ERG (04) 19 rev1

Wholesale Broadband Access via Cable

Paper as approved by the ERG12-Plenary on 11 Febr. 2005 for public consultation

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1 Introduction

1.1 Background

This paper examines the technical aspects of providing wholesale broadband access via cable in the light of the new European electronic communications networks and services (ECNS) regulatory framework.

It deals with whether and in what ways it is possible to implement cable bitstream equivalent access only in a case a cable operator is found to have significant market power (SMP) and consequently was designated as a SMP operator as the result of a market analysis and the imposition of an access obligation according to Art. 12 Access Directive is considered to be justified and proportionate.

In 2003, the European Commission published its *Recommendation on markets within the electronic communications sector* that were susceptible to *ex-ante* regulation. In relation to the market for 'wholesale broadband access' identified in the Recommendation as Market 12, it is stated that:

"This market covers 'bit-stream' access that permits the transmission of broadband data in both directions and other wholesale access provided over other infrastructures, if and when they offer facilities equivalent to bit-stream access."

The explanatory memorandum (p. 25) to the Recommendation adds that:

"*The question is whether the alternative infrastructures which compete are sufficiently widespread to justify the inclusion of this market in this Recommendation, that is whether cable, fibre optic, satellite and wireless networks which provide wholesale broadband access are sufficiently widely deployed or developed in the Community. While these networks are well deployed in some member states in most they are not. If alternative infrastructures continue to be developed and upgraded and competition increases, this market could become effectively competitive but for the moment alternative infrastructures are not available and so this market must be included in the initial recommendation. While wholesale broadband access on alternative infrastructures to the PSTN are in principle covered by the definition of wholesale broadband access, the extent to which such alternatives are part of the market that is analysed in detail by the NRA will be limited by, amongst others, supply substitution considerations."*

Cable operators in a number of European countries have successfully deployed broadband data services to millions of subscribers. Data over cable is primarily used for broadband Internet services. In some countries broadband connections via cable modem are comparable to or even higher than the number of digital subscriber line (DSL) connections. This being the case, the conclusion drawn in the explanatory memorandum may not hold in all cases. Achieving infrastructure-based competition is a desirable goal but the existence of several infrastructures alone will not automatically result in infrastructure competition.

All existing broadband-capable infrastructures as well as their impact on the broadband market should be assessed. Therefore an exercise ought to be carried out, being mindful of the principle of technology neutrality, to analyse whether broadband access over cable is indeed equivalent to that provided by DSL and if so, what regulatory measures could, or should be applied. NRAs are empowered to mandate access and impose obligations in accordance with the Access Directive, in cases where, as a result of market analysis, an operator is found to have significant market power in the market for wholesale broadband access. The question to be answered is: does cable offer facilities equivalent to DSL? This analysis would also include a green field approach, i.e. looking at all infrastructures in the absence of regulation. While at present this discussion is focussed on cable as the predominant alternative to DSL, eventually this reasoning will similarly apply to fixed wireless access (FWA), fibre, 3G, WiFi, WiMax or other broadband technologies that could become widespread and the possibility that wholesale broadband access could be provided over other infrastructures needs to be looked at.

The paper takes into account the ERG Common Position on [DSL-]BSA (ERG(03)33rev1) as adopted by the ERG Plenary on 2nd April and published on 23rd April 2004. It is envisaged to combine the 2 documents and consult on the expansion.

In common with the ERG Common Position on the approach to appropriate remedies in the new regulatory framework (NRF), the following analysis focuses primarily on the 3rd stage of the process set out in the NRF with respect to regulatory obligations linked to significant market power (SMP). It does not assume a certain market definition nor does it in any way predetermine an outcome of a the market definition or SMP assessment exercise. It does not preclude or replace the market review to be run by the individual NRA taking adequate account of national circumstances[1].

If, following the appropriate analysis, an NRA concludes that functional equivalency between data over cable and DSL does indeed exist, then the next step would be to compare bitstream access as defined for DSL and to analyze the applicability of the definition to cable networks in order to assess the (technical) possibilities to provide bitstream access via cable networks.

