-level PoIs, this is very unlikely in practice due to the large number of nodes and additional feeder links to be foreseen).
- Service agnostic: able to support a multitude of services (scope for product differentiation and innovation by access seekers similar to LLU). If there are multicast packets, they are to be transported transparently.
- Uncontended[2]: the access connection, or capacity, between the end-users' premises and the local exchange where interconnection takes place should be

[2] The access provider will have to impose a limit on the maximum uncontended bandwidth per line that is available since access nodes are not dimensioned to be non-blocking when fully loaded, but rely on statistical multiplexing. Indeed, it is not economically feasible to simultaneously provide to everyone an uncontended end-end capacity equal to the full line rate. The access provider will have to determine how much "uncontended" (i.e. guaranteed) bandwidth he can realistically offer per line to access seekers. There can be some remaining "non-guaranteed" bandwidth on top of that, that will be subject to a given contention ratio.
Note: this is no different in practice from physical unbundling. Any operator will apply statistical multiplexing in his first aggregation point, but now the access seeker cannot do it itself but has to rely on how the access provider deals with it. The tricky point with virtual unbundling is to avoid expectation that the maximum physical capacity is uncontended on all lines. But the guarantee is there: what is offered by the access provider as "uncontended" (lower than the maximum bitrate that could be reached) is, well, uncontended.

dedicated to the end-user. This interpretation excludes sharing a line between multiple Access Seekers.

- Control of access: sufficient control of the access connection should be available (including possibility to vary QoS parameters) in order to provide different types of services.
- Control of CPE: choice of interoperable CPEs or sufficient control by access seekers if it is owned by the infrastructure provider.

Virtual unbundling involves multiple access seekers using the same access node. As a result, special attention needs to be paid to a number of topics during definition between all stakeholders:

- The connectivity capabilities (e.g. capacity, QoS) need to be well defined in SLAs with the Access Provider. The easiest approach is to use a set of pre-defined quality profiles. The Provider needs to guarantee the SLAs, by managing the priority markings and possible but not necessary oversubscription for example.
- Combining multiple multicast IPTV services on a same node could lead to multicast address overlap. The Provider's network must be able to cope with such overlap to avoid any interference.
- The CPE positioned by the seeker must be interoperable with the access node of the provider. This can be done based on a "whitelist" of CPEs, or by case-by-case validation.
- For the sake of operational simplicity, interaction at OAM level (provisioning, monitoring, trouble-shooting) should be kept at the highest possible level, in the OSS.

Virtual Unbundling partly virtualizes the line by terminating the subscriber line on the equipment (DSLAM or OLT) of the access provider. The access seeker can connect directly to this equipment at the cabinet or local exchange level, thus avoiding the access provider's aggregation network. Although the physical lines themselves are not under control of the access seeker, Virtual Unbundling offers a high level of control over the connections in terms of transparency (for IP configuration and Ethernet transport), QoS, and multicasting capabilities. While in principle (limited) control of physical layer parameters is possible, this would result in significant operational complexity.

Next-generation bitstream

Next-Generation Bitstream is another wholesale product which is imposed or proposed part of the remedies in market 5. ***It consists of an access link to the customer premises (over copper or fibre) bundled with a backhaul service to a defined set of handover points (also called points of interconnection).***

Next-Generation Bitstream virtualizes connectivity further by pushing the PoIs to the edges of an aggregation network operated by the access provider. Multiple SLA parameters at individual connection or aggregate level can be negotiated between the access provider and the different access seekers.

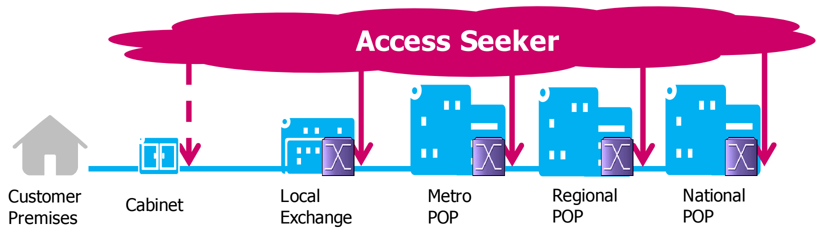


Figure 2: *Next-Generation Bitstream (Ethernet-based)*

There are several benefits which come with Next-Generation Bitstream products:

- Scalability: depending on the size of the network, reducing the amount of PoIs (interfaces) can become a necessity. Several levels become possible (metro, regional, national).
- Flexibility for the end-user: a single user can subscribe to "virtual" connections from multiple access seekers (compared to only one with legacy bitstream).
- Flexibility for the access seeker: aggregating a large amount of users per PoI allows to maximize the statistical multiplexing gain when dimensioning the network capacity.
- Flexibility for the access providers: the provider can take responsibility for L3 configuration, CPE management, hosting of end-user self-provisioning portal, etc. and offer this as a paid service to the access seekers (not available in legacy bitstream).

