WIK-Consult • Report

Study for the Commission for Communications Regulation (ComReg)

Next Generation Bitstream Access

Final

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List of abbreviations

ADSL	Asymmetric Digital Subscriber Line
AON	Active Optical Network
ARCEP	Autorité de régulation des communications électroniques et des postes
ARPU	Average Return Per User
ATM	Asynchronous Transfer Mode
AURA	Amsterdam, Utrecht, Rotterdam and Arnheim
BC-TV	Broadcasting Television
BNetzA	Bundesnetzagentur
BPON	Broadband Passive Optical Network
BRAS	Broadband Remote Access Server
BROBA	Belgacom Reference Offer for Bitstream Access
BRUO	Belgacom Reference ULL Offer
BSS	Business Support System
CDR	Call Data Record
CoS	Class of Service
CPE	Customer Premises Equipment
DiffServ	Differentiated Services
DSLAM	Digital Subscriber Line Access Multiplexer
DTAG	Deutsche Telekom AG
DWDM	Dense Wavelength Division Multiplexing
e.g.	for example
EC	European Commission
ECTA	European Competitive Telecommunications Association
EDP	Electronic Data Processing
EFM	Ethernet in the Ffirst Mile
ERG	European Regulators Group
ESS	Ethernet Service Switch
etc.	et cetera
ETSI	European Telecommunications Standards Institute
EU	European Union

FIFO	Fist in first out
FT	France Telecom
FTTB	Fibre to the Building
FTTC	Fibre to the Curb
FTTH	Fibre to the Home
FTTx	Fibre to the x (Various fibre solutions)
GbE	Gigabit Ethernet
Gbit/s	or Gbps Gigabit per second
GPON	Gigabit Passive Optical Network
HDTV	High Definition Television
i.e.	that is
ICMP	Internet Control Message Protocol
IGMP	Internet Group Management Protocol
IntServ	Integrated Services
IP	Internet Protocol
IPTV	Internet Protocol Television
ISDN	Integrated Services Digital Network
Kbps	kilobit per second
KPN	Koninklijke PTT Nederland
LAN	Local Area Network
LLU	Local Loop Unbundling
Mbps	Megabit per second
MCL	Metro Core Locations
MDF	Main Distribution Frame
Mpeg	Moving Picture Experts Group
MPLS	Multi Protocol Label Switching
ms	milliseconds
MSAN	Multi Service Access Nodes
MTTR	Mean Time to Repair
n.a.	not available
NGA	Next Generation Access
NGN	Next Generation Network

NL	Netherlands
OAO	Other Authorised Operator
OFCOM	Office of Communications
OLT	Optical Line Termination
ONT	Optical Network Terminator
ONU	Optical Network Unit
OPEX	Operational Expenditure
OPTA	Onafhankelijke Post en Telecommunicatie Autoriteit
OSS	Operations Support System
PIM-SSM	Protocol Independent Multicast – Source Specific Multicast
POI	Point of Interconnection
PON	Passive Optical Network
PoP	Points of Presence
PSTN	Public Switched Telephone Network
QoS	Quality of Service
RFQ	Request for Comments
RSVP	Resource Reservation Protocol
RTP	Real-time Transport Protocol
SAM	Service Aware Manager
SC	Street Cabinet
SD	Standard Definition
SDF	Subscriber distribution frame
SDSL	Symmetric Digital Subscriber Line
SDTV	Standard Definition Television
SIP	Session Initiation Protocol
SLA	Service Level Agreement
SLU	Sub Loop Unbundling
SNR	Signal to Noise Ratio
TDM	Time-Division Multiplexing
UBR	Unspecified Bit Rate
ULL	Unbundled Local Loop

VATM	Verband der Anbieter von Telekommunikations- und Mehrwertdiensten
VBR	Variable bitrate
VC	Virtual Channel
VDSL	Very High Speed Digital Subscriber Line
VLAN	Virtual Local Area Network
VoD	Video on Demand
VoiP	Voice over IP
Vs	Versus
WBA	Wholesale Broadband Access

1 Executive Summary

Bitstream access currently accounts for over 85% of the alternative operators DSL lines in Ireland and it appears very likely that bitstream services will remain of critical importance in the Irish broadband market. Population density and dispersion indicates that the economic incentive for local loop unbundling is and will likely remain focused on larger urban centres. The ladder of investment model assumes that Other Authorised Operators (OAOs) will, over time, climb higher rungs of the investment ladder and eventually unbundle the local loop. In a Next Generation Access (NGA) architecture an OAO needs to unbundle the sub-loop and collocate at the street cabinet so the effort required for OAOs to reach a high rung on the ladder will rise in the NGN. Accordingly this implies that OAOs might be even more inclined to concentrate their infrastructure based activities on dense urban centres in Ireland making bitstream relatively more important for the rest of the country. It also indicates that OAOs may not need all levels of bitstream access throughout the country as there will be fewer incentives to access bitstream at DSLAM level in rural areas.

Current Irish but also European bitstream wholesale services are not suitable to deliver mass market triple play services. This is primarily due to a lack of sufficient Quality of Service (QoS) of bitstream access at IP level, which is the major option for mass market services. NGN bitstream based on Ethernet instead of ATM (aggregation) networks are just emerging. There is only one reference offer in Europe that includes multicast functionality to enable IPTV on an Ethernet bitstream wholesale service. This is a draft offer in Italy which has yet to be approved by AGCOM, the Italian regulator. Today international OAOs are primarily implementing their triple play services on the basis of unbundled loops rather than bitstream. Irish OAOs economic LLU footprint may not reach far enough to sustain wider area competition through triple play packages.

The key issues of the NGN bitstream are related to QoS, adequate access points and sufficient capacity on the access line. With the rise of value-added service-bundling the NGN retail portfolio demands distinct quality features also in the residential market. Applications like Voice over IP, IPTV, Video on Demand, Gaming, etc. have different requirements regarding bandwidth, delay, jitter and packet loss. Therefore an NGN bitstream must include adequately designed classes of service so Irish OAOs can compete with eircom's future NGN retail service portfolio. In addition OAOs must have suitable options for access to the bitstream at different hierarchy levels of eircom's network. These must enable OAOs to build economically feasible business cases with different grades of added-value through backhaul infrastructure of their own. The closer to the end-user OAOs can access bitstream the better they can control and shape traffic by themselves.

Therefore WIK Consult believes that - contrary to most current bitstream products - NGN bitstream access must have

- access at as many levels as economically feasible and demanded (including DSLAM access and a stand-alone bitstream option),
- multiple (2-5) service classes that have clearly defined parameters (packet loss, delay, jitter, bandwidth),
- access line capacities of 20Mbps downstream and 5Mbps upstream to enable e.g. 4 parallel channels of IPTV on the access line,
- multicast functionality to facilitate efficient IPTV distribution in aggregation/core networks and
- a high degree of automation in all aspects regarding Operation Support Systems / Business Support Systems, especially with regard to performance monitoring and management on an individual user level basis

The analytical basis for these suggestions are laid out within the report. WIK Consult's study highlights emerging NGN retail triple play services packages assessing the technical implementation strategy of selected major international operators and analyses the state of wholesale bitstream implementation in Europe in detail. On this basis WIK Consult develops a detailed set of service classes with well defined quality parameters and OSS interworking functions as input to the discussion between the incumbent and the OAOs in Ireland.

The report suggests that realisation of QoS should be up to the incumbent (either through mechanisms on Ethernet and IP layer or through simple over-engineering of the network). Obligations need to take eircom's own retail services and network infrastructure into account. Irish market parties should jointly define their needs and may base their comments and suggestions on WIK Consult's draft definition.

2 Introduction

2.1 Goal of the study

The objective of this study is to specify the characteristics of the future wholesale bitstream access products necessary to ensure openness and competition in a Next Generation Network. The study provides a detailed view of the technical and operational characteristics of next generation bitstream products in order to offer guidance for developing the regulatory requirements for wholesale bitstream access necessary to promote competition in an NGN in Ireland.

2.2 Structure of the study

The structure of WIK's study follows ComReg's requested scope and covers the following issues

- **Survey of retail triple play product offerings and assessment of technical strategies being adopted by leading European operators based on FTTx infrastructure:** This survey provides a snapshot of the current retail triple play bundle offerings in the European market and their technical implementation. It assesses how operators have chosen different strategies in the realization of triple play services.

- **Overview of emerging NGN wholesale bitstream products:** This work package assesses the technical and economic parameters of emerging NGN bitstream wholesale access.

- **Assessing technical requirements for an optimum wholesale product suite:** Based on interviews and the results of work package two this work package provides guidance on the requirements for a bitstream product that ideally facilitates sustainable competition and efficient infrastructure investment in an NGN environment.

- **Evaluation of Irish operators' proposed retail and wholesale products**: The frameworks of an optimum wholesale product will then be compared with the proposed wholesale products in the Irish market.

- **Difficulties of NGN implementation:** The final work package sums up information on practical implementation difficulties that were encountered in the roll out of NGN/NGA by leading European operators.

2.3 WIK's methodology

Although traditional telecommunication networks and NGNs can be distinguished in theory, the migration towards NGN has only recently begun and is a continuing process. Therefore the study faces significant challenges in comparing traditional networks and service provision with NGN on an empirical basis. Accordingly, in a preparatory step, the study specifies the key characteristics of NGNs that need to be considered in this context.

Even though NGN implementation is not yet complete in any country there are intermediate steps and announcements that may serve as a basis for the analysis. The study begins with a review of selected implementation strategies of European operators. This is conducted first on the retail side (chapter 3 - Work Package 1) and then on the wholesale side (chapter 1 - Work Package 2) to assess which elements of current retail triple play offers and bitstream wholesale service could be perceived as NGN. Work Package 1 is composed of case studies of selected triple play operators to convey the status quo in migration to NGN.

ComReg needs to set an adequate framework for NGN bitstream in the Irish wholesale market. Accordingly the study suggests the requirements for an optimum product suite from regulatory economic analysis and interviews with operators and regulatory authorities. It is necessary to incorporate a trade-off between desirability and feasibility: for example it can be assumed that access to the bitstream is desirable on all possible interconnection nodes in order to facilitate the extension of OAO's own infrastructure along the ladder of investment. However the incumbent should not be burdened with disproportionate costs.

Based on this analysis the study provides a recommendation for the framework for bitstream access in Ireland. It also highlights practical implementation difficulties experienced in other countries to aid the development process for an Irish NGN wholesale regime.

2.4 Preparatory remarks: Towards Next Generation Networks

The advancement of current telecommunication networks is usually labelled Next Generation Network (NGN). The ITU's working definition states that an NGN is a "packet-based network able to provide services including Telecommunication Services and able to make use of multiple broadband, QoS-enabled transport technologies and in which service-related functions are independent from underlying transport-related technologies […]"[1].

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1 http://www.itu.int/ITU-T/studygroups/com13/ngn2004/working_definition.html.

The deployment of an NGN changes the framework for OAOs in many respects. This is especially important with regard to the scope of OAOs' infrastructure-based services. Therefore we must ask ourselves how and to what extent the NGN development will change the structure of network access to wholesale products (local loop and sub loop unbundling, line sharing, bitstream) and how this compares with the traditional bitstream world. Impacts result primarily from:

- Next Generation Access networks with FTTx
- Changes in the aggregation networks
- Extended requirements for delivering IPTV (e.g. through multicasting)
- Complete integration of PSTN voice in the NGN

2.4.1 Implications of FTTx architectures on wholesale services

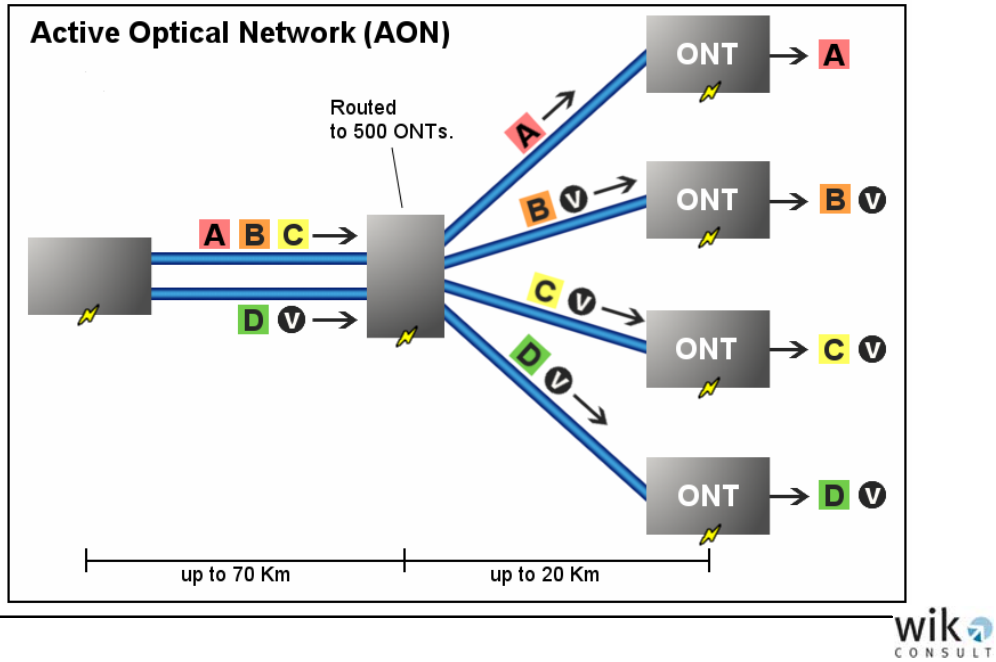
There are different implementation strategies for the realization of FTTx. Generally speaking, the respective architectures can be divided into three types which are:

- *AON (Active Optical Networks)*
- *PON (Passive Optical Networks)*
- *Passive Point-to-Point architectures.*

These architectures differ with respect to a couple of dimensions, not the least with regard to the ability to enable wholesale services:

In ***Active Optical Networks (AON****)* electrically powered components, such as a switch, router, or multiplexer (e.g. VDSL DSLAM) are installed between the end-user and a respective network node (see Figure 2-1) in Street Cabinets. These components distribute the traffic from the Main Distribution Frame (MDF) site onto each customers access line individually and collect and concentrate traffic from individual customers. The line between the MDF and the components located in street cabinets is fibre. The line between the street cabinet and the customer site may be fibre or copper. In the case of a fibre access line the Optical Network Unit or Optical Network Terminator (ONU/ONT), situated at the customers premise, converts the optical signal into an electrical signal. In the case of a copper access line the function of the ONU/ONT and the multiplexer are performed by the same system (e.g. a VDSL access multiplexer (DSLAM)).

Figure 2-1: Active Optical Network (AON) infrastructure



Source: Alloptic (2007).

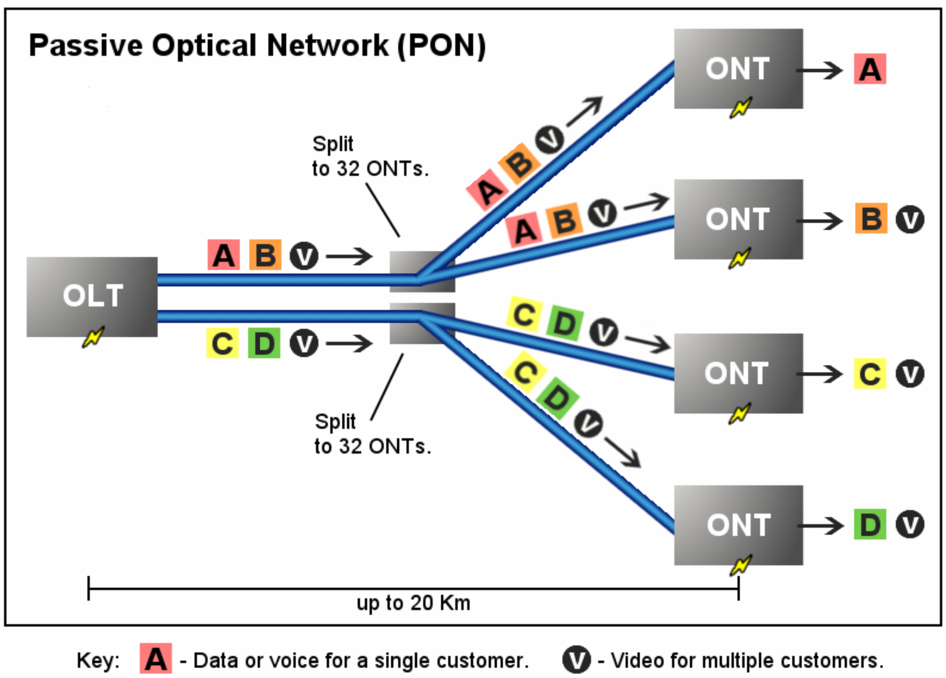
The IEEE 802.3ah standard enables AONs to support symmetrical speeds of 100Mbps. AONs are more “intelligent” than PONs and thus are better suited to remote management; however, higher OPEX costs are incurred in maintaining remote active components and the Ethernet switches need a power supply. As of 2007, the most common type of active optical networks are called *active Ethernet*, a type of Ethernet in the First Mile (EFM). Active Ethernet uses optical Ethernet switches to distribute the signal, thus incorporating the customers' premises and the central office into one large switched Ethernet network.

Active Optical Networks are primarily deployed as Fibre to the Curb to overcome long copper loop lengths. When rolling out Fibre to the Building or to the Home (FTTB, FTTH) there is an incentive to rely on passive infrastructures in order to reduce operating cost. FTTB/FTTH deploys fibre also in the section between street cabinet and the customer site in order to overcome bandwidth or line length restrictions.

Normally a ***Passive Optical Network (PON***) is a point-to-multipoint fibre to the premises network architecture that doesn’t require any active electrical components between the end-user terminating equipment and the respective network node. PONs use unpowered optical splitters to enable a single optical fibre out of the MDF site to serve multiple premises, typically up to 32. A PON consists of an Optical Line Termination (OLT) at the MDF and a number of ONUs/ ONTs at the end user site (see Figure 2-2).

An OLT is the service provider's endpoint placed at the MDF. It is a device which transmits and receives optical signals using asynchronous transfer mode, Ethernet or other proprietary protocols. Because the optical signal is split several times without amplification the signal attenuation leads to smaller distances between MDF and end-users than those achievable in Active Optical networks.

Figure 2-2: Passive Optical Network (PON) infrastructure



Source: Alloptic (2007).

In comparison with active optical networks, passive optical networks have significant advantages and disadvantages. They avoid the complexities involved with keeping electronic equipment operating outdoors. The major disadvantage of a PON architecture is the need to transmit each signal to everyone served by the splitter, so that the ONU filters the relevant traffic destined for its customers.

PONs actually encompass three competitive standards.

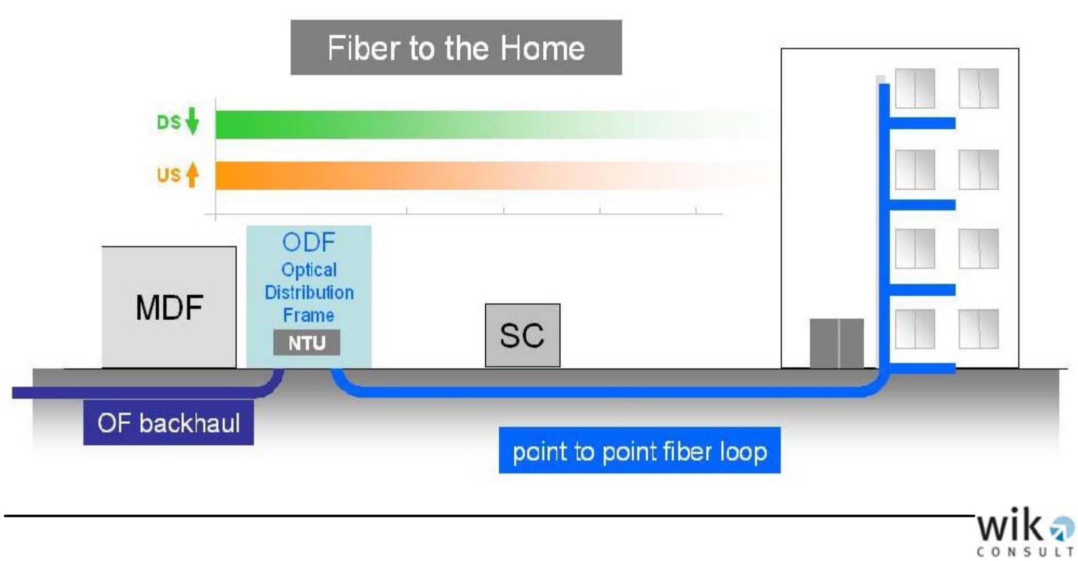
(1) BPON (ITU G.983) evolved from ATM PON works with 622 Mbit/s down- and 155 Mbit/s upstream. This standard is, however, superseded by other PON variants with better performance characteristics.

(2) GPON (ITU G.984) is based on the combination of ATM, Ethernet, and TDM and allows a shared downstream speed up to 1.24 / 2.48Gbps and up to 622M / 1.24Gbps upstream. It is possible to connect a maximum of 64 users per tree (<15km), 32 users (<20km) or 16 users (up to 30km). When 2.5Gbps are shared among 32 users, a ‘sustained rate’ of 80Mbps per subscriber is possible.

(3) EPON (IEEE 802.3ah) is based on Ethernet as the transmission protocol only. It yields a shared bandwidth of 1.25Gbps downstream, and of 1.25Gbps up-stream. A maximum of 32 users per tree (<20km) is possible allowing a ‘dy-namic rate’ of 30 – 100Mbps per subscriber, depending on simultaneous usage.

Passive optical networks can also be configured as ***point to point networks***. In this architecture, each fibre leaving the MDF extends to only one customer. Accordingly there is no splitter between MDF and the customers premise (see Figure 2-3). Such networks are able to provide extremely high bandwidths since each customer gets his own dedicated fibre extending all the way to the MDF. However, this approach needs more fibre between the “splitter location” (Street Cabinet) and the MDF site, larger optical MDF and more interfaces in the communication equipment. Therefore Point-to-Point networks tend to be more expensive.

Figure 2-3: Point to Point architecture



Source: ARCEP (2007)

Considering the regulatory implications of these architectures there are several options concerning unbundled access and also for wholesale bitstream access, depending on the access network structure.

Considering the impact factors on wholesale services regulatory framework variables include obligations to provide collocation at the MDF, access to backhaul fibre between street cabinet and MDF with access to the street cabinet, collocation at the street cabinet and unbundled access to the optical or copper line from street cabinet to the end user.

The option of unbundled access at the MDF site is possible only as long as the roll-out has been conducted as a true Point to Point Fibre to the Home architecture with fibre all the way into the individual household. If there is Fibre to the Building in the case of a multi-dwelling unit, then unbundling could only be realised for the complete building. In this case the incumbent could still provide a bitstream service which could be accessed at the MDF site or at a different location closer to the core network.

From the business perspective of a future wholesale offering, the three FTTx architectures differ considerably. In an **Active Optical Network** OAOs could collocate equipment at the street cabinet and gain access to each customer's specific access line (fibre or copper). However OAOs might choose not to unbundle at the MDF, but could obtain bitstream access at the MDF or higher network level. Bitstream access at the street cabinet is only a theoretical solution, because if an OAO already is in the street cabinet it can also collocate there.

Table 2-1: Wholesale options in Active Optical Networks

	MDF level	Street cabinet level
Collocation	possible	possible
Bitstream Access	possible	(possible) low incentive

Source: WIK Consult.

In a **Passive Optical Network** there is only a limited option of unbundling. An OAO could get access to the street cabinet in order to collocate its own splitter beside the incumbent´s and then would need unbundled access to the subloop and the backhaul infrastructure (fibre, duct). Because there is no active equipment at the street cabinet level there is no opportunity to access a bitstream service there; consequentially bitstream access is possible only at the MDF or closer to the core network.

Table 2-2: Wholesale options in Passive Optical Networks

	MDF level	Street cabinet level
Collocation	possible	(limited possibility)
Bitstream Access	possible	impossible

Source: WIK Consult.

A PON configured in Point-to-Point architecture enables unbundling from the MDF or the street cabinet since every end-user has a dedicated fibre which may be unbundled separately; however, due to the fact that there this is a Passive Optical Network without active equipment at the street cabinet there is again no ability to access bitstream at the street cabinet.

Table 2-3: Wholesale options in Point to Point PONs

	MDF level	Street cabinet level
Collocation	possible	possible
Bitstream Access	possible	impossible

Source: WIK Consult.

In addition, there are new approaches towards wholesale services based on new innovations by equipment manufacturers. Generally, there would be two approaches to colocation for sub-loop unbundling: an additional external street cabinet for the OAO or collocation inside the incumbent's cabinet. An example of an additional new approach is the line card leasing model which resembles a hybrid sub-loop unbundling / bitstream product in the context of an FTTC / VDSL deployment. Each line card in a DSLAM can be independently managed in a multi-tenant manner by the incumbent and the OAOs, who rented such a card. The OAO rents the sub-loop while the incumbent operates the DSLAM with a multi-tenant functionality in the street cabinet. The OAO is able to manage the port of their customer on the incumbent's infrastructure.[2] The incumbent would need to handover the traffic at the street cabinet, the MDF site or even on a higher network level in a wholesale bitstream manner.

This line card leasing model might provide economic advantages, as it requires neither multiple street cabinets nor multiple DSLAMs within the cabinet; however this is a proprietary approach and - to the best of our knowledge - has not been implemented anywhere to date. Still, it may serve as an example of potential changes for architecture and wholesale services when migrating to the NGN.

Since Local Loop Unbundling (LLU) cooperation options are specifically addressed in a separate study we will not include detailed views about LLU and sub loop unbundling here, but focus on the related wholesale bitstream options.

2 See Wulf, Alf Hendryk (2007): Access requirements and access options in a VDSL environment. Presentation at WIK VDSL conference March 2007.

2.4.2 Changes in the aggregation network

With FTTx architectures being deployed the NGN will require backhaul networks extending to the street cabinet and/or leading to optical main distribution frames. Furthermore many industry observers believe that the network architecture of the access network will migrate from ATM to Ethernet because of the potential for cost reduction and the higher bandwidth of Ethernet compared to ATM.

Work package 2 (chapter 1) analyses the interconnection structure of current and emerging NGN bitstream services in detail. At this point it is important to bear in mind that the number of aggregation nodes will change (for example less main distribution frames if these are phased out) as will the location of potential interconnection points (for example requiring unbundling to move towards the sub-loop or introducing super aggregators which may serve as new access point for bitstream).

In addition the traffic management and provisioning of different QoS classes through an Ethernet aggregation network has a different scope than that in an ATM environment. ATM aggregation networks can carry user traffic in Virtual Channels which can have a defined quality and bandwidth. Ethernet can carry traffic in defined and separated VLANs but the standardized QoS mechanisms are limited. Notably, the IEEE 802.1q protocol provides a mechanism for tagging Ethernet frames so as to indicate the desired QoS characteristics.

As an alternative, QoS could be realised by means of IP-protocol based instruments like Differentiated Services (DiffServ, a simple protocol that signals the desired QoS) and/or MPLS (Multi Protocol Label Switching), or conceivably by the Resource Reservation Protocol (RSVP, the rarely implemented protocol of the Integrated Services Architecture). DiffServ and MPLS cannot *guarantee* a connection with dedicated QoS features like ATM, but they can provide a reasonable probabilistic assurance.

The overall value of QoS in IP-based networks continues to be hotly debated. Even though DiffServ/MPLS have been widely implemented *within* networks for perhaps ten years, they are rarely implemented *between* IP-based networks, and their value remains unclear. Telephony engineers argue that IP-based networks deliver adequate QoS only when they are massively, wastefully engineered (pejoratively referred to as over-engineering). Internet engineers tend to counter that an IP network, like a circuit-switched network, has to be designed with some excess capacity; that the presence or absence of differentiated QoS makes little difference in the required capacity under realistic assumptions; and that bandwidth is cheap anyway these days. Whether the excess capacity should be viewed as over-engineering or merely as normal and proper design is thus largely a matter of taste.

What is clear from North American experience is that consumers have limited ability to distinguish among different levels of QoS (even for delay-sensitive services like VoIP), and that their willingness to pay a premium for better-than-best-efforts QoS is limited.

With all of that said, it is the access network where differentiated QoS is likely to be most beneficial, and it is also in the access network that differentiated QoS is most easily implemented. Whatever the merits of IP QoS in general, it makes sense in the access network, and is thus relevant for bitstream.

2.4.3 Video distribution

Electronic communication can be structured in three fundamental methods: unicast, broadcast, and multicast. Unicast traffic is sent to a single specific destination such as a host computer, web server or a particular end user (communication between two endpoints). Broadcast traffic is forwarded to all users of a network (one to all). Multicast traffic is delivered to a specific subset of the network's users (one to a defined subset of users).[3]

There are many forms of IP television (IPTV). In this section, our primary concern is with "live" IPTV, where the end-user essentially tunes in to a serial broadcast; however, IPTV could also be used for highly interactive services (for example, "picture in picture" services where an athlete's statistics are displayed in a small window while watching a game), or Video on Demand (VoD).

Live IPTV is a typical multicast service. TV programs are distributed to the subscribers of the service, thus to a subset of all users. The easiest way to implement such an IP-TV service would be to distribute all programs permanently throughout the network to all possible users (broadcast), so that each subscriber who is allowed to receive them can pick the programs he/she wants to see. This is the way radio, satellite and cable-TV networks operate. Keeping in mind that each program will need 2 – 5 Mbit/s downstream capacity, and there may be up to 100 programs, that mode of operation is not possible in NGN based networks. Even receiving 4 or 5 programs in parallel would be a challenge for capacity of the access networks.

Therefore IPTV servers are placed in the network that establish communication on demand between the server and the receiver, transmitting just one program. This may be realised by establishing unicast communications between the server and the receiver, or by enlarging a multicast group, when the underlying network supports multicast and when some other subscribers already are receiving that specific program. To that extent

3 Source: Spirent (2003): Whitepaper multicast routing.

one could say that the network extends the server capability by multiplying the program stream.

How many servers for live IPTV are placed in the network depends on the network architecture (e.g. the ability to support multicast) and the number of subscribers being supported. In a network with a multicast feature one server (or two for redundancy) could be sufficient, assuming that the server has sufficient capacity to serve all the video streams simultaneously. In a network without multicast support one would typically want the servers to closer to the customers as they have to serve the customers in an unicast manner. In this second case, the placement of the servers represents an economic trade-off between the cost of transmission versus the cost of the server locations and the servers themselves. If the cost of transmission is high relative to the cost of servers and server locations, that would argue for moving the servers as close as possible to the users.