1.2 Data over Cable Overview

In the mid-90s, development began on cable modems. These made the most of the high bandwidth capacity inherent in cable hybrid-fibre coaxial networks to allow the two-way transmission of high-speed data. Since that point in time, many cable TV operators have been upgrading their networks to permit bi-directional communications in order to become

[1] E.g. the existence of other important broadband infrastructures.

multiple service operators (MSOs) and provide “triple-play” services – video, voice and data.

Initially, while cable modem technology matured, each vendor provided proprietary systems that would not interoperate with those from another. However, the cable operators did not appreciate being in a situation where they could potentially be held hostage by a single supplier and market pressures resulted in a standards group – under the auspices of CableLabs[2] – being set up to devise and manage the development of a data-over-cable standard. This led to the Data Over Cable Service Interface Specification (DOCSIS).

DOCSIS was rapidly adopted as the industry standard, with all the major vendors producing equipment that was supplied to CableLabs for qualification and certification. Due to the importance of the European cable TV market, which used slightly different technical parameters from North America, a European flavour of DOCSIS was developed – EuroDOCSIS. Advances in technology meant that to date, three versions of the DOCSIS standard have been released – DOCSIS 1.0, 1.1 and 2.0 – each with the EuroDOCSIS equivalent. In theory any certified DOCSIS/EuroDOCSIS cable modem can interoperate with a qualified cable modem termination system (CMTS).

1.3 What is “Open Access”?

“Open Access” is a term used to describe the situation where a cable operator provides data services to multiple Internet Service Providers (ISPs). There are some localities in the United States where Open Access is available, there are various trials underway in a number of countries and in Canada and Israel, the system is in widespread use.

1.4 Regulatory Background

1.4.1 Regulatory Developments in North America

In early 1999 the OpenNET coalition, an Internet service provider (ISP) lobbying group, began a crusade to open U.S. data over cable networks to multiple ISPs. The cable industry quickly termed this "forced access" and claimed it was impossible to implement. However OpenNET's message began to resonate with consumers and regulators and the cable operators and their proprietary ISP partners began to prepare opposing arguments.

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[2] http://www.cablelabs.org/

The city of Portland, Oregon made the first move in May 1999 when a federal court validated the municipality's multi-ISP cable regulations, although the decision was later overturned on an appeal. Canadian regulators acted next in October 1999, when the Canadian Radio and Television Commission (CRTC)[3] issued Telecom Decision CRTC 99-8 that ordered the country's four largest MSOs -- Rogers Cable, Videotron Communications, Shaw Communications, and Cogeco Cable Canada -- to file firm tariffs to provide competitive ISPs with wholesale access to their cable facilities. Since then, much effort has been put into the development of a regulatory framework to support interconnection for data over cable.

In the United States, the FCC classified cable modem services as an “information” [4] rather than a “telecommunications” service in terms of the Telecommunications Act of 1996. This decision in 2002 to classify cable Internet companies as information services meant they were not subject to the stricter rules governing telecommunications services. This did not go down well with the phone companies that offered Internet services since they felt that they were subject to discriminatory treatment since they were obliged to provide third-party access.

As recently as October 2003 a ruling by a three-judge panel of the U.S. Ninth Circuit Court of Appeals suggests that cable-based ISPs should be subject to the same strict rules governing phone-based Internet service providers, which are generally required to open their lines up to competing services. The appeals court ruling centres on how to interpret the Telecommunications Act of 1996, specifically whether cable-based Internet services ought to be classified as telecommunications services, information services, or a combination of the two.

In March 2004, the U.S. Ninth Circuit Court of Appeals declined to review a lower court's ruling that had overturned the FCC's classification of cable modem service as an "information service." The case originally arose regarding whether local municipalities could require cable operators to open their networks to other ISPs.

The appeals court noted that "to the extent that (a cable operator) provides its subscribers Internet transmission over its cable broadband facility, it is providing a telecommunications service as defined in the Communications Act."

1.4.2 Regulatory Treatment for Cable in Europe

In Europe, not much regulatory attention was given to cable initially, with emphasis being placed mainly on fixed line telephony incumbents. Regulatory treatment was mainly reserved for the audiovisual aspect of cable.