Next-Generation Bitstream features are:

- Point(s) of interconnection or handover point(s): Metropolitan Point Of Presence (MPOP), regional or national level
- Physical layer: any access technology
- Ethernet level protocol interface delivery to users
- Customer premises equipment (optical network unit and/or residential gateway): managed by infrastructure provider or access seeker
- Access seeker's control over QoS: several traffic classes defined from frame loss, frame delay, frame delay variation, guaranteed and non-guaranteed capacity, priority bits…
- Access seeker's control over bandwidth – also called service contention by managing the mapping of the access link (allocated to a single user) to the backhaul link (shared among multiple users)
- The network provider offers multicast to all access seekers
- Access seeker's choice on offering its own IPTV service or from other IPTV providers with the flexibility to connect to different content providers (advanced multicast forwarding)
- Access seeker's choice on specifying the roles of access and core equipments in managing subscribers and services (forwarding models)
- Price control: compatible with cost orientation, equivalence-of-inputs, accounting separation, price/margin squeeze tests…
- Service level Agreement (SLA) between infrastructure provider and access seekers
- Additional options: redundancy, Operations, Administration and Maintenance (OAM), 24/7 SLA…

Next-Generation Bitstream has an additional criterion, an essential one which is the overall contention offered to the end-user which was already available with legacy bitstream.

Next-Generation Bitstream access virtualizes the line further by pushing the Points of Interconnect (PoIs) to the edges of an aggregation network operated by the access provider. Connectivity to subscriber lines is aggregated into bigger pipes and offered to the access seekers at different aggregation levels (at LEX, metro, regional, national POPs). Next-Generation Bitstream offers a lot of flexibility from a comprehensive level of control for the access seeker (with exception of first-mile settings), to having the access provider taking up some responsibilities on behalf of the access seeker in terms of service management or subscriber management (e.g. IP configuration of the end-user devices).

IP-level Bitstream access product

Ethernet-level bitstream solutions must deal with the scalability aspects of layer 2 (number of VLANs and MAC addresses). The introduction of MPLS can circumvent them. Another way is to terminate layer 2 at one (or multiple) routing stages in the Access Provider. The bitstream then has a connectivity at IP-level and becomes an “IPstream”. Additionally, IPstream is more flexible; the access provider is in charge of IP-level configuration and could add some of its own services to the service basket offered by the access seekers (such additional services are called white label services).

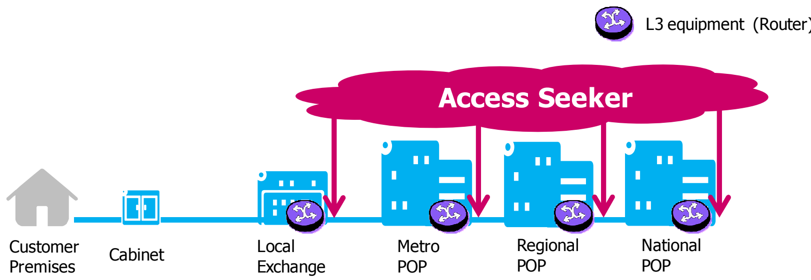


Figure 3: IP-level Bitstream

Whereas going for an IP-level bitstream brings additional flexibility for traffic routing and control by the access provider – this increases significantly the complexity for the access provider. Indeed, the access provider now becomes responsible for the IP-level configuration of the end-user gateway, has to dimension a suitable subnetting for his network, must balance the load in routing signalling across the routing stages in his network, must possibly support multiple routing protocols to different access seekers, and relies on knowledgeable personnel to manage all this. In an Ethernet-level bitstream, this complexity is kept at the level of the access seeker. Moreover, for offering transparent LAN Services, an Ethernet-level bitstream is needed.