When there are several IPTV servers they may alternatively receive the programs through a multicast communication with a head-end system, which receives the program from different sources (radio, satellite, cable, servers, …).

A bitstream product with multicast functionalities implies large bandwidth resources in the incumbent’s aggregation network. Considering multiple operators buying wholesale access from the incumbent each of the programs by each operator requires 2 – 5 Mbit/s downstream. 5 service providers with 100 programs each would need 1 – 2,5 Gbit/s bandwidth to each access aggregation point. Accordingly this could result in the need to support a large amount of bandwidth in the aggregation network. However as long as DSLAMs are backhaul by fibre with GbE or 10GbE there should not be a technical bottleneck. Chapter 4.2.3 deals with trade-off considerations of different approaches for realisation of IPTV delivery.

A bitstream product suitable for a TV-stream has additional requirements regarding the signal transport quality with respect to jitter, delay and packet loss (see chapter 4.2.2.2 and 5.1).

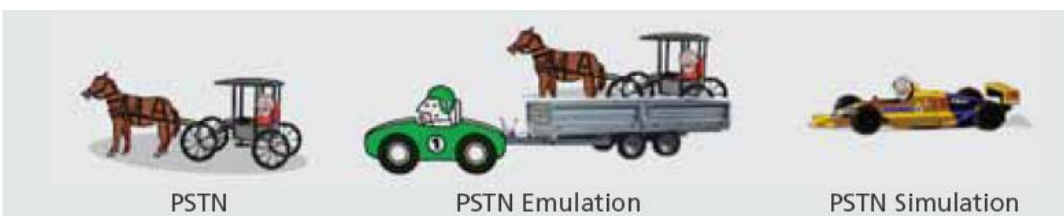
2.4.4 Integration of PSTN voice in the NGN

As IP becomes an increasingly central component of the architecture in the NGN a number of issues arise regarding the integration of voice services. In addition to non wholesale related regulatory aspects (such as emergency services and lawful interception) the incumbent’s implementation strategy for VoIP in the NGN is a critical issue as it directly impacts on the wholesale and interconnection options for OAOs.

Regarding voice integration ETSI has defined two subsystems called PSTN *Emulation* and PSTN *Simulation*. [4]

- PSTN/ISDN **Emulation** – "Provides PSTN/ISDN-like service capabilities using session control over IP interfaces and infrastructure": PSTN Emulation creates a service in an NGN that is effectively identical to the PSTN (same feature set and user interface). In the PSTN emulation nothing changes for the end-user.
- PSTN/ISDN **Simulation** – "Provides PSTN/ISDN service capabilities and interfaces using adaptation to an IP infrastructure": PSTN/ISDN Simulation is more about allowing evolution into a new NGN environment rather than replicating the old environment exactly (e.g. it can use a variety of new terminal types such as VoIP phones, offer new value-added features, but also not offer some old ones). This approach does not require the mapping of every complex PSTN supplementary service into SIP. PSTN Simulation Service always uses IMS, which is termed a PSTN Simulation Subsystem. Due to the relatively high cost of IP terminals this approach is mainly used for business customers

Figure 2-4: Visualisation of the difference between PSTN/ISDN Emulation and Simulation



Source: BT.

Wholesale voice depends on the amount of points of interconnection, which may be reduced compared to the PSTN implementation, and the way how the interconnected traffic will be charged. With ‘Bill & Keep’ for example cash streams between the operators may no longer exist. But wholesale voice is not the subject of this study.

Wholesale bitstream access can be used to access end customers for voice services. Transferring voice in an IP-based network will require some rather high QoS guaranties concerning bandwidth, jitter, delay and packet loss.

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4 Source: Light Reading (2005): The Role of IMS in PSTN-to-VOIP Migration.

3 Survey of retail triple play product offerings and technical implementation strategies (WP1)

3.1 Introduction

Triple play offerings are typically defined as service bundles of voice telephony, IP-based video (IPTV), and broadband data (e.g. fast Internet access).[5]

The aim of this work package is to provide an overview of retail triple play packages and an assessment of the underlying technical strategies. Therefore we have analysed on a case study basis examples from the three designated countries (Netherlands, France and Germany) complemented with examples from Italy where both emerging NGN retail and NGN wholesale have already been realised. This provides ComReg with an outline of the triple play strategies of incumbents and alternative operators. A first overview is given in the table below (see Table 3-1).

Table 3-1: Triple play retail offerings in France, Germany, Italy and the Netherlands

Provider	No. of triple play subscribers	Name of the offer	Price per month/€	Max. bandwidth (downstream) / access strategy
France Telecom (FR)	577,000* (01/2007)	Livebox	29,90 -44,90 (09/2007)	18 Mbps ADSL 2+ - 100 Mbps **FTTH**
Free Telecom (FR)	310,000* (01/2007)	Freebox	29,99 (09/2007)	22 Mbps ADSL 2+ - 100 Mps **FTTH**
Deutsche Telekom (DE)	< 10,000 (11/2006)	Entertain Basic/Comfort	49,95 - 84,95 (09/2007)	16 Mbps ADSL 2+ -25 Mbps **FTTC**
Telecom Italia (IT)	< 30,000 (10/2007)	Alice Tutto Inclusio TV	52.00 (09/2007)	20 Mbps ADSL 2+ / **FTTC** under development
Fastweb (IT)	< 250,000** (09/2007)	Var.	45.00 – 77.00 (09/2007)	10 Mbps **FTTH** - 20 Mbps ADSL 2+
KPN (NL)	10,000 (10/2006)	Internet+bellen+televisie	52,90 (09/2007)	6 Mbps ADSL 2+ / **FTTC** under development

Under development indicates that there is no commercialised offer at the moment.
Source: WIK Consult analysis of operator website and * e-Media Research. ** WIK Consult estimation[6]

It is noticeable that some operators have embarked on a FTTC strategy whereas others have chosen to run fibre all the way to the home through FTTH. A number of factors influence the economics of the two architectures. Some shall be highlighted here briefly.

5 Given the purest definition of an NGN, competitive bundles may prove to be Double Play: residential broadband service and mobile broadband service. Everything else would be an application riding on the network. Applications could be offered by the network operator or unaffiliated provider. In our proposal, we confine our remarks to the service offerings normally thought of as triple play.

6 Based on Fastweb quarterly report of 30 September 2007 considering residential subscribers and average IPTV penetration in newly acquired customers. Other sources (Screendigest/Goldmedia) quote about 250,000 customers at the end of 2006.

- Number and location of MDF and street cabinets: The less street cabinets there are per MDF, the less locations fibre must be extended to from the MDF which makes FTTC relatively more economical. The more street cabinets there are per MDF the more investment has to be undertaken to backhaul each of them. This makes FTTH relatively more attractive.
  In addition the number of access lines per street cabinet influences the economics of a FTTC business model. The more lines there are per street cabinet the more potential customers there are and the higher the number of efficient operators who may compete for subscribers through their own FTTC infrastructure.

- Distribution of line lengths: Due to the relation between bandwidth and length of the loop, short loops enable higher bandwidth thus making a FTTC relatively more attractive. Long sub loops do not enable a significant increase in bandwidth through FTTC therefore making FTTH relatively more attractive.

These factors have been summarized in Table 3-2 which shows that they vary significantly between countries.

Table 3-2: Overview of structural parameters in Germany, the Netherlands, France and Italy

Country specific infrastructural parameters	Germany	Netherlands	France	Italy
Number of incumbent Copper lines	36,989,000 **	7,373,000 **	33,365,500 **	21,278,077**
Number of incumbent DSL lines	6,146,000 **	1,549,000 **	5,150,465 **	6,431,310**
Number of total DSL lines	7,068,683 **	2,071,000 **	7,183,611**	7,863,432**
Number of FTTx subscribers	n.a.	70,000 ***	8,000 ***	233,000**
Average length of sub Loop in metres	300 *	1000*	750 *	400 *
Number of MDFs	7,900 **	1,350 **	13,500 **	11,300**
Number of Street Cabinets	290,000 **	28,000 **	120,000 **	145,000****
Average Number of SC per MDF	40 *	21 *	10 *	13
Average Number of Copper lines per MDF	4,682	5,461	2,472	1,883
Average Number of Copper lines per SC	128	263	278	147
Percentage of Population living in rural areas in %	15	2.2	23	14

Sources: * JP Morgan (2006): "The fibre battle"
**ECTA Broadband Scorecard (3 Q/2006)
***Idate: FTTx Situation in Europe 02/2007
****Telecom Italia (2007)

Source: WIK (2007).

However these can only be considered as part of the problem. The difference between countries extends towards other factors such as (distribution of) population density or access to low cost ducts, other infrastructures that facilitate FTTH deployment or even neutral FTTH networks.

For example the Netherlands have a very large concentration of population in urban and suburban areas. This makes it considerably easier for operators to deploy FTTx to a large part of the population. In fact numerous regional initiatives have arisen that deploy FTTH with non-discriminatory access for all operators. In France there are accessible sewers which have been made available to operators under very favourable conditions (for example in Paris). Accordingly carriers have an added incentive (in addition to the long average sub-loop lengths) to deploy FTTH.

This shows that local access conditions defined by specific socio-demographic, technological-economic and regulatory framework strongly influence the triple play / NGN deployment strategies of operators.

3.2 Case Studies

In the following chapter we highlight six case studies for triple play roll outs. The following structure has been used to analyse the operators:

- Overview of retail service packages
- Current network architecture
- Realisation of triple play and migration to Next Generation Networks

3.2.1 France: France Telecom

3.2.1.1 Overview of retail service packages

France Telecom launched its first triple play offer in 2004. France Telecoms current retail triple play offers are:

Table 3-3: France Telecom's current triple play offers

	Livebox 8 Megamax	Livebox 18 Megamax	Livebox FTTH
Price per month/€	29.90	34.90	44.90
max. bandwidth	8 Mbps (ADSL 2+)	18 Mbps (ADSL 2+)	100 Mbps (FTTH)
Broadcasting TV Services	yes (54 Channels)	yes (54 Channels)	yes (54 Channels)
On Demand Services	yes (extra charge)	yes (extra charge)	yes (extra charge)
Online Flatrate	yes	yes	yes
Voice Flatrate: to national fixed link	yes (France métropolitaine)	yes (France métropolitaine)	yes (France métropolitaine)
Voice Flatrate: to mobile	Not included, but 30 minutes per month free of charge	Not included, but 30 minutes per month free of charge	Not included, but 30 minutes per month free of charge

Source: WIK Consult analysis of operator website.

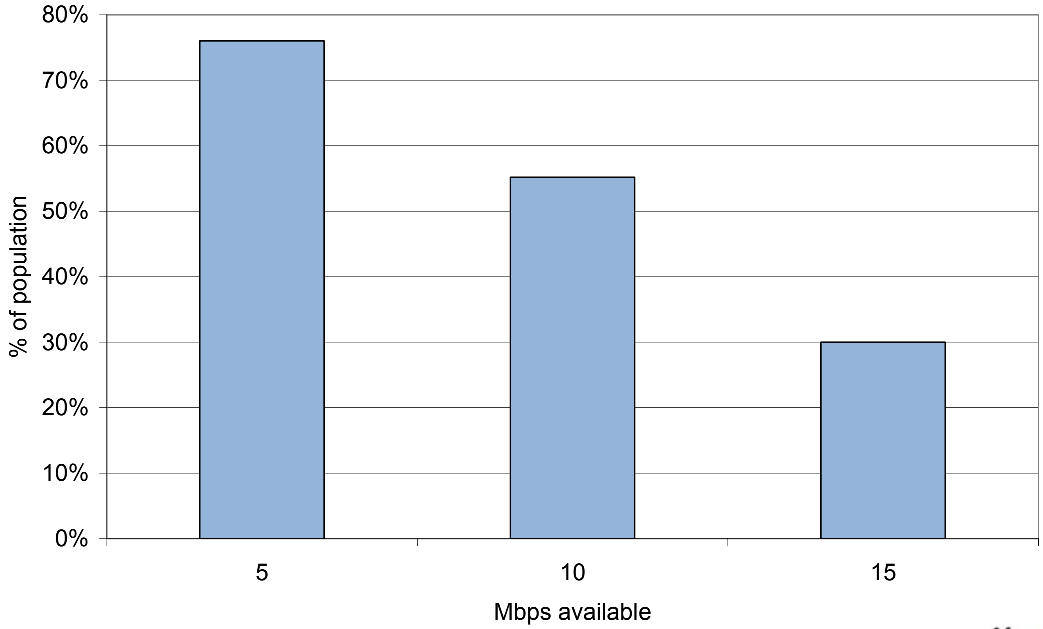
3.2.1.2 Current network architecture

FT's current network consists of about 13,500 Main Distribution Frames (MDFs) and about 120,000 street cabinets. This equals approximately 9 cabinets per MDF[7]. In France the average sub loop length is approximately 750 m[8]. France Telecom is mainly offering ADSL 2+ based internet access lines. Depending on sub loop lengths Figure 3-1 shows bandwidths available in France for ADSL2+ retail customers:

7 See JP Morgan (2006): The fibre battle.

8 See Hennes (2007): From FTTH pilot to pre-rollout in France. Presentation at WIK-Conference "The way to next generation networks" 21st of March.

Figure 3-1: Bandwidths available in France per % of population



Source: WIK (2007).

Since summer 2006 FT is running FTTH field trials in 6 Arrondissements in Paris and in the department Hauts-de-Seine. These field trials cover several thousand households. France Telecom uses Point to Multipoint Passive Optical Network (GPON) technology to realise its FTTH deployment. This GPON technology allows the connection of up to 64 clients by one fibre and offers bandwidths up to 2.5 Gbps downstream and 1.2 Gbps upstream. France Telecoms FTTH trials can be characterised by following facts:

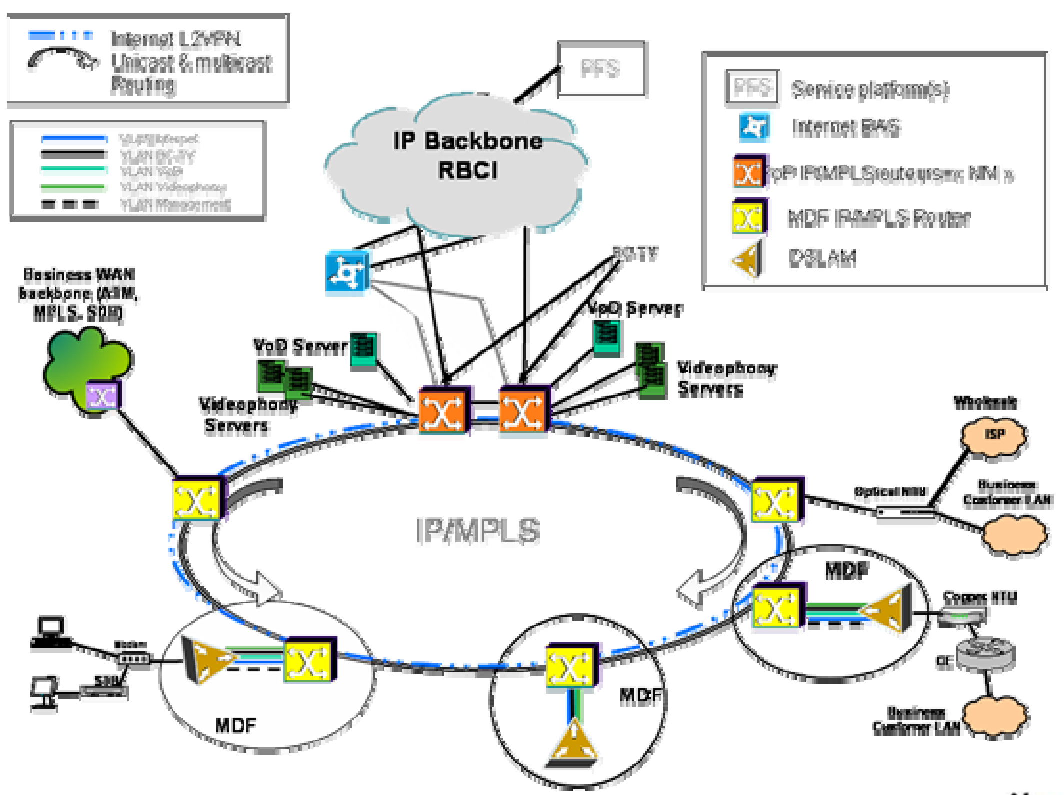
- Field trials in Paris and the department Hauts-de-Seine (since summer 2006)
- 100,000 km of fibre implemented
- 1000 € estimated investmented per subscriber
- 10,500 Households passed
- 500 Subscribers (5 % penetration rate according to households passed)
- 70 € ARPU per month
- 700 signed cooperation agreement with real estate syndicates (conseils syndicaux d'immeubles)

3.2.1.3 Realisation of triple play and migration to Next Generation Networks

FT has further FTTH implementation plans for the cities of Marseille, Lyon, Lille and Toulouse. The Company is targeting 150,000 – 200,000 active customers and up to 1 Million homes passed by FTTH solutions in 2008. The planned investment for this second stage of France Telecom's FTTH deployment is approximately 270 million Euro until 2008[9].

Figure 3-2 depicts the realisation of France Telecom's triple play retail offer. Similar to the realisation of KPN's 'Mine TV' IPTV service France Telecom uses separate content servers for Video on Demand services (VoD Servers) and Live Broadcasting services (BC-TV).

Figure 3-2: France Telecom's triple play infrastructure



Source: France Telecom (2006).
RBCI = Réseau Backbone de Collecte Internet (French for IP backbone)
Internet BAS = Broadband Remote Access Server (BRAS)

9 See Hennes (2007): From FTTH pilot to pre-rollout in France. Presentation at WIK-Conference "The way to next generation networks" 21st of March.

France Telecom locates their VoD server on city level, analogue to Telecom Italia's strategy. Multicasting is used to enable IPTV distribution from central servers to the DSLAM (it remains unclear whether channels are distributed to the IP PoPs through a separate backbone). While Fastweb in Italy relies on QoS mechanisms on OSI layer 2 France Telecom is implementing QoS in the IP level by implementing MPLS all the way to the DSLAM.

France Telecom is currently under pressure to substitute old and outdated PSTN switches for a substantial part of their network (about 10million lines). Accordingly France Telecom needs to choose between migrating directly to an NGN platform with PSTN/ISDN Emulation & Simulation or investing into modern TDM technology which would take away the pressure of NGN implementation (at potentially premature product levels). At the end of 2006 France Telecom planned to complete the PSTN reconstruction by the end of 2007.

3.2.2 France: Free Telecom (Iliad)

3.2.2.1 Overview of retail service packages

Free Telecoms current triple play offer is marketed under the label "Freebox".

Table 3-4: Free Telecom's current triple play offers

	Freebox ADSL	**Freebox FTTH**
Price per month/€	29.99	29.99
max. bandwidth	22 Mbps (ADSL 2+)	100 Mps (FTTH)
Broadcasting TV Services	yes (100 Channels)	yes (100 Channels)
On Demand Services	yes (extra charge)	yes (extra charge)
Online Flatrate	yes	yes
Voice Flatrate: to national fixed link	yes (France métropolitaine + 28 other destinations like USA, Germany, U.K. etc.)	yes (France métropolitaine + 28 other destinations like USA, Germany, U.K. etc.)
Voice Flatrate: to mobile	Not included	Not included

Source: WIK Consult analysis of operator website.

3.2.2.2 Current network architecture

Free Telecom (a subsidiary of the Iliad corporation) is the main competitor to incumbent France Telecom in the French market. In December 2006 Free Telecom had acquired approximately 2.3 million ADSL subscribers. Currently Free Telecom has access to 908[10] DSLAM-equipped Main distribution frames (MDF). Free Telecom also accesses 75.9% of their subscribers via unbundled local loop. Approximately 90% of Free Telecom's ADSL subscribers are connected by ADSL 2+ technology. Furthermore about 75% of Free Telecom's customers receive bandwidths that can support triple play services.

3.2.2.3 Realisation of triple play and migration to Next Generation Networks

Free Telecom is targeting about 2.8 million ADSL subscribers for 2007. Furthermore the company aims to reach a total of 2,200 Main Distribution Frames in 2008 via full unbundled local loop.

The company's NGN strategy focuses on FTTH deployment. Free Telecom plans to provide 4 million French homes with FTTH by 2012 through an active point-to-point architecture. This equates to a population of 10 million. Free Telecom's FTTH deployment plans focus geographically on Paris and its suburbs. Furthermore, a wider FTTX deployment is planned for the cities of Montpellier, Lyon and Valenciennes. Regarding its prospective FTTH deployment, Free Telecom expects a total investment of 1 billion Euros. For 2007 the company estimates investments to total 300 million Euros. For the period between 2008 and 2012 the company expects additional annual investments up to 150 million Euros. Free's FTTH deployment strategy doesn't focus on the entirely replacing of ADSL2+ by fibre, instead the company plans fibre areas to coexist with ADSL2+ areas. The company selects prospective fibre areas according to the following criteria:

- Density of existing Free Telecom subscribers in the particular area: Free will only target areas where it has a minimum 15 % market share of existing landlines, not only ADSL lines.
- Cost of civil engineering alternatives like sewers or micro trenches in the particular area.

10 Of total 13,500 MDFs in France.

3.2.3 Germany: Deutsche Telekom

3.2.3.1 Overview of retail service packages

Deutsche Telekom launched its IPTV service in late 2006. At that time only a VDSL based IPTV offering was announced. In March 2007 the German incumbent extended its offer towards ADSL2+ access lines. The ADSL2+ based offer is available for 17 million homes, which equals a coverage of 44 %. According to its original deployment plans Deutsche Telekom is aiming to cover approximately 8 million homes in 50 Cities with VDSL 2+ until 2009. Deutsche Telekom's current triple play offers are:

Table 3-5: Deutsche Telekom's current triple play offers

	Entertain Basic	**Entertain Comfort**	**Entertain Comfort Plus**	**Entertain Comfort VDSL**	**Entertain Comfort Plus VDSL**
Price per month/€	49.95	59.95	74.95	69.95	84.95
max. bandwidth	16 Mbps (ADSL 2+)	16 Mbps (ADSL 2+)	16 Mbps (ADSL 2+)	25 Mbps (VDSL)	25 Mbps (VDSL)
Broadcasting TV Services	no	yes (>100 Channels)	yes (>130 Channels)	yes (>100 Channels)	yes (>130 Channels)
On Demand Services	yes (extra charge)	yes (extra charge)	yes (extra charge)	yes (extra charge)	yes (extra charge)
Online Flatrate	yes	yes	yes	yes	yes
Voice Flatrate: to national fixed link	yes	yes	yes	yes	yes
Voice Flatrate: to mobile	Not included	Not included	yes	Not included	yes

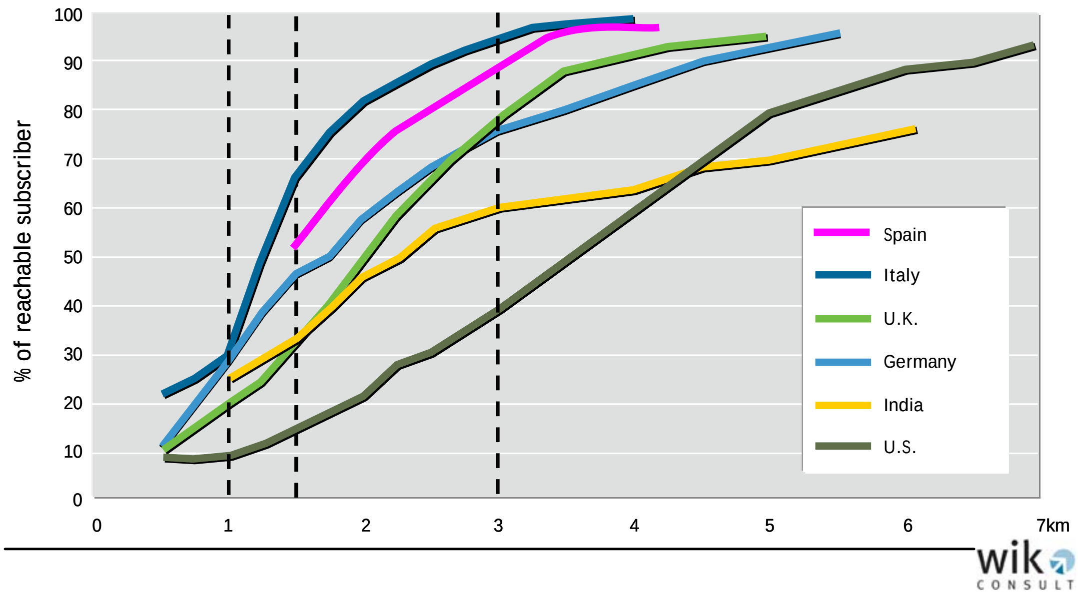
Source: WIK Consult analysis of operator website.

3.2.3.2 Current network architecture

DTAG's current network consists of about 7,900 Main Distribution Frames (MDF) which are entirely accessible on the basis of fibre, and about 290,000 street cabinets. This equals approximately 40 cabinets per MDF[11]. In Germany the average number of access lines per cabinet is less than 200[12]. Furthermore, the network is composed of 23 transit switches. The average Sub loop length is approximately 300 metres. In Germany about 75% of the population are connected to local loop lines shorter than 3 kilometres (see Figure 3-3).

11 See JP Morgan (2006): The fibre battle.
12 See JP Morgan (2006): The fibre battle.

Figure 3-3: Local loop lengths in selected countries

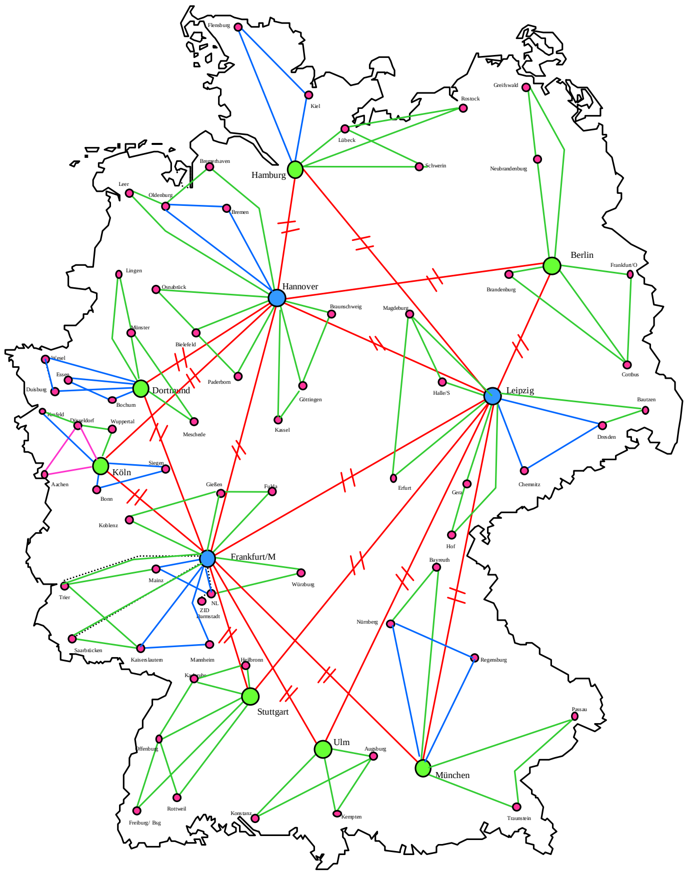


Source: Alcatel-Lucent (2007)

Competitiors can get (regulated) access to the incumbents network at 474 POIs for PSTN interconnection traffic, and at 73 PoPs for IP interconnection traffic. In the 1990s there was a major overhaul of DTAG's network by virtue of digitization and the implementation of ISDN.

Deutsche Telecom's IP network (see Figure 3-4) consists of three Core Routers (blue spots) which are located in the cities of Hanover, Frankfurt and Leipzig and eight Sub Core Routers (green spots) which are located in Hamburg, Berlin, Dortmund, Cologne, Stuttgart, Ulm and Munich. Every Sub Core Router is connected to at least two Core Routers. Furthermore Core Routers and Sub Core Routers act as traffic aggregation points for 62 Edge Router locations (red spots).

Figure 3-4: Deutsche Telekom's IP network



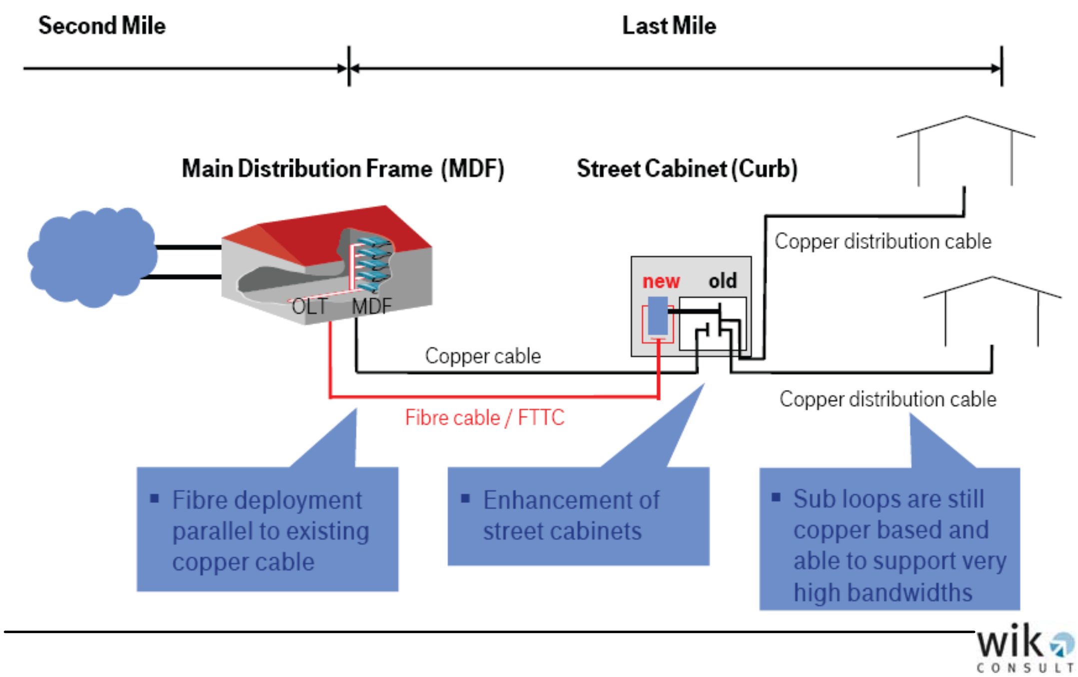
Source: Deutsche Telekom (2001).