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[3] http://www.crtc.gc.ca/cisc/eng/cisf3g8g.htm

[4] http://ftp.fcc.gov/Bureaus/Cable/News_Releases/2002/nrcb0201.html

With the advent of the new regulatory framework for electronic communications in July 2003 that covered all electronic communications networks (including cable) and services, in which the principle of technology neutrality was enshrined, a number of relevant markets have been identified including one for wholesale broadband access.

1.5 Description of the Relevant Market

The Relevant Market (Market 12) in question is defined as follows[5]

Wholesale Broadband Access

This market covers "bitstream" access that permits the transmission of broadband data in both directions and other wholesale access provided over other infrastructures, if and when they offer facilities equivalent to bitstream access.

Bitstream access is defined as *"the situation where the incumbent installs a high speed access link to the customer premises and then makes this access link available to third parties, to enable them to provide high speed services to customers. The incumbent may also provide transmission services to its competitors, to carry traffic to a "higher" level in the network hierarchy where new entrants may already have a point of presence. The bitstream service may be defined as the provision of transport capacity between an end-user connected to a telephone connection and the point of interconnection available to the new entrant".*[6]

Bitstream access grants the beneficiary (OLO, ISP) the ability to effect changes to the technical parameters with which the service is provided to the end customer.

This definition in the Recommendation can apply equally well to cable networks **if** it can be illustrated that the data service provided by a cable operator is functionally equivalent to that provided by a fixed line telephony operator.

When performing the market analysis in order to define markets, NRAs therefore also should analyse to what extent alternatives form part of the market in question. In a number of European countries that have extensive cable networks, analysis should consider whether broadband access via cable networks competes on the retail and/or wholesale level[7] with broadband access via PSTN (xDSL) taking into account both supply side as well as demand side substitutability considerations.[8]

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[5] Official Journal of the European Union, L 114/48, 8.5.2003
[6] ONPCOM01-18Rev1
[7] And accordingly may or may not be included in the market.
[8] In case the analysis leads to the conclusion that broadband access via cable is not in the same market as broadband access via the PSTN, a new market may have to be identified applying the 3-criteria-test described in the Recommendation on relevant markets (2003/311/EC) and notified according to the Art. 7 FWD procedure.

1.6 Common Position on Bitstream Access

The European Regulators' Group (ERG) has reached a common position on [DSL]bitstream access. This position was outlined recently in a document derived from a consultation paper published by the ERG[9] in July 2003. The document did not seek to cover other forms of wholesale broadband access such as unbundled and shared access. Neither did it deal with the issue of bitstream access for other broadband technologies. It outlines the regulators' understanding of bitstream access and the regulatory approach. NRAs should take into the utmost account its conclusions when taking decisions, but nonetheless the ultimate responsibility remains with the individual NRA.

The ERG Common Position identified certain key elements defining bitstream access, which are the following[10]:

- a high speed access link to the customer premises (end user part);
- transmission capacity for broadband data in both direction enabling new entrants to offer their own, value-added services to end users;
- new entrants have the possibility to differentiate their services by altering (directly or indirectly) technical characteristics and/or the use of their own network;
- bitstream access is a wholesale product consisting of the access link and "backhaul" services of the (data) backbone network (ATM, IP backbone).

Based on the above, it appears quite possible, that a data over cable network will be able to provide each and every one of the key elements of bitstream access functionality. Most of the content of the ERG Bitstream Access document will remain valid for cable networks. However, since the networks were initially deployed for different purposes, significant technical differences between DSL and cable exist, restraining a "straight swap" between the treatment of the two technologies. However, it follows from the principle of technological neutrality that the regulatory aspects should apply consistently.

[9] http://erg.eu.int/documents/index_en.htm#ergdocuments
[10] Cf. p. 3 of ERG (03) 33rev1

2 Technical Considerations

2.1 Typical Data-over-Cable System

The diagram below illustrates the typical layout for a data-over-cable network. The various elements are also described.

