CEO Roundtable

WG2: Technical Framework for Digital Delivery – Open Access, Interoperability and Connectivity

Final report

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1 Executive Summary and Key Recommendations to the European Commission

The future high speed Internet landscape will be a multi-carrier and multi-technology environment. This will result in additional exercises with respect to the interworking of networks, platforms, terminal devices and B2B processes and availability of end-to-end services. In order to foster investment and innovation in NGA/N and the Internet Ecosystem, it is undoubtedly necessary to achieve sufficient levels of interoperability and standardisation.

The goal of this Working Group was to achieve a common understanding of the role and the leverage of interoperability and standardisation for facilitating investment and innovation in NGA/NGN and the Internet Ecosystem. The Working Group (WG) has specifically focused the discussion on two options, which are widely accepted as technologically feasible today or in the very near future and that will help achieving the goals specified in the Digital Agenda for Europe (DAE) in a timely and efficient manner.

1. **Technical Evolution towards a future proof NG environment.** This includes the promotion and harmonized implementation of "Open Access" conceptions for Next Generation Access understood as a technological neutral concept which enables every operator to target all customers and which thereby offers the customers the biggest choice possible.,
2. **The need for QoS based Interconnection.** This includes the definition of a basic set of "quality classes" and the adoption of a roadmap for their wide implementation in order to enable new Internet business models and guaranteeing the security and quality of service delivery.

The Working Group also noted a lack of interoperability with proprietary applications and platforms that have reached widespread adoption by the internet users. As a consequence 3rd party innovation may be hampered and the freedom of choice by end users may be limited, especially when trying to migrate or transfer data/content out of "walled gardens". Other examples include proprietary DRM solutions, codecs and protocols as well as mobile application platforms for web stores or developers. There was not sufficient time to solve the issue in the WG. Hence, the initial discussions within the WG did not lead to concrete recommendations but there is broad agreement that this should be carefully analysed in the near future.

Chapter 2 summarizes and documents the outcomes of the WG's discussions on suitable access options and standards that should be further promoted. Chapter 3 illustrates the current state of IP interconnection standards that will allow QoS differentiation, both "within the Internet" and "outside the Internet", and derives key recommendations. The appendix contains further information, specifically an input[1] document to the WG that provides an overview of the IPeXchange framework (as specified by the GSM-Association). This does not imply that the group considers IPX to be the only viable quality assured IP interconnection solution that is ready for implementation[2].

Evolution towards a future proof NG environment

In order to foster investments, the WG focused on identifying timely, economically justifiable and technologically feasible access options whilst recognizing that the business case for infrastructure investment is highly uncertain (due to high investment needs, uncertain regulatory interventions,

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[1] Joint paper provided Telefonica and Vodafone.

[2] The i3Forum has also conducted extensive standardization work which is documented on www.i3forum.org

unpredictable future demand as well as willingness to pay). This includes the future role of wireless access technologies. While wireless access will certainly allow offering higher bandwidths where fibre deployment is not economically justifiable it is also evident that wireless will not alone be sufficient to achieve the ambitious bandwidth goals specified in the DAE. For capacity intensive services like e.g. HDTV streaming fixed broadband access technology will in parallel remain necessary.

Evidently Mobile broadband access with the technologies WCDMA/HSPA and LTE is increasingly available throughout Europe and delivers a basic internet access to users of smart phones and computers. Mobile broadband is an infrastructure based alternative to deliver a high speed broadband experience. Mobile broadband will play a significant role in delivering broadband to remote areas in many countries.

The WG focussed its discussion on identifying the most promising options to promote investment in and access to fixed net deployments that will deliver the politically desired speeds. The WG acknowledged that the debate on “ideal” architectures – P2P vs. GPON – and according regulatory prescriptions has been going on for a while and will be part of the debate in WG3.

While the WG could not agree on all issues and the definition of Open Access there is a broad support on important cornerstones and the benefits of Open Access:

- Open Access should be understood as a technological neutral concept which enables every operator to target all customers and which thereby offers the customers the biggest choice possible.
- Open Access constitutes a market driven commercial negotiation. As such it should have priority over regulatory intervention.
- Whenever - yet to be agreed - Open Access rules are met, investors should have the certainty that regulatory interventions, if any, will not pre-empt commercial negotiations and flexibility for price setting.
- If operators do not behave in accordance with Open Access rules other procedures may be needed that ensures access and competition in the considered geographical area, e.g. through appropriately regulated access based on the market analysis process and SMP finding in that region.
- Such an Open Access Model promotes investment incentives, ensures nationwide interoperability, increases network utilization and provides fair access conditions based on market-driven mechanisms.

A special focus of this document will be on NG BSA given the standardization gaps. Furthermore the standardization needs in the area of physical unbundleability, with particular focus on wavelength unbundleability were selected in order to enable competition on the active layer and over a shared fibre infrastructure.

The standardisation of the SLA to be offered by each solution, both passive and active, is a key component for the implementation and application of open principles in the NGA environment.

Evolution towards a future proof NG environment: Key recommendations

As a conclusion, the WG recommends the European Commission to:

1. Promote the adoption of an ‘Open Access’ concept throughout the EU, i.e. open access to ducts, symmetrical access to in-building wiring and market-driven wholesale bitstream (as described in chapter 2)

2. Play a facilitating and coordinating role to help the industry agree on the standardisation of Next Generation Bitstream wholesale offerings. This NG BSA should be based on connectivity at Layer 2. The further details of the enhanced functional requirements like QoS, OSS, flexible interconnection, etc. should be specified[3].
3. Enable the deployment of alternative technical solutions to promote investment in rural broadband deployment (e.g. wireless technologies, VDSL2-Vectoring).
4. Assure a clear definition of the “A10-NSP” and “U” interfaces and prepare the way for a shared management of the NTU/Home Gateway between access seeker and access provider.

The need for QoS based Interconnection

The Group recognized that there are no known significant standardization gaps with regard to QoS interconnection. Much to the contrary, there is a multitude of partially overlapping standards. What is lacking is a broad agreement on standards that should be widely adopted and on how they should be implemented in detail.

There is a general consensus that a small number of quality classes are needed in addition to today’s “best-effort” internet and should be implemented across network boarders as soon as possible. There is no need to decide whether this should be done “within” or “outside” of the public Internet because both options are feasible and desirable. They complement each other and serve different purposes. Extranet solutions outside the public Internet are generally considered to better achieve guaranteed End-to-End quality for service delivery (e.g. speed, packet loss, security). Extranet solutions are already widely standardised, up to the point of market readiness and actual implementation (in the case of the IPX solutions from the i3Forum and the GSMA). At the same time the vast majority of the participating companies agreed that there is merit in establishing concrete definitions of quality classes at the network borders in order to enable relative quality of services to be supported across networks within the public Internet.

QoS Based Interconnection: Key Recommendations

As a conclusion, the WG recommends the European Commission to:

1. Seek a tangible “Quick Win” by actively encouraging the practical implementation and usage of industry agreed interconnection standards (such as IPX) which enable new technical and commercial models for quality assured end-to-end services across network borders.
2. Reinforce explicit political support for business models based on quality and price differentiation[4] and establish the legal certainty needed to invest into actual deployments of increased transport capacity.
3. Encourage the harmonization of QoS models between the GSMA and i3 Forum.
4. Encourage standardization of parameters for QoS classes and associated parameters for use “within” the internet, i.e. at the level of IP transport interconnection, to enable new business models for all players along the internet value chain
5. Promote the timely finalization of ongoing work regarding QoS IP mapping within the ITU (e.g. new rec. Y.QoSmap) and ETSI.

[3] There where also proposals to study wholesale access based on Layer 3, but this option seems not to be supported by access seekers currently.

[4] This includes – of course – the obligation to make non-discriminatory offerings to both sides of the two sided market.

2 NG Access and NG BSA

The future high speed Internet landscape will continue to be a multi-carrier and multi-technology environment (“patchwork networks”). This will result in additional exercises with respect to the interworking of networks, platforms, terminal devices and B2B processes as well as the availability of end-to-end services. In order to foster investment and innovation in NGA/N and the Internet Ecosystem and to ensure competition and consumers’ choice, it is undoubtedly necessary to achieve sufficient levels of interoperability and standardisation. The objective of this Working Group (WG) was to achieve a common understanding of the role and the leverage of interoperability and standardisation for achieving those goals. In a second step the WG identified the most promising options and agreed on technical reference architectures.

For this purpose, the Working Group explored the following issues and questions in a technologically neutral manner:

- What are the issues, including the appropriate openness of current or future standards?
- What are the minimum requirements to ensure interoperability between networks, devices and platforms?
- What are the priorities and how should they be addressed?
- What could/should be influenced by the European Commission?