3.2.3.3 Realisation of triple play and migration to Next Generation Networks

In contrast to KPN's NGN deployment plan, Deutsche Telecom is pursuing an "overlay strategy". The Next Generation Core Network is initially being built over the current network. Until the scheduled end of NGN deployment (2012), a step by step transition process will be initiated.

For the access network Deutsche Telekom has announced plans to deploy fibre between the MDFs and street cabinets (FTTC) and to install VDSL solutions (see Figure 3-5).

Figure 3-5: Deutsche Telekom's VDSL solution

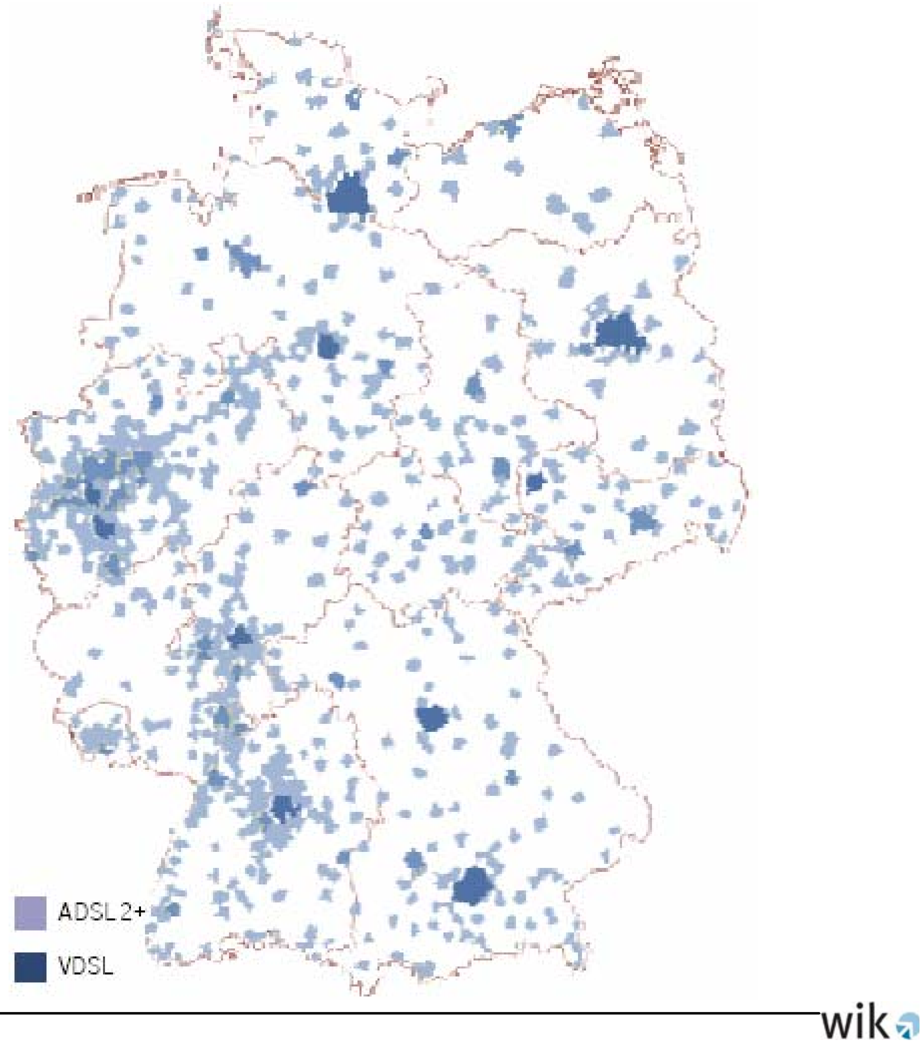


OLT – Optical Line Terminal
Source: Deutsche Telekom (2006).

Deutsche Telekom deploys fibre parallel to the existing copper cable between the Main Distribution Frame location and the street cabinet. The existing Street Cabinets are expanded into so-called Outdoor-DSLAM locations. The DSLAM collects digital signals from its many modem ports and multiplexes them into one signal. The sub loops remain copper based.

Geographically the company focuses on densely populated areas. Currently (as of October 2007) the network deployment covers 12 metropolitan areas with about 5.9 million potential customers (see Figure 3-6 The figure emphasizes the small geographical footprint of the roll out area. On the basis of its original plans Deutsche Telekom aims to deploy fibre in Germany's 50 biggest cities by 2008. The overall investment budget amounts to roughly 3 billion Euro. Up to the end of 2006 the company had spent about 550 million Euro for its network upgrade, however Deutsche Telekom temporarily stopped its further VDSL deployment because of uncertainties regarding the prospective regulatory treatment of the network. Deutsche Telekom's VDSL network is able to provide bandwidths up to 50 Mbps per subscriber, however currently Deutsche Telekom only offers access speeds up to 25 Mbps for retail customers.

Figure 3-6: Deutsche Telekom: ADSL2+ and VDSL Coverage



Source: Kopf (2007). Presentation at WIK-Conference “The way to next generation networks” 21st of March.

Deutsche Telekom’s triple play services are based on Cisco systems Internet Protocol Next Generation Network (IP NGN) architecture and use Cisco IP set top boxes supporting the Microsoft TV IPTV Edition software platform. Furthermore Deutsche Telekom uses the Alcatel 7750 Service Router as a component of its IPTV platform.

3.2.4 Italy: Telecom Italia

3.2.4.1 Overview of retail service packages

After a successful trial in approximately one thousand Italian households, Telecom Italia's IPTV service (marketed under the label "Alice TV ") was launched on December 2, 2005. Telecom Italia's current retail triple play offer ("Alice Tutto Inclusio TV") is priced at 52.00 Euros per month. IPTV is only offered where bandwidths of 20 Mbps (ADSL2+ based) are available (see Table 3-6).

Table 3-6 Telecom Italia's current triple play offer

	Alice Tutto Inclusio TV
Price per month/€	52,00
max. bandwidth	20 Mbps (ADSL 2+)
Broadcasting TV Services	yes (approx. 100 Channels)
On Demand Services	yes (extra charge)
Online Flatrate	yes
Voice Flatrate: to national fixed link	yes
Voice Flatrate: to mobile	Not included

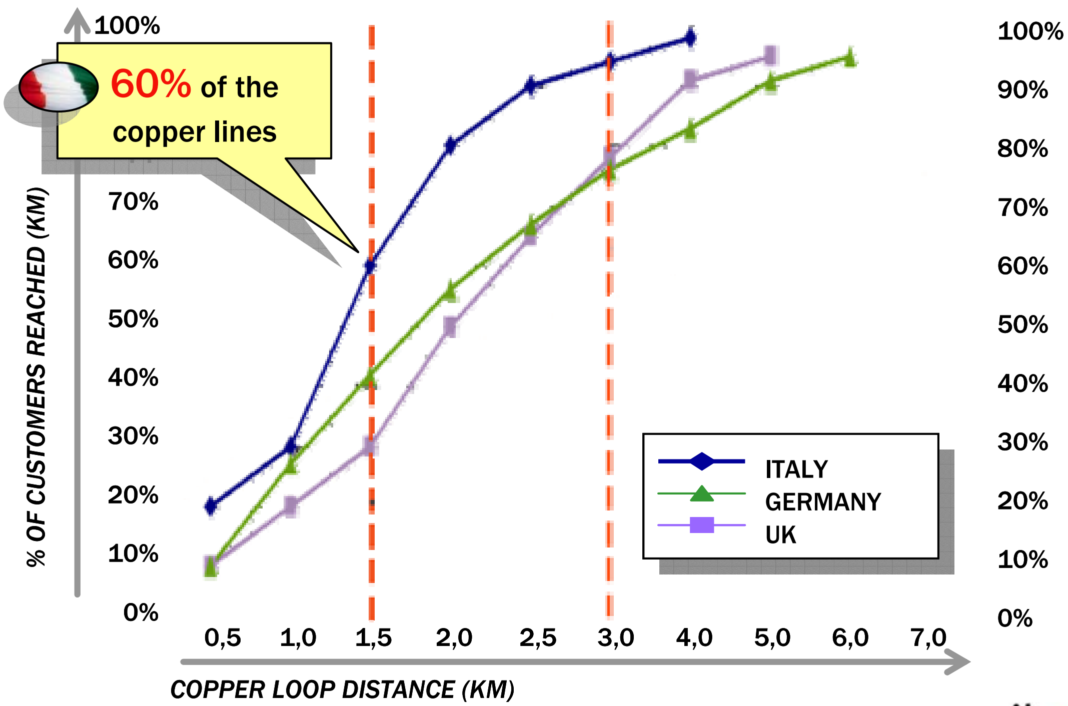
Source: WIK Consult analysis of operator website.

3.2.4.2 Current network architecture

In Italy there are approximately 11,300 Main Distribution Frames (MDFs) and about 145,000 street cabinets (the average number of lines per cabinet is about 150 in Italy). Unlike Germany, the MDFs are not yet solely accessed on the basis of fibre. Indeed, only about 6,000 of the MDFs are already fibre based (as of December 2006). The MDFs accessible by fibre enable the provision of ADSL for about 89% of the population.

Figure 3-7 shows the distribution of loop lengths in comparison with other countries. It is apparent that Italy has a very high percentage of short loop lengths, indeed the shortest loops of all countries considered. This allows for high bandwidths from the main distribution frame with ADSL2+ technology. The average sub loop length in Italy is approximately 400 metres.

Figure 3-7: Local loop lengths in Italy, Germany and the United Kingdom.



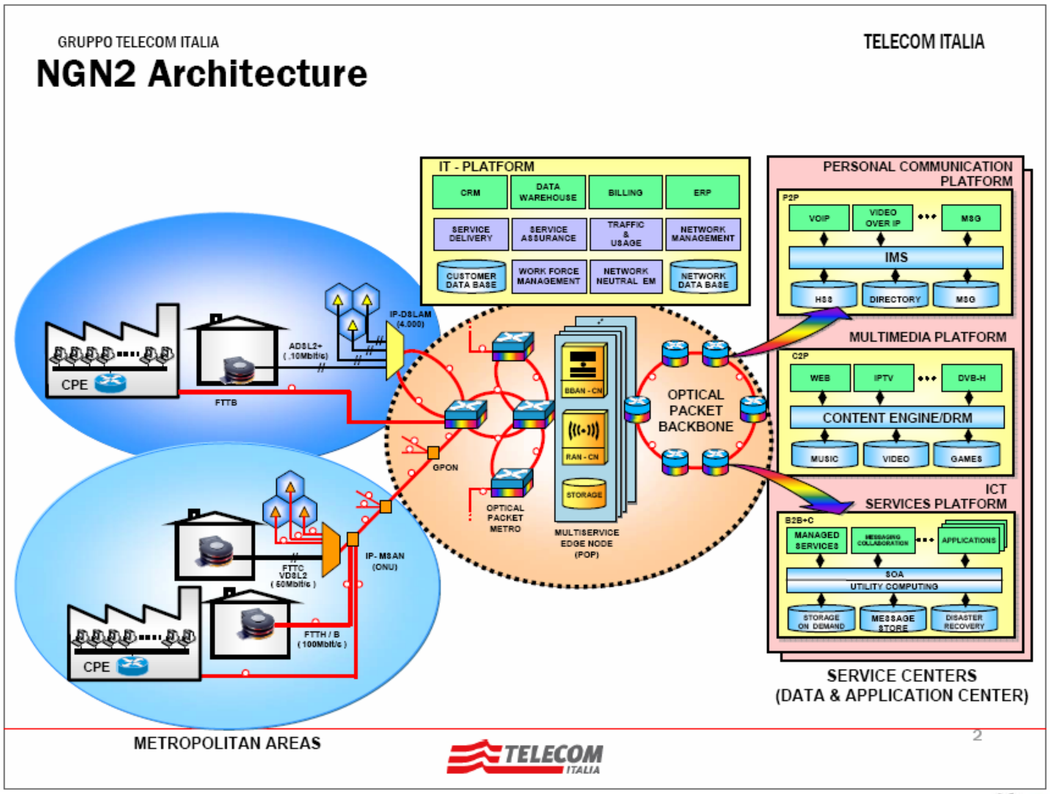
Source: Telecom Italia (2007)

3.2.4.3 Realisation of triple play and migration to Next Generation Networks

Telecom Italia's IPTV service "Alice TV" uses separate Video on Demand (VoD) and Live Streaming servers. The Video on Demand servers are located at the Central Offices, while the live streaming servers for IPTV are located higher in the network, usually at a backbone level tandem node. This architecture refers to the rationality that Video on Demand services should not occupy bandwidths at higher network levels because of the service's inability to use multicast architectures; VoD is a unicast relation between server and end-user (see chapter 2.4.3).

Telecom Italia is currently deploying NGN technology ("piano NGN2"). The intention is to deploy mixed FTTC/VDSL2, FTTH and FTTB solutions (see Figure 3-8). It is also reported that Telecom Italia is investigating WiMAX wireless broadband technology to fill in the gaps in coverage in the NGN2 system, making high speed services available to 99% of the population by the end of 2009.

Figure 3-8: Planned NGN architecture of Telecom Italia



Source: Telecom Italia (2006)

Telecom Italia (TI) launched the transition of the traditional PSTN transmission mode towards IP in their core network in the year 2000. TI is deploying an overlay strategy, which means that in the short term there will be two parallel infrastructures (PSTN based and IP based) in Telecom Italia's core network. Within the migration towards NGN Telecom Italia will drive a PSTN emulation strategy meaning that customers will continue using their existing terminals.

In March 2007 TI announced plans to invest EUR 6.5 billion over the next ten years in rolling out its NGN2 infrastructure. The system will support broadband access at speeds of up to 50Mbps. Telecom Italia's NGN deployment plans are characterised by the following elements:

- Implementation of a fully IP based network
- Deployment of 60,000 kilometres of optical fibre until 2018

- Shutdown of 1,000 Main Distribution Frames out of 11,300 up until 2018 mainly in urban areas (Telecom Italia plans to shut down the first MDF in 2011 or 2012). This reduction of less than 10% of MDF compares with a envisioned reduction of about 85% of MDFs in the Netherlands.

- Extension of ADSL 2+ coverage from 51% up to 67% coverage from 2007 to 2009 (see Figure 3-9).

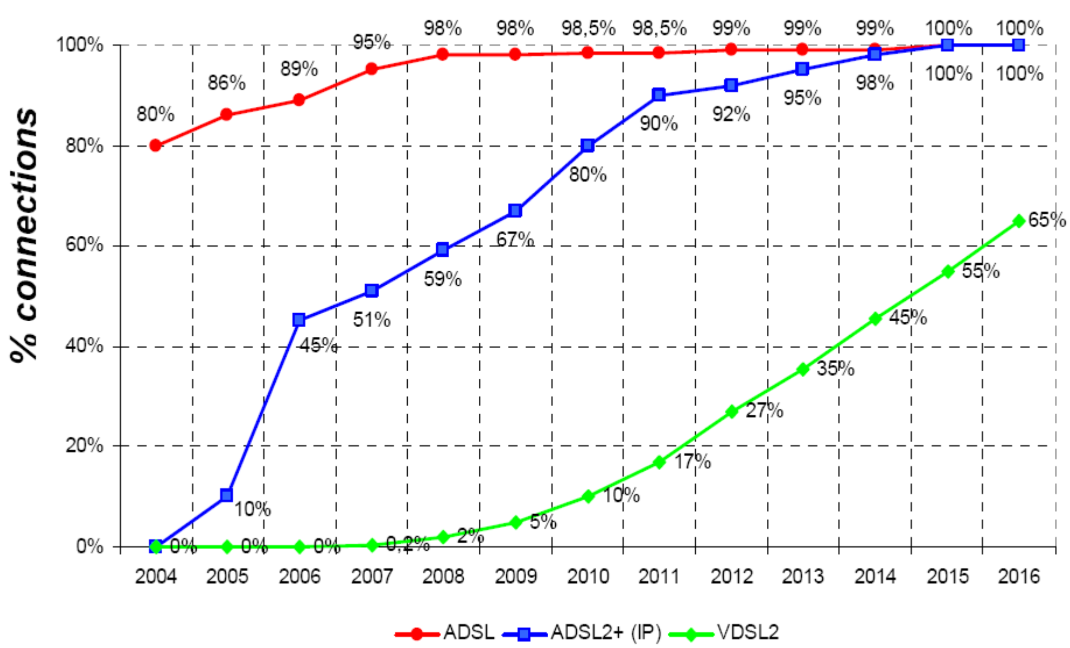
- Until 2009: Realizing a fibre and VDSL2 coverage of 5% of overall Italian population - corresponding to 20 main cities - (see Figure 3-9) until 2009.

- Until 2016: Realizing a fibre and VDSL2 coverage up to 65% of the Italian population covering 1140 urban centres and passing 13 million households (making 75,000 Street Cabinets out of 145,000 VDSL2 capable[13]).

- The overall investment budget is planned to be about 6.5 billion € covering a relatively long period from 2007 to 2018.

Originally it was expected that VDSL would be available in Italy in the course of 2007. But up until October 2007 no VDSL service by Telecom Italia was available in Italy.

Figure 3-9: Telecom Italia's Access technologies deployment plan



Source: Telecom Italia (2007)

13 See Agcom (2007): The evolution towards NGNA and the regulatory issues.

3.2.5 Italy: Fastweb

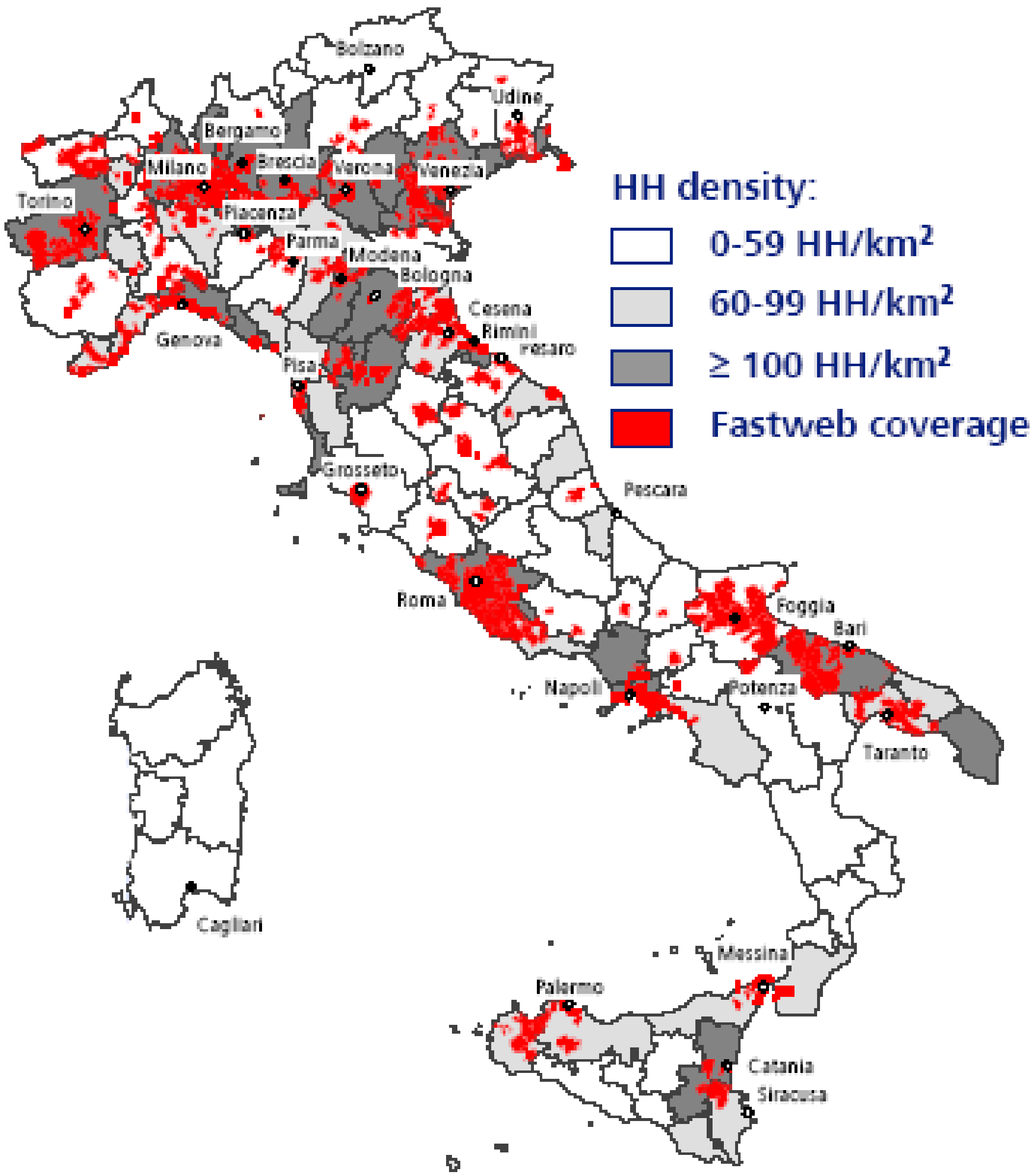
3.2.5.1 Overview of retail service packages

Fastweb is Telecom Italia's main competitor in Italy. As of September 30, 2006, Fastweb had 957,400 customers of which 84 percent were residential and 16 percent were business[14]. The company focusses its activities on high density city regions (see Figure 3-10).

Fastweb is continuing to expand its network: by the end of 2010, Fastweb targets to cover half of all Italian homes and connect all Italian cities with more than 45,000 inhabitants. Fastweb launched its IPTV service "Fastweb TV" in October 2001. Fastweb's triple play offers aren't marketed as bundles but sold as separated modules (Table 3-7). The ADSL 2+ service is realised through LLU.

14 See http://newsroom.cisco.com/dlls/2006/prod_120406c.html.

Figure 3-10: Fastweb's broadband coverage



Source: Swisscom (2007).

Table 3-7: Fastweb's current triple play offers

	Italia & Mobile Zero Naviga Senza Limiti Fastweb TV	Italia Senza Limiti Naviga Senza Limiti Fastweb TV	Italia & Mobile Zero Naviga 30ore Fastweb TV	Italia Senza Limiti Naviga 30ore Fastweb TV
Price per month/€	77,00	65,00	57,00	45,00
max. bandwidth	10 Mbps (FTTH) 20 Mbps (ADSL 2+)	10 Mbps (FTTH) 20 Mbps (ADSL 2+)	10 Mbps (FTTH) 20 Mbps (ADSL 2+)	10 Mbps (FTTH) 20 Mbps (ADSL 2+)
Broadcasting TV Services	yes (~100 Channels)	yes (~100 Channels)	yes (~100 Channels)	yes (~100 Channels)
On Demand Services	yes (extra charge)	yes (extra charge)	yes (extra charge)	yes (extra charge)
Online Flatrate	yes	yes	Not included, but 30 hours per month free of charge	Not included, but 30 hours per month free of charge
Voice Flatrate: to national fixed link	yes	yes	yes	yes
Voice Flatrate: to mobile	Not included, but 250 Minutes per month free of charge	Not included	Not included, but 250 Minutes per month free of charge	Not included

Source: WIK Consult analysis of operator website.

3.2.5.2 Current network architecture and realisation of triple play

Fastweb was one of the first operators to develop an IP based telecommunications network for Voice, data, video and IP-TV. Fastweb's network architecture is fully IP based. The largest Italian cities are directly connected by a backbone with more than 12,400 kilometres of optical fibre and IP over DWDM technology. At the network layer, standard IP multicast is adopted to transport video streams through the Fastweb network, forming a multicast tree spanning all network routers and switches. The video servers are located at a few central sites and multicast 83 TV-channels (2006) with approximately 280 Mbit/s, encoded with MPEG-2.

Ethernet-based architecture is deployed in the last mile. The customer access is realised by FTTH or LLU with xDSL. Residential and small business customers are connected to a Home Access Gateway (HAG, see Figure 3-11). The HAG is essentially an Ethernet Switch, which converts traditional analogue phone ports to VoIP and performs both signalling and voice transport tasks.[15]

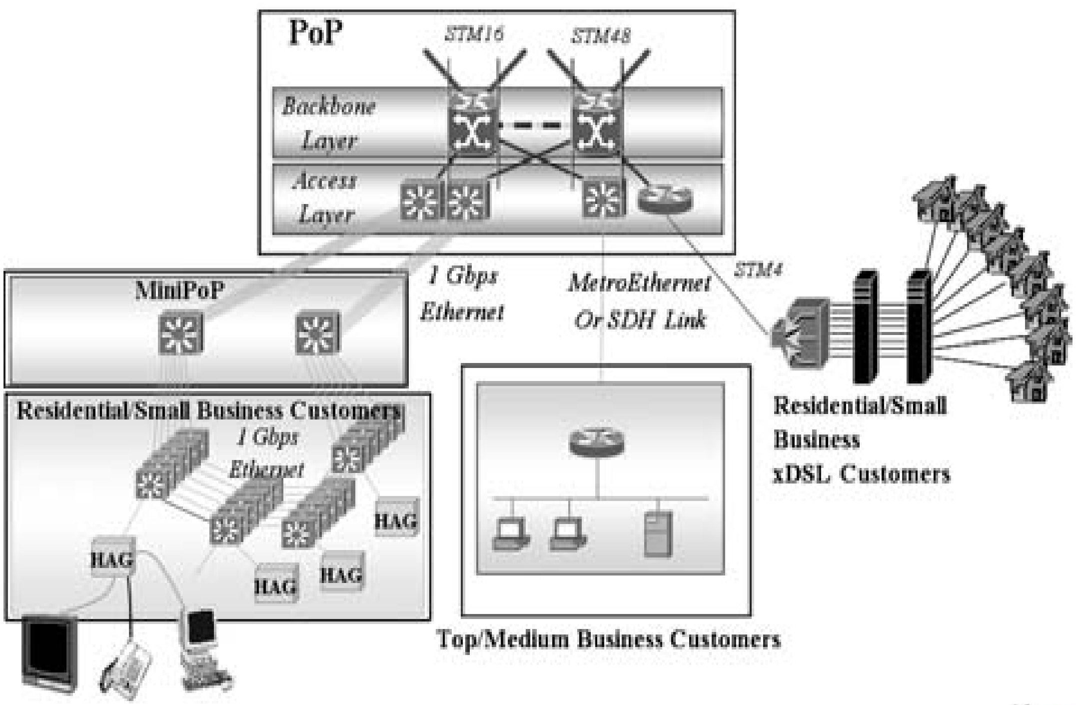
In the case of FTTH the HAG is connected upstream by a 10 Mbit/s Ethernet port (10-base-F), driven in a half-duplex manner. The HAGs are connected to a layer 2

15 See Imran, Mellia and Meo (2006): Measurements of Multicast TV over IP.

switch in the basement, and these switches are then connected via a bidirectional fibre ring (GEthernet) to Mini-PoPs, where they are concentrated on two Layer 2 switches. Both switches of the Mini-PoPs are connected to the PoPs by several GEthernet trunk lines. Top / medium business customers are connected directly to the PoPs by a fibre link, communicating over Ethernet or SDH.

In the case of LLU access the HAG is connected to an xDSL modem and a DSLAM, collocated at the MDF sites of Telecom Italia. Two speeds are offered (downstream / upstream): 6Mbps / 512kbps or 20Mbps / 1Mbps. The DSLAMs are connected to a router at the PoP by STM 4 or 16 SDH fibre links.

Figure 3-11: Fastweb's Infrastructure: FTTH and xDSL access, PoP and Backbone layers



Source: Birke, Mellia, Petracca 2006.

3.2.6 Netherlands: KPN

3.2.6.1 Overview of retail service packages

KPN launched its triple play service with a 'selected members' test-offering in May 2006 and the service has been more widely available since January 2007. KPN's current triple play offers are:

Table 3-8: KPN's current triple play offers

Triple Play Offer	**Internet + bellen + televisie***
Price per month/€	52,90
max. bandwidth	6 Mbps (ADSL 2+)
Broadcasting TV Services	Yes (approx. 50 channels)
On Demand Services	yes (extra charge)
Online Flatrate	yes
Voice Flatrate: to national fixed link	Not included, but free calls to national fixed line at weekends and weekdays from 12 PM to 8 AM
Voice Flatrate: to mobile	Not included

* The IPTV offer is marketed under the label "Mine TV"

Source: WIK Consult analysis of operator website.

3.2.6.2 Current Network architecture

Figure 2-12 shows KPN's existing network. It consists of a copper wire based access network (local loop). The local loop consists of two network levels: the subnetwork (sub loop) and the primary local loop. A copper wire connection runs from each customer location to a street cabinet[16]. The network consists of about 28,000 street cabinets and about 1,350 Main Distribution Frames (MDF)[17]. This equals an average number of approximately 21 street cabinets per MDF. The average sub loop length in the Netherlands is approximately 1000 m[18]. Access to KPN's copper wire local loop is enabled at two levels: at the level of the Main Distribution Frame (Unbundled Local Loop) and access at the Street Cabinets (Sub Loop Unbundled).

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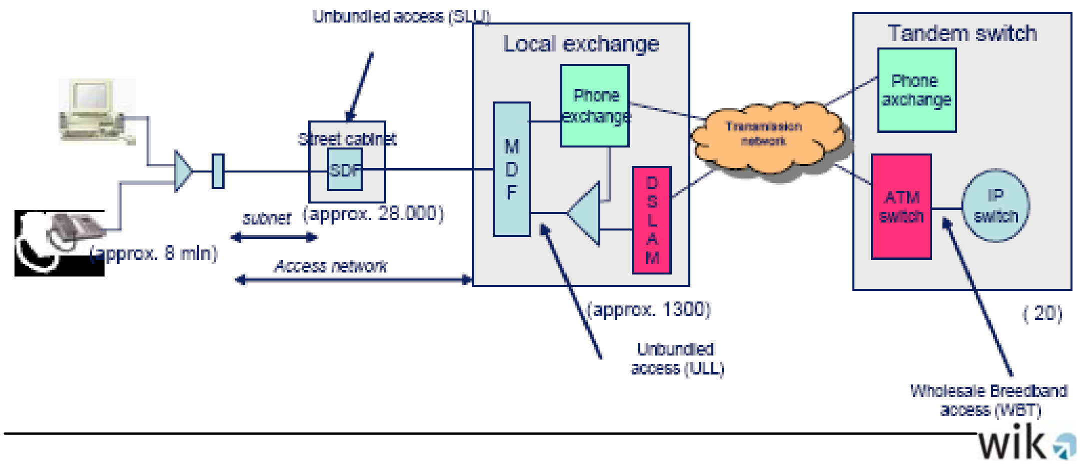
16 See OPTA (2006) : KPN's Next Generation Network: All-IP, Positionpaper, October 2.
17 See JP Morgan (2006): The fibre battle.
18 See Groebel (2007) : Next Generation Access roll out in Germany. Presentation at ANACOM Conference Lisbon, July 27.