IP Bitstream is very similar to Next Generation Layer 2 Bistream in the sense that it supports any service[3] (except for L2 transparency) including SLAs, the contention ratio will be determined by both the Access Provider and Access Seeker, and the level of PoIs is flexible (in practice it will be determined by the first routing stage in the Provider’s network).
There is an additional trade-off for the Access Provider between flexibility of its own service offering and complexity at IP level (has to manage the IP configuration of the end-users, and manage routing in its network). The Access Seeker on the other hand can play a simpler role (to concentrate on the application offering) but relies on the Provider for the IP configuration.

[3] Although possible at IP level, transport of multicast data is typ. done at L2 between the encoder and user

Assured Service Quality connectivity product

Without the ASQ connectivity product, the delivery of digital services from any service provider (application, content, cloud, etc...) to customers could traverse some networks in best effort mode: such a network would not provide any guarantees that data is delivered or that a user is given a guaranteed quality of service level or a certain priority. In a best-effort network all users obtain best-effort service, meaning that they obtain unspecified variable bit rate and delivery time, depending on the current traffic load. This is a major impediment to the development of high-grade digital services (use of high definition audio codec for audio conference calls, 4K video distribution whether it is on-demand or broadcasted and communications, relying on cloud services when data and processing power are in remote locations, etc…).

The proposal from the Commission is to secure the delivery of high-grade services while offering to all types of service providers access to network infrastructures. A major difference between the ASQ product and the previous bitstream products is that the ASQ product coverage can be beyond the access & aggregation network (and IXP in reference to the EC proposal for a single market in telecommunications). The service provider can thus deliver high grade services even if it is not directly connected to the targeted access provider.

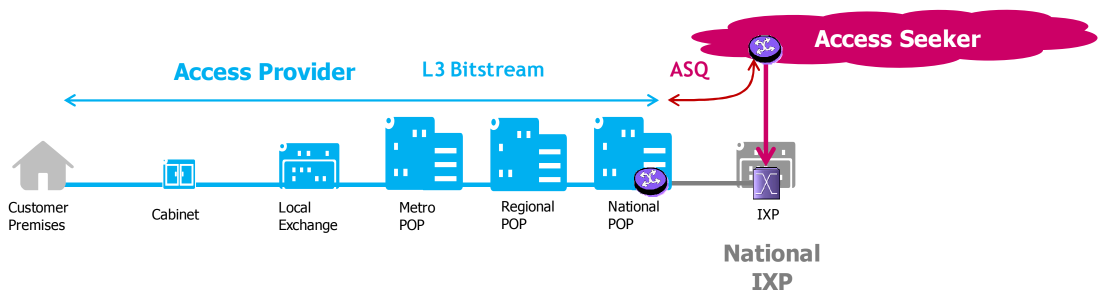


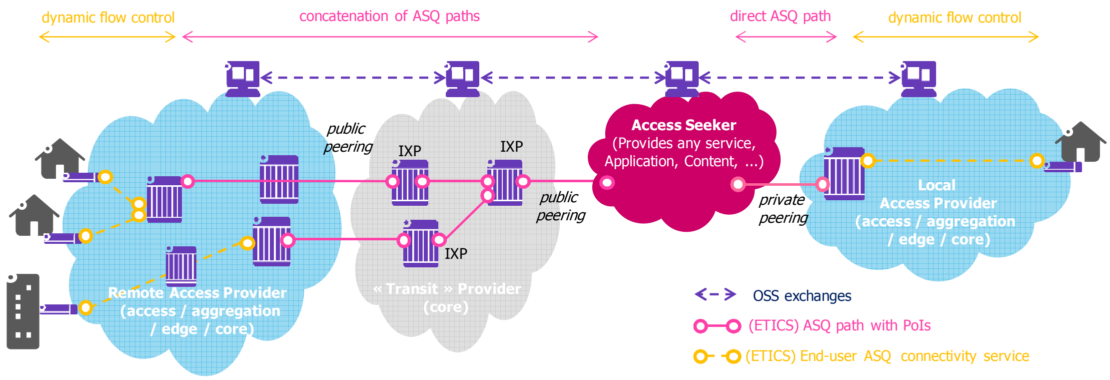
Figure 4: ASQ connectivity Product via IXP (at national level)

The ASQ connectivity product offers differentiate by bandwidth, the level of network performance they assure defined by a set of QoS parameters (delay, jitter and loss) and availability. They predefined performance in terms of business and technical attributes described in SLAs. Their points of interconnection should be at the Internet Exchange Points (IXPs). This ASQ connectivity product as defined by the Commission could in principle be implemented with existing products, but there is no functional specification set yet.