2.1 The benefits of Open Access

As shown by various national and international (scientific) FTTx-roll-out studies and business cases the economics do not support the rapid deployment of a full scale fiber-based NGA network. A common view is the fact, that in general the fixed cost of deployment is much higher than the variable cost (additional cost per customer). Hence, the initial investment costs are very high, while the expectations for an acceptable payback period are uncertain and depend significantly on the uptake rate for superfast broadband. As a consequence only a limited NGA roll-out can be expected, most likely focusing on very densely populated areas. Uncertainty about the future regulatory and competitive landscape further hampers the prospects for wide-spread NGA rollout.

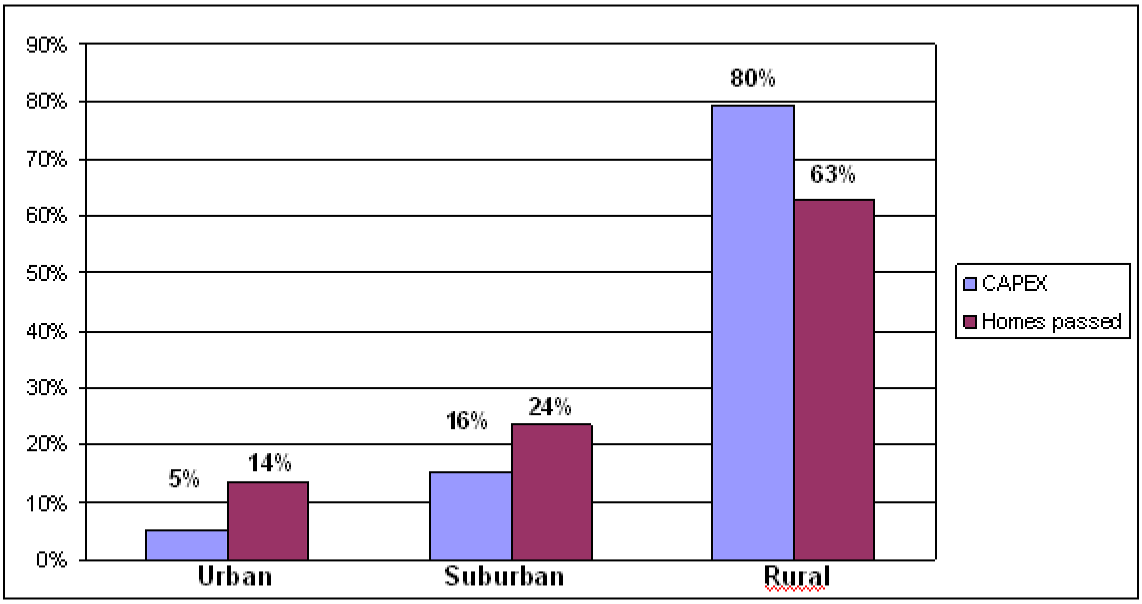

Fig: 1: FTTH deployment: share of investment per deployment cluster, derivate from the WIK presentation from the Ultra Broadband Conference 2010 in Berlin

Most studies differentiate the total area to be covered into three clusters: urban, suburban and rural. Independent of the given technology, the CAPEX and customer distribution curve has a similar shape in most European countries. This is due to the fact that roughly 70-80% of the CAPEX is attributable to construction costs. Depending on the business case, deployment typically starts very cost effective in urban areas. But CAPEX is dramatically rising on a per capita basis as population density falls.

The achievement of the Digital Agenda for Europe goals crucially depend on the wide spread deployment of broadband infrastructure. In broader terms, European investment levels are substantially below those in the U.S.: OECD data shows that in Europe (EU-15) investment per capita amounts to $144, whereas in the U.S. $247 per capita are invested in telecommunications infrastructure (source: OECD Communications Outlook 2009). For suburban or rural areas this lack of private investment is further aggravated. For this purpose additional technical solutions to encourage broadband deployment in remote rural areas should be evaluated.

Additionally, the future NGA landscape will continue to be a multi-carrier, multi technology environment leading to a “patchwork-network”. Numerous initiatives comprising vertically integrated telecommunications operators, service providers but also municipalities and utilities reveal, that there will be different competition models in which “Open Access” becomes relevant. “Open Access” is not specific to a certain competition model, technology or form of industrial organization. It is an overall objective to assure interoperability and to promote incentives to invest and innovate and to ensure competition and consumers’ choice.

According to BEREC report (11) 05 on “open access”: *The term “open access” is neither defined in the Regulatory Framework, nor in any other legal document. Generally, it is understood as referring to a form of wholesale access whereby operators are offered transport and non-discriminatory wholesale access, thereby enhancing competitions at the retail level.*

The WG could not solve all issues related to the Open Access conception. In excess of the below mentioned cornerstones of Open Access the WG did not work out further details in particular with respect to concrete regulatory measures which need to coincide with Open Access conceptions. But basically and essentially there is a clear need to arrive at a harmonized “Open Access” definition and thereby establish a clear and coherent set of rules. For this purpose Open Access should be understood as a concept which is based on commercial negotiations for bilateral access. As such Open Access takes priority over regulatory intervention. Whenever Open Access rules are met investors should have the certainty that further regulatory interventions will not occur or will only materialize on a level that does not pre-empt commercial negotiations and price setting flexibility. However, in case that Open Access rules are not met other procedures may be needed to assure access in that particular geographical area, e.g. through appropriately regulated access based on the market analysis process and SMP finding in that region. Such an Open Access concept promotes investment incentives, increases network utilization and provides fair access conditions based on market-driven mechanisms.

As it is not the focus of WG2 to discuss the evolution of detailed access regulatory policy this paper identifies and evaluates technological solutions that are coherent with wide spread network deployment. The working group discussed and analyzed different access options which are to be seen as appropriate levers for timely and efficiently achieving the DAE's objectives.

Although a special focus will be on NG BSA given the standardization gaps are evident, the paper will also touch on the standardization needs in the area of physical unbundlability, with particular focus on wavelength unbundlability (there is much less need for fiber line unbundling specification due to copper line unbundling experience), which will enable competition on the active layer over a shared fibre infrastructure that could increase competition, product differentiation and network renewal investments.

2.2 Passive and Active Access

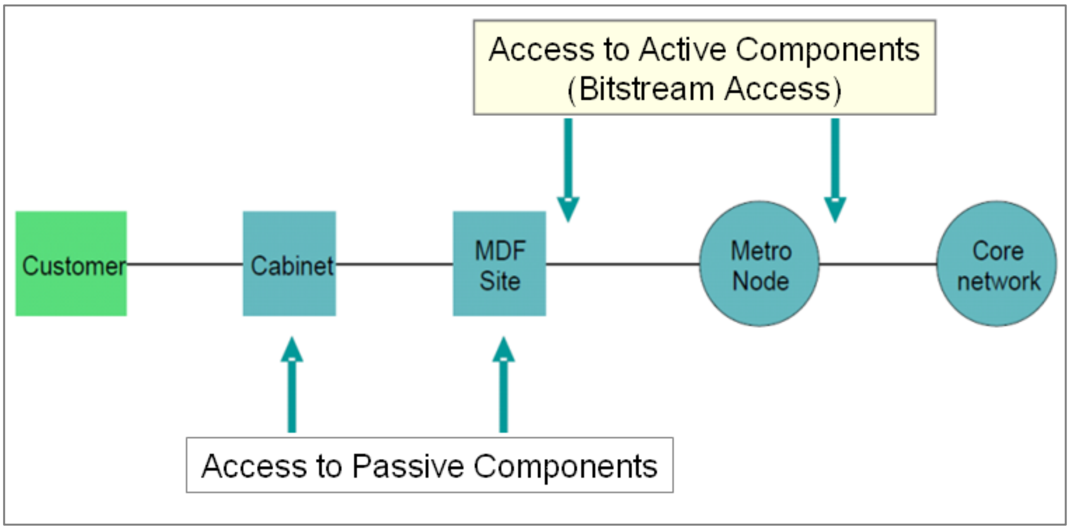

Fig. 2: Passive and Active Access

In the NGA context, cooperation between network operators and service providers will be even more important. To be able to use the lines, connections and applications, uniform and standardized interfaces and reference architectures are required at different levels – topology, physics, transport, quality of service (QoS) and SLA, signaling and controlling, DRM, network management and processes. All of these have to ensure the ability to provide a standardized interface to any access seeker and it is essential to describe or standardize the technical parameters for the interconnection interface.