Figure 3-12: Current KPN broadband network



Source: OPTA (2006).

3.2.6.3 Realization of triple play and migration to Next Generation Networks

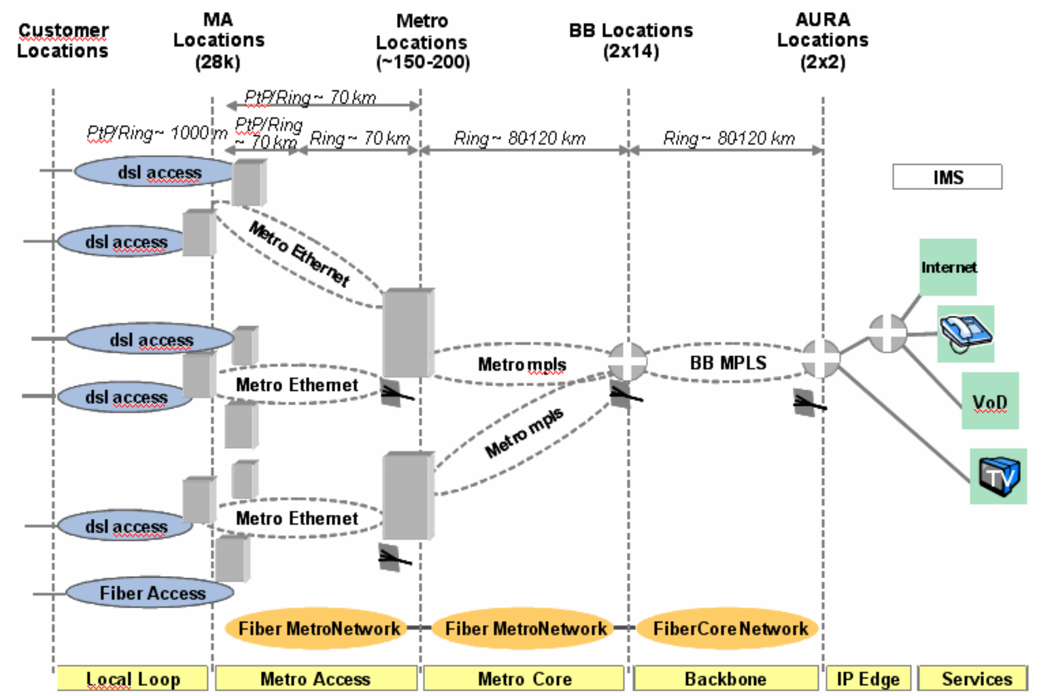
Currently KPN offers IPTV services over ADSL2+ connections with coverage of up to 60% of Dutch households, but is not taking off as fast as was expected a few years ago.

KPN currently is about to introduce an All-IP network in the Netherlands. The planned investment outlays are about 1.5 billion. Euro. Figure 2-13[19] mirrors the stylized facts of the new All-IP network of KPN. The figure shows that the All-IP network consists of different network levels:

- Access network (local loop)
- Metro access network,
- Metro core network,
- Backbone,
- Server and Service infrastructure (IP-Edge).

19 See OPTA (2006): KPN's Next Generation Network: All-IP, Positionpaper; October 2.

Figure 3-13: KPN's next generation All IP Network



Source: OPTA (2006): „KPN's Next Generation Network: All-IP", Positionpaper, OPTA/BO/2006/202771; October 2, 2006; WIK Consult.

KPN plans, beginning in new construction areas, to replace the copper based access network by a fibre solution (FTT Home, FTT Office). This fibre based access network will also be linked to the existing cabinets. Overall, approximately 28,000 street cabinets will remain in the Netherlands as these are 'starpoints' of the remaining copper access network.

The new network entails that the function of the traditional MDFs is transferred to the cabinets. This means in particular that a new device is placed into the cabinet (the NG-DSLAM), where the customer access line is connected. By means of this device it is possible to provide all services in an integrated way, like e.g. broadband Internet, VoIP and IPTV, in addition to plain old telephony services. These new devices are called "Multi Service Access Nodes"[20] (MSAN).

In the new KPN network the NG-DSLAMs in the cabinet will be linked to so called Metro Core Locations (MCL) via fibre rings. There will be about 200 MCLs, which will be established at former MDF locations. Each NG-DSLAM will be linked to the Ethernet

20 See OPTA (2006): KPN's Next Generation Network: All-IP, Position paper; Appendix 1, p3.

routers within the MCLs on the basis of Ethernet technology. The connection between Sub loop Distribution Frame (SDF) and the MCL is also called SDF-backhaul. The remaining MDFs of the currently existing 1,350 MDF locations will not be needed any longer and will therefore be closed down and sold to refinance the upgrade.

The different MCLs will be linked to 14 so-called “Broadband Locations“ with built-in redundancy. This network is based on fibre rings, DWDM and Ethernet connections. In addition to the network layers mentioned so far KPN has defined a fourth network layer, the 4 redundant “AURA locations“ (which stands for Amsterdam, Utrecht, Rotterdam and Arnheim). The Ethernet transport networks will be linked via these network nodes to other networks e.g. IP, VoIP, IPTV distribution networks, etc[21].

In October 2005 KPN selected Alcatel to upgrade its broadband aggregation network in order to deliver triple play services across the country. KPN uses a next generation Ethernet aggregation network from Alcatel to offer services such as video on demand and IPTV to its residential subscribers. The Alcatel solution, which includes the Alcatel 7450 Ethernet Service Switch (ESS) and the Alcatel 5620 Service Aware Manager (SAM), delivers triple play services from 28 main Points of Presence (POP) located in 14 different regions.

3.3 Summary

The review of selected carriers’ service portfolios has shown that commercialisation of triple play retail offers varies significantly between countries. While the services themselves are largely similar (broadband, voice, IPTV and Video on Demand) the degree of commercial availability and installed base of customers is very different.

In addition, the degree to which incumbents have defined and published concrete plans for the NGN/NGA also varies considerably. Dutch incumbent KPN has probably gone the farthest so far in trying to sketch their visions and enter a dialogue with the regulatory authority and OAOs. It was shown that how carriers realise their Next Generation Access infrastructure strongly on a variety of factors in the local framework (structural parameters such as number of lines per street cabinet as well as political and demographic aspects).

On the migration to the NGN/NGA we may conclude that some carriers prefer to follow an overlay strategy where both legacy PSTN and NGN infrastructure are operated in parallel until the old network is deactivated. This is the case in Germany, Italy and in

21 See OPTA (2006): KPN’s Next Generation Network: All-IP, Position paper; Appendix 1, p4.

France. Another approach is envisioned in the Netherlands where KPN intends to deploy NGN infrastructure and switch over all traffic when it is finished hence avoiding having to operate two infrastructures in parallel. Naturally the regulatory authority needs to define rules for the migration process. Examples of these rules are outlined in chapter 4.2.4).

4 Emerging NGN wholesale bitstream products (WP2)

This work package intends to analyze the characteristics of existing bitstream offers in an NGN environment. However, our analysis has shown that at this moment there is clearly a lack of NGN specific bitstream access wholesale offers. Hence we have reviewed NGN migration plans where they are available and also current conventional bitstream reference offers in order to assess:

- the design of current bitstream key characteristics and
- indications for the design in an NGN environment

The analysis addresses the key elements that define (emerging next generation) bitstream product sets

1. Points of interconnection (access points)
2. Quality of Service and further key service parameters
3. Localised content storage (Provisioning of ancillary services in the context of video delivery)
4. Strategic wholesale framework of the migration to NGN
5. OSS/BSS interfaces regarding product ordering, fault handling, remote access

Before beginning the analysis of the above elements a quick overview of current wholesale bitstream adoption is conducted in order to appreciate the relevance of bitstream and the evolution of wholesale markets.

4.1 Status Quo: Usage of bitstream access in the European Union

Bitstream is characterised by the European Regulators Group (ERG) as a high speed access link to the customer premises (access link) with transmission capacity for broadband data in both directions (backhaul link). New entrants should have the possibility to differentiate their services by altering (directly or indirectly) technical characteristics and/or the use of their own network.[22]

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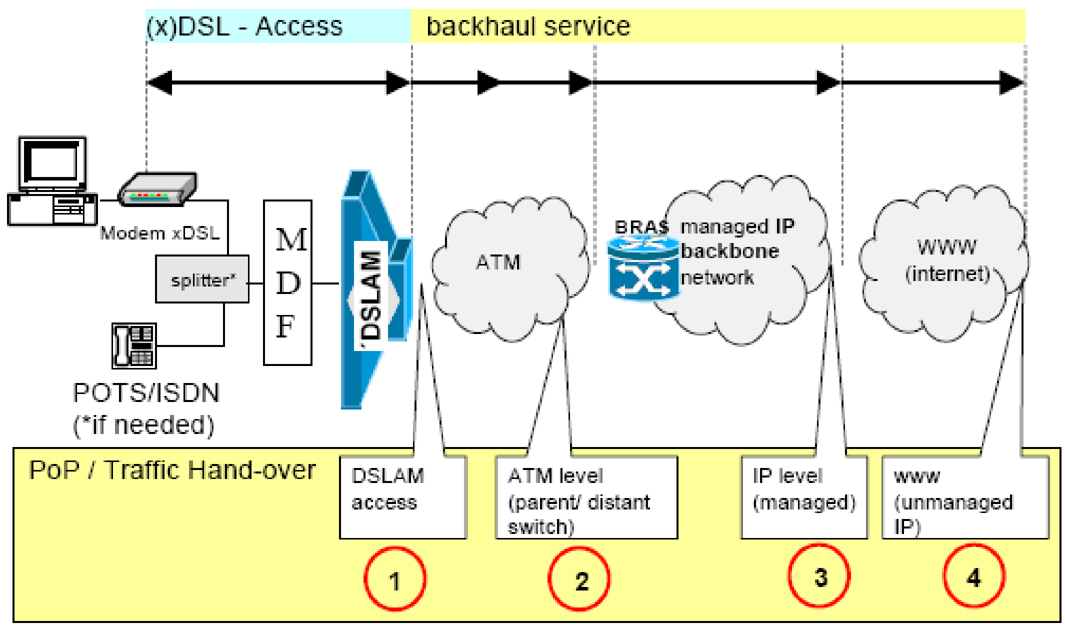
22 ERG (2004): Common Position on Bitstream access, p.3.

Figure 4-1: Bitstream Definition by the ERG



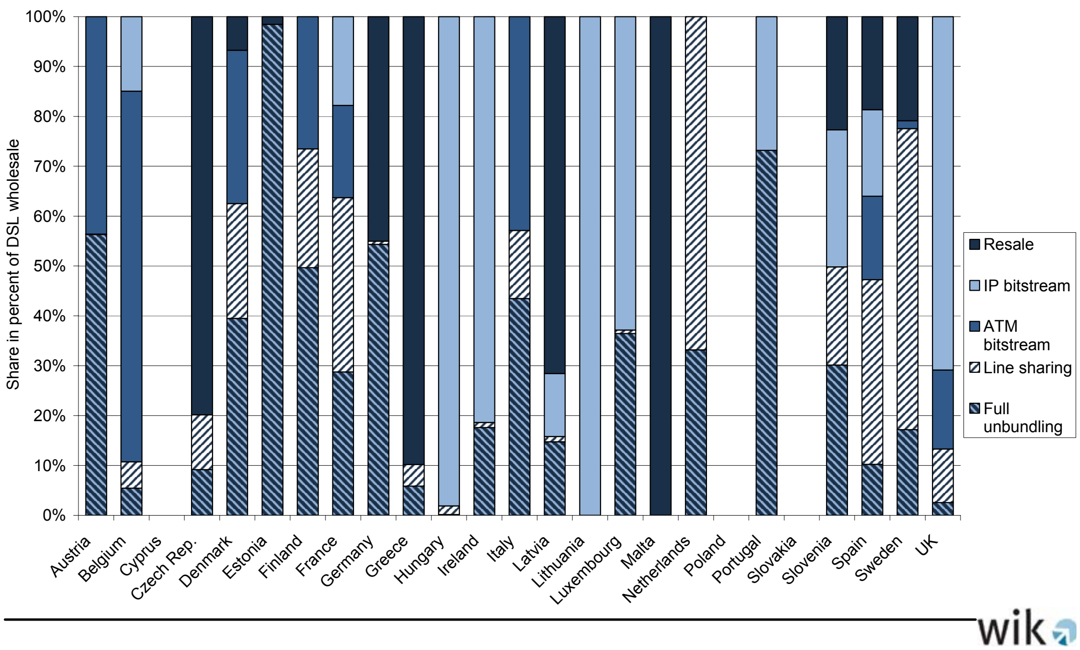
Source: ERG (2004), p.4.

Considering the ERG bitstream definition with its concept of the location of interconnection points (see Figure 4-1) it is however important to decide whether a specific wholesale service should be considered as bitstream or as resale. For example OFCOM previously did not consider the IP Stream product to be bitstream[23] but appears to have changed its perception with the upcoming market analysis[24]. This is also an explanation for differing statistics on wholesale usage in Europe such as the differences between ECTA's broadband scorecard and EU's implementation report data. The reason for these difficulties lies in the fact that bitstream is really classified by more than one dimension as it is not only the point of access (as shown in the ERG diagram) but also the achievable Quality of Service differentiation that defines the major characteristics of bitstream. The analysis in this chapter will highlight the options for QoS differentiation in order to provide a better understanding of the defining bitstream parameters.

Figure 4-2 gives an overview of the wholesale usage of individual wholesale products compared to all incumbent DSL wholesale lines. It shows on one hand that wholesale usage remains heterogeneous in the member states and on the other hand that very often just one or two products dominate.

23 OFCOM (2004): Review of the Wholesale Broadband Access Markets, p. 12.
24 OFCOM (2006/2007): Consultation - Review of the wholesale broadband access markets 2006/07. OFCOM does not propose to find a distinction between Datastream and IPStream anymore.

Figure 4-2: Wholesale usage in the EU (Q3-2006)

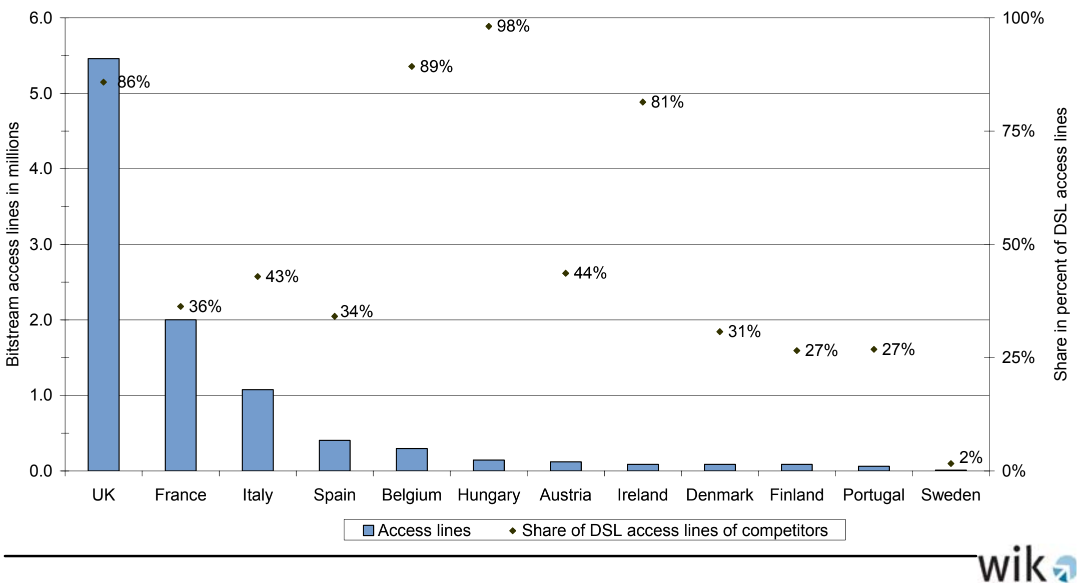


Source: WIK analysis of ECTA data.

Figure 4-3 shows that there are only a few countries with a high number of bitstream lines even though there are some countries – like Ireland – where this accounts for a significant size of the wholesale market due to the small total number of lines. Previous WIK analysis[25] indicates that bitstream played an essential role for the development of the wholesale market for example in France, the UK or Belgium (see Figure 4-4). Notable too is the relative decrease of bitstream usage over time and the relative increase of unbundled access. However, aggregated European figures have to be treated with care since they are heavily influenced by the major industry nations in which unbundling already plays an important role, and which are not comparable to Ireland.

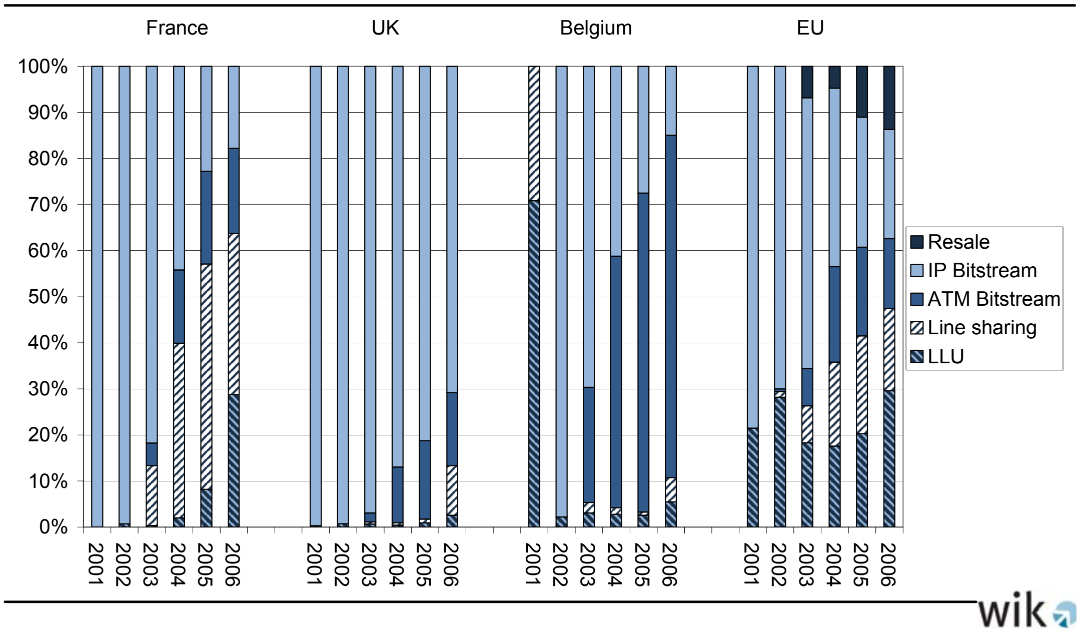
25 Jay, Stephan (2007): Bedeutung von Bitstrom in europäischen Breitbandvorleistungsmärkten (Significance of bitstream in European broadband wholesale access markets). WIK Diskussionsbeitrag 299, Bad Honnef.

Figure 4-3: EU Member states with more than 10.000 bitstream lines (Q3-2006)



Source: WIK analysis of ECTA data.

Figure 4-4: Development of wholesale usage (relative share of total DSL lines by OAOs)



Source: WIK analysis of ECTA data (data refers to the third quarter of each year)

Drawing on this empirical analysis it is viable to say that

- bitstream access is implemented in about half of EU member states
- bitstream access is extensively used in less than a dozen countries
- bitstream access has been a critical pillar of wholesale markets in these countries
- there are indications that bitstream access has been used as stepping stone in the framework of operators migrating along the ladder of investment

For detailed analysis of (emerging NGN) bitstream offers this study has targeted the following countries in addition to Ireland because of their current level of adoption: (in declining order) France, Italy, Spain, Belgium; or because of the current debate on the access conditions for bitstream in the NGN (Netherlands) and QoS features of bitstream in general (Germany).

4.2 Assessing the key elements of bitstream product sets

4.2.1 Point of Interconnection (access point)

The Point of Interconnection (throughout this study we will more precisely refer to bitstream network *access*)[26] denotes the location where bitstream traffic is handed over to the access seeker. There are a variety of theoretically feasible levels in the network hierarchy which can be used although not all of them have so far been extensively used within existing bitstream wholesale services. Access at the location of the DSLAM (today predominantly the main distribution frame site rather than a street cabinet), the parent ATM Switch/BRAS or distant ATM Switch/IP PoP are discussed. However there might be other locations as the NGN becomes more clearly defined. Note that the Figure 4-5 takes a slightly different perspective on the possible access locations for bitstream than the ERG definition in Figure 4-1: Both ATM and IP may be accessed at parent and distant switch level.

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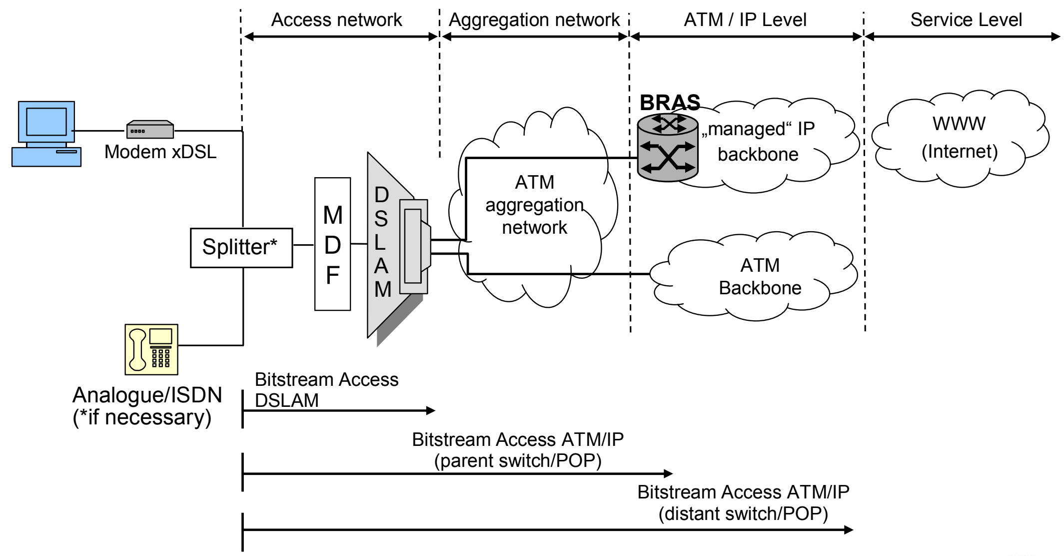
26 At the NGN core, key regulatory challenges revolve around interconnection rather than access. The two are interrelated, but they are not at all the same.
- Interconnection can be viewed as the ability of one network operator to enable its customers to link to the customers of another network operator;
- access can instead be viewed as the use by one network operator of certain capabilities of another network operator as a component of the formers service, and in support of the formers customers.

In other words, with access one operator effectively leases capacity from another. Interconnection concerns the latter's customers, while access does not necessarily have anything to do with the customers of the latter network operator. Access is an inherently asymmetric relationship, with one operator procuring capability from another; interconnection is in principle symmetric, even though the relative market power of the participants in an interconnection relationship is not necessarily symmetric. See Marcus, Scott / Elixmann, Dieter (2007): Regulatory Approaches to Next Generation Networks: p.4; WIK Consult.

Figure 4-5: Common bitstream hand-over points



Source: WIK/BNetzA (2006) S. 30.

Table 4-1 shows that while hand-over at parent switch level is available throughout the bitstream access markets, hand-over at DSLAM or distant switch level is not.[27] Hand-over at DSLAM (MDF) level is only implemented in Italy and Belgium. However the Belgium offer does not actually contain a DSLAM (MDF) level handover anymore since Belgacom was allowed to remove it due to a lack of demand. There are no figures for the actual take-up of handover at DSLAM (MDF) level (in Italy or Belgium) but to date it appears that there has been no explicit demand.

This might change with the implementation of an NGN/NGA and the implications for phasing out MDF locations and with the strategic decisions of alternative operators regarding their own roll-out for FTTC/VDSL and FTTH.

27 WIK conducted an analysis of bitstream reference offers in the major European broadband markets as agreed upon with ComReg. Regarding Germany work is still in progress by the authorities and the incumbent to finalize an acceptable reference offer. The data provided refers to the first proposal by T-Com for IP bitstream from December 2006 and the following industry comments up to August 2007. The proposal for ATM bitstream has not been publicly commented yet and could not be included here. Neither ATM nor IP bitstream is available in Germany at the time of writing.

Table 4-1: Comparing the level of access points

Handover level	IE	FR	IT	ES	BE	NL	GER	Summary
DSLAM	no	no	yes	no	yes	no	no	2 / 7
Parent Switch	yes	yes	yes	yes	yes	yes	yes	7 / 7
Distant Switch	yes	yes	yes	yes	no	yes	no	5 / 7

Source: WIK Consult analysis of reference offers.

There is certainly a connection between the level of the interconnection point and the ability to influence QoS. For example in the German discussion IP bitstream is intended to be handed over directly behind the BRAS without any transport in the incumbent's IP core network. Because traffic is aggregated over the incumbent's ATM concentration network there is a strong difference between this IP bitstream and an IP bitstream handed over as per Option 3 of the ERG diagram. Furthermore one can imagine that access to the bitstream at the first aggregation level of the network (at the DSLAM level) would result in obtaining the traffic only affected by the access line, and not by other customers' traffic and an incumbent's overbooking scheme.

The number and location of access points varies with the type of bitstream delivered. Accordingly a further differentiation has to be undertaken with respect to ATM, Ethernet or IP bitstream products. It is the perception of regulators and OAOs that incumbents will migrate to Ethernet in the aggregation network obsolescing the use of ATM technology on the way to an all IP network.[28] Only first indications for wholesale services based on such Ethernet networks have arisen and the only European example known to us is the Italian bitstream offer which incorporates a dedicated section for a true Ethernet bitstream.[29]

28 Examples include the BNetzA's 2006 report on IP Interconnection and the statements in the following consultation. Although this development appears to be dominant still exists uncertainty still exists regarding the ability of QoS related issues in an Ethernet – All IP environment and associated barriers to completely migrate to All IP networks.

29 The Italian bitstream offer in its form displayed here appears to be a draft that still requires acceptance by the regulator. However Telecom Italia has implemented an Ethernet concentration network for some regions.

Table 4-2: Comparing interconnection point levels in *current* offers differentiated by bitstream type

	IE	FR	IT	ES	BE	NL	GER
PSTN lines (millions)	1,7	27,8	21,3	17,3	3,2	6,1	35,6
Access Points (differentiated by bitstream delivery)							
ATM Bitstream	15 regional PoPs or aggregated traffic handover at one or more PoPs	40 ATM switches or 1 national	79 ATM switches or at DSLAM level	109 ATM switches	8 ATM switches, DSLAM	National (1), regional (4) or local (14)	/
IP Bitstream		40 regional or 1 national	/	2 national or 7 regional	/	/	73 regional
Ethernet Bitstream	/	/	Distant node (30), Parent node (62) or DSLAM	/	/	/	/

Source: WIK consult analysis of reference offers.
Note: DSLAM access in Italy is only required for MDFs where less than 50 lines have been unbundled.

The consultation for the German IP bitstream reference offer showed that OAOs wanted interconnection to bitstream at the MDF level (in the context of VDSL access). In addition they requested access at, and ducts to, the Sub loop Distribution Frame. BNetzA ruled against these claims reasoning that the regulation on IP bitstream covered only access at the broadband PoP.

Table 4-3: Comparison of aggregated bandwidth options for bitstream handover

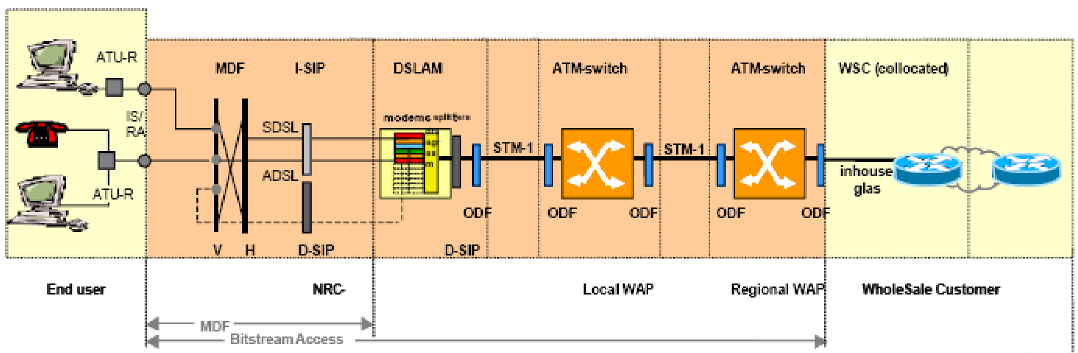
	IE	FR	IT	ES	BE	NL	GER
	Bandwidth in Mbps						
ATM bitstream	2M, 45M 155M	155M 622M	2M, 8M 155M	2M, 34M 155M	2M, 34M 155M	155M 622M	
IP bitstream	100M 250M 500M	10M, 30M, 60M, 100M, 300M 600M GbE	/	155M 622M GbE 2500M	/	/	34M 155 M 622 M GbE 2500M
Ethernet bitstream	/	/	155M 622M 2500M	/	/	/	/

Source: WIK Consult analysis of reference offers.

Table 4-3 shows that bandwidth options for IP and Ethernet bitstream provide much higher bandwidth than ATM bitstream access. GbE may be expected as minimum requirement for the NGN bitstream.

Few incumbents have finalised their NGN architecture. KPN has already published plans for the structure of the NGN bitstream access levels. The following figure first shows the *current* bitstream access points. Operators can choose to either access at 14 local wholesale access points (denoted WAP in the figure), 4 regional (in Amsterdam, Utrecht, Den Haag or Rotterdam) or 1 national (in Amsterdam).