The Assured Service Quality connectivity product is inspired by the work of the EU funded project ETICS[4] (all the technical and business documents are public and available on their website). Beyond this, the ETICS project has also laid out a foundation for a more forward-looking approach to end-end service assurance based on extended ASQ concepts.

In short, ETICS introduced two types of ASQ services: ASQ paths, for aggregated traffic between nodes within and between networks (intra- and inter-network), and end-user ASQ connectivity services for individual flows between an end-user and a node inside the access provider's network. These two levels are adapted respectively to the wholesale and retail markets.

[4] ETICS (Economics and Technologies for Inter-Carrier Services) at https://www.ict-etics.eu/



<u>Figure 5:</u> ETICS concepts: ASQ paths & end-user ASQ connectivity services

ASQ paths will typically be managed in core networks and on boundary routers, and end-user ASQ connectivity services more in edge/access nodes. ASQ paths will be long lasting services negotiated (and eventually resized) from time to time, while end-user ASQ connectivity services will be dynamically mapped into the ASQ paths at the dynamicity of end users' flows. **Note that this dynamicity differentiates the ASQ connectivity service concept from the Bitstream or Virtual Unbundling case (where end-user connectivity is provided on a more static per-subscription basis).**

A further distinction is that an ASQ path can cover a PoI-to-PoI transport (e.g. offering a transit service for a remote access seeker), or a so-called "Point-to-Region" service.

The PoI-to-PoI ASQ service in core networks clearly complements the above mentioned bitstream services. The Point-to-Region service defined by ETICS is a bit different. A region is defined by a group of addressable destination points (e.g. a set of IP addresses, an IP prefix, etc.). An access provider can combine a Point-to-Region ASQ with an access and aggregation segment PoI-to-PoI ASQ. The combined Point-to-Region and PoI-to-PoI ASQs may not offer the same level guarantees. For example, Point-to-Region ASQ may have fixed guarantees such as used in context of triple play TV service and the PoI-to-PoI ASQ could only have soft or relative QoS guarantees (ala diffServ, a.k.a. "better than Best Effort" by some operators in ETICS), or it could be the other way round (relative guarantees in the access, and stricter guarantees in the aggregation and core parts). Offering only statistical guarantees per end-user flow proves to be lighter touch for the access provider, but of course would not allow for a full end-end service guarantee. (Stricter guarantees in the access segment could be offered with additional control admission on end user flows to avoid degrading already established end-user flows.)

In addition to the classical QoS parameters mentioned above, an ETICS ASQ path can take into account routing policies, so that the traffic can be bounded to a geographical area. Different technologies (IP routing, MPLS-TE) can be used. Another difference relies on the fact that an ASQ path could be proposed not only on private interconnection points but also on public ones. Different routes can be chosen, depending on the technical criteria and on the price of the ASQ path. An end-to-end ASQ path can be built in cascaded manner, through bilateral agreements among operators along the path, or in a centralized manner when an operator has the knowledge of ASQ (segment) paths proposed by other operators, which allows it to build the end-to-end ASQ path on its own.

HOW TO BUILD A WHOLESALE ACCESS PRODUCT?

A wholesale access product is built upon requirements from the access provider and access seekers, and obligations set by national regulatory and competition authorities.

Requirements

Wholesale access products should allow a minimum feature set for unicast and multicast connectivity, and QoS and management requirements.

The features described are based from customer deployments and the contribution of Alcatel-Lucent to several telecommunications industry alliances and technical forums. A short selection hereafter have published documents related to access wholesaling and more.

Country	Industry alliance or technical forum
Australia	Communications Alliance Ltd.
Germany	NGA Forum
International	Broadband Forum Metro Ethernet Forum
UK	NICC Standards Ltd.