The established architecture of access networks differentiates between the passive and active infrastructure, the network level, service level, and the technology in the end customer area. The passive infrastructure comprises cable trenches, cable ducts, and fiber optic cables. The active network is based on this infrastructure and consists of network devices and systems, as well as business and operating support systems which allow end users different applications. Fiber optic-based access network architectures are summarized under the term FTTx, encompassing Fiber to the Curb or Cabinet (FTTC), Fiber to the Building (FTTB) and Fiber to the Home (FTTH). Since with each stage the fiber optic moves closer to the customer premises, and therefore the possible bandwidth that is available to customers increases, this also describes a possible migration strategy (of course FTTH can also be deployed directly from the start).

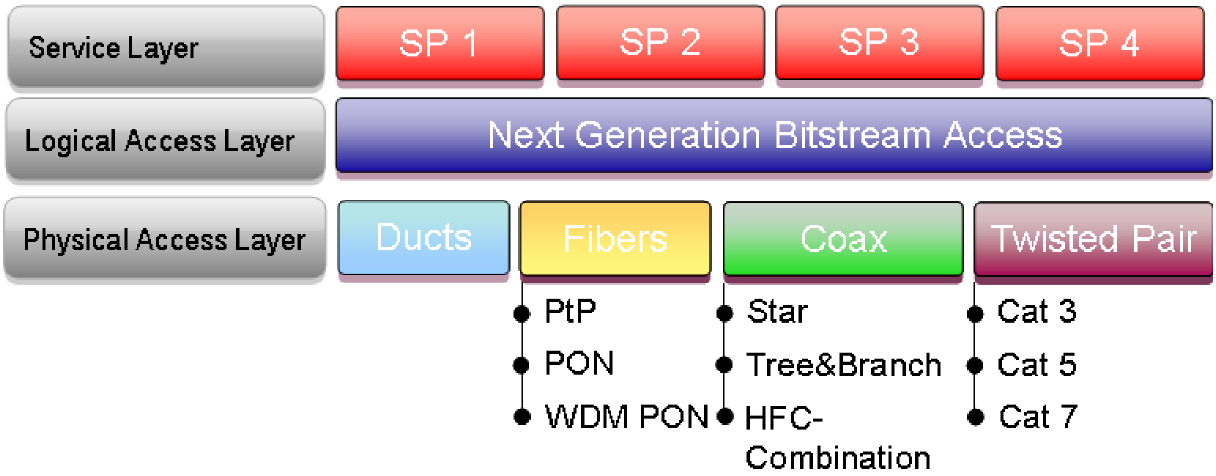

Fig. 3: Interaction of different layer, player and networks (illustrative)

Today, fixed access networks can be realized with different technologies like typical telecommunication networks with copper, fiber, cable or wireless. Depending on the requirements from the customer's perspective and economic framework conditions, networks can be set up as active (Active Optical Network, AON) or passive (Passive Optical Network, PON) access networks with fiber optic technologies.

Next generation access shall be a technology neutral concept based on two network levels, which are defined as physical passive access and virtual active access. Network access could be offered as duct access, as an unbundled optical fiber, as the wavelength transported to it, or as Bit Stream Access (BSA). In this context, a BSA with special properties is also known as a virtual subscriber connection. The network provider takes care of the SLAs described within the wholesale access service definition. The access seeker provides his service via the network provider's network to his customers. On the other hand the access seeker may be in direct interaction with one or more content or service providers to enable theses services to his customers.

For the further expansion of broadband access networks, it is recommended that the focus is placed on investing in infrastructure and technology to expand high performance, optical access networks. The technical and operational concepts of these networks should be coherent with openness principles from the start. The necessary standardizations and reference architectures that largely exist from the standardization committees have to be adapted and further developed accordingly. With regard to virtual active access (e.g. NG-BSA) the standardization gaps are more prominent compared to physical passive access. Hence, the WG took special effort in identifying respective standardization needs. The most important sources of the standards and reference architectures to be complied with are the Broadband Forum, NICC, FSAN, FTTH Council, MEF, ITU-T, ETSI/TISPAN, 3GPP and the Telemanagement Forum.

2.2.1 Standardization Gaps and Needs for the Passive Access

Physical passive infrastructure may include e.g. the right of way or access to ducts. The – theoretically possible – passive access is widely described in different papers and articles[5].

Currently the highest layer of passive access unbundling is the fiber unbundling at the metropolitan point of presence; in a long term perspective also unbundling of the wavelength could be included. Depending on the technological evolution market readiness can be expected between 2015 and 2017 given that the decision and standardization of efficient wavelength unbundling is still ongoing. The latest version of the whitepaper agreed by FSAN (Full Service Access Node) on the next generation of PON systems includes a section on spectrum (wavelength) flexibility, which will pave the way for openness at layer 1 over a shared fibre (open PON). In addition, technology agnostic industry initiatives such as OLI (Open Lambda Initiative) have been set up by the vendor community with the participation of a subset of operators with the intent of "enabling infrastructure sharing to foster a highly competitive landscape in optical metro-access networks by minimizing network duplication". The discussion within the FSAN and OLI initiatives is currently in the initial phase, and although it is not expected to have an impact before 2015, it is essential that policy makers and operators give the appropriate level of priority to the wavelength unbundling aspects as it may provide benefits in the long run.

2.2.2 Standardization Gaps and Needs for the Active Access

Focus of the WG was to contribute to and clarify options on the active access layer as there are several optional descriptions. Discussions on the technical definition of an NG BSA product take place in several European Countries (e.g. UK, Germany and Italy). A European view on the suitable technical standards for NG BSA could be promoted as an outcome of this activity.

In order to achieve EU wide harmonization NG Bitstream Access has to be defined in a technologically neutral manner, i.e. accessibility has to be granted for every underlying technology. Current possible technologies are Point to Point structures or hybrid – Fiber-Coax – multiple medium architectures as well as XPON systems. The choice of the used technology may depend on the historically given structure of the networks and ducts as well as the availability of duct space and the structure, location and number of customers.

2.2.2.1 NGA Interfaces and specifications

To enable the NG Bitstream Access product, a clear defined A10-NSP and U interface is needed to ensure the freedom of technology for the access provider and the security to establish processes for the access seeker.

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[5] Telecoms infrastructure access, Ofcom, 3 March, 2009.
Next Generation Access - Collection of Factual Information and new Issues of NGA Roll-Out, BEREC, Feb. 2011

The interface description shall:

- gives a view of the delivery from the access seekers customer side, interface "U"
- describes the expectation of the access provider to the traffic of the access seeker, interface "A10-NSP"

Fig. 4 shows the "U" and "A10-NSP" interfaces in current xDSL CGA reference architecture. It is expected the NGN network architecture may change, and currently being discussed.

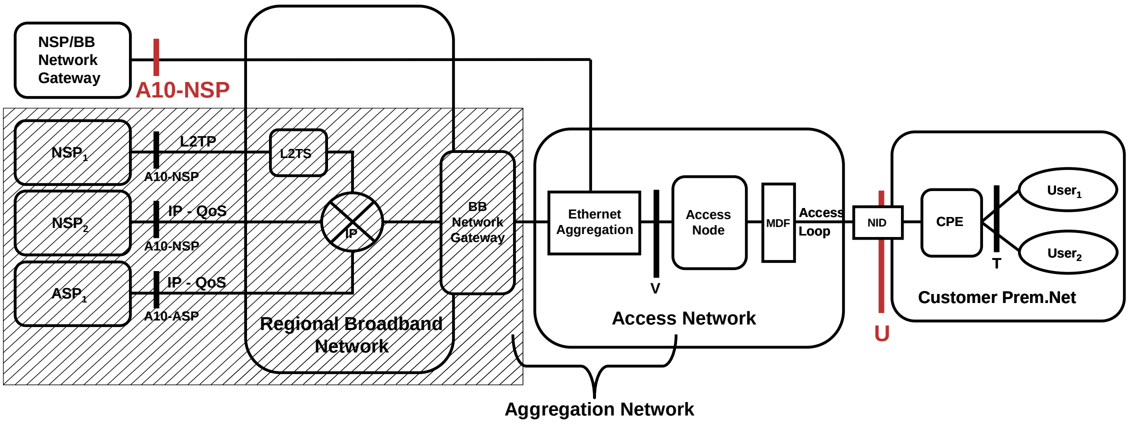


Fig. 4: NG Bitstream Access Interface Reference Architecture[6]

2.2.2.2 Key characteristics of an NG BSA

To offer services over a broadband access network, independent of the type of access provider (e.g. cable network provider or telecommunication network provider) an access seeker will need to interface with the access network provider both at the customer premises and at the access seekers point of interconnect. The demarcation between the access network provider and the access seeker in the end user premises is called the Network Termination Unit (NTU). In order to provide a wholesale access, an access network provider offers connectivity from the access seeker's point of interconnect to the NTU.