Figure 4-6: Current bitstream access in the Netherlands



Source: KPN bitstream reference offer 2006.

The access points in KPN's NGN architecture will change: KPN intends to provide bitstream access at the level of the Metro Core Location (local access at about 200 sites), at the level of the Core Location (regional access) or at the level of the 4 AURA locations (referred to as national access). See Figure 3-13 for an overview of the hierarchy levels of the Dutch NGN vision.

The empirical observations presented in chapter 3 give an indication of the tendency to reduce the number of PoPs in a NGN architecture and hence also reduce the number of access points within the wholesale regime. This result has also been deduced in an emulation study conducted by Hackbarth/Kulenkampff (2006)[30].

However in the case of KPN there will actually be more access points for bitstream than before because the "local" access now happens at the metro core location level of which there will be about 200 compared to the 14 of the current bitstream reference offer.

30 See Hackbarth, Klaus / Kulenkampff, Gabriele (2006): Technical aspects of interconnection in IP-based networks with particular focus on VoIP. UC / WIK Consult study for BundesNetzAgentur.

Table 4-4: Planned bitstream access point evolution in the Netherlands

Access level	Number of access points today	Number of access points in the NGN
"local"	14	200
"regional"	4 (Amsterdam, Utrecht, Den Haag or Rotterdam)	(2x)14
"national"	1 (Amsterdam)	4 (Amsterdam, Utrecht, Rotterdam, Arnhem)

Source: WIK Consult analysis of reference offer and KPN presentations.

Table 4-5: Additional benchmark: Bitstream Access options foreseen in the BT NGN

Access level	Number of access points today	Number of access points in the NGN
MDF/ MSAN	none	(6000) unclear whether bitstream access will be granted
Metro	125 ATM bitstream	120
IP Core	10 IP bitstream	10

Source: WIK Consult analysis of reference offer and OFCOM (2005): Next Generation Networks - Future arrangements for access and interconnection presentations.

In the absence of concrete NGN implementation or the formulation of concrete plans (with the exception of the Netherlands) analysis of the access point structure must largely focus on the theoretical discussions and consultations.

Historical network structures have strongly determined the access regime with regard to access points (ATM and IP). The number of access points per network level does not necessarily indicate efficient network structure but rather resembles historical network structures. Implementing an NGN increases the economies of scale with regard to transport (despite increasing demand expressed in MBit/s), thus reducing the number of access points on each network level. However FTTC is increasing the number of network nodes (and thus access points) on the lowest level within the network hierarchy.

On the assumption that the access seekers want a bitstream access with a high QoS, ideally with the constant bit rate of the access port, and without the bitstream being influenced by the traffic of the other customers on higher aggregation layers, intuitively only the DSLAM layer remains for a transparent bitstream access.

Concerning future NGA structures with FTTC this would result in deploying backhaul to each street cabinet. However the VDSL Access Multiplexers will be connected upstream per fibre to an Ethernet aggregation switch. Up to that switch one can assume that there is no effective traffic concentration or influence on the customers' traffic between the DSLAM and the first Ethernet aggregator. This is because there are no real bandwidth limitations on the fibre link (and no overbooking) except possible effects caused by the link interface cards. Therefore bitstream access on the layer of the first Ethernet aggregation switch might result in a similar traffic quality as the access point at the DSLAM layer, thereby reducing the amount of access points dramatically.

Thus the decision of where to locate the access point will be a trade off between the cost of a backhaul network as close to the customer as possible (DSLAM layer) and the quality degradation of an access at the next higher level, or even at levels above.

4.2.2 Quality of Service and further key service parameters

Reflecting on the definition of bitstream, e.g. by the ERG, the ability to differentiate technical parameters of the broadband services is an integral part of a bitstream wholesale product. These key parameters are primarily related to the two components of bitstream

- Access technology and bandwidth of the access line on the last mile
- Quality of Service and traffic management of the transport service in the aggregation network

The ability to influence QoS is seen as critical since broadband is heterogeneous with different quality requirements (e.g. sustainable bitrate, packet loss, delay, jitter) for different services. This will become of even higher importance in the NGN environment where the integration of multiple services on a single infrastructure is bound to be at the centre of developments. The availability of different classes of service is hence the prerequisite for differentiation from the incumbent.

In addition a dominant strategy of marketing bundled services and preferably marketing them with a single bill without any remaining contractual relationship between the end-user and the incumbent is noticeable. OAOs may realize this through unbundling of the local loop or through a stand-alone bitstream wholesale product which does not require the end-user to buy a PSTN/ISDN line from the incumbent. Without a stand-alone bitstream the OAO may only bundle broadband and VoIP through unbundling the local loop. Accordingly stand-alone bitstream is an important option to enable competition in areas where competitive offers based on unbundling are not available (e.g. for economical or technical reasons).

4.2.2.1 Access technology and bandwidth on the access line in the last mile

The access bandwidth on the last mile is a bottleneck that can become a barrier for the introduction of retail triple play services. Therefore available access technology and bandwidth impact on the ability to differentiate and define the bitstream product set. Usually the incumbent provides the same access technologies for wholesale that they are using for their own retail customers. Considering that in the case of the two implementations of VDSL In Belgium and Germany, neither have a VDSL access option in their standard offer. However in Belgium it appears that only administrative barriers within the market definition and analysis process for market 12 delay the ruling to implement VDSL as it is already stated in the reference bitstream offer.[31]

It appears that only Ireland and Spain do not offer SDSL access on either the retail or wholesale side.

	IE	FR	IT	ES	BE	NL	GER
	Bandwidth in Mbps						
Retail (Incumbent)	ADSL	ADSL ADSL2+ SDSL	ADSL ADSL2+ SDSL	ADSL	ADSL SDSL VDSL	ADSL ADSL2+ SDSL	ADSL ADSL2+ SDSL VDSL
Wholesale (Bitstrom)	ADSL	ADSL ADSL2+ SDSL	ADSL ADSL2+ SDSL	ADSL	ADSL SDSL	ADSL ADSL2+ SDSL	ADSL ADSL2+ SDSL

Source: WIK Consult analysis of reference offers.

According to the German consultation for bitstream proceedings, all of the large carriers have requested VDSL access to become part of the bitstream reference offer.

In order to be able to provide competitive services compared to those of the incumbent the competitors also need access to the resources the incumbent uses for himself, at least on a wholesale level. If the development of NGN and NGA results in the usage of new customer access techniques these techniques or at least the wholesale products one can derive thereof should be accessible to the competitors, with all QoS parameters possible or at least with all QoS parameters the incumbent uses for itself.

The following table compares the retail and wholesale bandwidth in the respective key markets. As expected the offered speeds vary between the countries.[32] Regarding the

31 „In the future, this offer will be extended to other DSL technologies, after approval by BIPT as soon as these technologies are tested and at least 3 months before they are commercialized (retail and/or wholesale) by Belgacom." Belgacom bitstream offer 2007, page 4.

32 We assume that among the reasons are different frameworks regarding structural parameters (loop lengths and diameters, line quality, population density, relation of Sub loop Distribution to Main Distribution frames) and intensity of competition.

national comparison of wholesale and retail the bandwidth levels are usually equal. This also means that OAOs may not surpass the bandwidth offered by the incumbent.

Table 4-6: Comparison of downstream bandwidth (incumbent retail vs. bitstream access)

		IE	FR	IT	ES	BE	NL	GER
		Downstream bandwidth in Mbps						
Retail	**≤ 1M**	1	1	0.6	1	0.5; 1		1
	≤ 6M	2; 3		2	2; 3; 4;	4	1.5; 3; 6	2; 6
	≤ 16M		8		8			16 (ra)
	≤ 25M		18 (ra)	20 (ra)		17 (V)		25 (V**, ra)
Wholesale	**≤ 1M**	0.5; 1;	0.6; 1;	0.6; 1; 2;	1; 2	1;	* 1.2	1
	≤ 6M	2; 3; 4; 6	2 (ra);	4 (ra)	4	4	4	2; 6
	≤ 16M		10 (ra)	7 (ra)	8		8; 12	16
	≤ 25M		22 (ra)	20 (ra)				

V = VDSL, ra = (partly) rate adaptive; no indication for rate apation in ES, BE; M - Mbps
* = 7 increments below 1Mbps,
** 50Mbps on demand.

Source: WIK consult analysis of reference offers and operator websites.

German OAOs also issued demands regarding the implementation of rate adaptive mode on the access line not only for ADSL2+ but also for ADSL. They basically requested signalling of realised bandwidth from DSLAM to BRAS, provision of the current line specific maximum bandwidth and the ability of the OAO to freely choose the speed of the access line. None of these demands were placed on the incumbent, because a) signalling was deemed to be technically impossible, b) maximum bandwidth provisioning could lead to technical inefficiencies (buffer overflow and packet loss because the access line rate is smaller than the service rate provisioned through the aggregation network) and might mislead consumers as the marketed 25Mbps of ADSL2+ will only rarely be technically possible.

An additional aspect is the scalability of the end user speed indicated for example through the total number of options. The total number of profiles reflecting combinations of up and downstream bandwidth and QoS classes is provided in the following table. Note that with different combinations of up and downstream as well as access technology and QoS classes there are more profiles than there are access line bandwidth options.

Table 4-7: Total number of access line profiles

<table>
<tr><th></th><th>IE</th><th>FR</th><th>IT</th><th>ES</th><th>BE</th><th>NL</th><th>GER</th></tr>
<tr><td>ATM</td><td>11</td><td rowspan="2">20
(10 with stand alone option)</td><td>27</td><td>8</td><td>32
(8 access line x4 QoS classes)</td><td>14</td><td>/</td></tr>
<tr><td>IP</td><td>6</td><td>/</td><td>6</td><td>/</td><td>/</td><td>3</td></tr>
<tr><td>Ethernet</td><td>/</td><td>/</td><td>27</td><td>/</td><td>/</td><td>/</td><td>/</td></tr>
</table>

Source: WIK Consult analysis of reference offers.
Note: Considering asymmetric access lines only as not all compared countries have an SDSL bitstream.

4.2.2.2 QoS and traffic classes

The primary aspects of quality of service concern the ability to define traffic classes and influence the traffic management. Because of the separation of transport and application layers in the NGN architecture a large number of new and creative ideas for applications we cannot yet foresee may come up. Furthermore we believe that the data communication needs (including QoS) may be classified for different application types, for example applications with:

- poor quality needs (best effort with different traffic speeds),
- high data transfer quality (business),
- unidirectional voice (and music),
- bidirectional voice with different numbers of voice channels
- unidirectional video
- bidirectional video with different numbers of video channels,
- ….

A general classification of services has for example been done by Hackbarth/ Kulenkampff (2007) who propose four general service classes (see Table 4-8).

Table 4-8: Common classification of services according to QoS requirements

Service class	Delay and Jitter requirements	Bandwidth requirements
Real-Time Service (inelastic)	Must be limited	Average bandwidth must be guaranteed
Streaming service (semi-elastic)	Higher delay possible but jitter must be limited	Average bandwidth must be guaranteed
Data services (elastic)	Not critical	Average bandwidth must be guaranteed
Best effort services	Not critical	Not critical

Source: Derived from Hackbarth, Klaus / Kulenkampff, Gabriele (2006): Technical aspects of interconnection in IP-based networks with particular focus on VoIP. UC / WIK Consult study for BundesNetzAgentur.

Concerning the larger scope of applications which will appear with the implementation of NGN we believe that the amount of different wholesale bitstream profiles needed for applications will increase. This leads us to the analysis of current bitstream reference offers which shows that ATM bitstream usually enables such traffic management and provides multiple traffic classes. However the offers differ with regards to the number of virtual channels/paths that the alternative operator may request per end user/DSLAM. IP bitstream products on the other hand tend to have very few opportunities to manage the traffic and do not usually encompass different service classes (with the exception of France). On the other hand the German Bundesnetzagentur has imposed the obligation to at least supply a minimum quality suitable for telephony services which is to be defined using maximum allowable values for packet loss, jitter and delay.

In an NGN environment the aggregation network will likely be based on Ethernet. Ethernet can carry traffic in defined and separated VLANs, but the standardized QoS mechanisms are limited. Notably, the IEEE 802.1q protocol provides a mechanism for tagging Ethernet frames so as to indicate the desired QoS characteristics.

As an alternative, QoS could be realised by means of IP-protocol based instruments like Differentiated Services (DiffServ, a simple protocol that signals the desired QoS) and MPLS (Multi Protocol Label Switching). DiffServ and MPLS cannot *guarantee* a connection with dedicated QoS features like ATM, but they can provide a reasonable probabilistic assurance.

There continues to be debate as to whether it is more cost-effective to use solutions like DiffServ/MPLS to ensure suitable delay/jitter characteristics versus simply allocating adequate capacity. In either case, QoS is assured only in a statistical (rather than in an absolute) sense. We return to this point later in this report.

The Ethernet bitstream offer in Italy utilizes VLANs and different Classes of Service to generate differentiated traffic classes. In addition it includes multicast functionality (see chapter 4.2.3 on ancillary services). Furthermore it is the only offer with dedicated maximum values for packet loss, delay and jitter. The values out of the Italian bitstream offer are actually stricter than those requested by German alternative operators (see Table 4-13).

Table 4-9: Comparison of QoS and traffic management options

	IE	FR	IT	ES	BE	NL	DE
ATM	VBR or UBR (only 1 VC per DSLAM port)	"Best effort" & "Premium" (2 per end user)	Up to CBR (up to 10 VC per end user*)	Up to CBR	Up to CBR (12 VC per DSLAM, up to 10 per end user)	Only VBRrt and UBR+[33] (up to 16 VCs per end user)	/
IP	UBR only (only 1 VC per DSLAM port)		/	Only best effort	/	/	minimum quality guar-antee
Ethernet	/	/	VLAN, CoS, multicast	/	/	/	/

***** many more (100s) possible for the SDSL product
Source: WIK Consult analysis of reference offers.

As an example the options of the Italian offer are presented here because the Italian bitstream appears closest to what might become a NGN bitstream product.

The three different ATM traffic classes of the Italian reference offer are defined by the following characteristics:[34]

- Constant Bit Rate (CBR): characterised by the peak cell rate (which is constantly delivered).
- Variable Bit Rate – real time (VBR-rt): characterised by peak cell rate and sustainable cell rate.
- Available Bit Rate (ABR) or Unspecified Bit Rate+: characterised by a peak and minimum cell rate (MCR).

While what is shown in the following tables describes the ATM section of Telecom Italia's bitstream offer it may equally highlight the possible structure of a NGN Ethernet bitstream offer. The CBR and VBR-rt profiles are shown in Table 4-10 and resemble Virtual Channels of the ATM bitstream.

33 Maximum and minimum bandwidth defined.
34 See Reference Offer page 46. This section actually refers to the ATM part of bitstream access and therefore states *cell* rates rather than *bit* rates. In an NGN Ethernet context the characteristics of service classes would more generally be referred to as peak *bit* rate, sustainable *bit* rate and minimum bit rate. The terms have the following meaning:
- Peak Cell Rate (PCR)= maximum cell rate allowed
- Sustainable Cell Rate (SCR) = average cell rate enabled
- Minimum Cell Rate (MCR) = minimum cell rate guaranteed

Table 4-10: VBR-rt and CBR profiles in the Italian bitstream

CBR profile	PCR (kbit/s)		VBR-rt Profile	SCR (kbit/s)	PCR (kbit/s)
C0	32		V0	37,5	48
C1	48		V1	150	192
C2	64		V2	200	256
C3	128		V3	300	384
C4	256		V4	400	512
C5	512		V5	600	768
C6	1024		V6	1200	1536
C7	2048		V7	1600	2048
C8	3072		V8	3200	4096

Source: Telecom Italia reference offer 2007 pages 66-70.

The ABR class may either be ordered shared (as traffic aggregated in a Virtual Path) or dedicated (a single Virtual Channel per end user). Table 4-11 Shows the options for VP ordering.

Table 4-11: Virtual Path options for ABR traffic class in the Italian bitstream offer

MCR=90% PCR		MCR=75% PCR		MCR=50% PCR		MCR=33% PCR		MCR=25% PCR		MCR=10%PCR	
PCR (kbps)	MCR (kbps)	PCR (kbps)	MCR (kbps)	PCR (kbps)	MCR (kbps)	PCR (kbps)	MCR (kbps)	PCR (kbps)	MCR (kbps)	PCR (kbps)	MCR (kbps)
1.536	1.382	1.536	1.152	1.536	768	1.536	507	1.536	384	1.536	154
2.048	1.843	2.048	1.536	2.048	1.024	2.048	676	2.048	512	2.048	205
2.560	2.304	2.560	1.920	2.560	1.280	2.560	845	2.560	640	2.560	256
3.072	2.765	3.072	2.304	3.072	1.536	3.072	1.014	3.072	768	3.072	307
4.096	3.686	4.096	3.072	4.096	2.048	4.096	1.352	4.096	1.024	4.096	410
5.120	4.608	5.120	3.840	5.120	2.560	5.120	1.690	5.120	1.280	5.120	512
6.144	5.530	6.144	4.608	6.144	3.072	6.144	2.028	6.144	1.536	6.144	614
7.168	6.451	7.168	5.376	7.168	3.584	7.168	2.365	7.168	1.792	7.168	717
8.192	7.373	8.192	6.144	8.192	4.096	8.192	2.703	8.192	2.048	8.192	819
10.240	9.216	10.240	7.680	10.240	5.120	10.240	3.379	10.240	2.560	10.240	1.024
12.800	11.520	12.800	9.600	12.800	6.400	12.800	4.224	12.800	3.200	12.800	1.280
15.360	13.824	15.360	11.520	15.360	7.680	15.360	5.069	15.360	3.840	15.360	1.536
17.920	16.128	17.920	13.440	17.920	8.960	17.920	5.914	17.920	4.480	17.920	1.792
20.480	18.432	20.480	15.360	20.480	10.240	20.480	6.758	20.480	5.120	20.480	2.048
23.040	20.736	23.040	17.280	23.040	11.520	23.040	7.603	23.040	5.760	23.040	2.304
25.600	23.040	25.600	19.200	25.600	12.800	25.600	8.448	25.600	6.400	25.600	2.560
30.720	27.648	30.720	23.040	30.720	15.360	30.720	10.138	30.720	7.680	30.720	3.072
		34.000	25.500	34.000	17.000	34.000	11.220	34.000	8.500		
				40.960	20.480	40.960	13.517	40.960	10.240		
				51.200	25.600	51.200	16.896				
						61.440	20.275				

Source: Telecom Italia reference offer 2007, p. 50.

Table 4-12 highlights the options for Virtual Channel ordering. For each access profile there are a number of options to specify the Minimum Cell Rate.

Table 4-12: Virtual Channel options for ABR traffic class in the Italian bitstream offer

Access Profile (down & upstream in kbps, Access technology)	MCR option range downstream (kpbs)	MCR option range upstream (kpbs)
640/256 ADSL	5-600 (11 options)	5-128 (7 options)
1,280/256 ADSL	5-600 (11 options)	5-128 (7 options)
1,280/512 ADSL	10-600 (8 options)	10-256 (7 options)
2,048/256 ADSL	5-600 (12 options)	5-128 (7 options)
2,048/512 ADSL	20-1024 (8 options)	20-512 (6 options)
4,096/256 ADSL	20-50 (2 options)	20-50 (2 options)
7,168/512 ADSL	20-256 (options)	20-192 (5 options)
20,480 ADSL2+	40-4096 (10 options)	40-512 (6 options)

In every case the PCR of both down and upstream is equal to the line rate.
Source: Telecom Italia reference offer 2007 pages 53-55.

Interestingly no control mechanisms have been set up within the reference offers to enable the monitoring and compliance with the agreed quality parameters (neither in the ATM offers, nor in the French offer which includes a 2 channel IP bitstream or the German offer with a minimum quality guarantee). Furthermore there is no penalty regime for failing to meet quality parameter standards in place (however the analysis of current IP bitstream offers also showed that there is hardly any concrete definition of parameters anyway). For example the recent (August 2007) German decision points out that the incumbent has an incentive to supply the required minimum quality because he is providing VoIP services as well. The wording of the German regulator allows the assumption that BNetzA expects that in the NGN environment, differentiated QoS for an IP bitstream will be implemented.

German OAOs requested such differentiated QoS in a varied way. There were requests for

- *4 different VCs per end-user*
- *2 different VCs per end-user*
- *2 different VCs just on the access line between the CPE and DSLAM (with a view towards "protecting the customer from himself" to secure enough bandwidth for e.g. VoIP)*

BNetzA only obligated T-Com to provide a minimum quality so as to ensure VoIP operation. This was done by requesting that the incumbent include maximum values for packet loss, delay and jitter. These values were not specified by BNetzA except for stating that they need to ensure VoIP quality. Reasoning was based primarily on technical restrictions of the incumbent's ATM aggregation network.

Table 4-13: Examples of demands and implementation of concrete QoS values

	Packet loss	Latency	Jitter
Telecom Italia reference offer ATM bitstream 2007	<0,001%	<36ms (Interleaving), <20ms (Fastpath)	<= 6ms
Demands in the German consultation process for IP bitstream 2007			
VATM (association of competitive operators)	<0,01%	<15ms	<5ms
Telefonica Germany	<1%	<40ms	<10ms

Source: Telecom Italia reference offer, comments to the German consultation process.

Contention on the aggregation network impacts the quality of the broadband service, too. Hence it is critical for competitors to be able to control the contention ratio for their products. The ability to do this differs between ATM and IP (usually no or less choice with IP bitstream services). Despite the fact that the contention ratio impacts on the quality of the broadband service, we would like to emphasise that it is simply a planning figure without any features for actual QoS control by the network operator or OAO.

Table 4-14: Comparison of contention options

	IE	FR	IT	ES	BE	NL	(GER)
ATM	2 options – 10:1, 24:1	*	2:1 on the access line	*	*	4 options: 1:1, 1:4, 1:10, 1:20	n.a.
IP	2 options – 24:1, 48:1		/	*	/	/	No options
Ethernet	/	/	*	/	/	/	/

Source: WIK Analysis of bitstream reference offers

***** no options stated in the reference offer. However in Italy access seekers can choose between a variety of MCR options for the ABR and VBR class of service.

note: There is not usually a choice to combine every access line option with a different contention option. Instead there are preconfigured combinations of access line speeds with one or more contention options. Furthermore usually overbooking ratios apply to the level of the aggregation network. However the Italian bitstream offer specifically provides overbooking potential of the access line itself when applying more than one virtual channel per end-user.

Wholesale bitstream access products in NGN networks will need different VCs for each customer port, each with the ability to define individual QoS. The QoS needed will be determined by the applications being served through that VC and may be classified into application groups (e.g. for video streaming, IP-TV, VoIP, business data exchange, best effort internet, …). The QoS parameters should be at least a definition of the access bit rate (e.g. minimum bit rate, peak bit rate, sustainable bit rate) and their traffic behaviour (e.g. jitter, delay), and the packet loss ratio.

4.2.2.3 Stand-alone Bitstream

A stand alone bitstream option enables an operator to supply a broadband access line without the associated PSTN connection. The primary regulatory driver for stand-alone bitstream obligation is a retail offer for a stand-alone DSL access line without PSTN/ISDN by the incumbent. Non-discriminatory access will result in the incumbent being obliged to provide a wholesale equivalent.

In addition the need to compete as full service providers with bundled, single bill services has arisen in many mature markets.

The success of bundled voice and broadband services (without further ties to another operator) has been a key reason for BNetzA to oblige T-Com to introduce a stand alone bitstream offer in the ongoing German IP bitstream introduction process.[35]

Stand-alone DSL allows OAOs to provide a bundled offer of broadband and VoIP that does not require the end user to retain any contract with the incumbent. Therefore it extends the geographical scope of competition of such bundles from those areas with the OAO's unbundling presence to those without. Accordingly the stand-alone bitstream option is a key element of the product set especially against the background that NGN architecture foresees voice integration. This option only exists in a few countries so far however.

Table 4-15: Stand alone bitstream availability

	IE	**FR**	**IT**	**ES**	**BE**	**NL**	**GER**
ATM	No	Yes	Yes	No	Yes	yes	/
IP	No	Yes	/	No	/	/	Yes
Ethernet	/	/	Yes	/	/	/	/

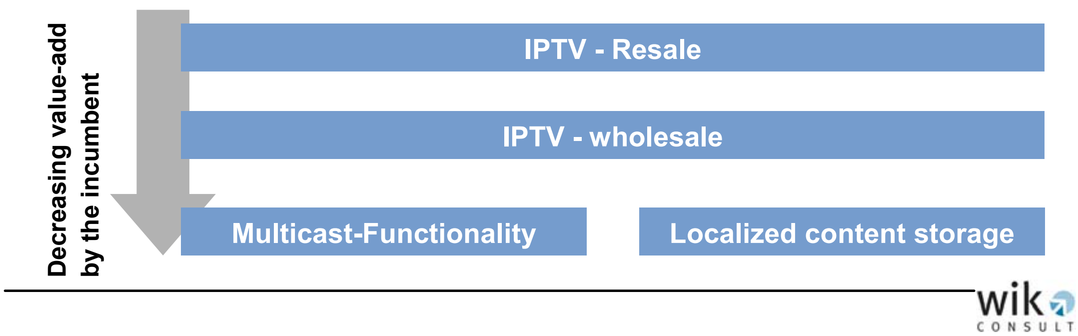
Source: WIK analysis of reference offers.

4.2.3 Localized Content storage (Provision of ancillary services in the context of video delivery)

Regarding the implementation of ancillary services for video delivery different approaches could be theoretically foreseeable (see Figure 4-7):

35 Decision of BNetzA 28.8.07 regarding the bitstream access reference offer.

Figure 4-7: Ancillary services for video delivery



Source: WIK Consult

1. Resale of the incumbent's IPTV service: This could be the resale of a package identical to that of the incumbent which would be completely realised through the incumbent's IPTV platform.

2. Wholesale of the incumbent's IPTV service: This could include the re-bundling of the incumbent's programming which would still be provided completely by the incumbent's IPTV platform.

3. Localized content storage

   - Shared usage of the incumbent's video servers: This could include programs of the OAO to be transported to the incumbent's video servers from where they would be delivered to the end-user under the incumbent's control.

   - Co-location of OAO's video servers: This could include the OAO to position their own servers at the location of the incumbent's video servers or at appropriate different sites.

4. Enabling multicast functionalities in the bitstream:

Approaches one and two are certainly outside of the scope of a bitstream service. The discussion about the third approach is strongly tied to the trade off between being able to provide multicast functionalities in the network or not (see introduction). In a multicast environment servers may be located in a central position in the core network. In a non-multicast environment bandwidth requirements would expand dramatically if each IPTV channel was delivered individually and redundantly for separate users so servers would need to be located "locally", closer to the end-user.

In the latter case the economics of the IPTV / VoD business model might not necessarily be the same for the incumbent and the OAO because of the different installed base of customers. Hence it could be more economic for the incumbent to place the video servers closer to the end user as there are more subscribers whose ARPU contributes to amortize the equipment. Therefore the preference for locating video servers may differ and OAOs might be inclined to position their servers closer to / in the core network.

Still the issue of localized content storage also implies the question of whether OAOs might require video server positioning at a level that is closer to the end-user than their preferred option for bitstream interconnection. However the analysis within market 12 of the EC recommendation does not - at this time – lead to a rationale for *bitstreams* separated by their application. All current definitions point towards bitstream as encompassing the access to *the complete bitstream*. Accordingly the real issue of localized content storage comes down to the availability of different interconnection options for bitstream. With a suitable graduation of such options the OAO would then be able to apply the architecture that best suits their business model.

Multicast functionalities (listed here as fourth approach) encompass implementation of a routing system minimizing the number of data flows from a server to various customers. This is achieved by multiplying the data flows only when they are as close as possible to the destination. The implications of multicast functionality have already been detailed in the introduction, chapter 2.4.3.

Today there only is one example where multicasting is integrated as part of the bitstream reference offer, and this is Italy.

Telecom Italia has published its wholesale bitstream offer[36] with an IP Multicast feature, which is still in a pilot phase (and not yet approved by AGCOM), so not all technical details and no economic conditions, particularly pricing, have been published yet. With this offer Telecom Italia is seeking pilot partners to investigate the product in praxis further. A general technical framework and some pricing elements do exist but as of today (Q3 2007) there are no existing customers for this offer..

Telecom Italia divides its network into macro areas (larger regions) and offers access at one point of this macro area on an IP over Ethernet level. The access point for each region has not yet been determined but will be agreed upon together with the access seeker who may usually choose between 1 and 2 sites for getting access. The size of a multicast area of a wholesale customer may be smaller than the macro area of Telecom Italia and can be defined DSLAM per DSLAM.

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36 Telecom Italia 06/2007, Bitstream reference offer, pp109.

The bandwidth of the access will be determined by the sum of all channels, that should be distributed via multicast down to the DSLAMs, and is determined by the access seeker. It may be structured so that the edges of the multicast tree are thinner than the root (e.g. that the bandwidth of the edge path is lower than the bandwidth of the access point), but there will still only be as many channels carried as the bandwidth is configured for.

The traffic will run in VLANs based on the Ethernet platform of Telecom Italia. One VLAN is dedicated for the multicast, another is dedicated for upstream communication and control. For each operator separate VLANs will be implemented. All multicast VLANs will get a separate class of service (CoS = 3), which has not yet been specified according to detailed quality parameters.

Each customer may signal the DSLAM and the server as to which, and how many, channels they want to receive. They cannot receive more channels than can be transported through the multicast edges and especially over his xDSL-access line.

The multicast functions are based on international standard protocols:

- IGMPv2 (Internet Group Management Protocol (RFC 2236)) for the signalling on the client side
- PIM-SSM (Protocol Independent Multicast – Source Specific Multicast (RFC 4601) for the distribution of the multicast routing information).

The pricing is structured to include some overall cost for technical analysis and interoperability testing and for configuring on the macro area level, cost for the access point equipment, for the activation of each channel to be multicast, for the activation and the transport of each channel onto each DSLAM and for the activation of the second control VLAN per each DSLAM. Concrete prices are not yet established.

Up to now this service offering is not yet available, which is not surprising as the offer has just been published in June 2007.

In summary, we can conclude that up to now no wholesale bitstream products do exist which are dedicated to IP-TV support of wholesale customers. There are some hints that such a service based on a multicast enabled network may be less complicated and in total will need less bandwidth than distributing many local content storages for that purpose (and so reduce the overall cost), because the content storages also require the complete TV signal to be distributed via a (fixed) multicast.