Table 2: Telecommunications industry alliances and technical forums

Unicast connectivity

The access seeker must be able to reach any user, with a predetermined packet format (agreed upon with the access provider). The connectivity will have the usual features of transparency (e.g. for business users taking a Transparent LAN service offer), control of user-to-user connectivity, security (e.g. protecting against malicious spoofing), separation between users and seekers, and data integrity. The chosen technology must be able to meet the scalability expectations of the access provider.

What matters for access seeker	What matters for access provider	Mechanisms for access provider
• can access any user, • possibly with in-band visibility user line, • possibly with L2 transparency (TLS)	• can offer connectivity between UNI and NNI, with separation per seeker • can control access to services • can enforce security measures (anti-spoofing etc...)	• Broad range of Ethernet, MPLS and IP features in DSLAM/OLT and Edge Nodes • Security and subscriber management features

Table 3: What matters for unicast connectivity

Multicast connectivity

Similarly as for unicast, any user must be reachable and with the appropriate scalability. Specifically for multicasting, the access provider equipment must be able to perform the replication of a single stream into multiple streams for individual users. Additionally, the multicast addressing scheme deserves special attention; either the access seekers can agree upon avoiding overlapping multicasting addressing, or if this is not the case the access provider must have mechanisms in place to cope with such potential overlaps. Finally, the access provider must restrict the access of a given user to the channel bundles he or she has subscribed to.

What matters for access seeker	What matters for access provider	Mechanisms for access provider
• can access any user, • can apply its own multicast IP addressing scheme (Source address (1 per source), Group addresses (1 per channel))	• can offer connectivity between UNI and NNI based on multicast replication (tree building), with separation between the Seekers • can protect already watched channels from resource starvation (Resource Admission Control) • can control access per user to channel (bundles)	• IGMP proxy/snooping/reporting at various points • Source specific multicasting / Multiple IGMP channels

Table 4: What matters for multicast connectivity

QoS and contention

The access provider must provide QoS-awareness, to differentiate between different traffic classes, and offer a range of corresponding SLA guarantees to candidate access seekers. On the other hand, the access provider also enforces the bandwidth limitations associated to the SLAs, preventing misuse of its network, and protecting the in-profile traffic.

There is no contention as long as the sum of the individual services can fit within the existing capacity of the equipment. Such a dimensioning is typically only done for the highest priority traffic classes in residential services, and for all guaranteed rates in business services. Note that multicast is a special case as it involves "creating" new traffic at the replication points.

What matters for access seeker	What matters for access provider	Mechanisms for access provider
• can access any user with predictable guarantees in terms of capacity (and delay, jitter, loss) for given applications (with associated given CoS). Non-guaranteed traffic will experience a given contention ratio. • fairness: not be discriminated wrt other Access Seekers • has tools to monitor SLAs	• can offer a range of SLA profiles based on such guarantees • in a cost-efficient way (= may perform overbooking in its network, has to take care of necessary capacity upgrades when needed) • can enforce bandwidth limits per user.CoS (profiles) and per aggregated seeker capacity, to preserve its network • can protect running services (Resource Admission Control) and control access	• Full provider network must be QoS-aware, in other words applies prioritization with proper queuing buffer acceptance and scheduling, (re)marking (optionally colouring) • Policing at UNI and NNI. Traffic Engineering of the network capacities. • Resource Admission Control and Authorized Admission Control • At PoI, agreement on connectivity services, CoS with their marking, performance guarantees per CoS

authorization to services

Table 5: *What matters for QoS and contention*

Management requirements

The access seeker needs per-user configurations to be applied in the equipments of the access provider. Such configurations depend on the user's selected services and SLAs. Also, access seekers will need information from the access provider in terms of statistics and connectivity & fault monitoring for their respective users. For automating these processes, interaction at OSS level is needed between the access provider and the access seekers. Additionally, a web-based portal could prove useful for end-users to select their access seekers and their associated profiles and services. This portal could then give updated feedback to the OSS layer.

What matters for access seeker	What matters for access provider	Mechanisms for access provider
• Manage users & their subscription profiles • Generate billing towards users • Alarm notification and troubleshooting support from Access Provider	• Service Provisioning • Provision and update user profiles • Tools for service and network management and trouble-shooting	• OSS/BSS platforms for interaction with EMS/NMS layer and access seekers

Table 6: *What matters for management requirements*

Extra requirement for synchronous payload: synchronization

It is possible to extend the offer of wholesale access products beyond the traditional packet-based residential and business applications. Two examples are the support of legacy leased lines (carrying TDM) and Mobile Backhauling. Their specificity is that these applications require to carry data based on signals organized in synchronous sub-channels instead of asynchronous packets.