2.2.2.3 Next Generation Bitstream Access Stakeholder and Requirements:

1. **Access provider**: The NG BSA provider is responsible for the provision of active and passive infrastructure over which NG BSA traffic is delivered. The NG BSA provider offers standardised interfaces to which NG BSA user can connect, and delivers the NG BSA user traffic between these interfaces, across the NG BSA domain. The NG BSA domain extends from the end-user premises to an interconnect point higher up in the network.

2. **Access seeker** (Service Provider): The NG BSA access seeker purchases access from the NG BSA provider to deliver services such as e.g. voice, video and internet connectivity. The NG BSA access seeker has a direct, contractual relationship with the end-user or with other

[6] Source: Broadband Forum TR-101

communications providers on a wholesale basis. NG BSA access seeker may include ISPs and triple-play operators.

3. **Customer:** The customer is the ultimate recipient of services provided over NG BSA and has direct business relationship with the NG BSA access seeker or the network operator.

4. **CPE:**

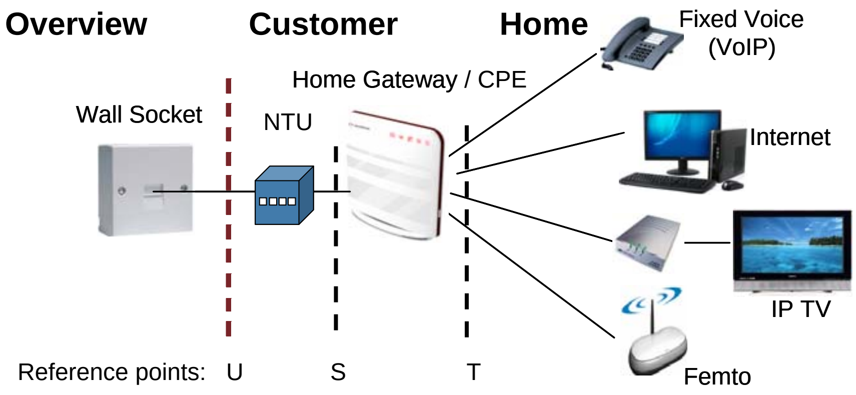


Fig. 5: In-house Reference Points

The figure illustrates the different reference points of the in-house network, while parts of these reference points can also be deployed outside the house or flat. The NTU displays the access network provider demarcation point. The NTU provides only a standardized LAN interface like Ethernet. All other interfaces like WLAN or POTS-Interfaces, IPTV-Interface etc., shall be provided by the Home-Gateway (of the access seeker). The Home Gateway or CPE is the service delivery point for the access seekers' customer.

The access provider needs to ensure the NTU deployed at the user premise is compatible with the equipment deployed by the access provider at the access node (e.g. central office). In this way the access provider can configure, manage and monitoring the NTU.

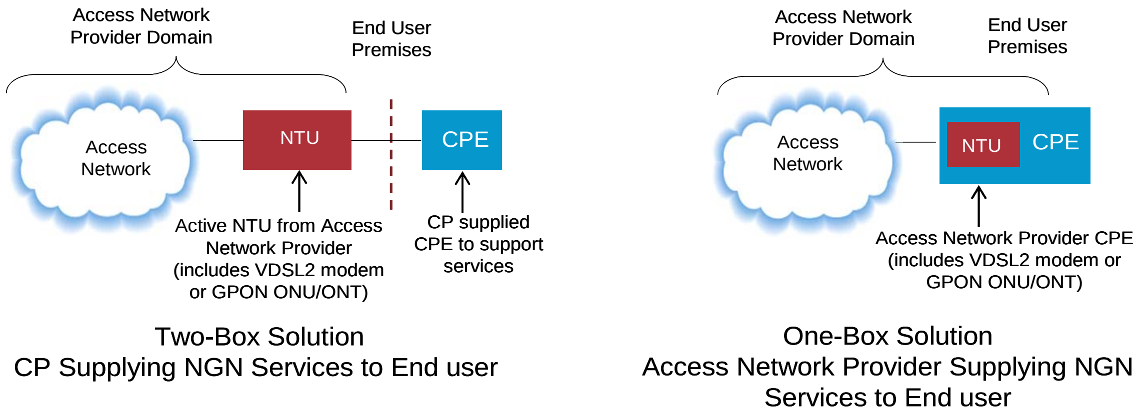


Fig. 6: One- and Two Box solution of the NTU and the CPE

Both one and two box solutions shall be possible. At the beginning of deploying new technologies it is not possible to ensure the interoperability of different vendors of NTU and access network node equipment. In that phase the two box solution could be deployed and used by the customers of the access providers and access seekers. In this case the NTU should present just Ethernet ports. Once interoperability across access node and NTU equipment manufacturers is achieved the one box solution could be used and the management of the device would then have to be shared by the access network provider and the access seeker, according to their respective roles. Given the importance of such interoperability for the development of a competitive market, greater efforts in achieving interoperability between CPEs and access network equipment is necessary. Similar to cable modems, a standardisation body, e.g. ETSI or the Broadband Forum can do the testing and certification of NTU interoperability.

Since a concatenated NTU might be unavoidable until the full standard implementation of all NTU functionalities is available, a separate NTU with an Ethernet port should be deployed.

Some participants asked for an un-branded (white labelled) NTU provided from the access provider. However, it was not possible to achieve an agreement.

2.2.2.4 Quality of Service and Class of Service

QoS and Class of Service support is demanded by almost all access seekers. However, there is no common understanding about the number of classes needed and about the technical parameters of the specific classes.

According to the ITU-T definition E.800, QoS[7] generally expresses the degree of satisfaction of a user of a service. Such a service is characterized by parameterized, application-relevant properties. Accordingly, one differentiates between service-related, operational, and security-related service features.

If one refers to the end-to-end service features according to TR-126 from the Broadband Forum (formerly DSL Forum), the QoE[8] (Quality of Experience) is a more practical degree, especially with regard to triple play.

So that the communication methods “human to human”, “human to machine” (human to network application function) and “machine to machine” (network application function to network application function) can advance smoothly, quality has to be ensured at a more abstract level.

Increasingly multimedia communication must be able to take place as purely as possible. In particular, interactive real-time applications or mission-critical applications are sensitive to QoS parameters[9] such as:

- Data rate (Throughput)
- Traffic profiles
- Delay times (latency)
- Delay variation (Jitter)
- Probability of package loss (bit error rate, frame loss, package repeat, package sequence)

[7] Collective effect of service performance parameters which ultimately determines the degree of satisfaction of a user of a service.

[8] QoE is the overall performance of a system from the point of view of the users. QoE is a measure of end-to-end performance at the services level from the user perspective and an indication of how well the system meets the user’s needs.

[9] When transferring upstream products, precisely with unbundled media such as copper, fiber optic, wavelengths, electrical and optical properties also have to be considered that depend on the network that already exists or still has to be expanded (for example, mutual influencing in the copper cable depending on the feed point mainframe, street cabinet or bending radii with fiber optic cables) and therefore have to be measured.

- Availability

These set of application related quality descriptions can be translated to a common set of four QoS classes enabled by the network:

- Real-time class
- Streaming class
- Transactional class
- Best Effort class

These classes where described in several European R&D projects (e.g. Muse) combining the QoS requirements of the application with given network parameters. The industry should agree on a set of quality classes and their KPIs for the access domain.

2.2.2.5 Multicast functionality

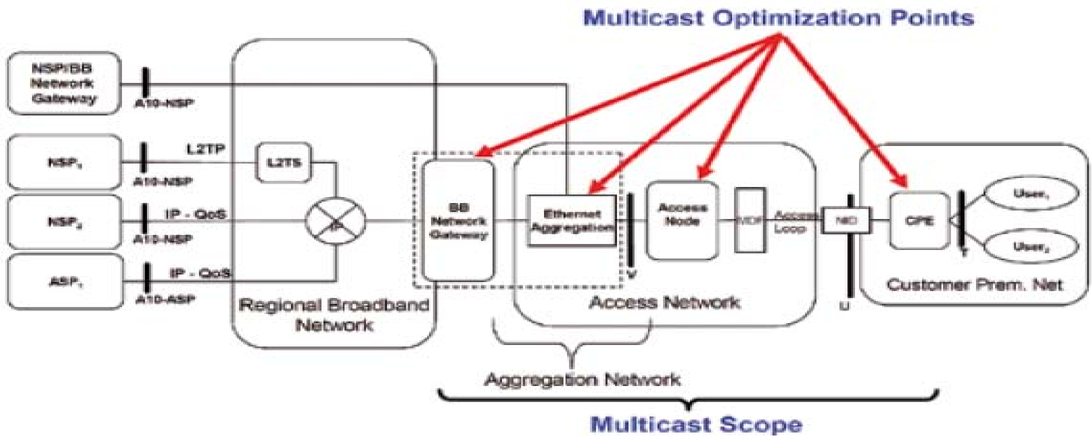


Fig. 7: Possible Multicast Replication Points of a Telecommunication Network[10]

As shown in the figure above in the example of a telecommunication network, it can be seen, that there are different possible multicast replication points. Beside these possible replication points, there are also different protocols possible. This shows that there are many ways to implement the multicast functionality.