4.2.4 Strategic wholesale framework for the migration to NGN

This chapter deals with migration aspects from traditional wholesale access services to wholesale under an NGN architecture. The key issues characterizing the migration path are the roadmap (timeline for phasing out legacy networks and migrating to NGN), access features and migration-related aspects of ordering and provisioning (such as the possible unavailability of service for the end users during the switch over period). This also includes supporting processes such as bulk migration, since OAOs may wish to migrate all their customers from existing wholesale services to the new platform. Bulk migration aspects will be dealt with in the OSS/ BSS Interface section because they are orientated more towards operative processes rather than strategic network migration.

Principally the incumbent's migration towards NGN should not jeopardize the competitiveness of the involved markets.[37] Hence it is necessary to develop policy guidelines for the migration process in order to sustain investments, for example in LLU, for a reasonable time period and enable the migration to other wholesale products such as sub-loop unbundling at the street cabinet.

This report will refer primarily to the Dutch plans because they have already been more clearly concretized both by the incumbent and the regulatory authority than in most other markets. Even though eircom have announced that they will operate an overlay strategy of parallel infrastructures it is already clear that legacy networks must be terminated at some point in the future due to the added cost. Accordingly thoughts and visions from the Dutch regulator will aid ComReg in its own policy development for the migration phase.

4.2.4.1 OPTA's position towards the Dutch NGN

KPN's plans for the Dutch NGN were introduced in the first work package (chapter 3.2.6). The central element of this migration to NGN is KPN's goal of phasing out Main Distribution Frames and the repercussions this creates for the wholesale (and retail) markets. OPTA seeks an alternative that "adequately compensates for the elimination of the MDF access rung on the investment ladder and also involves an incentive for market parties to further roll out their networks."

If it is not realistic for a party to roll out its own SDF backhaul (and if there is no SDF offer from another party including KPN), OAOs may switch bitstream access[38] from different levels of KPN's network (see above). However OPTA clearly states that in the

37 These could include the wholesale market for unbundling (market 11), for high and low quality broadband access (market 12), for termination of leased lines as well as retail markets for broadband Internet access, fixed telephony, data communication services and leased lines. See also OPTA (2006) KPN's Next Generation Network: All-IP Position paper, page 4.

38 KPN refers to bitstream as Wholesale Broadband Access (WBA).

intended context of providing incentives for operators to proceed along the ladder of investment bitstream access would be a step backwards compared to unbundling at the MDF. Accordingly a sole bitstream access is not a suitable replacement.

OPTA gives the opinion that a suitable, “fully fledged” alternative to MDF access for unbundling must comply with three conditions:

1. The alternative must address potential competition problems in all of the concerned markets (unbundling, high and low quality wholesale broadband access as well as retail broadband access).

2. This alternative must satisfy the supremacy of infrastructure competition meaning that access and price obligations must not negatively influence investment incentives for market parties but rather promote climbing the ladder of investment.

3. Accordingly measures undertaken should be directed at “highest level wholesale markets”. In line with the doctrine of infrastructure competition this should hence prefer measures that allow highest possible value-add by the OLO.

According to OPTA’s position paper a “fully fledged” alternative could consist of the following components.

- A regulated offer from KPN for unbundled access to the sub-network, as well as the related facilities such as co-location at the street cabinet for purchasing SLU.

- Phase-out conditions for the withdrawal of access already granted

- A regulated wholesale broadband (bitstream) offer from KPN for the areas where KPN does not yet offer sub loop unbundling and/or SDF backhaul and the MDF locations are phased out.

- A regulated offer for the delivery of glass fibre and/or glass-fibre routes by KPN, as well as the related facilities such as co-location on the Metro Core Location (MCL) and the street cabinet for installation and delivery of backhaul by third parties.

- A regulated offer from KPN for SDF backhaul, as well as the related facilities such as co-location on the MCL and street cabinet for purchasing backhaul from KPN or delivery of backhaul by third parties.

OPTA also reflects on the joint deployment of infrastructure as upcoming FTTx architectures require increased fibre roll out towards the end user.[39]

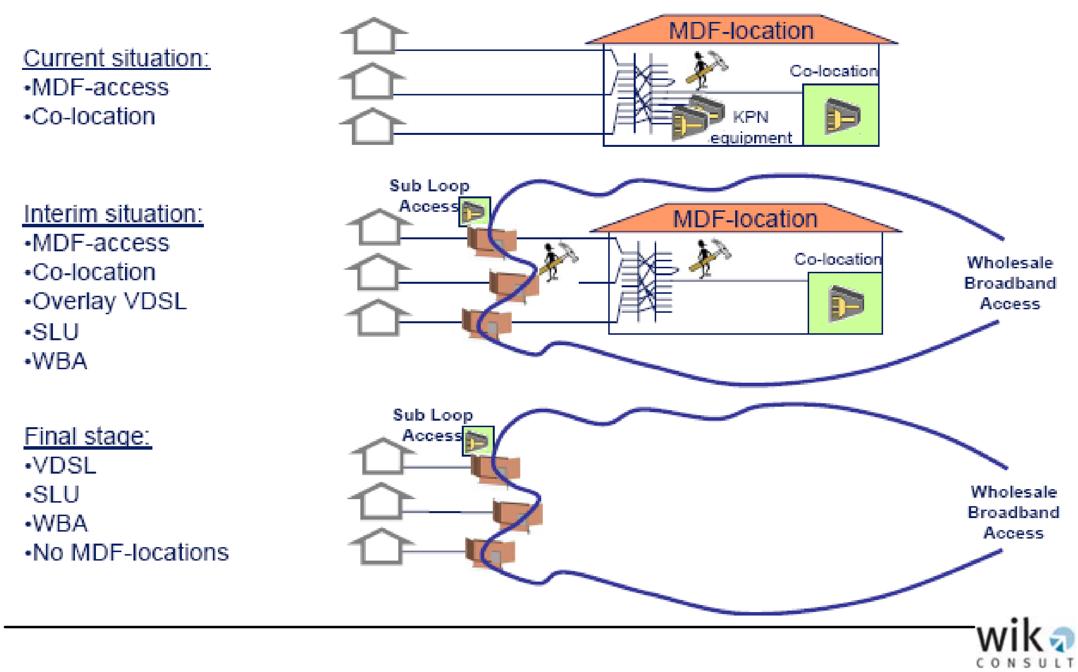
4.2.4.2 OPTA's requirements for the migration phase

OPTA considers three distinct phases of migration for which the regulator needs to adopt appropriate regulatory measures:[40]

- Phase 1: Access to main distribution frame (MDF) still possible
- Phase 2: Transition period with reduction of MDF locations
- Phase 3: All-IP access network completed, MDF locations phased out

These phases mirror KPN's planned stages for NGN implementation (see Figure 4-8).

Figure 4-8: KPN's roadmap for NGN implementation



Source: KPN presentation 'Op weg naar All IP, 29 March 2006

39 See OPTA (2006) KPN's Next Generation Network: All-IP Position paper, page 37/38.
40 See OPTA (2006) KPN's Next Generation Network: All-IP Position paper, page 9.

During the transition through these phases OPTA is proposing the following schedule as frame condition for the phase out of MDF locations:

Table 4-16: Summary of suggested time frame

Critical issue	Suggested period	Comment
Lead time for SLU reference offer introduction	6 months	An accepted sub loop unbundling reference offer is a prerequisite for MDF phase out
Reasonable phase out period		Usually the reasonable migration period unless reasonable depreciation period is longer
• Reasonable migration period	At least 2 years	The time customers require to be able to migrate from MDF to SDF
• Reasonable depreciation period	5 years	After the last delivery at an MDF whose phase-out has not been announced

Source: WIK Consult / OPTA (2006): KPN's Next Generation Network: All-IP Position paper, page 30-31.

OPTA writes:[41]

> *"The first condition is that phasing out of MDF locations cannot begin before KPN has published an SLU reference offer, which has been evaluated by the Commission and that satisfies the requirements stipulated in the market decision. The reference offer must also include a complete migration offer for the migration from MDF to SDF, including strict quality levels. Parties must be informed of the reference offer in a timely manner, that is to say six months before the SLU offer is introduced."*

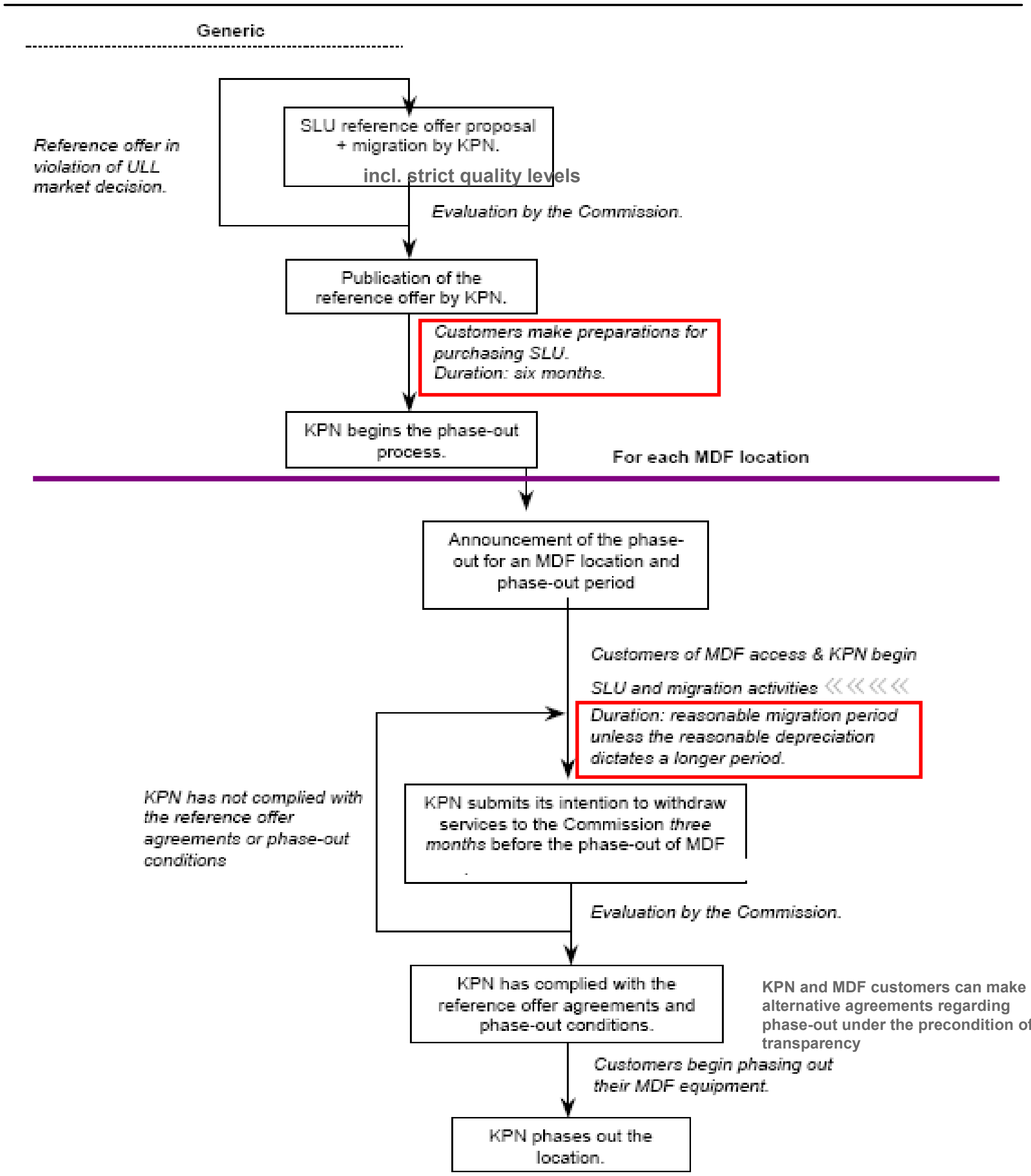
> *"Phasing out of the MDF locations can begin six months after publication of the reference offer. KPN must formally announce a phase-out on its website and must notify both the customers at that location and the Commission of the intended phase-out in writing. KPN must maintain a reasonable phase-out period for the phase-out of an MDF location. This period is determined by the time customers at that location reasonably require to be able to migrate from MDF to SDF (reasonable migration period) and the period that the customers at that MDF location may reasonably expect for the depreciation of the one-off investment in their basic configuration (reasonable depreciation period)."*

> *"The Commission considers a period of five years after the last delivery of a basic configuration at an MDF location (whose phase-out has not yet been announced) to be a reasonable depreciation period. For migration from MDF to SDF, the Commission's preliminary opinion is that a period of at least two years is reasonable. The reasonable phase-out period for a specific MDF location is the reasonable migration period, unless the reasonable depreciation period after the last delivery of a basic configuration is longer. In that case, the reasonable depreciation period after the last delivery of a basic configuration for that location must be used as the reasonable phase-out period."*

41 OPTA (2006) Position Paper All IP: S. 30f.

OPTA's suggested migration path and its preconditions is shown in Figure 4-9.

Figure 4-9: OPTA's view of conditions governing the phase-out process



Source: OPTA (2006): KPN's Next Generation Network: All-IP Position paper, page 29.

Within phase 2 the LLU access obligation at the MDF depends on whether the incumbent KPN has officially announced the phase out of the specific MDF. With a mere announcement of intent (or if KPN has not given any notice yet) KPN is still obliged to offer LLU at the MDF.

4.2.5 Operational aspects, OSS and BSS interface

This chapter specifically addresses operational aspects that are related to processes and daily interaction between access seeker and the incumbent. The study details the following three aspects

- Bulk migration
- Operations Support System (OSS)
- Business Support System (BSS)

4.2.5.1 Bulk migration

The analysis of wholesale markets has shown that inappropriate or a lack of bulk migration processes has been a key barrier for alternative operators trying to migrate customers from resale to bitstream or from bitstream to unbundling.[42]

The following applies in the case of bulk migration processes to bitstream or an unbundled line by Belgacom[43]. These project based mass migrations require minimum quantities of at least 10 lines in the same exchange at the same time and a minimum of 250 lines per month. The process is valid for migration to both bitstream and unbundled lines from a resale offer or from bitstream / unbundled lines of another OAO.[44]

Bulk migration is carried out in three phases:

1. Project Initiation Phase
    - Communication of request
    - Collection of information (migration type, geographical needs, timing, …)
    - Set up of migration list and planning
2. Preparation phase: At the end of this phase, a final Go/No Go is given by the access seeker. This provides the opportunity to cancel or amend the migration of any given line.

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42 Jay, Stephan (2007): Bedeutung von Bitstrom in europäischen Breitbandvorleistungsmärkten (Significance of bitstream in European broadband wholesale access markets). WIK Diskussionsbeitrag 299, Bad Honnef. page 29, 34, 58.

43 Belgacom (2006): Annex K: Migrations for BRUO and BROBA.

44 Belgacom states „The initial solution may be either a retail mass market service, or corporate solution (e.g. Leased Line, VPN, SDSL, …), a Belgacom service or that of another Beneficiary, a BROBA or a BRUO service of the same or another Beneficiary."

3. Installation Phase (excerpts)

   - There are no roll-back, no amend nor cancel possibilities as soon as the installation phase is started
   - Belgacom will establish processes to minimize the interruption duration. The targeted duration of interruption of service is 40 minutes.
   - The documentation in the Belgacom legacy systems is adapted on the execution date + 2 working days
   - The SLA repair conditions start as from this date. Before this date, repairs are done on a best effort basis, until further study of Belgacom.
   - Belgacom will perform all actions of the deactivation process of the initial product.

4.2.5.2 Operations Support System (OSS)

OSS Systems are a group of EDP (Electronic Data Processing) systems supporting the operational processes of a telecommunications operator. They span the complete customer life cycle from order entry to service termination with all the changes of the services in between and all problem handling, error recovery and troubleshooting during the service delivery.

In order to ease the cooperation between interconnected operators one can establish interfaces or gateways between the relevant OSS subsystems, so that data can be interchanged quickly and without (transmission) faults, needing just a minimum of human interaction. Where one operator is providing access to another, these linkages are effectively essential in order to enable timely competitive access to services.

According to our operational experience we have distinguished between the following relevant process elements which reflect the processes of the customer life cycle:

- Order Entry
- Provisioning
- Configuration Management/ Changes
- Alerting
- Operational Management and Fault Analysis (1rst to 3rd Line Maintenance)
- Line Testing
- Performance Monitoring

A customer order is processed in the **order management system** of their service provider. The contract is verified and registered, the addresses and relevant product information is stored and resources are reserved The resources required from another operator are then ordered (e.g. LLU, Bitstream Access, …). Between interworking order entry systems this ordering is done in an automatic manner by transferring the relevant part of the order to the order entry system of their partner, which will verify the order, acknowledge the order entry, and process the order to provide and allocate the relevant resources. It will respond to the originating ordering system to indicate the date and time when the ordered service will be delivered, but may also indicate some fault conditions (e.g. no access available, service not available, address does not exist, existing customer contract not yet terminated, etc).

When faults arise, some human interaction between the operator and its end customer will usually be required in order to agree upon the proposed delivery time or to clear the fault issues; however all interaction between the operators before that stage can be carried out in an automatic manner. This type of interface is implemented in many competitive environments in Europe as it saves OPEX on both sides and because typically a large amount of data has to be exchanged. Furthermore the transferred data is not subject to additional errors being generated by human error.

The **provisioning system** generates and sends the required parameters into the relevant part of the network in order to enable it to open the network access and to establish the connection. Some of these parameters include the quality of service attributes NG access should provide. In the case of bitstream access these required parameters are transferred to the network of the operator who provides this access.

The **configuration management** system makes it possible to change attributes of a customers service or connection in a direct manner without involving the commercial aspects (running through the order entry). Sometimes the service provider will need to change the status of the customer access e.g. to switch it off for a short period of time without terminating the service (for example because a bill is overdue for payment), to close a loop for testing purposes, or to change QoS parameters in a given framework. For operators who provide service via wholesale bitstream access, these operations have to be conducted on the network equipment of the bitstream access provider. Thus opening the management systems of this operator for its wholesale customer would allow fast reactions to customer demand. For security reasons, the management systems typically allow only access to the ports of the wholesale customer, and only for a dedicated set of operations.

The network management systems of a network operator react with **alerts** if there is a change of status of the network entities. It would of course improve customer relations-service if network alerts were transmitted to the operator providing the service when they occur so that the help desk is informed if the customer reports an error and ideally can state how long the outage is likely to last.

Even better coordination could be reached by automatically exchanging the relevant trouble tickets of the trouble ticket systems (**operational management and fault analysis system**), so that the operating staff of both networks have access to all relevant information of network operation, change and failure repair, and the relevant interim status. The operators could then see which actions (and tests) the other party has already performed. This can reduce the amount of “Ping Pong Repair” involved (the fault is in your network – no, in yours, …) and will improve the MTTR (Mean Time to Repair). A user help desk can inform the customers accordingly.

If the wholesale customer can perform **line tests** in the wholesalers network this can also reduce the time to remotely allocate and identify failures, especially at the customer site. Failures which fall under the responsibility of the wholesale customer can be identified sooner and without operator staff interaction.

Having access to the **performance monitoring** tools of the wholesaler would enable the wholesale customer to supervise the QoS characteristics of the bitstream lines and could also help the wholesale customer to identify customer VCs which are running out of capacity in a timely fashion, so that the wholesale customer could attempt a just-in-time upsell to its retail customer, or to enable it to complain if appropriate about poor QoS performance.

Summary

Summarizing the advantages of interworking OSS ends: Good interworking can result in a better service for the end customers and in a higher customer satisfaction.

Interworking between the OSS functions is often performed by human interfaces, sometimes supported by fax (as is the case in Germany). The interworking of the OSS should be improved to provide access to all relevant network data, customer data and system resources to ensure effective and efficient business and network operations from a customer perspective. . A further improvement could be achieved by allowing access to the dedicated systems of the wholesaler, where the wholesale customer gets access to the relevant data and system resources of its end customers, but only to that extent that such access cannot harm third party customers.

Feedback from discussions

Up to now and as far as the operators in Ireland have answered the WIK questionnaire, OSS interworking appears to be limited to a general interface for the order entry, plus some information exchange about major network events in the wholesalers network.

On the other hand not many in-depth ideas of a closer interworking of the OSS of the OAO and the incumbent (wholesaler) exist.

Order entry works reasonably on the basis of a general file transfer interface. This co-operation has been classified by all operators as absolutely necessary. In addition some operators would like to prioritize some of their orders, which at the moment all are processed in a FIFO manner. It might also make sense to coordinate the provisioning of some services to be delivered at the same time or in a dedicated order, because they belong to the same project. Eircom also offers the possibility to check the line availability in advance of an order (in a traffic light manner, i.e. red light – green light).

Concerning the **provisioning or configuration** there is a classification between absolutely necessary and good to have. One operator would like to have the opportunity to temporarily terminate a service. Some expressed the need to configure quality parameters of the access and backhaul network in contracted limits (e.g. getting a defined bandwidth and selecting different VC and QoS by itself). Some carriers suggested better status information during the provisioning process, particularly when the first attempt fails.

Alerting of major network faults is exchanged with some competitive operators, but obviously not with all of them. None of the OAOs asked for a customer port based alert.

The cooperation by exchanging trouble tickets between the **operational management and fault analysis tools** according to eircom is implemented, however there is only proactive alerting by eircom for major faults (see above); however one competitor claims that it is not implemented, some do not have a major interest in getting such an interface

Access to **line testing** tools has been qualified by most operators as good to have, as well as the access to performance monitoring tools; however both functions have not been described in a more detailed manner except for the need to access bit error counters and SNR data. In one case, access to jitter, delay and packet loss has been qualified as nice to have.

4.2.5.3 Business Support System (BSS)

The exchange of billing information is processed by exchanging the relevant CDR per file transfers. There have been no deficits reported. Looking into the future of bitstream access with QoS one operator identified its need to receive one line item per customer port. Market participants have not provided any details.

We believe that generating the CDRs so as to reflect products ordered, and with a degree of detail which allows verification of the amount charged and fulfils legal obligations (e.g. detailed bills), is adequate.

4.3 Summary

It was shown what the characteristics of bitstream are like today and which of the parameters might already be considered to be NGN bitstream. The importance of the network access was stressed and it became apparent that at the moment there is no commercialised bitstream access at the DSLAM level. It became equally clear that there is a general lack of quality in current (IP) bitstream wholesale services.

The Italian bitstream offer was used as an example to highlight in which direction flexibility in parameters and functionalities an NGN bitstream might evolve. However this offer is also not yet commercialised yet and still requires acceptance by the Italian regulator AGCOM. Yet it is a first step in including multicast functionalities in a wholesale bitstream offer. Equally a first time is the German decision to request a minimum quality for the upcoming IP bitstream offer from Deutsche Telekom. However this offer is – again – not yet available in the market. This means the empirical basis for NGN bitstream analysis is low.

5 Assessing technical requirements for an optimum wholesale product suite (WP3)

The goal of this work package is to provide guidance on the technical requirements of future wholesale products in an NGN environment. In our view the following questions characterize the critical issues that have to be targeted:

1. At which **network level** will access be required?
2. Which **service classes** and how many VCs/VLANs per customer will be required?
3. What **access line speeds** are required?
4. What further functionalities for **video distribution** are required?
5. What are operational requirements regarding **OSS**?
6. In addition: What are key characteristics of adequate **SLA?**

Eircom's NGN retail product bundle should constitute the benchmark for the functionalities of an NGN bitstream product in light of functional equivalence; however eircom has not provided concrete plans for the NGN retail service composition. Therefore the study draws on the analysis of (emerging) triple play services (Work Package 1 – chapter 3), existing bitstream offers and announcements of NGN bitstream implementation (Work Package 2 – chapter 1), interviews with selected operators and regulatory authorities and further analysis of likely service bundles. In particular WIK-Consult has led discussions with eircom and 5 Irish alternative operators to ascertain the visions and needs for NGN bitstream.

However the feedback from interviews with OAOs in Ireland made it clear that most operators have not built a vision for services and quality or OSS requirements in an Irish NGN. Therefore the overall feedback and specifically concretized demand for QoS was relatively thin. Accordingly this study is based primarily more strongly on the analysis of international existing retail and wholesale offers, consultation processes and discussions with key stakeholders.

Therefore, this chapter begins assessing the likely technical requirements of triple play service bundles in the NGN. In a second step, we provide an assessment of specific Irish framework parameters in order to incorporate the local context in the evaluation. Thirdly, we present recommendations and guidelines for the critical issues.

5.1 Retail service bundles in the NGN and their technical requirements

As it has been shown in Work Package 1 (chapter 3) emerging next generation retail services comprise at least Broadband Internet access, VoIP Telephony, IPTV and Video on Demand, often cited as Triple-Play. In addition gaming, video-conferencing and telecommuting (or more generically data services) are often cited as part of the NGN-based product bundle.

The driver for the increase in downstream bandwidth is primarily HDTV. The amount of bandwidth required for video transmission depends on the video quality (for example Standard Definition vs. High Definition where higher quality increases the demand for bandwidth) on the one hand and on the advances in compression technology (for example the migration from mpeg2 to mpeg4 codecs where higher/more efficient compression reduces bandwidth) on the other. Therefore bandwidth requirements for video should be treated carefully, as sources may differ due to different assumptions.

But in designing Next Generation Access networks one should not forget the upstream side of the communication needs. The drivers for upstream bandwidth are content sharing and peer-to-peer applications. An example of the bandwidth budget required for different applications in the NGN is listed in the following table:

Table 5-1: Bandwidth demand estimate by 2008-2010

Application	Downstream bandwidth		Application	Upstream bandwidth
Standard Definition TV (SDTV)	3 Mbps/channel		Basic broadband Internet access	2 Mbps average
High Definition TV (HDTV)	9 Mbps/channel		Personal content upload	3 Mbps/channel
Basic broadband Internet access	5 Mbps average		Gaming	2Mbps/session
Gaming	2 Mbps/session		Video Conf., Learning	3 Mbps/session
Video Conf., Learning	3 Mbps/session		VoIP (toll quality)	100kbps
Home working / data services	4 Mbps average			
VoIP (toll quality)	100kbps			

Source: Alcatel, WIK-Consult (2007).

For our purposes we assume that a video signal (e.g. an IPTV channel) will require 2-5Mbps (addressing both SD and HDTV format) taking into account that future Codec advances will contribute to reducing HD-bandwidth from about 9Mbps to about 5Mbps. The applications not only differ by their demand in bandwidth but also with regard to their requirements to the primary QoS parameters of delay, jitter and packet loss. These different requirements are listed in Table 5-2.

Table 5-2: QoS requirements of different applications

Application	Delay	Jitter	Packet Loss	Guaranteed bandwidth
Basic broadband Internet access	uncritical	uncritical	uncritical	uncritical
Home working / data services	important	important	important	important
Video on Demand	important	important	critical	**critical**
IPTV	**critical**	**critical**	**critical**	**critical**
VoIP	**very critical**	**very critical**	**very critical**	**critical**
Video Conf., Learning	**very critical**	**very critical**	**very critical**	**critical**
Gaming	**very critical**	**very critical**	**very critical**	**critical**

Source: WIK-Consult

For practical purposes operators will be inclined to aggregate these multiple different services into several service classes. Research led by the university of St. Gallen (Switzerland) suggests the following implementation with 4 different classes of service (see Table 5-3).

Table 5-3: Suggested classes of service definition (University St. Gallen)

Class of Service	Examples	Technical QoS parameters	
Interactive	Voice Telephony/Conferencing Video Telephony/Conferencing Online-Gaming Interactive TV Feedback	Bandwidth: Delay (one way): Jitter: Packet Loss:	16 – 500 Kbps 100 – 200 ms < 30 ms < 1 %
Multimedia	Broadcast TV Video on Demand Streaming Audio Internet Radio Voice Messaging	Bandwidth: Delay (one way): Jitter: Packet Loss:	384 Kbps – 14 Mbps 400 – 1000 ms < 1000 ms < 0,1 %
Critical	Business Application e.g. SAP, eHealth	Bandwidth: Delay (one way): Jitter: Packet Loss:	16 Kbps – 16 Mbps 100 – 200 ms < 100 ms < 0,1 %
Best Effort	E-Mail Web-Browsing P2P Internet Downloads	Bandwidth: Delay (one way): Jitter: Packet Loss:	up to line rate < 2000 ms n.a. n.a.

Source: Brenner, Dous, Zarnekow, Kruse (2007): Qualität im Internet - Technische und wirtschaftliche Entwicklungsperspektiven, p. 31.

5.2 Irish impact factors on the decision making process

Having considered the general technical requirements to the underlying broadband network the objective for ComReg should be to enable functional equivalence for Irish OAOs. This means that (only) to the extent that eircom is providing triple play services described in chapter 5.1, the technical underpinnings must be implemented in the bitstream offer such that OAOs are not disadvantaged relative to eircom.

In addition to this general guideline, the specific local circumstances must be considered because the most effective strategy for operators to roll out the NGA and to provide triple play services to the end user depends on a number of specific local characteristics, including[45]

- Customer density and dispersion
- Copper loop lengths and sub-loop lengths
- (quality and) topology of existing network architecture (especially number of street cabinets per MDF)
- Presence of multi-dwelling units

With regard to separate studies being undertaken for ComReg on the issue of infrastructure roll-out and the prospects of unbundling we will only briefly address these characteristics and consider their impact on bitstream.