The transport of TDM payload over a Packet Switched Network can be done by leans of pseudo-wire tunnels. Whenever synchronous payload is to be transported, a synchronisation signal will be required at the end terminal (e.g. a TDM switch or a Base Station). Such signal must be provided by the network. The precision requirements of the synchronisation depend on the application type (frequency synchronisation for leased lines and 2G/3G, frequency and phase synchronisation for some LTE variants). The delivery of the synchronisation can be either transparent for the access network (each connection carrying an own clock signal) or provided by the access network itself (a single clock reference for all connections). Also, different technologies exist to distribute a clock signal throughout a packet-based switched network. Finally, different access technologies use different techniques to carry synchronisation on the physical layer (DSL, PON, point-point).

The technical complexity is out of scope of this document, but it is clear that an agreement between the Provider and Access Seekers is needed on the delivery method and precision of synchronisation.

Extra requirement for nomadism: authentication

The growth in wireless data consumption (both by means of mobile networks and WiFi offload or hotspot networks) goes on unabatedly. Wholesaling could also be extended to support wireless connectivities, taking into account device nomadicity (i.e. roaming between different wireless networks). Whenever nomadicity would be linked to traffic differentiation (like in Hotspot 2.0), QoS will be needed (both at SLA level and as mechanism in the network). As SLAs are monetized, a proper device authentication stage will be required. Multiple authentication technologies exist, involving protocol exchanges between the terminal and the access network.

The choice of authentication method is out of scope of this document. A suitable authentication interaction between terminal and Access Provider network will be needed for supporting nomadicity.

OBLIGATIONS FROM NATIONAL REGULATORY AND COMPETITION AUTHORITIES

To check that an efficient access seeker would be able to compete with an access provider, access providers offering wholesale bitstream access are mandated to comply with certain obligations relevant to:

- Transparency
- Equivalent conditions of access
- Non-discrimination
- Procedures for migrating to NGA access
- Pricing

Transparency

A transparency obligation comprise of a number of clearly specified KPIs (such as ordering, delivery, fault repair, quality of service…), an effective enforcement and monitoring mechanism (such as internal or external regular audits) and publication of the KPIs.

Equivalent conditions of access

The wholesale access products offered by the access provider to access seekers are comparable to the products it provides to its retail division:

- in terms of functionality, price, systems and processes (Equivalence of Input, i.e. EoI)
- in terms of functionality and price, but they may be provided by different systems and processes, i.e. using different inputs (Equivalence of Output, i.e. EoO)

In principle, equivalence of input is favoured to ensure that all players rely on the same conditions. If it is deemed disproportionate due to the cost of reorganising provisioning systems, equivalence of output will apply with potential non-discrimination measures to ensure that the access seekers are not discriminated against the access provider's retail business.

Non-discrimination

To safeguard competition, it is common to have measures for the access provider not to discriminate access seekers. These measures may impact the characteristics of wholesale products such as on:

- Technical features: impose a multicast functionality in a bitstream access product to enable access seekers to provide video services like IPTV and video on demand
- Pricing: request for ex-ante price control obligation
- Technical and economics parameters: carry out technical and economic replicability tests on retail offers in case of equivalence of output
- Operations: equality of treatment with equivalence of input and not output (as described earlier)
- Accounting separation

Procedures for migrating to NGA access

It is required from the access provider to put forward a migration procedure for access seekers in the event of planned changes in its network topology, particularly:

- the timing for replacing parts and
- any plans to decommission currently used interconnection points.

The assurance of efficient switching processes from physical unbundling will allow access seekers to switch their customers from legacy to NGA/NGN networks.

Pricing

Pricing is set or reviewed from carrying out a margin-squeeze test to ensure that access seekers are in a position to match the access provider's offer if they wanted to (this is at least the recommendation from the European Commission).

SUMMARY

These wholesale bitstream and IPstream access products have all the features to allow competitors to deliver services with a degree of control that is similar to that achieved with physical unbundling. They allow differentiation provided that access seekers secure some key features and SLAs and SLGs under transparency and non-discriminatory terms.