The standardization efforts around NGN optimization points are underway. Potentially agreeing on one of two multicast optimization points need to be implemented, which should simplify the definition and implementation of multicast functionality.

Given the specificity of each European market, each market shall have the right to consider the implementation of a multicast functionality or leave it, depending on the need or the services e.g. linear TV. If multicast is required, a strict allocation of the functionality to a certain reference point of

[10] Source: Broadband Forum TR-101

the NG Bitstream Access would not allow deploying possible future innovative technologies nor protocols.

Depending on the given structure and market situation of the countries within the European Community, there shall be a decision on each market, if the implementation of multicast is required or not. If multicast is required, the access seeker shall have the right to assume a multicast function.

The multicast functionality shall be described with its related interface description. The technical realization and the decision for the location of the multicast replication point should be decided after appropriate conversations among key stakeholders, namely the access provider and access seekers and if needed the regulatory body. A multicast will be provided per access seeker and to the access seekers customers.

2.2.2.6 Ethernet based

A NG Bitstream Access product should be Ethernet based and offer connectivity at Layer 2. IP based solutions (Layer 3) typically do not offer sufficient flexibility to access seekers and are not demanded by them.

To enable future technological evolution, the interfaces should be defined in a joint effort but the freedom of choice for implementation should be kept for the access network provider.

2.2.2.1 Flexible Interconnection Points

A flexible NG Bistream Access product should offer access seekers 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 access seeker 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.[11]

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 access seeker to leverage their own core network capacity (and hence this Regional product should be cheaper than the National interconnect variant) but the access seeker 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 access seeker to collect the traffic directly at the location where the Access Node (and 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.

[11] Within the national interconnection negotiations about the resilience need to be taken into account

2.2.2.2 Requirements from Business and Operation Management Perspective

Since NG BSA business partners will not have direct access to the other partners' management systems one challenge will be the installation of IT-interfaces in order to exchange information according to the BSS/OSS requirements and functions. For example in case of:

- availability check of the access line
- provisioning of access lines according to customers product requirements incl. the "line identifier"
- failure tests the actual line information, etc.
- monitoring of service parameters

2.3 Technical solutions to encourage broadband deployment in rural areas

The costs of broadband deployment in less dense areas are substantially higher compared to dense urban areas. This renders business cases for wide deployment – especially for nationwide fibre deployment (FTTH) – very difficult to justify from the investor perspective. This chapter identifies technical alternatives that could be less expensive solutions and improve the availability of better bandwidth for all on the short-medium term and therefore might increase the incentives for investment and thereby improve the availability of broadband for all, including less dense areas. The technological restrictions and potential negative impacts on competition will obviously have to be taken into account.

Existing limitations based on the current regulatory regime will be abstracted from during this analysis.

2.3.1 Wireless solutions

Wireless broadband access with the technologies WCDMA/HSPA and LTE is already available in many parts of Europe and delivers the basic internet access to users of smart phones and wireless computers.

Wireless broadband provides a high speed broadband experience and the performance will improve in the future. The achievable data rates will depend on:

- Available spectrum bandwidth
- Spectrum allocation:
    - higher allocation leads to a smaller coverage but less customers covered with a higher data rate per customer
    - lower allocation leads to a wide coverage with a higher number of customers per base station but low data rate per customer

Statements about absolute data rate performance are under heavy discussions in the industry.

However, there will always be a significant performance difference between wireless and fixed networks, but wireless solutions will play a vital role in delivering fast broadband to areas lacking the adequate fixed infrastructures due to challenging economics (e.g. sparse population density in rural areas).

Wireless services, including mobile broadband are usually offered by several mobile network operators (MNO) each holding the right to use different parts of the radio spectrum. In most markets there are also mobile Virtual Network Operators (MVNO) that do not have a network of their own, but lease capacity from a MNO.

The competition on a mobile broadband market is thereby provided by several operators providing service. In the case of residential stationary use of mobile broadband an alternative competitive offer to fixed broadband access over fiber, copper or cable do exist.

Wireless broadband has the limitation that it can not deliver huge amounts of data in a cost efficient manner. Therefore fixed broadband continues to be used for capacity hungry applications like continuous watching of high quality video (IPTV) or business applications, but still in rural areas wireless broadband is often more cost efficient to deploy than fixed broadband.

2.3.2 Bonding

VDSL2 bonding technology is currently available and already being deployed by operators in North America (AT&T and others), APAC (PTCL in Pakistan), and Europe. Bonding allows operators to double the bitrates on VDSL2 lines (e.g. from 20Mbps at 1000m to 40Mbps at 1000m), or to deliver the same bitrates over longer distances (and thus connect more subscribers). Bonding requires two available copper access lines per subscriber, which could be challenging and not feasible in the large scale mass market case.

2.3.3 Vectoring

VDSL2 Vectoring technology including a commercial CPE, will become available in 2011, and trials have already been successfully completed with operators in North America and Europe (including Belgacom, Telecom Austria, Swisscom, Turk Telecom, PT Luxembourg, and others). Vectoring allows operators to boost speeds on VDSL2 lines by removing the crosstalk, and operate each line in near perfect, crosstalk-free conditions. Typically, this results in performance gains up to 100% (double the data rate). With Vectoring, operators could increase bitrates at 1000m to up to 40Mbps, and to up to 100Mbps at 400m. Vectoring is only economically feasible and delivering significant results when all lines are terminated on the same DSLAM (this allows cross talk noise conditions on all lines to be taken into account and cancelled).

To reap the full potential of these technologies this installation needs to be accompanied by reduced access regulations. A second telecommunication provider would not be allowed to collocate in the same cabinet nor in a disturbing range to ensure the full potential. However, this restriction has to be weighted against the benefit for the customers to achieve higher bandwidth and enable participation in the digital world for rural areas. In fact this technical limitation will not become very relevant as within rural areas even nowadays collocation in fact does not play a substantial role. The new entrants focus on the attractive dense urban areas for collocation. Furthermore, competition and choice for the customers remains through the usage of an NG-BSA.

2.3.4 Other Alternative Upcoming Options

Beyond Bonding and Vectoring, copper evolution continues with research in two noteable areas:

(i) G.Fast aims to boost speeds over very short copper loops (e.g. 200m or less) with a data rate up to 1 Gbps by looking at new coding techniques, but here is also crosstalk compensation and therefore no share of a cable prerequisite. Work is ongoing at the ITU, and requirements are also being developed in BBF.

(ii) Phantom Mode technologies combines Bonding and Vectoring to enable a virtual pair (created on top of two physical lines) to deliver up to 300Mbps at 400m (over two pairs). While these technologies are not yet ready for deployment, they provide operators with a continued evolution path for their existing copper infrastructure.

2.4 Where and how to close standardization gaps

2.4.1 Basic Principles

From the experience of network operators, a few best practice rules can be defined for a future-proof network expansion with open access systems:

- **Long-term perspective:** The new infrastructure must be suitable to meet the anticipated longer-term requirements.
- **Stable but flexible:** Requirements-oriented extensions with new lines or an upgrade of individual lines have to be possible in the network at any time.
- **Migration:** The migration to a follow-on technology in the existing infrastructure must be possible without interruption to operation.

From the network operator’s point of view, there are a few additional fundamental requirements on the design of an FTTH/FTTB network with open access systems:

- **Zero touch:** It should be possible to activate and change services without field work by engineering staff.
- **Keep it simple:** Heterogeneous solutions and platforms that are operated in parallel should be avoided wherever possible.

2.5 Recommendations for further steps

The industry should agree on voluntary symmetrical offering of Next Generation Bitstream. The details of the enhanced functional requirements like QoS, OSS, appropriate NTU/CPE model, flexible interconnection, etc. should be specified.

As a conclusion, the WG recommends the European Commission to:

1. Promote the adoption of an ‘Open Access’ concept throughout the EU, i.e. open access to ducts, symmetrical access to in-building wiring and market-driven wholesale bitstream (as described in chapter 2)

2. Play a facilitating and coordinating role to help the industry agree on the standardisation of Next Generation Bitstream wholesale offerings. This NG BSA should be based on connectivity at Layer 2. The further details of the enhanced functional requirements like QoS, OSS, flexible interconnection, etc. should be specified[12].