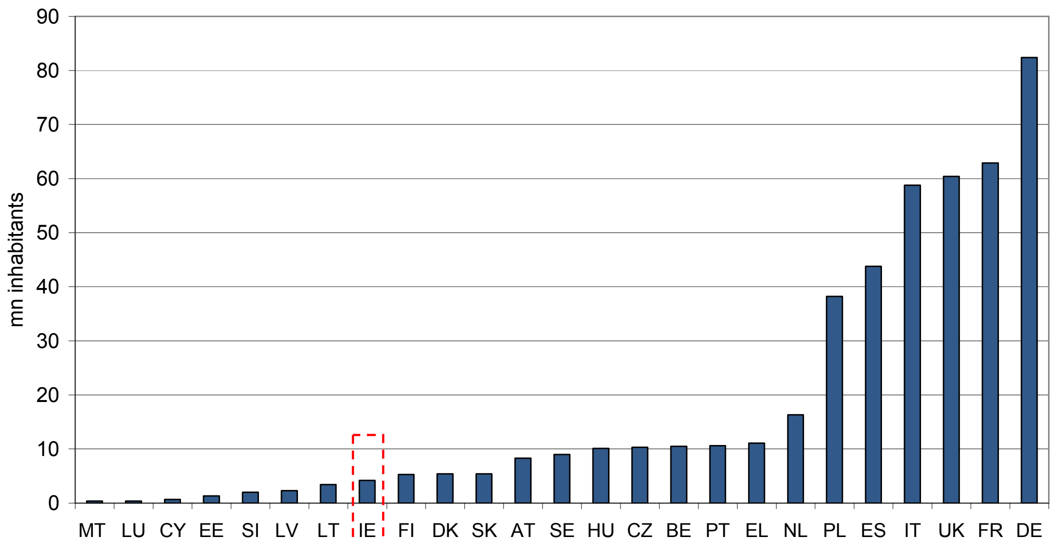
To a large degree population density defines the economic potential of retail offers. Broadband business models will more readily become economically feasible where a given investment in infrastructure reaches a large number of potential customers. The Irish distribution shows however that there are large parts of the country where population density is relatively low compared to metro areas like Dublin (see Figure 5-2). Effectively the customer potential could be classified into two different geographic classes (see below), corresponding to high density (mostly urban) and low density (rural). This significantly reduces the incentive for OAOs to invest into their own infrastructure outside of major cities. The lack of incentive for using unbundled access in less dense areas increases the importance of bitstream access for OAOs.

Furthermore Ireland's overall population is also relatively low compared to other EU countries (see Figure 5-1). In the context of preparing NGN services this makes investments into IPTV architectures more difficult for Irish operators because there are fewer potential customers who could amortize the investments than in larger countries. Because parts of the investment are sunk into central servers, IPTV deployments reach break-even much faster when there is a larger customer base. This means that incentives to rely on cooperation and wholesale solutions are higher than in markets with a larger population.

45 See ERG (2007): ERG Opinion on regulatory principles of NGA, p. VI.

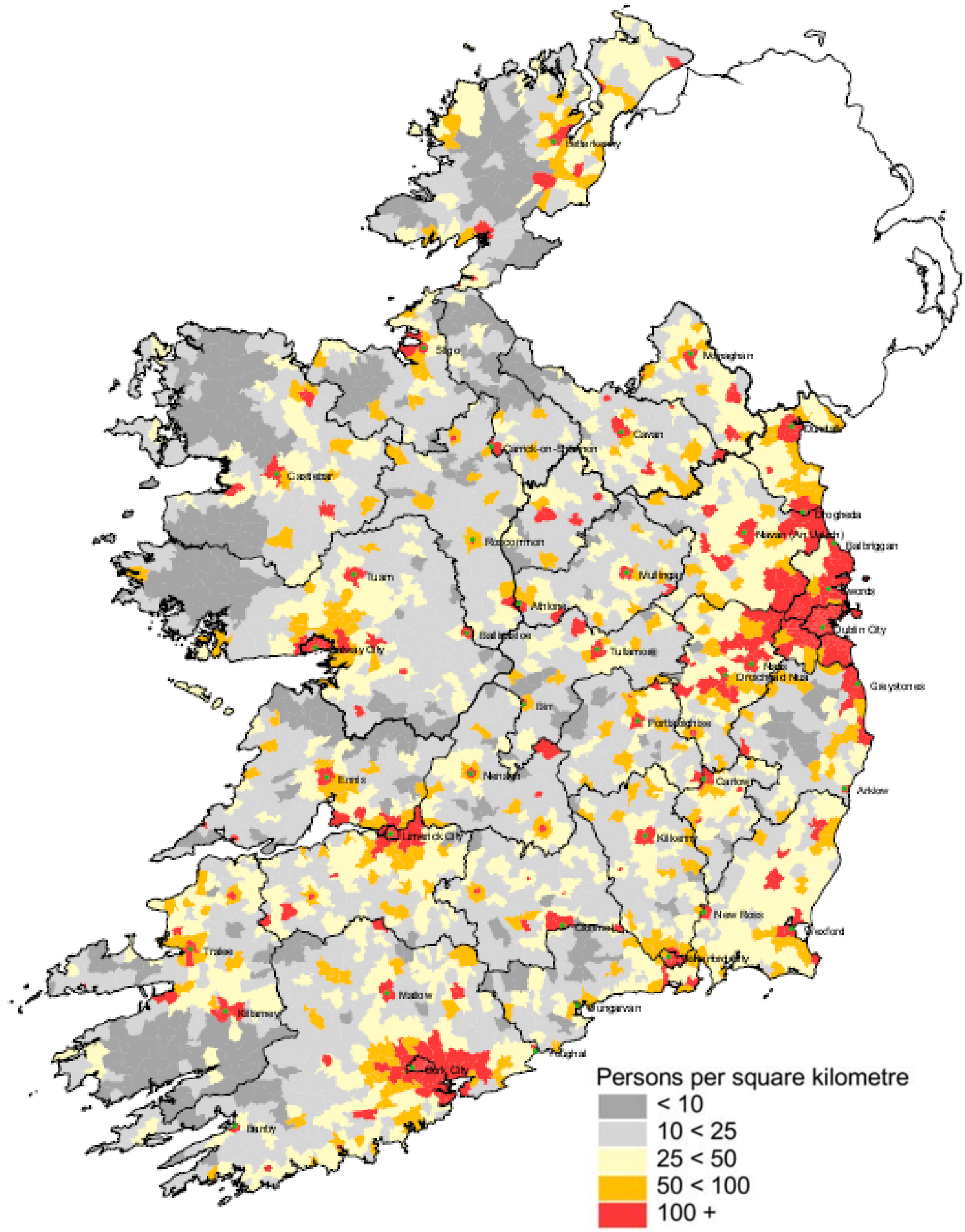
Therefore it can be deducted from the size and dispersion of the population that bit-stream services will likely play an important role for the majority of geographic areas in Ireland.

Figure 5-1: Population in EU-25 member states (millions)



Source: Eurostat (2006): Statistics in focus - Population and social conditions 16/2006.

Figure 5-2: Population density of Irish electoral divisions, 2006



Source: Central Statistics Office (2006): Census 2006 – Volume 1, p. 9.

5.3 Deduction of technical requirements for an optimum bitstream product

The analysis of existing bitstream services in Work Package 2 (chapter 1) has shown that QoS provisioning to enable retail bundles in an NGN environment (non-ATM) barely exists today. Also, the operators in Ireland could not describe a concrete set of requirements yet. Based on the analysis in the preceding chapters this section of the report presents reasoning and recommendations for the key parameters identified. Probably of highest concern are the levels at which access to the bitstream will be granted and the degree of QoS provided.

5.3.1 Network access to the bitstream

According to the ladder of investment theory, OAOs require a range of complementary wholesale services that allow them to sequentially reach the necessary scale to climb onto the next rung where they will deploy additional infrastructure of their own. This also applies to bitstream services with respect to different access point options. In the discussions for this study OAOs have repeatedly stated their wish to have the greatest possible flexibility to adapt wholesale sourcing to their strategy. Accordingly, OAOs request the largest possible choice of access points.

Generally it can be assumed that where economically feasible OAOs would prefer to bring in the highest added value through their own infrastructure. The usage of such different access options will therefore differ according to a) the geographical region serviced (high potential vs. low potential, e.g. in rural areas) and b) the evolutionary phase the OAO is currently progressing through (e.g. characterised by the installed base of customers). We will return to the question of appropriateness for granting access on every hierarchy level throughout the country in chapter 5.3.1.2.

5.3.1.1 Desirable access levels

A differentiated choice of access points at different levels should form an integral part of the NGN bitstream. Network access at the following **hierarchy levels** appears generally possible:

- **DSLAM / MSAN level** (including access at MDF and street cabinet level): By accessing the bitstream directly at the DSLAM the OAO gains the ability to completely control the aggregation of traffic because in an xDSL architecture no overbooking of traffic has happened up to this point (each end user has a dedicated line).
  The critical issue associated with bitstream access at this lowest network level is the ability for the OAO to backhaul the bitstream. This is especially difficult when

backhaul is required to street cabinet level in an FTTC architecture. Accordingly an optimum bitstream product with access at DSLAM on street cabinet level requires complementary availability of appropriate backhaul means (ducts, dark fibre, managed bandwidth, …).

- **Equivalent street cabinet access option at higher level**: There is an alternative to true bitstream access at the SDF which would render the same quality but does not necessitate that OAOs build out fibre to the street cabinet. Accessing a bitstream product at the next aggregation level (e.g. Main Distribution Frame site) may yield the same quality under the following conditions:

    - The number of user per DSLAM does not exceed a certain threshold (e.g. ~400)

    - The DSLAM in the street cabinet is backhauled with fibre to the next aggregation level (e.g. MDF site) and the backhaul is realised at the level of GbE or perhaps even at 10 GbE.

  Then every end-user can be serviced transparently e.g. with 20Mbps without any quality reductions through aggregation.

Table 5-4: Sample calculation for an SDF-equivalent access at the MDF

Downstream bandwidth required per user	20Mbps
Number of users per DSLAM	400
Total bandwidth demand (@ 1 erlang)	8Gbps
Incorporating concurrent network usage factor @ 0,2 Erlang	1,6Gbps
Incorporating concurrent network usage factor @ 0,5 Erlang	4 Gbps

Source: WIK-consult

This provides a quality of bitstream access at the MDF site which is comparable to that of accessing bitstream at the street cabinet level . Such a concept may imply higher investments into upstream capacity for the incumbent (see the effects of scaling the Erlang factor). These increased costs would have to be reflected in the price of bitstream access.

- **Parent / distant switch:** Bitstream access at any point upstream from DSLAM / MSAN to a core-router would be a feasible access level. In the eircom terminology these could be aggregators, super aggregators, edge routers and core routers.

Likely **access protocols** are Ethernet (on OSI layer 2) and IP (on OSI layer 3) in continuation of current protocol - hierarchy combinations:

- Bitstream access at DSLAM / MSAN, aggregator and super-aggregator level would be based on Ethernet (to the extent that replacement of ATM networks has been completed).
- Bitstream access at edge routers - which we reckon will be the locations of the BRAS - could be either Ethernet or IP, depending on whether handover will happen in front of or behind the BRAS.
- Bitstream access at the core router would be IP. This would likely be a national bitstream offer with just a few handover points for redundancy.

Hand-over should be realised through (Gigabit) Ethernet interfaces which could then be scaled in multiples of e.g. 1 GbE or less (this is already common practice).

5.3.1.2 Considering the trade-off between desirability and feasibility

While it would be desirable to enable bitstream access at all of these levels, it appears that there are at least two different geographically separate markets in Ireland: The Dublin metro area and some of the large cities on one hand, and the rest of the country on the other hand (see chapter 5.2). As indicated above, it appears realistic to assume that OAOs will focus their use of unbundled access on metro areas and will fall back on bitstream for other parts of the country.

Considering the demand side requirements for efficient IPTV delivery (sufficient number of customers), this may deter OAOs from building appropriate architectures. Hence they do not require the same degree of flexibility in the choice of different bitstream access levels in eircom's network in rural areas. The incentive for alternative operators to access the bitstream at a level close to the customer to have more control over QoS and network management is driven by the desire to offer services that depend on the QoS provided by the underlying broadband access facilities, e.g. IPTV. Accordingly there might be no demand for access to bitstream at DSLAM / MSAN and maybe not even for intermediate levels such as aggregator in these less dense areas. This implies that obligations for bitstream access at certain levels might differ depending on the geographic region.

As a second point the structural characteristics stated in chapter 5.2 also apply to eircom's strategic planning of Next Generation Access networks. Lack of sufficient demand for an economical roll-out of FTTx in rural areas of Ireland could (and very likely will) generally prevent the extension of NGA to a national scale. As a result it is likely that eircom will not offer NGA based services to its retail customers and equally there will be no infrastructure on which next generation wholesale services could be based upon. In this context, public policy initiatives to extend NGN to areas not serviced by the market could be appropriate.

The implied efficient trade-off between a) choice of different access levels for OAOs and b) proportionality of obligations on eircom in light of actual market demand in the short-medium term, leads us to the opinion that there could be differentiated obligations for greater Dublin than for other regions in Ireland, e.g.

- Tier 1 - Dublin metro area: bitstream access at street cabinet and higher levels
- Tier 2 - areas: bitstream access only at levels above DSLAM / MSAN, e.g. at the first aggregation node and above.

Ideally consultation within the industry would enable to identify those parts of the country where the full scale of bitstream access options needs to be implemented.

Promoting competition on different levels of the value chain for different geographies is already considered by regulators. OFCOM states "*it may be appropriate for regulation to promote competition at different levels of the value chain for different geographies. The impacts of network type, geography and customer densities are likely to be even more pronounced for next generation access deployments than they are for existing local access infrastructure.*"[46]

Indirectly such an approach is pending implementation in Italy. There the obligation to provide bitstream access is phased out for specific exchanges when there are more than 50 unbundled lines.[47] It appears that this instrument is applied to encourage infrastructure competition by migrating OAOs from bitstream to LLU.

The implied importance of bitstream vs unbundling for a large part of Ireland also leads to the conclusion that the **stand-alone bitstream option** should be obligatory. In previous chapters it was already highlighted how stand-alone bitstream contributes to enabling competition through bundles of broadband service and fixed line telephony. While a combination of wholesale line rental and bitstream may achieve similar results marketingwise today, in an all-IP NGN environment the OAO will have an incentive to operate a VoIP only architecture. In this respect stand-alone bitstream is required because otherwise there is no instrument for OAOs to offer complete bundles without end-user ties to the incumbent in those areas where no loop unbundling is undertaken.

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46 See OFCOM (2006): Regulatory challenges posed by next generation access networks, p. 24.

47 The Italian reference offer specifies that the obligation to provide bitstream access at DSLAM level ceases when at least 50 unbundled lines at the respective exchange have been activated. When this threshold has been reached Telecom Italia must continue to provide the existing bitstream lines but starting a year later no new bitstream access lines (at DSLAM level) will be activated. See bitstream reference offer (2007) page 13 and Cullen International (2007): Flash message 52/2007 Italian market analysis notification.

5.3.2 Service classes

Some applications - such as voice, video or gaming - require a sufficient Quality of Service. Sufficient QoS may be realised by simply provisioning (much) more bandwidth than necessary under common usage conditions or else by implementing specific mechanisms (e.g. DiffServ / MPLS, or conceivably RSVP). In either case the QoS is probabilistic rather than guaranteed. The initial question for OAOs is whether to accept a *best efforts only* wholesale that is adequately over-engineered to grant suitable performance or to only accept guaranteed service classes with defined latency, jitter, packet loss and bandwidth. As retail services move towards triple play bundles in an all IP world, a mere over-engineering may not be enough to satisfy the needs of operators and service providers.

Chapter 5.1 discussed the technical requirements of NGN retail services. These form the basis for the analysis of an optimum bitstream product. However there is little empirical guidance from existing bitstream products. Regarding **QoS classes** the Italian bitstream offer includes maximum values for packet loss (0,001%), latency (<36ms / 20ms with or without interleaving) and jitter (≤6ms) as documented in Work Package 2 (chapter 4.2.2). It allows three different Class of Service (CoS), similar to the French offer where there is a basic and a prioritized “premium” channel. In addition the Italian offer carries multicast traffic separately in a third VLAN labelled “CoS = 3”.

Despite the relatively small current operational experience it appears justified to require eircom to offer *multiple* service classes. The exact number (whether it be just two as currently in France, three as in the Italian bitstream offer, four as demanded in the German consultation for IP bitstream or more) may depend on the implementation of services in Ireland. The interviews that we conducted with Irish operators do not enable us to derive a definitive answer. As things stand it appears that 5 different classes of service (best effort, 2 classes for data, voice and IPTV) would constitute a very powerful and advanced bitstream product suite.

Regardless of the number of classes that will actually be implemented the bitstream access options must be defined by

- Traffic parameters: Peak bit rate, sustainable bit rate, minimum bit rate
- QoS parameters: Latency, jitter, packet loss (keeping in mind that the bitstream is only part of the total end-to-end path)[48]

We have drafted 5 classes as basis for discussion. Requirements have been adapted from the suggestion in Table 5-3 and several options should be available for the repre-

48 Interesting work on end-to-end measurement has been conducted by the Quality of Service Working Group within the MIT Communications Futures Program (CFP), see Inter-provider Quality of Service - White paper draft 1.1, November 2006.

sentative parameters stated here - analogue to the structure of the Italian reference offer. The suggestion should be discussed with carriers and potentially with (corporate) end-users e.g. within an industry forum.

Table 5-5: Draft definition for detailed Classes of Service

Class of Service	Technical QoS parameters	
"Interactive" Examples: Voice Telephony/Conferencing Video Telephony/Conferencing Online-Gaming Interactive TV Feedback	Peak Bit rate:	2000 Kbps
	Sustainable bit rate	100-2000kbps
	Minimum bit rate	100kbps (and further upgrade options)
	Delay (one way):	36 ms
	Jitter:	<6 ms
	Packet Loss:	<1 %
"Multimedia" Examples: Broadcast TV Video on Demand Streaming Audio Internet Radio Voice Messaging	Peak bit rate:	20Mbps (and further downgrade options)
	Sustainable bit rate	5Mbps (and further options)
	Minimum bit rate	100kbps (and further upgrade options)
	Delay (one way):	400 – 1000 ms
	Jitter:	< 1000 ms
	Packet Loss:	< 0,1 %
"Critical Data" Examples: Business Application e.g. SAP, eHealth	Peak bit rate:	16 Mbps (and further downgrade options)
	Sustainable bit rate	4Mbps (and further options)
	Minimum bit rate	512kbps (and further upgrade options)
	Delay (one way):	36 ms
	Jitter:	<20 ms
	Packet Loss:	< 0,1 %
"Less Critical Data" Examples: Business Application e.g. Office, mail, large file transfers	Peak bit rate:	20Mbps
	Sustainable bit rate	4Mbps (and further options)
	Minimum bit rate	512kbps (and further downgrade options)
	Delay (one way):	400 – 1000 ms
	Jitter:	<500 ms
	Packet Loss:	< 1 %
"Best Effort" Examples: E-Mail Web-Browsing P2P Internet Downloads	Bandwidth:	up to line rate
	Sustainable bit rate	/
	Minimum bit rate	/
	Delay (one way):	< 2000 ms
	Jitter:	n.a.
	Packet Loss:	n.a.

Source: WIK Consult.

A related issue is the question of **how many VCs/VLANs** should be made available for each end-user. Considering that the total concurrent service delivery may include two IPTV channels (e.g. to two different TV sets or one to the TV and one to the video recorder), one or two VoIP calls and parallel best effort Internet access etc. the operator may have the incentive to allocate more VCs / VLANs than there are service classes, e.g. two real-time VCs / VLANs for video, two for voice and one for best effort Internet access. The example implies a total of 5 VCs / VLANs per home but this might easily be exceeded as further services are implemented (for example Irish OAOs referred to Home Security Services in the conducted interviews). Already some current ATM bitstream offers account for up to 16 VCs per end-user (Netherlands).[49] Accordingly the recommendation must be to require *multiple* VLANs per end user, potentially 10-20.

Irish OAOs have expressed their concern about **contention ratios** of the current Irish bitstream offer and the need for lower ratios.[50] As previously noted we would not consider the contention/overbooking factor as primary QoS parameter since the user experience is not entirely in control of the operator but rather depends on the concurrent usage of all subscribers. Through the introduction of dedicated QoS classes, QoS-sensitive traffic would be given priority. Accordingly the feedback from the discussion with Irish OAOs may be interpreted in that sense that a 48:1 overbooked broadband service is already at a very low Quality of Experience level for best effort service category and would constitute the lowest possible quality acceptable in an NGN environment.

The exact definitions for the individual parameters must be included in the reference due to enable a common understanding of meaning and measurement. During the German consultation for IP bitstream the VATM suggested the following definitions which may serve as *examples* of the structure: [51]

- *Packet loss is defined as unsuccessful delivery of IP measurement packets of a size of 1500 Bytes between DSLAM port and an agreed measurement point. A packet is considered lost when it is not delivered within the predetermined delay.*
- *Delay is defined as average run-time in ms that ICMP (Internet Control Message Protocol) test packets of 200Byte size need for a one way trip.*
- *Jitter is the deviation of the delay of RTP (Real-time Transport Protocol) packets (500 RTP packets per 10 second period), sent in even sequence in 2-minute intervals.*

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49 The Italian offer even scales to 100s and 1000s of VCs for the symmetric ATM bitstream.
50 The currently most widely used 1 and 2 Mbps IP bitstream options are only available as 48:1 contention. Other bandwidth options are available as 24:1.
51 VATM (2007): 2nd Opinion of the VATM in the IP bitstream consultation, p.23f. This paragraph was included to highlight the structure rather than the concrete values.
Work of the MIT group addresses quality metrics and measurements in more detail.

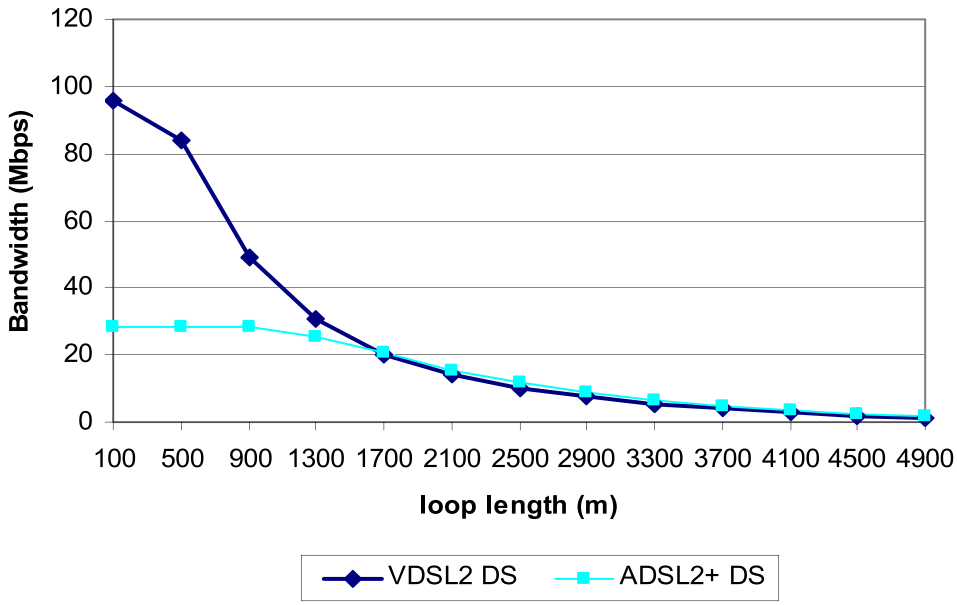
5.3.3 Access line speed and access technology

The requirements of a next generation triple play retail bundle constitute the benchmark for access line speed (bandwidth on the last mile between the end-user and the DSLAM) and access technology. It is clearly obvious that the key driver for increased downstream bandwidth is IPTV / video-related content exchange. According to the bandwidth requirements detailed in chapter 5.1 a common budget for multichannel IPTV offer with 4 channels simultaneously and in HD quality provided to the home would absorb about 20Mbps downstream. Because video applications surpass traffic demand of other applications we will for the moment use this conservative figure as a basis even though technically, bandwidth requirements should be added on to each other. A return channel of about 5Mbps would allow video based two way communication, for example interactive video gaming (in addition to VoIP and other services with relative to that low upstream demand).[52]

Depending on the loop lengths this bandwidth budget may or may not be suitably delivered from the main distribution frame through ADSL2+ technology. Using xDSL technology from the Street cabinet may not be necessary in some areas given that the total loop length is short enough (i.e. shorter than about 1300m). Very long loops might then again rather create incentives for a direct FTTH / B roll-out.

52 Care should be taken as these are guidelines indicating a rough magnitude of bandwidth that could be deemed feasible in the near future.

Figure 5-3: Loop lengths and bandwidth of ADSL2+ and VDSL



AWGN: Additive White Gaussian Noise, here at –140dbm/Hz (simulation of a real channel)

Source: Lucent.

Independent of how access is realised (ADSL2+ from the MDF, VDSL2 from the street cabinet or even FTTH/B) we would expect an NGN bitstream service to provide at least 20Mbps downstream and 5Mbps upstream. However the primary decisive factor remains that access line speed and access technology should at least be equal to what eircom is retailing to its end users.

5.3.4 Functionalities related to video distribution (multicasting & localized content storage)

It appears that an efficient IPTV architecture requires multicast functionalities in the network (see chapters 2.4.3). In addition we would assume that Ethernet networks in the NGN will have such multicast functionalities. So far there are however no practical experiences which could provide insights for example into the scalability of multicast architectures.

Should eircom not introduce multicasting for its own benefit and IPTV architecture then the issue of localized content storage becomes more important. Chapter 4.2.3 already highlighted the rationalities associated with multicasting and local content servers. Without multicasting the need for localized content storage is much higher than in a multicast-enabled environment. Yet the issue of localized content storage appears to be more a question of suitable access points than of wholesale services by eircom. So in the absence of multicast functionalities OAOs need appropriate bitstream access points in order to place their own servers at economically feasible locations.

5.3.5 Operational requirements: An ideal Operation Support System

The goal of an ideal OSS interworking is to get as close as possible to a position where the access through an access providing network of a third party is comparable with the situation of operating an own access network – at least in an OSS point of view. In chapter 4.2.5.2 we have already structured the customer life cycle processes of an operator into the following elements:

- Order Entry
- Provisioning
- Configuration Management/ Changes
- Alerting
- Operational management and Fault Analysis (1rst to 3rd Line Maintenance)
- Line Testing
- Performance Monitoring

Now we will outline an ideal OSS interworking surrounding for operators who cooperate in the area of wholesale bitstream access in an NGN environment. We will use the answers provided by the operators and will also expand on these by drafting a scenario which does not yet exist – and where one can discard single or groups of features, if they are not agreed upon to be implemented.

All these proposals for procedural interworking need the will to cooperate by all parties. The OSS interworking with incumbent wholesaler (eircom) will have to be performed in a standardized way, because it will not be able to support individual interfaces and processes for each of the wholesale customers. Therefore the operators have to agree upon common interworking processes.

Concerning BSS interworking no specific bitstream access requirements for the NGN have been identified as long as the relevant billing data is transferred in a common data format over the already existing interface.

5.3.5.1 Order Entry

The orders are sent to eircom and are processed in the order as they have been sent by the wholesale customer. In an ideal (or at least improved) process there would be a feature that enables the wholesale customer to explicitly prioritize some of the orders so that they will be executed within a guaranteed desired time frame.
In addition a feature should exist to concatenate or group orders (for single access lines), which belong to the same end customer or an end customer project. These features will enable the wholesale customer to serve some VIP customers or its project customers in time; independent of the rest of orders which have been placed, and independent of the amount of orders being placed by that operator in total. Of course this prioritization may be limited to a certain amount of orders as an absolute figure or as a percentage of the total amount of orders per time (for example per month) because the incumbent (eircom) has to plan their resources (and share these between all customers). But enabling the interface to carry such a priority information is not sufficient. The complete order process between the parties has to be adopted or enhanced accordingly.

Feedback for the placed orders should also be given in an electronic manner, containing not only the confirmation or rejection and its reasons, but as well a flag should the expected delivery date not match the desired date, so that an immediate communication can be initiated between the access seeker and his customer.

The important function to verify the availability of an LLU product (e.g. an end customer access) in advance - so that it can be checked during the sales process (pre-qualification of the line) to determine if a customer can be served at his site(s) is already implemented today. In a NGN environment this feature should also enable to check if the line quality needed for a customer access can be provided, and if not, when network upgrades will be conducted. In addition to the line pre-qualification an order pre-qualification capability must exist to ensure that all the necessary information required to process and validate the order is correctly gathered in near real time. (Real means less than 10 seconds.)

5.3.5.2 Provisioning

Not all customer provisioning runs without problems or faults so there is a need to feed back information about problems and resultant delays. Sometimes there may also be a requirement to change the order, perhaps because particular features can not be delivered in the desired way. The process between the operators should be established such that the information flow between them is quick and the electronic interface should support that by labelling the attributes of an order response and the response of a reported problem accordingly.

5.3.5.3 Configuration Management/ Changes

There is a need to influence the customer configuration in a direct manner immediately or at least within hours, not being delayed by an order process, which normally lasts days or even weeks. Functions, where this can make sense, are the immediate switch off and on of an end customer access without terminating the wholesale contract according to that access, and the change of access features (e.g. bandwidth or other QoS parameters). The immediate switch on and switch off of the customer access may be needed when the customer is overdue to pay its bill and again after payment. This will not affect the wholesalers network regarding its design, capacity or operation, and will not harm or negatively influence other customers.

Configuring or changing the features of an end customer access can be helpful when the customers claim poor performance or quality. But in relation to the wholesalers network this has to be seen in a different manner. All changes resulting in upgrading the properties of an end customer access (improve bandwidth or other quality parameters) affect the rest of the wholesalers network. They may only be conducted, when they have been agreed upon in advance, e.g. by ordering a performance framework which is not yet consumed by the existing configuration (e.g. the end customer access has a constant bit rate, but still is configured by poorer performance parameters).

Another feature which might be helpful in end to end testing is the possibility to close loops on the customer access port or in the customer modem. So an immediate testing could be started by the wholesale customer to check the complete line as if it would be part of its own network.

All these features could be enabled by establishing a mechanism whereby operators gain controlled access to the network (element) management system of the access provider or by using the possibly existing multi-tenant functionality of the network management system to give access to the end customer ports of the wholesale customer only and with a restricted set of commands being allowed to be executed. In order to prevent other customers of the access provider or even parts or the complete access providing network to be harmed this configuration of the network management system has to be performed very carefully and thoroughly.

5.3.5.4 Alerts

Ideally, if the OSS systems are set up correctly, the wholesale provider should be informed as quickly as possible about failures (e.g. the connectivity fails or there is a major performance degradation) occurring to his customers by receiving alerts which will be generated by the network equipment of the access provider. If major failures occur which affect more than one customer there should be one alert with a list of end customer ports and their locations being affected. The alerts should as well carry the information of what has happened and a time stamp. So the wholesale customer can already inform his customers what failure occurred when they call to claim for it.