ALCATEL-LUCENT POSITION

Alcatel-Lucent supports both market infrastructure- and service-based competition models, i.e. all wholesale and retail broadband/service products configured on ISAM/FTTU and IPD equipments which support such competition models including virtual unbundling (ISAM/FTTU + Ethernet switches, IPD SAS) and next-generation bitstream and IPstream (ISAM/FTTU + IPD ESS/SR). Note that the individual feature support is to be assessed on a per-platform case.

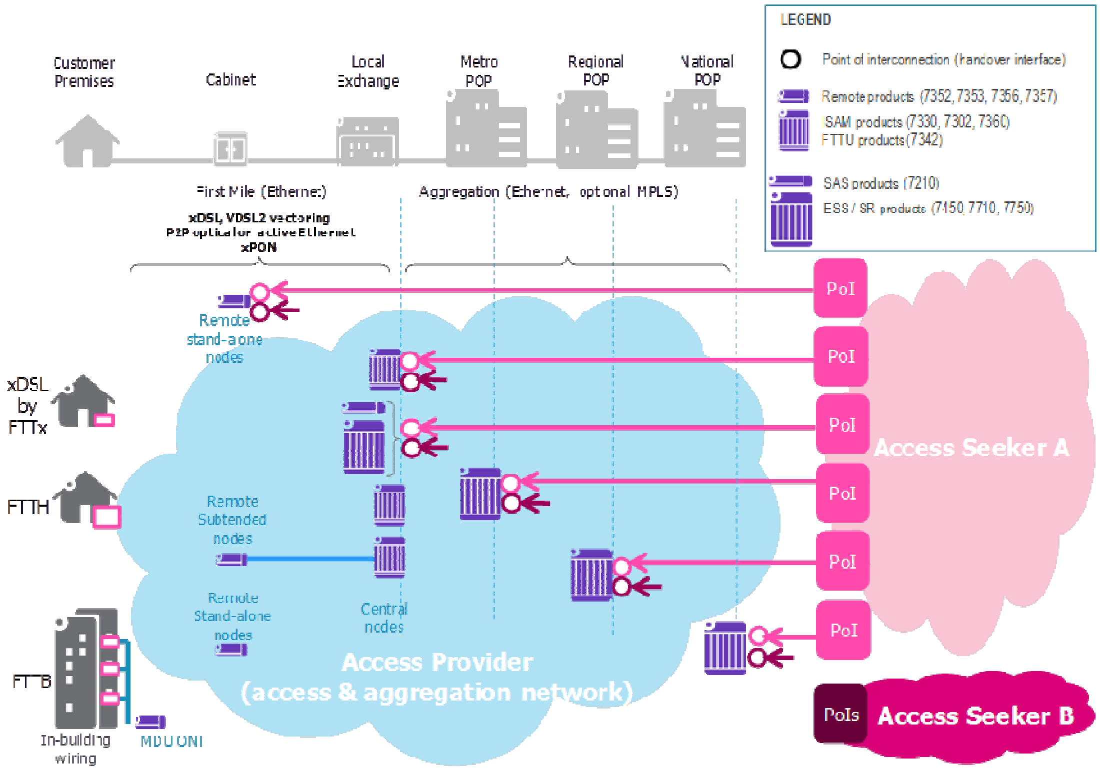


Figure 7: ALU products in context of Fixed Wholesaling

Alcatel-Lucent is a major contributor to country specifications and standardisation of wholesale products with telecom carriers, national regulators and standardisation bodies.

Alcatel-Lucent has also been at the forefront of research in specifying and testing ASQ connectivity products (European FP7 ETICS research project) and welcomes any initiative toward the development of enterprise-grade services.

It is to be noted that whereas the Virtual Unbundling and Next-Generation Bitstream solutions can be based on existing products, the ETICS approach of ASQ products represents more an evolution path, with some aspects being possible in current network architectures, and other concepts requiring more advanced technologies and yet-to-be developed products, as described in the following table. Also the underpinning OSS/BSS layer would require updates and new platforms.

Authors

Corporate Public Affairs – Florian Damas

Broadband Access BU – François Fredricx

Bell Labs – Nicolas Le Sauze and Richard Douville