3. Enable the deployment of alternative technical solutions to promote investment in rural broadband deployment (e.g. wireless technologies, VDSL2-Vectoring).

4. Assure a clear definition of the “A10-NSP” and “U” interfaces and prepare the way for a shared management of the NTU/Home Gateway between access seeker and access provider.

[12] There where also proposals to study wholesale access based on Layer 3, but this option seems not to be supported by access seekers currently.

3 IP based QoS Interconnection

3.1 Introduction

The Working Group 2 agreed on the need to research the definition, the number and the main characteristics of classes of quality related to interconnection of IP transport networks, taking into account the works that have been led within the different standardization and industry bodies (e.g. ITU, IETF, GSMA, i3 Forum and ETSI 3GPP). In fact, the diversification of traffic in terms of classes of quality is necessary at interconnection of IP networks in order to satisfy the different requirements associated to each service (e.g. SIP) and/or application (video streaming) coming through such interconnection.

The WG2 recognized that the number and characteristics of classes of quality have not been defined homogenously in each standardization body and sometimes there is a complete gap of standardization of such classes managed at interconnection between IP networks.

Within this chapter we show how each standardization body defines and describes classes of quality at interconnection of IP networks, highlighting the common views among standards and taking into account the capabilities enabled by IP technologies.

The IP networks will be multi-service as on the same infrastructure it will be possible to transport many services having different requirements in terms of quality (i.e. loss, delay, jitter…). The IP transport connections should take into account this need of quality differentiation, mapping each traffic flow in a class of quality adequate to the requirements associated to a type of service (voice, video, data,…).

The mapping of IP traffic in different classes of quality is an important first step for enabling the differentiation and management of quality also between interconnected IP networks. However, this feature alone is not able to guarantee an absolute end-to-end quality (from end-user to another end-user or from a service centre to an end-user). In fact, the interconnection is not aware of the service (e.g. SIP sessions) transported by IP packets, so it’s not possible to give any guarantee on the level of quality associated to each single service. It is reasonable to say that the diversification of IP traffic at transport level in classes of quality enables a “relative” quality of IP services/applications, which means that the quality could be associated to an IP traffic flow shared by many applications and services requiring the same quality objectives at IP transport level.

3.2 The definitions of classes of quality at interconnection of IP transport networks

In this paragraph it is pointed out the situation that it is possible to retrieve in standards regarding the definition of classes of quality at interconnection of IP networks.

Definition can be be found in the GSMA and i3 Forum specifications of interconnection of IPX networks. Four classes of quality that should be managed at interconnection of transport layers of IPX networks are defined. The concept of QoS in IPX is based on QoS requirements and on the SLA agreement needed to implement those rules within the IPX.

Both the GSMA and i3 Forum IPX models endorse and mandates the IETF and 3GPP recommendations. They currently define four classes of traffic, but the introduction of a fifth class specifically for signalling (eg SIGTRAN and Diameter) associated with the provision of services is currently being discussed. The 4 traffic classes are so defined:

- **Conversational** – Typically in this class are placed services that needs tight delay and jitter values
- **Streaming** – Normally expectations are not as tight as in conversational class as UE normally buffering
- **Interactive** – Corporate sensitive traffic which needs reserved bandwidth to guarantee service requirements
- **Background** – Typically the packet size in background class is pretty big, and traffic is not that much affected by delay and jitter, as long as packets are not dropped in network to avoid retransmissions and extra load to network.

The Appendix contains a more detailed description of the IPX and reports on how IR.34 also maps classes of quality on some well know end services.

The i3 Forum as well (see Technical Interconnection Model for International Voice Services - Release 4.0 May 2011) defines classes of traffic that could be associated to IP packets transporting voice traffic. The following table describes the traffic classes defined for all the interconnection configurations described in the i3 Forum's technical specification.

Traffic class	Traffic type
Voice Media	Speech / Voice bearer.
Voice Signaling	Voice Control Traffic (SIP, SIP-I signaling protocols)I
Mobile Signaling	SMS and roaming (TCAP signaling protocol)
Other Customer Traffic	Internet traffic, other data traffic

Table 1: i3 Forum Mapping of Traffic Classes and Traffic Types

In particular, i3 Forum differentiates classes of traffic for transporting media and signaling associated to the voice traffic. Other type of data traffic, like internet, is transported in a separated class of traffic.

It can be seen that both GSMA and i3 Forum identify two classes of quality: one for voice and another one for data traffic, having best effort requirements. Moreover the members of the GSMA and i3 Forum are working closely together to align the two models.

The analysis didn't identify any other consolidated standards where it is possible to find a complete and clear definition of classes of quality at interconnection of IP networks.

Given IPX specifications originated from GSMA, the principles have been designed for mobile networks. For this reason IPX is a good starting framework for end to end QoS interconnection, but that adaptation and extensions will have to be worked on to fulfil the requirements of fixed infrastructures.

3.3 Mechanisms adopted in the IP transport networks for QoS management

The IETF Diffserv is the most used and referred architecture for managing and differentiating classes of quality inside or between IP networks. Both IPX GSMA and i3 Forum refer to such architecture.

DiffServ has been defined in IETF RFC 2474 and RFC 2475, which specify the overall mechanism and the encoding of the DSCP field contained in the IP packet header. The DSCP field (six bits) can assume values according to different Per Hop Behavior (PHB). The Class Selector PHB uses encodings compatible with the IP Precedence (3 bits) field, originally specified for IP packets in RFC 791. Its adoption is widespread in IP networks.

It will not be recommended to integrate DiffServ into the NG BSA, but it can be seen as a recommendation to describe the classes like they are described with DiffServ.

This means that up to eight classes of priority could be enabled inside most of IP networks, depending on the number of queues implemented in the routers.

IP Precedence	DSCP with Class Selector PHB
111	111000
110	110000
101	101000
100	100000
011	011000
010	010000
001	001000
000	000000

Table 2: IP Precedence values and the corresponding DSCP encodings using the Class Selector PHB

The values 111 and 110 are typically used only internally to an operator’s network for IP routing and signaling protocols, leaving six encodings available for the definition of traffic classes at the interconnection of today IP public networks. The encoding of IP Precedence is also compatible with the MPLS header that has only three bits available for traffic classes (RFC 3032): this is relevant as far as MPLS is used in most of operators’ networks.

3.4 Mapping QoS in IP packets

It is necessary to highlight that IETF doesn't force vendors to implement specific solutions or operators to deploy them in their networks. The management of Quality of Service is not an exception: IETF has developed different alternative models to manage QoS, but the Differentiated Service architecture is the most widely adopted.

In that sense the lack of strict recommendations could represent a problem, in particular because any operator could map IP packets in different Diffserv classes and so at interconnection could be necessary a re-mapping and an agreement among operators due to the lack of standard references.

The standardization of mapping for QoS in IP packets could be found in two cases: one is a tentative still on going inside ITU; another one is again the IPX context.

A tentative of standardizing QoS mapping in IP is leading by the Q17 of ITU SG 12 that has recently proposed a new Rec Y.QoSmap "Qos mapping and interworking between Ethernet, IP and MPLS" with the intention to simplify technical Ethernet, MPLS and IP QoS interconnection negotiations. However, the recommendation is still in a first draft version and so it will take time before its approval and its implementation inside SLAs and technical requirements usually defined in negotiations among IP network providers.

A context where it is possible to retrieve a complete and strict encoding for DSCP at interconnection level is IPX, which declines each one of the four class of quality in different priorities and policies with which the packets could be handled at IPX network interconnection:

QoS Information		**Diffserv PHB**	**DSCP**
Traffic Class	**THP**		
Conversational	N/A	EF	101110
Streaming	N/A	AF41	100010
Interactive	1	AF31	011010
	2	AF21	010010
	3	AF11	001010
Background	N/A	BE	000000

Table 3: Traffic Classes in the IPX specification

Where:

1. Traffic Handling Priority (THP) specifies the relative importance of applications that belong to the Interactive traffic class.

2. Diffserv Per Hop Behaviour (PHB) is the packet forwarding function carried out by the Diffserv-capable routers on the path of a given packet flow. PHBs can be seen as the Diffserv classes of service. Different types of PHB are defined for Diffserv according to IETF documents.

3. Differentiated Services Code Point (DSCP) indicates the PHB that a packet belongs to. The DSCP values are recommended values in IETF.

As showed in the table before the IPX uses only six levels of priority with which IP packets are handled at interconnection: the interactive class of quality is declined in three classes of priority, corresponding to the assured forwarding behavior specified in IETF RFC 2597.