Network management systems produce a large amounts of alerts stating all changes which happen in a network. In order to prevent flooding the wholesale customer they have to be filtered for the really relevant information concerning end customer faults. The definition of theses filters can be done in a bilateral manner. The resulting alerts then have to be transferred to the wholesale customers operation centre by a gateway which processes the alerts immediately (without time delays).

5.3.5.5 Operational Management and Fault Analysis

Transferring alerts is only one step towards a closer cooperation in the field of operational management and fault analysis. The wholesale customer may benefit from being informed what is happening during the failure analysis and repair, in order to be able to inform his customers. At least business customers are interested in getting in-between status information about an outage and the estimated time for repair. This information can be exchanged by sending copies of the trouble tickets concerning the failure to the wholesale customer.

If there are failures or problems which can only be solved by the cooperation of both access seeker and access provider a direct exchange of trouble tickets could improve cooperation when trouble tickets document which tests have already been performed and with which results. This can reduce the Mean Time to Repair (MTTR) by preventing reciprocal blames (“fingerpointing”)

In the case that problems or failures cannot be solved within the given time frame a well defined escalation procedure has to be described (e.g. contact person, fixed and mobile telephone number, fax number, mail address, …) and executed. The final stage must be the top management of both parties.

5.3.5.6 Line Testing

As already pointed out in the paragraph about configuration cooperation it is helpful to immediately conduct tests when a customer claims for dysfunctions. This tests may include tests for general and specific functions and features of a end customer access or a wholesale access point, and tests about their ability to perform the (contracted) quality. They may be realised by directly configuring test loops on end customer ports and modems, but as well a wholesale customer can start dedicated test routines in his own network and/ or in the network of the access provider, where the results have to be given back to the initiator of such a test. Many tests can be done in a standardized and automatic manner, so an interface for launching automatic tests and returning the results should be established between wholesale customer and access provider. Because tests may influence the behaviour of the end customer port while they are performed, each wholesale customer may only trigger tests for its own end customers.

5.3.5.7 Performance Monitoring

Performance monitoring is the method of network providers to monitor if the network performs properly. It helps to indicate when and where the network is reaching performance thresholds, is performing underneath quality / performance standards or is even running out of capacity. So agreeing on performance and quality standards and their monitoring with the access provider and getting access to his performance monitoring tools would enable the wholesale customer to timely react on performance degradations. In the cases where the customer runs out of capacity because of its network traffic growth the access seeker can immediately induce an up selling. Furthermore the access seeker can verify if he gets the contracted performance and can react accordingly.

Performance monitoring can be realised by using tools sited in the routers of the network, which will use some of the router's processor capacity, or by external equipment being introduced onto the transmission lines. A major amount of performance monitoring may therefore impact the total network performance by reducing the router throughput. External separate equipment on the other side causes additional cost and therefore cannot be sited everywhere in the network for immediate measurements. So beside the principal possibility to get access to the performance monitoring tools the parties have to agree upon which types of monitoring can be performed in principal and where and when (e.g. permanently or case by case), and which can be conducted on separate order only and with some preparation time in advance. The results of the performance monitoring should be accessible to the wholesale customer immediately, e.g. by a web based gateway or a http session.

The performance monitored should comprise at least the performance parameters contracted for the end customer access lines and the access points to the wholesale service in total (e.g. sustainable bitrate, peak bitrate, minimum bitrate, delay, jitter, packet loss, …)

5.3.5.8 Bulk Migration

Bulk migration is a situation where the access seeker has to place a major amount of orders at the same time in order to provide new access products or realize changes in existing access lines for a larger amount of customers or at least for a larger amount of access lines. Theses orders typically can not be provided simultaneously. Bulk migration is a project that has to be agreed upon with the wholesale access provider, who typically should provide a minimum set of lines being processes per area and day and who has to allocate dedicated resources for that project. Bulk migration should also enable to bundle access lines into groups that are performed together so that customers with several access lines can be migrated in a dedicated time frame.

If only some configuration parameters of the customer access have to be changed the parties can also agree upon conducting that migration by executing some scripts, which directly change the customer configuration, without being processed through the complete order and provisioning processes.

Bulk migration on the order entry level can be communicated over the existing order entry gateway, which should be amended by the grouping function. Additionally provision should be made for future Wholesale bulk migration paths which may arise out of the development of new NGN based products. The communication of a bulk migration on the configuration change level have to be agreed upon on a bilateral manner. Sometimes the access providing operator can create the relevant scripts by himself, depending on what has to be migrated.

5.3.6 Service Level Agreements (SLAs)

Service Level Agreements are part of the contract between contractor and client establishing transparent quality levels for the assured service. Typical SLA elements include time schedules for line provisioning or fault repair, service availability and associated penalties. The issues are not necessarily NGN specific, and for comparable services they do not necessarily depend on the network platform they are produced on (e.g. for voice services). SLAs have been included here for two reasons:

- Firstly IPTV is expected to be a primary pillar of the NGN service portfolio. Experience has shown that (residential) customers react more sensitive to faults in their TV service than their voice or broadband service. Therefore a higher quality of fault repair and responsiveness is required in SLAs of the NGN or at least for the IPTV services or the respective wholesale products.

- Secondly, OAOs and specifically Irish OAOs are more dependent on *active* wholesale services (bitstream) from the incumbent rather than *passive* LLU. This means that SLAs gain importance as the dependency increases.

The typical SLA for the existing wholesale bitstream product in Ireland is shown in Table 5-6.

Table 5-6: Overview (highlights) of SLAs in the current Irish bitstream service

	Process / Conditions	Penalty
Bitstream Port Provisioning	Order handling process: OAO submits order (day 0), eircom accepts/rejects order (day 0) and allocates an Appointment Date which is at least 10 days after the first contact. Penalties only apply to delays related to the Appointment Date. There is no (standard) maximum time frame within which the Appointment Date has to be set.	Up to 5 days delay: 10% of connection fee per day After 5 days delay: 100% of connection fee per day
Bitstream Port service availability	99,5% availability, measured per previous four quarters as ([total number of hours in the Year] – [total number of hours out of service]) / [total number of hours in the year] A fault will only count once towards out of service hours.	50% of monthly line rental
Fault repair	There is no guaranteed time frame for fault repair. Acknowledgement of fault report is estimated to be 4 working hours.	
Penalty exemption	eircom will be exempt from penalty payment in the event it is successful in delivering 90% of bitstream ports to an individual access seeker within the SLA timescales. eircom performance will be assessed on a monthly basis to determine if the 90% threshold has been met. eircom will be exempt from penalty payment in the event it is successful in meeting service assurance SLA commitments in 95% of an access seeker's lines in a particular quarter	

Source: WIK-Consult analysis of reference offer.

Irish operators have specifically addressed SLA-related requirements in the interviews conducted. The key aspects reported were firstly the ability to apply different service classes (gold, silver, bronze) to different customers. For example this should include standard and express fault repair. In addition Irish OAOs requested to be able to prioritize important customers in the initial first-time provisioning process.

The feedback received reinforces the relevance of SLAs whose importance will rather rise than fall in an NGN environment due to potential higher degree of active, bitstream type of wholesale with multiple applications and differentiated QoS needs. Accordingly such SLAs have to be specified in multilateral negotiations (e.g. an industry group) and may include penalties if the appropriate QoS goals are not met.

5.4 Summary

The following table summarises the recommendations for an optimum bitstream product suite. However it must be kept in mind that the primary guideline still points to the equivalence of eircom's retail and wholesale offering. Accordingly, while the following represents a vision for an optimum framework of parameters, the actual bitstream may have less pronounced characteristics when applied to eircom's network architecture and service portfolio.

Furthermore it appears equally important to keep in mind that the actual implementation of QoS characteristics may differ in form of maximum and minimum values. However the critical output of this study is that QoS (and the further parameters) of the bitstream needs to be defined in a form similar to the following structure.

Table 5-7: Technical requirements of an optimum bitstream product

	Optimal NGN bitstream
Level of bitstream access	Access at as many levels as economically feasible is required: DSLAM/MSAN, aggregator, super aggregator, edge router, core router. This includes bitstream access at street cabinet level. Access obligations differ depending on geographic region. Stand-alone option is required.
Service classes	Multiple service classes are required (2-5). Service classes must have • defined QoS parameters for delay, jitter and packet loss • a bandwidth defined through peak bit rate, sustainable bit rate, minimum bit rate. Contention must be defined for the best effort class of service. QoS and bandwidth must be suitable for the respective class of service. An example has been drafted in Table 5-5. A concrete explanation of parameters and their measurement must be included. In addition multiple VCs/VLANs per end-user are required (10-20).
Access line parameters	20Mbps downstream / 5 Mbps upstream could be an initial benchmark for the upper end of bandwidth requirements (driven by video applications)
Functionalities for video distribution	Multicast functionality is required.[53] Should multicasting not be possible it needs to be evaluated whether bitstream access on levels close enough to the end-user in combination with (a separate) collocation option for video servers can be an alternative.
OSS functionalities	High degree of automation required for all relevant OSS aspects Monitoring of QoS and configurations possible at the level of individual end-users

Source: WIK Consult.

53 However multicast alone is not sufficient as the bandwidth on the access line must be adequate, too.

6 Evaluation of Irish operators' proposed retail and wholesale products (WP4)

The goal of this Work Package is a) to benchmark the current Irish retail broadband offers with emerging next generation retail offers from other countries and b) to compare the characteristics of current Irish wholesale offers with those of an optimum wholesale product as defined in Work Package 3 (chapter 5.3). This evaluation needs to take into account the limitations originating from the specific Irish framework that have been discussed in (chapter 5.2).

6.1 Evaluation and benchmarking of retail products on the Irish market

Table 6-1 depicts Irish broadband retail offerings of relevant Irish operators:

Table 6-1: Overview of retail broadband offers in Ireland (0ct. 2007)

	Eircom	**BT Ireland**	**Chorus / NTL (cable)**	**Digiweb (also FWA & satellite)**	**Irish Broadband (also FWA)**	**Magnet Networks (also FTTH/B)**	**Smart Telecom (also FTTH/B)**
Speed range	1M – 3M	1M – 3M	1M – 6M	1M– 6M	1M – 6M	1M – 8M	1M – 7M
Additional IP services	None	None	Cable based Digital Voice and TV	None	None	IPTV, VoIP	IPTV, VoIP

M – Mbps, FWA – Fixed Wireless Access
Source: WIK analysis of operator websites

The Irish retail offers compete on similar bandwidth levels (see Table 6-1). There are very few offers that go beyond basic Internet access and require QoS for IP-based applications such as VoIP or IPTV: Most voice offers are based on true narrowband voice through Wholesale Line Rental (WLR) and Carrier Pre-Selection CPS[54]. Smart Telecom and Magnet have started triple play services with VoIP and IPTV. Smart Telecom's "Smart Vision" is reportedly available in seven Dublin districts and counties, Magnet intends to deliver triple play over both unbundling (about 50 exchanges) and FTTH footprint (about 30,000 homes passed). The UPC-owned cable operators offer IP telephony over their cable networks but are stilling rolling out service to reach all their customers.

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54 In 2006 24% of fixed voice subscribers used an alternative provider for voice telephony services. The majority of carriers were CPS and WLR operators. See 12th implementation report of the EU Commission, Annex 1, p. 126.
"Wholesale Line Rental (WLR) allows alternative suppliers to rent access lines on wholesale terms from BT, and resell the lines to customers, providing a single bill that covers both line rental and telephone calls." Source: OFCOM (2004): Wholesale Line Rental: Reviewing and setting charge ceilings for WLR services, p. 2.

Regarding business customers eircom does not provide symmetric DSL. Therefore the range of (SME) business services is also built on ADSL which remains the sole broadband option for many companies outside the large urban centres. Digiweb and Irish Broadband build upon their own Fixed Wireless Access (FWA) infrastructure but only Irish broadband leverages its infrastructure to provide a symmetric bandwidth offer for professional users (2 or 3 Mbps).

So as a result the quality level offered by current broadband offers for both, consumers (the target of triple play services) and professional users, is low.

- Bandwidth is relatively low compared to other European broadband markets. Forfás found Ireland to rank 3rd within EU-15 price comparison for entry-level DSL in November 2006[55]; in a more recent study for ComReg Ireland ranked 5th (see Figure 6-1). However considering the Irish broadband options detailed above (mainly up to a few Mbps) Ireland is trailing behind regarding higher bandwidths and the cost per Mbps (see Figure 6-2).

- Only a few services with specific requirements for QoS such as VoIP or IPTV/VoD are commercialised. IPTV is clearly in its infancy in Ireland. Forfás also states this lack of quality of service which constitutes a barrier especially for the development of Irish small and medium enterprises.[56]

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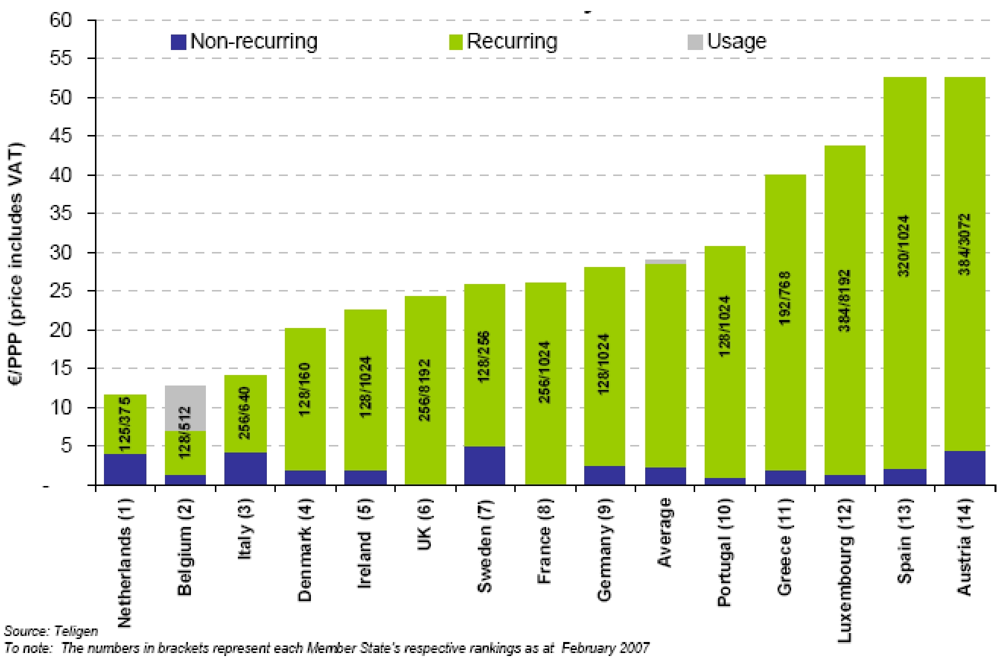
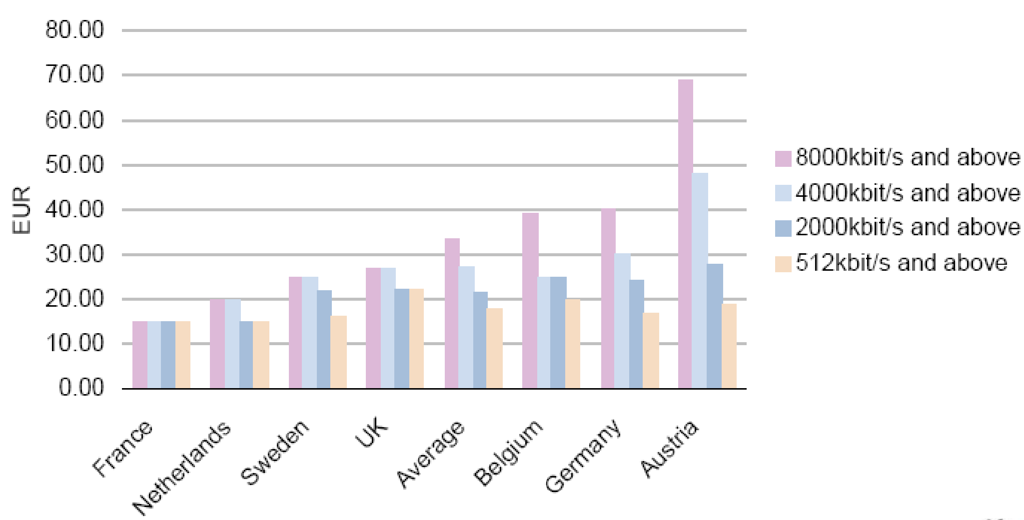
55 See Forfás (2006): Overview of Ireland's Broadband Performance, p. 21.
56 See Forfás (2006): Overview of Ireland's Broadband Performance, p. 26.

Figure 6-1: International benchmark: Lowest Monthly Rental ADSL Basket (May 2007)



Source: ComReg (2007): Quarterly Key Data Report - September 2007, p. 28.

Figure 6-2: International benchmark of lowest price offer in different downstream speed ranges (November 2006).



Source: Analysis (2007): A Comparative Study of Retail Prices for Broadband Internet Connections and Triple- Play Offers in Belgium and Six Other European Countries, page v.

6.2 Evaluation of Wholesale services in Ireland

Several operators are providing wholesale services in Ireland, however most alternative examples (eNet, ESB Telecom) do not include last mile access in a mass market context but rather focus on bandwidth/fibre on a metro or inter-city scale. BT Ireland is selling wholesale broadband services based on unbundled lines and bitstream bought from eircom but the primary focus appears to be related to voice, bandwidth, IP transit and hosting rather than last mile access.

Wholesale on alternative infrastructures (fixed wireless, cable, FTTH/B) does not seem to play a role in Ireland. Accordingly eircom remains the primary wholesale broadband provider with access to the end-user. According to the goal of this study a comparison between eircom's current bitstream service and an optimum bitstream product is conducted (unbundling will not be considered). This allows us to identify accomplishments and shortcomings against the vision of an ideal future bitstream.

The following table compares the features derived in Work Package 3 (chapter 5) with the features of eircom's current bitstream product.

Table 6-2: Comparison of optimal NGN bitstream with current eircom bitstream

Congruence		Optimal NGN bitstream	Current eircom bitstream products
Level of bitstream access	↓	Access at as many levels as economically feasible is required: DSLAM/MSAN, aggregator, super aggregator, edge router, core router. This includes bitstream access at street cabinet level. Access obligations differ depending on geographic region. Stand-alone option is required.	Access only at two levels (regional and an aggregated level through use of eircom's transport service *"Bitstream (Ethernet) Connection Service"*). No access at DSLAM possible.
Service classes	↓	Multiple service classes are required (2-5). Service classes must have • defined QoS parameters for latency, jitter and packet loss • a bandwidth defined through peak bit rate, sustainable bit rate, minimum bit rate. Contention must be defined for the best effort class of service. QoS and bandwidth must be suitable for the respective class of service (see suggestion in Table 5-5) A concrete explanation of parameters and their measurement must be included. In addition multiple VCs/VLANs per end-user are required (10-20).	No defined QoS parameters (latency, jitter, packet loss). ATM Bitstream • VBR class has two contention ratio choices (24:1 and 10:1) for each of the three different downstream / upstream combinations (4M/256k, 2M/256k, 1M/128k). • UBR class has fixed contention (24:1) for each of the five downstream / upstream combinations (4M/256k, 2M/256k, 1M/256k, 1M/128k, 512k/128k) IP Bitstream • UBR class with five bandwidth options with fixed contention: 24:1 for the three faster options 6M/512k, 4M/384k, 4M/384k; 48:1 for the two slower options (2M/256k, 1M/128k) Only one VC per end user.

Comparing the Irish bitstream offer with the Italian offer a difference in guaranteed throughput is noticeable. In Ireland the contention is defined at 10:1, 24:1 and 48:1. In Italy the percentage of Minimum Cell Rate in relation to Peak Cell Rate is defined. The best quality in Ireland is 10:1 which means *theoretically* the Minimum Cell Rate equals 10% of Peak Cell Rate. The other two options would equal 4% and 2 % respectively. In the Italian offer the lowest grade of MCR/PCR ratio starts at 10% and it extends to 90% (see chapter 4.2.2.2) However this theoretical calculation does not reflect the empirical availability of bandwidth which – because concurrent downstreaming at individual peak speed occurs very rarely – will usually reach a much higher percentage of the Peak Cell Rate. Therefore the calculations stated above only reflect the worst case.

Access line parameters	↓	20Mbps downstream / 5 Mbps upstream could be an initial benchmark for the upper end of bandwidth requirements (driven by video applications)	Maximum of 6Mbps rate adaptive (ADSL)
Functionalities for video distribution	↓	Multicast functionality is required. However multicast alone is not sufficient as the bandwidth on the access line must be adequate, too. Should multicasting not be possible it needs to be evaluated whether bitstream access on levels close enough to the end-user in combination with (a separate) collocation option for video servers can be an alternative.	none
OSS functionalities	→	Secure, controlled access by operators to the incumbent OSS in order to allow the wholesale operators to manage the offering and their customers experience in real; or near real time. High degree of automation required for all relevant OSS aspects Monitoring of QoS and configurations possible at the level of individual end-users	Unified gateway exists for automatic order entry, information system about access availability, information about major network faults. However pro-active alerting, prioritized provisioning etc. are not available.

Source: WIK-Consult analysis.

Clearly there are significant differences between the current Irish bitstream product offering and its ability to support the characteristics of an NGN bitstream. While eircom has started to provide information on the likely composition of an NGN bitstream product this is not sufficiently detailed to match them with the suggested ideal bitstream. On the other hand the retail offers of eircom (and its competitors basing on xDSL) also do not reflect an NGN service portfolio (see chapter 6.1). Therefore the lack of congruence does not in itself constitute lack of functional equivalence.

However a number of reasons imply that the regulatory framework should strive for changes towards the envisioned optimum product because:

- The demand for Quality of Service will rise in the NGN
- Bitstream services will be the primary wholesale product for a large part of Ireland

6.3 Summary

The retail offers for an IP-based broadband access do not differ very much from each other and do not guarantee QoS, but are best effort based. A wholesale bitstream offer exists which includes a rudimental QoS definition by describing a maximum over booking factor.

Future bitstream access products in a NGN environment will need different access speed sizes and service classes, which are detailed regarding traffic quality like throughput, delay, jitter and packet loss. Therefore the existing wholesale bitstream products have to evolve for meeting future needs, especially concerning guaranteed quality of service.

Annex Ia: The questionnaires

The questionnaire for Irish OAOs

A. Features of NGN Bitstream Access

1. What do you expect to get buying a wholesale bitstream access on a NGN environment?
2. What type and differentiation of QoS do you intend to offer on your retail level?
3. What type and differentiation of QoS will you need as wholesale service?
4. How many VC per end user port will you need?

5. How many distinct classes of service will you need on a wholesale product (for voice, IPTV, data/internet, video conferencing / online gaming, …)?

6. Which access speeds will you need?

7. Which tools do you believe to be a pre-requisite for a reliable QoS in a wholesale network?

8. Where do you need access to the wholesalers network?

   (a) hierarchy level,

   (b) location,

   (c) protocol level

9. Please specify your co-location and backhaul requirements (incl. type, protocol and speed)?

B. OSS

10. What kind of gateways / interfaces would you appreciate concerning the wholesalers OSS systems? Please classify (a: absolutely necessary; g: good to have; n: nice to have) and reason.

    (a) Order entry

    (b) Provisioning

    (c) Operational management and fault analysis (trouble ticket …)

    (d) Alerting (…)

    (e) Performance Monitoring (…)

    (f) Configuration Management / Changes (…)

    (g) …

C. BSS

11. Which type of interfaces do you need?

12. What specifications / differentiations according to your services do you need for your wholesale and customer access (…)

13. Do you require differentiation of billing data for each end customer access per volume, connection time, QoS criteria (which), …? Please specify.

The questionnaire for eircom

A. Network infrastructure

1. Network hierarchy, locations, and access

    (a) Where is network access foreseen in the network hierarchy?

    (b) At which locations is network access foreseen?

    (c) At which levels of network hierarchy and locations will co-location be facilitated?

    (d) Will backhaul capacity be provided? By what means and granularity? Please specify.

    (e) Will backhaul connectivity be as well provided as duct or dark fibre infrastructure?

    (f) Will co-location include access to power supply and UPS?

    (g) Will co-location include access/ use of air condition?

    (h) Will co-location allow for interconnection? In which locations? With Eircom and with other collocated competitors?

2. Equipment selected (supplier, types incl. release numbers)

    (a) DSLAM

    (b) MSAN

    (c) CPE (customer node)

    (d) Equipment at aggregation nodes up to Edge Router

    (e) Core Router

    (f) MGC

    (g) SBC

    Please specify the interface you intend to use for access/interconnection.

3. Quality of Service

   (a) What type and differentiation of QoS is intended for retail services?

   (b) How many VCs are intended per port (end user port)

   (c) …. for wholesale services? (differentiated according to Ethernet and IP interfaces)

4. Service implementation and service related QoS strategy (voice, IPTV, data, video conferencing/gaming)

   (a) How many distinct classes of services are intended to be offered?

   (b) Will there be an individual VC dedicated to VoIP?

   (c) At which level of network hierarchy will VoIP interconnection be offered? At which locations?

   (d) What access speed classes are intended to be offered?

   (e) Which tools/means are applied in order to achieve QoS? (MPLS, …?)

B. OSS

5. OSS interface / gateway

What kind/type of interface is offered?

How do they correspond to existing wholesale product requirements?

What extent of automation is foreseen? (file transfer or other)

6. Wholesale related OSS processes

   (a) Line testing

   (b) Ordering

   (c) Procurement, Provisioning

   (d) Fault analysis, operational management (alerting: trouble ticket systems or filtered trouble information?, tracing features and degree of automation)

(e) Performance monitoring (ability of OAO to monitor QoS up to the end customer)

(f) Configuration management (which service parameters are available for being controlled by OAO? – as long as not relevant for billing and which relevant for billing)

(g) In case of contract amendment: to what extent? For example upgrade of access speed

C. BSS

7. Which type of interface will you offer?

8. Will billing data be transferred by File Transfer?

9. Does billing allow differentiation of the usage of each end customer access per volume, connection time, QoS criteria (which), ….? Please complete.

Annex Ib: IEEE 802.1 Q and Quality of Service

IEEE 802.1 Q is the standard which describes Ethernet VLANs and the necessary changes in the Ethernet header to recognize VLANs and treat the packets in the appropriate manner. The Ethernet frame is not encapsulated to include the additional information, but the header is enlarged by a 4 Byte VLAN tag. This tag includes a 12 bit field to identify 4096 different VLANs and a 3 bit field to describe 8 possible levels of priority for the frames. To enlarge the amount of VLANs double tagging or even triple tagging is possible.

IEEE 802.1 Q-2005 distinguishes between 8 traffic classes, which are allocated to the 8 possible priorities:

Priority	Acronym	Description
1	BK	**Background** – bulk transfers and other activities that are permitted on the network but that should not impact the use of the network by other users and applications
0 (Default)	BE	**Best Effort** – for default use by non-prioritized applications with fairness only regulated by the effects of TCP's dynamic windowing and retransmission strategy
2	EE	**Excellent Effort** – or "CEO's Best Effort", the best-effort type service that an information services organization would deliver to its most important customers
3	CA	**Critical Applications** – characterized by having a guaranteed minimum bandwidth as their primary QoS requirement and subject of some admission control to ensure that one system or application does not consume bandwidth at the expense of others. The admission control mechanism can range from pre-planning of the network requirement at one extreme to bandwidth reservation per flow at the time the flow is started at the other.
4	VI	**Video**, < 100 ms delay – or other applications with low latency as the primary

		QoS requirement
5	VO	**Voice**, < 10 ms delay and maximum jitter – (one way transmission through the LAN infrastructure on a campus)
6	IC	**Internetwork Control** – in large networks of several domains to distinguish the traffic for network control from the traffic of the immediate domain
7	NC	**Network Control** – characterized by a guaranteed delivery requirement to support configuration and maintenance of the network infrastructure

If the network systems do not provide 8 different queues to propagate the Ethernet frames according to their priority the traffic shall be allocated to the queues in the following way:

<table>
<tr><th>No. of Queues</th><th colspan="8">Defining Traffic Type</th></tr>
<tr><td>1</td><td colspan="8">BE</td></tr>
<tr><td>2</td><td colspan="4">VO</td><td colspan="4">BE</td></tr>
<tr><td>3</td><td colspan="2">NC</td><td colspan="2">VO</td><td colspan="4">BE</td></tr>
<tr><td>4</td><td colspan="2">NC</td><td colspan="2">VO</td><td colspan="2">CA</td><td colspan="2">BE</td></tr>
<tr><td>5</td><td>NC</td><td>IC</td><td colspan="2">VO</td><td colspan="2">CA</td><td colspan="2">BE</td></tr>
<tr><td>6</td><td>NC</td><td>IC</td><td colspan="2">VO</td><td colspan="2">CA</td><td>BE</td><td>BK</td></tr>
<tr><td>7</td><td>NC</td><td>IC</td><td colspan="2">VO</td><td>CA</td><td>EE</td><td>BE</td><td>BK</td></tr>
<tr><td>8</td><td>NC</td><td>IC</td><td>VO</td><td>VI</td><td>CA</td><td>EE</td><td>BE</td><td>BK</td></tr>
</table>

The table can be read that way that only if the transmission systems (Ethernet switches) support 8 queues minimum the voice and video traffic is transmitted through the same queue, thus with the same QoS.

The standard differs between 10 QoS aspects:

1. service availability
2. frame loss
3. frame misordering
4. frame duplication
5. transit delay
6. frame life time
7. undetected
8. maximum service data unit
9. priority
10. throughput

Prioritization is the tool to directly control transit delay and jitter as well as throughput, as long as the overall capacity of the link allows to transmit the traffic at all.

Defining more than 6 user oriented traffic classes or priorities for an Ethernet based infrastructure does not make sense because the underlying standards do not support that. But of course there may exist equipment, which supports more than the standards describe, or do it in a different, proprietary manner.

The standard does not define exact values for the different quality aspects, unless the delay values for voice and video. Considering these values one has to keep in mind that Ethernet networks normally are campus based and only part of a total communication link if the partner is sited outside the campus. In a WAN environment with wholesale bitstream access on an Ethernet WAN network the Ethernet of the wholesaler is as well a part of the total communication link and therefore only may consume a part of the totally needed quality (e.g. delay, jitter, packet loss, …).

The standard is just defining tools with which a network designer can establish QoS in his network for a given traffic load and distribution. Thus the effective QoS for an end user cannot be defined by the standard parameters itself, but by the traffic behaviour the customer (or the applications) needs to get.