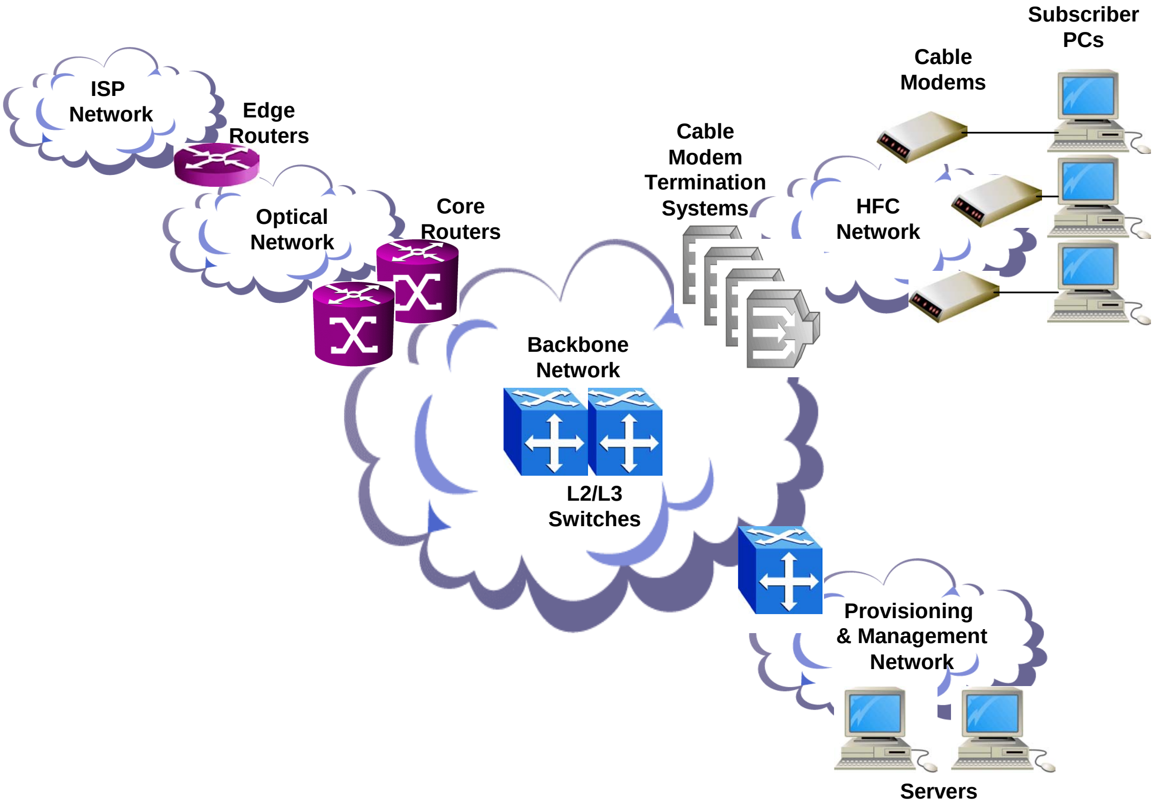


Figure 1: Typical Data over Cable Network Architecture

HFC Network: this provides access to the homes passed by the cable operator. For television purposes the hybrid fiber-coax network only needs to be able to deliver signals in one “downstream” direction – from the cable operator “headend” to the home. Typically the HFC network has a bandwidth of several hundred MHz. Older systems have about 550MHz of bandwidth available while new systems operate provide about 860 MHz. Since each analogue TV channel requires (in Europe) 8MHz, a cable system can accommodate around 50 to 100 channels. If the system can handle digital signals, due to their more efficient nature, several digital channels can be “squeezed” into a single analogue channel by using an appropriate modulation and compression scheme. This means that several hundred digital channels can then be transmitted over the network.

For data however, the communications need to be bi-directional. By adding certain elements to the HFC network, the system can be converted to “two-way” operation where signals can also now be sent from homes to the headend. The frequency range available for this is usually between 30 and 60 MHz. This is referred to as the “upstream” channel for communications.

The HFC network is normally divided into “nodes” each served by a device that acts as the optical-electrical interface between fiber and coaxial copper. Anything between a few hundred to several thousand homes may be connected to each node.

Cable Modems: are devices that allow high-speed access to data services such the Internet via a cable television network. While similar in some respects to a traditional analog modem, a cable modem is significantly more powerful, capable of delivering data approximately 500 times faster. A typical modem would have an RF interface to connect to the cable network and an Ethernet or USB interface to link with a PC or other LAN device.