3.5 The definition of QoS parameters at interconnection of IP networks

The previous analysis pointed out clearly that IPX is many steps forwards in the definition of quality management at the interconnection of IP networks. Moreover, IPX has specified also parameters, characterizing each class of quality:

- Availability (Service availability is a proportion of the time that IP Backbone Providers service is considered available to service providers on a monthly average basis); values for availability are defined in IR.34
- Jitter
- Packet Loss (Packet Loss is the ratio of dropped packets to all packets sent from the source to destinations in percents (Measured over a given period of time)
- Delay (Roundtrip delay is the total time that it takes to transmit an IP packet from the Source to the Destination and receive the reply packet from the destination at the source. (Measured over a given period of time, in milliseconds). Different values are documented for Roundtrip delay between originating and terminating Service Provider premises depending on the traffic class

3.6 The management of quality inside the IP networks

In this paragraph it is shortly presented how classes of quality may be defined and managed inside an IP network according to the standards adopted in mobile and fixed networks. As a possible enabler for achieving a quality managed as near as possible to the end-user, it is important to point out, where it is possible, likely correlations among classes of quality adopted at interconnection with the ones used inside each single network. Taking into account the results of the previous analysis, the IPX model is assumed as reference for a likely interconnection model of IP transport networks with management of classes of quality.

3.7 Mobile networks

The standard 3GPP TS 23.107 defines at the UMTS Bearer Services level four different QoS classes:

- conversational class;
- streaming class;

- interactive class;
- background class.

The Table 4 shows the main characteristics of the each class and some examples of service belonging to each class.

Traffic class	**Conversational class** **conversational RT**	**Streaming class** **streaming RT**	**Interactive class** **Interactive best effort**	**Background** **Background best effort**
Fundamental characteristics	Preserve time relation (variation) between information entities of the stream Conversational pattern (stringent and low delay)	Preserve time relation (variation) between information entities of the stream	Request response pattern Preserve payload content	Destination is not expecting the data within a certain time Preserve payload content
Example of the application	voice	streaming video	Web browsing	background download of emails

Table 4: UMTS QoS classes

The 3GPP TS 23.107 also defines which parameters should be defined for each one of the four classes and the value ranges for UMTS bearer service attributes.

Traffic class	**Conversational class**	**Streaming class**	**Interactive class**	**Background class**
Maximum bit rate	X	X	X	X
Residual bit error ratio	X	X	X	X
Transfer delay	X	X		
Guaranteed bit rate	X	X		
Traffic handling priority			X	
Source statistics descr.	X	X		
Signalling indication			X	

Table 5: some of the UMTS bearer attributes defined for each bearer traffic class

The interactive class could be then used also for transporting signaling protocols associated to IMS services, using a signaling indication (that is, when signaling indication is set to yes, the traffic handling priority is set to ‘1’).

The 3GPP TS 23.207 complements 3GPP TS 23.107 clarifying that whenever resources not owned or controlled by the UMTS network are required to provide QoS, it is possible to interwork with the external network that controls those resources in a number of ways, including:

- signaling along the flow path (e.g. RSVP, LDP);
- packet marking or labeling along the flow path (e.g. DiffServ, MPLS);
- interaction between Policy Control and/or Resource Management elements;
- Service Level Agreements enforced by the border routers between networks.

In particular the GGSN is required to support DiffServ edge function, while other QoS capabilities are not mandatory. In any case 3GPP TS 23.207 doesn't foresee changes to the QoS classes defined in 3GPP TS 23.107. Finally, it is necessary to point out that during EPS development some enhancements to the QoS model were made: there were introduced 9 QoS class identifier (QCI) that can be mapped into UMTS classes.

QCI	Traffic Class	Traffic Handling Priority	Signalling Indication	Source Statistics Descriptor
1	Conversational	N/A	N/A	Speech
2	Conversational	N/A	N/A	Unknown
3	Conversational	N/A	N/A	Unknown
4	Streaming	N/A	N/A	Unknown
5	Interactive	1	Yes	N/A
6	Interactive	1	No	N/A
7	Interactive	2	No	N/A
8	Interactive	3	No	N/A
9	Background	N/A	N/A	N/A

Table 6: Mapping between standardized QCIs and Release 99 QoS parameter values

In the case of mobile network, the analysis highlights that the classes of quality specified by 3GPP for UMTS networks are obviously compliant with IPX specifications, as these last one endorse 3GPP standards.

3.8 Fixed networks

Regarding fixed networks, as written above, there isn't today a well defined standard reference that defines the mapping of classes of quality in IP. However, as the strict relation among IP and Ethernet technologies, it is important to indicate also the activities finalized in the Metropolitan Ethernet Forum regarding Ethernet service interoperability between network Operators. The MEF covers QoS aspects within his Technical Committee and specifically in the Implementation Agreements:

- MEF 23: Carrier Ethernet Class of Service – Phase 1
- MEF 23.1 Carrier Ethernet Class of Service – Phase 2 (planned for end 2011)

The phase 1 has specified the Class of Service model structure including: number of specified CoS (3), associated Attributes (qualitatively), applicability of bandwidth profile options and DSCP components of the CoS Identifier. This phase does not include availability objectives. The CoS has been specified to both UNI and E-NNI.

MEF 23.1 Carrier Ethernet Class of Service – Phase 2 (Planned for end 2011) will set quantitative values for FD, FDV and FLR in order to guarantee accepted Network Performances between UNI/NNI interfaces for the different services. Future works in MEF may introduce an additional class of quality for transporting synchronization associated to mobile backhauling services.

It could be noted that the specifications given in MEF regarding Classes of Quality are quite different on what has been defined in IPX and 3GPP. So a sort of harmonization may be necessary in such cases and in particular among standards adopted in fixed and mobile contexts. This could be an open discussion item, which could be finalized in the standardization bodies like ITU and/or ETSI.

3.9 Recommendation for further steps

As a conclusion, the WG recommends the European Commission to:

1. Seek a tangible "Quick Win" by actively encouraging the practical implementation and usage of industry agreed interconnection standards (such as IPX) which enable new technical and commercial models for quality assured end-to-end services across network borders.
2. Reinforce explicit political support for business models based on quality and price differentiation[13] and establish the legal certainty needed to invest into actual deployments of increased transport capacity.
3. Encourage the harmonization of QoS models between the GSMA and i3 Forum.
4. Encourage standardization of parameters for QoS classes and associated parameters for use "within" the internet, i.e. at the level of IP transport interconnection, to enable new business models for all players along the internet value chain
5. Promote the timely finalization of ongoing work regarding QoS IP mapping within the ITU (e.g. new rec. Y.QoSmap) and ETSI.

[13] This includes – of course – the obligation to make non-discriminatory offerings to both sides of the two sided market.

4 Appendix

4.1 The GSMA's IPeXchange Solution

This document describes the technical means to bring guaranteed quality to IP based services in order to provide greater choice of services to customers compared to that which is possible via the internet today. This enables potential new business models which can be built upon standardized services and quality classes and can be implemented across a wide variety of networks and operators giving assurance of end-end performance and interoperability.

The IP Exchange Concept (IPX) provides such technical means and was originally developed by the GSM Association as an interconnect service based on common agreed technical specifications and using consistent commercial models. It provides a secure environment for delivery of traffic managed with QoS levels and performance to mutually agreed service level agreements.

IPX can be used to interconnect any IP service, including voice. To give full interoperability and end-end guaranteed quality, these services are standardised. Non standardised services can also be carried by providing a transport only interconnect which could also support Quality of Service classes.

IPX is fully scalable and allows for bi-lateral and multilateral (hubbing) models for interconnection. The use of a common approach to IP interconnect using IPX enables full global interoperability by a progressive implementation and rollout in local markets, across regions and leading to global interconnection. Using the existing carrier industry to provide the means of connectivity between networks and operators can ensure the global scale that is necessary to ensure a true alternative capability to the current internet.

IPX enabled services will offer greater choice to customers. It can be perfectly possible to offer a choice to customers for a particular service or application e.g. choosing between an application using 'best efforts' connectivity via the internet or a charged for, QoS enabled, application.

There are a number of carriers that have publically announced the launch of IPX services and they are currently promoting their service. Currently there would seem to be more active connectivity in Asia than in Europe

4.1.1 Introduction and background

Possible new business models for the internet can be built upon guaranteed quality, for example services and quality classes that are standardized such that they can be implemented in the form of inter-carrier IP interconnection across a wide variety of networks and operators and which give assurance of end-end performance and interoperability. This would encompass fixed line and radio access networks, aggregation networks, backbones, interconnect points as well as content providers, internet platforms and terminal devices. The focus of this document is for the technical means to bring QoS-based interconnection to the market.