In a cable network, data from the network to the user is referred to as *downstream*, whereas data from the user to the network is referred to as *upstream*. From a user perspective, a cable modem is a 64/256 QAM RF receiver capable of coping with up to 10 Mbps of data in one 6[11] or 8-MHz cable channel. Data from a user to the network is sent in a flexible and programmable system under control of the CMTS. The data is modulated using a QPSK or QAM transmitter with data rates from 64 kbps up to 10 Mbps. The upstream and downstream data rates may be flexibly configured to match subscriber needs. For instance, a business service can be programmed to receive as well as transmit higher bandwidth. A residential user, however, may be configured to receive higher bandwidth access to the Internet while limited to low bandwidth transmission to the network.

When a typical cable modem is switched on it goes through a multi-step process of frequency scanning, RF operating parameter determination, protocol negotiation, receiving a configuration file (say through trivial FTP) that determines service parameters (downstream/upstream speeds, QoS, filters, number of clients etc) from a provisioning server as well as obtaining an IP address via DHCP (Dynamic Host Configuration Protocol).

Cable Modem Termination System: is the access or concentration device. In effect it has two sets of interfaces - one on the HFC side that can communicate using the same protocols as the cable modems in the homes and another on the network side that provides connectivity into say an Ethernet or ATM network. CMTSes can be either Layer 2 (switch, bridge) or Layer 3 (router) devices. Each RF interface can, using the DOCSIS protocol, deliver up to 50Mbps in the downstream direction (using 256 QAM) and 10 Mbps

[11] North American systems use 6 Mhz while those deployed in Europe tend to operate at 8 MHz.

in the upstream direction (using 16 QAM). Users connected to this interface would clearly have to “share” this bandwidth.

Backbone Network: is typically located at the cable operator’s “headend”. It may also span and interconnect multiple sites if the operator’s network is large. The backbone network includes an aggregation point for the cable modem termination systems using typically Ethernet switches, a multitude of service provisioning, network management, billing and customer relationship management and various application servers required as well as core routers that connect to other operator sites, ISP networks, corporate wide-area networks or to upstream Internet backbones.

3 Technical Solutions

When considering the technical aspects of cable “bitstream”, two main issues need to be focussed upon

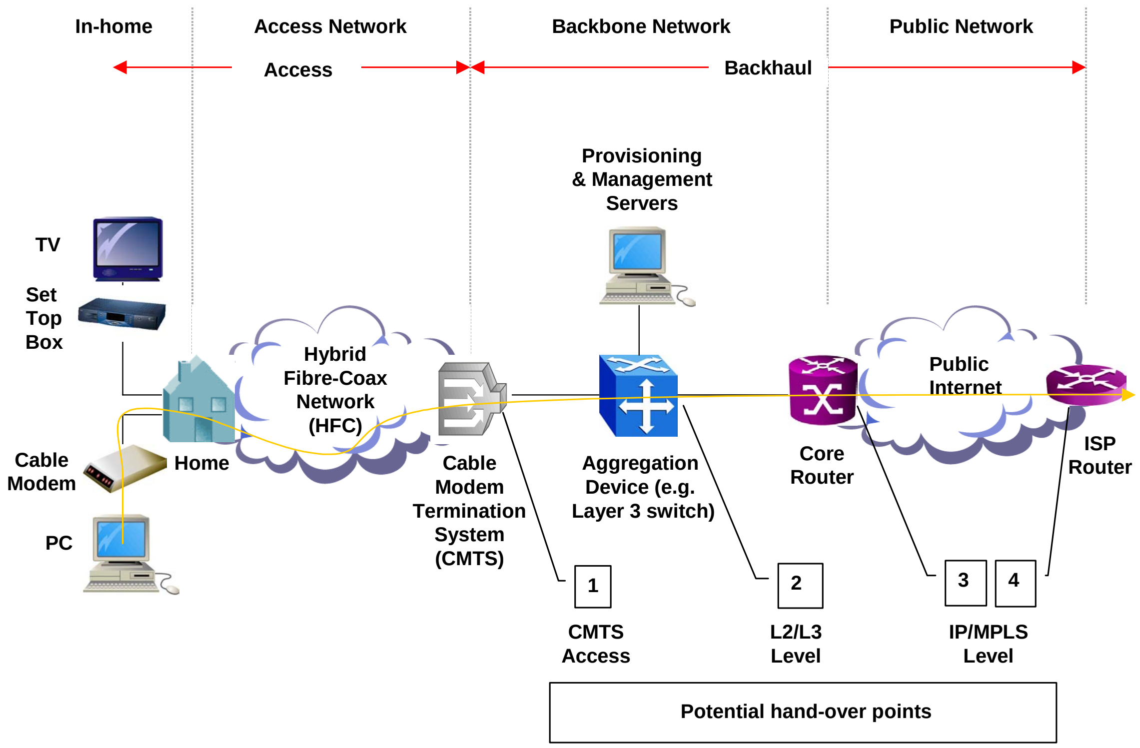
- the point of interconnection of third parties with the cable operator’s infrastructure;
- the technical solutions that allow correct “matching” between a subscriber and the appropriate service provider.

3.1 Possible Points of Interconnection

The diagram below illustrates a typical end-to-end network architecture for Internet access via a data over cable system. The arrow illustrates how traffic traverses the network from the user to the upstream ISP. As can be seen there are a number of potential points of interconnect. These will now be described and an assessment of their suitability made.

3.1.1 CMTS Access

This can actually be accomplished in either one of two ways. An alternate operator may decide to actually co-locate CMTS equipment at the cable operator’s headend and interface on the RF side to the HFC network. This is technically possible. However, CMTSes for each operator would need to use distinct frequencies in both the upstream and downstream portions of the spectrum of the HFC network. While this may be simple to achieve in the downstream, upstream spectrum is very limited, so potentially this could only work in a limited fashion with a small number of third parties.



Another problem derives from the way the DOCSIS protocol operates. A cable modem that is newly connected to a network will start scanning downstream frequencies and ranging to establish communications with a CMTS. This means that an attempt will be made to communicate with the first CMTS that responds. Some further work will be required to devise a system whereby the cable modem, if "belonging" to another operator's CMTS, will be given instructions to use that frequency pertaining to the other operator. For example cable modems may be "pre-configured" to search for a certain downstream frequency. Another way of potentially interconnecting at the CMTS is to handover at the network side, although no simple way of achieving this can be thought of presently.

Of course this type of solution almost echoes a "shared access" or "local loop unbundling" scenario. The alternate operator would either have to co-locate all other network devices required to provide service or would have to backhaul all traffic to their own network over leased lines or an optical backbone. This allows the new entrants the greatest degree of freedom in selection of network equipment, system parameters and service differentiation.

3.1.2 Interconnection at the aggregation point

This would assume that the alternate operator or ISP would use the "incumbent" cable operator's access network but install via co-location equipment within the backbone network that would handle all customer traffic destine to, or originating, from that particular ISP's network. Use can be made of either the Layer 2 or Layer 3 solutions described previously for traffic segregation past the CMTSes. This traffic segregation allows the new entrant to design its own service offerings. Once more, backhaul can be effected to the new entrant's own network at this stage. Alternatively OAM&P (Operations, Administration, Maintenance and Provisioning) servers can be installed within the incumbent's own network and managed remotely. This solution also gives the new entrant a significant amount of ability to differentiate its offerings from the incumbent.

3.1.3 Handing over at the service provider edge

This would imply using the incumbent cable operator's access and backbone's networks and management and provisioning servers. Due to the tunnelling facility described previously, a service level agreement can be contracted between the new entrant and the incumbent to ensure that the new entrant's service is guaranteed. Minimal service differentiation would be possible at this point apart from the type of upstream Internet connection that the new entrant decides to implement and any particular value-added services that can be implemented within their own networks.

3.1.4 Resale

Effectively here the new entrant is purchasing a wholesale broadband access product that includes ISP-services from the incumbent and can only "badge" it differently. This would not allow a new entrant to change any service parameters and can thus not be classified as "bitstream" access.