Initial discussions between the interested parties have shown that the Internet Exchange (IPX) concept that has been defined by the GSM Association provides a basis for end-end QoS enabled interconnect. In the responses to the WG2 questionnaire[1] IPX has been identified by a large number of respondents as being a potential "quick win" solution that is ready for implementation.

Work on IPX was initially started within the GSM Association by mobile network operators in 2005 and shortly afterward the dialogue was extended to include fixed operators, international carriers, internet companies and suppliers. White papers and public domain documents were published in 2006/7. The IPX is an interconnect service offered by a variety of carriers on a competitive basis but with common agreed technical specifications and using consistent commercial models. It provides a range of technical and commercial features that enable a new business model to be implemented to ensure a sustainable IP service business. Key attributes of IPX include the following:

- Secure environment – the IPX is a transparent IP network that is not addressable from the Internet;
- Flexible IP Service interconnection – bilateral and multilateral connectivity;
- Support for a cascading payments model - managing the flow of information necessary for settlements to be made between operators – rewarding all players in the value chain;
- Premium quality environment – traffic managed with QoS levels and performance to mutually agreed service level agreements.

Information on IPX[2] can be found at http://www.gsmworld.com/documents/ipx_brochure.pdf

Carriers have since taken these documents and have worked together to further develop this for the necessary methods of interworking to each other (hubbing) in order to ensure a seamless connectivity from end to end.

4.1.2 Requirements for IP interconnect which supports Quality of Service

IPX is a technical means to bring QoS-based interconnection to the market and is based upon a number of requirements and principles:

- Service Provider to Service Provider quality of service delivery: IP interconnect are able to support delivery of services to the terminating Service Provider with a pre-defined QoS. This is particularly important for real-time services which may have important end-end delay requirements.
- End-end flexible payment models: the ability to support different economic interconnection models including cascade payments.
- Openness to any service player wanting to get involved in the delivery of the service.
- Multiservice: the interconnect solution shall be capable of supporting multiple services together in order to achieve economic viability and efficiency.
- Security: to guarantee trusted communications.

The technical solution for QoS based IP Interconnect should be based on standards which can be adopted globally in order to allow for global interoperability of services. In addition, in order to allow for market driven rollout, the solution has to be scalable and have an evolving rollout from national in-country to regional to global interconnection.

4.1.3 IP Exchange (IPX)

The IPX is a global, private, IP network which supports Service Provider to Service Provider quality of service and the principle of cascading payments. In order to provide these features the IPX is aware of the services being carried. This ability to cascade payments enables new business models, for example a customer could download an application and pay via their service provider and recompense the application provider. Payment would be cascaded back via the service provider and carrier(s), this creating a “value chain” that should ensure payment for all parties involved in providing the service to the customer.

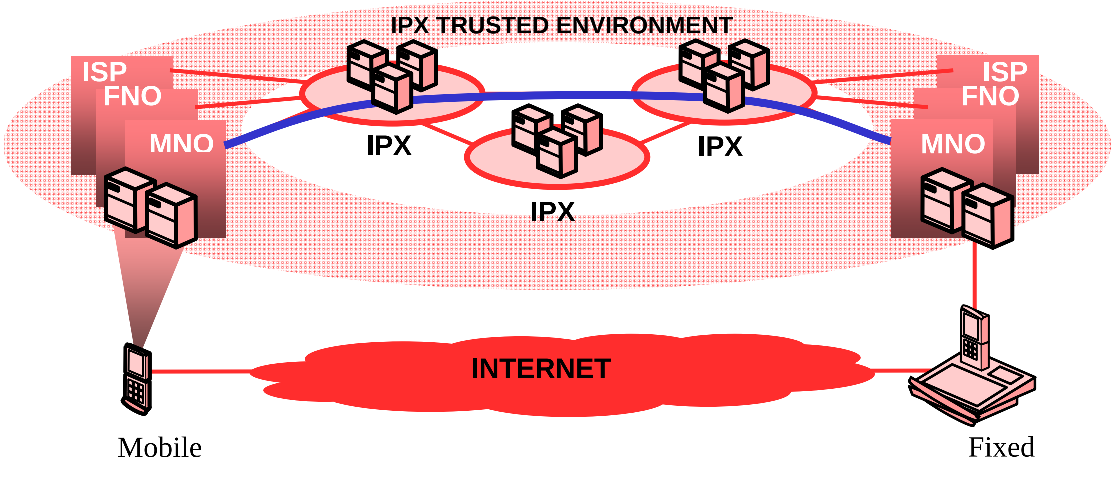
The IPX environment will consist of a number of IPX carriers operating in a competitive market, providing interconnect services to Service Providers. The IPXs will be mutually interconnected and all parties connecting will ensure (via SLAs) that the quality, security, and the technical and commercial principles of the environment are maintained.

4.1.4 IPX architecture

The IPX architecture consists of a transport network capable of providing Service Provider to Service Provider quality of service, for example the conversational traffic class, in a private network. Transparent service proxies handle service aware functions, such as multilateral connectivity management and service transaction accounting. They can also support protocol interworking where Service Providers use different protocol versions for a common service. Security is provided by establishing a separate routing domain from the Internet and by the separation of traffic within the IPX. Peer-to-peer traffic is separated from server-to-server traffic. Security also relies on the establishment of a trusted environment whereby all connecting parties implement robust security in their own networks.

Content and application providers can choose to offer their products via either route, (internet or IPX) or may choose to offer both with differing levels of service and charging models, this gives the opportunity for customer choice

IPX architecture may be suitable especially in case of multilateral connectivity and evolved services like RCS.



4.1.5 IPX services

The IPX may be used to interconnect any IP service. To provide interoperability (commercially and technically) amongst the community of Service Providers the interconnect aspects of the services must be standardised. An IPX provider is free to support any of the standardised services they consider viable and may offer other non-standardised value-added services to requesting Service Providers.

4.1.6 Standardised Services

Service-oriented interconnection requires standardisation of interconnect requirements for specific services. These standards should be based on market driven needs and are being added to the IPX portfolio of services as and when required. Carrier grade Voice over IP (and Voice over LTE), Telepresence and Rich Communication Services (RCS) are examples of real time services that require tight control over end-to-end delay and require conversational class of QoS.

4.1.7 Non-standardised Services

The IPX will provide the transport for many services that are run on a bilateral basis with settlement independent of the IPX provider. In this scenario, the IPX does not provide service-based interconnection but instead functions as a transport service, although QoS support may be provided. Charging could be based on the level of QoS provided. In such instances, the service does not need to be explicitly detailed in a service definition.

4.1.8 Connectivity models

The IPX supports three interconnect models, which Service Providers are free to choose on a per service basis:

- Bilateral Transport Only – the IPX provides transport at a guaranteed QoS. This model can be used for connection oriented (non-standardised service) interconnection between two service providers.
- Bilateral Service Transit – the IPX provides service oriented interconnection and cascading interconnect payment facilities. This enables an originating Service Provider to make a single payment to their IPX Provider who passes on a payment on to the remaining providers in the value chain.
- Multilateral Hub Service –the IPX provides service oriented interconnection cascading interconnect payments to a number of interconnect partners via a single agreement between the Service Provider and IPX. This "one-to-many" mode is operationally highly efficient for the Service Provider.

4.1.9 IPX scalability

The IPX concept is scalable to full global interconnection between all service providers for the foreseeable future. In particular the arrangements provide for multiple competing IPX providers working in an open ecosystem and in which any service player can connect. In order to simplify the need for multiple bilateral agreements between service providers, the hub service concept can minimise the need for multiple separate agreements and improves efficiency for service providers. This is very similar to the voice hub service provided by carriers today which enable and telephone caller to connect to any telephone number in the world

It is anticipated that the development and implementation of IPX can be evolutionary, in terms of the scale of interconnectivity and in terms of adding services as the market needs arise. Typically rollout of IPX might be in phases, starting with in-country bilateral interconnect between service providers, then extending to regional interconnection and finally moving to the hub based arrangements.

Provided that initial implementations are consistent with the service interconnect standards, interoperability between these will be assured as the global rollout advances.

4.1.9 IPX maps of classes of quality on applications

Application	protocol	PHB	Potential QoS class name
VideoShare	N/A	EF	Conversational
VoIP	RTP	EF	Conversational
Push to talk	N/A	AF4	Streaming
Video streaming	N/A	AF4	Streaming
Unrecognized GTP traffic	N/A	AF3	Interactive
DNS	DNS	AF3	Interactive
Online gaming	N/A	AF3	Interactive
WAP browsing	GTP_C, GTP_U	AF2	Interactive
WEB browsing	N/A	AF2	Interactive
Instant messaging	N/A	AF1	Interactive
Remote conn.	SSH, telnet	AF1	Interactive
Email sync	N/A	BE	Background
MMS	SMTP	BE	Background