3.2 Solutions for Identifying Subscriber Traffic

3.2.1 Layer 2 Solutions

Layer 2 solutions mirror those typically used by PSTN operators for digital subscriber line (DSL) services. This type of architecture can also be used to support subscriber self-provisioning, open access for ISPs, and security within a data over cable deployment. There are three possible options – PPPoE (point to point protocol over Ethernet), L2TP (Layer 2 Tunnelling Protocol) and DHCP (Dynamic Host Configuration Protocol). The first two rely on the installation of a PPPoE/L2TP client or the use of operating system clients on the subscriber's PC within the PC operating system while the other method relies on a 'trusted' DHCP server providing addresses for all served ISPs.

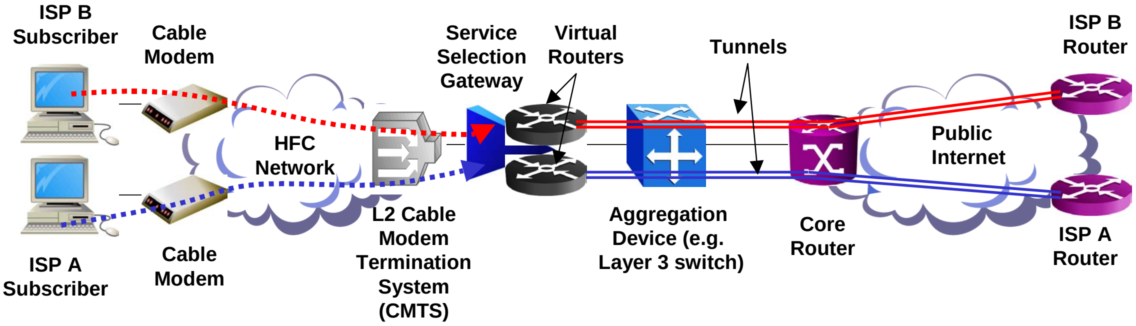


Figure 2: Multi-ISP Traffic Segregation in Layer 2 Access Environment

A key device here is a "Service Selection Gateway" (SSG) or "Broadband Services Node" (BSN) that allows identification of a client and the application of a set of service parameters to that particular user. This device would typically be located behind the CMTSes in the operator's backbone network. Upon a subscriber "logging on" i.e. launching the PPPoE client software, this would establish the protocol with the SSG/BSN. This could then provide the appropriate IP addressing, service policies and security tailored to that particular user's service contract. PPPoE allows a Layer 2 "Service Selection Gateway" or "Broadband Services Node" owner to map the subscribers to local ISP contexts (virtual routers) as well as into L2TP tunnels, while the DHCP architecture supports contexts. In this way, access to multiple ISPs can be provided since a "tunnel" exists between the subscriber and the ISP of choice.

Although PPPoE and LT2P are field-proven solutions, cable operators see three major drawbacks. First, client software is typically required on the end-user's PC, forcing them to log in for each online session, and thus, eliminating the "always on" benefit of cable modem connections. Additionally, service providers must provide technical support for the software, a costly proposition. Second, the use of tunnels adds overhead to packets, eating up valuable network capacity. Finally, the network provider cannot see the traffic contained in PPPoE or L2TP tunnels, preventing them from offering application-specific enhancements, such as guaranteeing bandwidth or latency for IP telephony or video services. Furthermore, these protocols typically cannot traverse a Layer 3 device and hence if the CMTS is router-based, these methods cannot be used. On the other hand, if older, proprietary cable modem termination systems are used that are based on bridge or ATM technology, these solutions could provide a mechanism for allowing secure third-party access to a cable infrastructure.

3.2.2 Layer 3 Solutions

Layer 3 solutions are more promising and in general have superseded Layer 2 offerings. These solutions encompass policy-based routing (PBR), multi-protocol label switching (MPLS) and IP-VPNs. All major router and CMTS vendors offer Layer 3 solutions for the implementation of open access. As the name implies, PBR involves implementing policies and rules in IP routers or switches to manage network traffic and services. By using these kinds of policies, a network operator can sell various levels of service to different ISPs and their subscribers. Technically, policies that require specific QoS treatment are implemented through DOCSIS 1.1 (which, unlike DOCSIS 1.0, supports QoS) controls on the cable modem access network, and then on the core network with standard IP techniques like multi-protocol label switching (MPLS) and Diff-Serv, or ATM virtual circuits (VCs). The latest version of DOCSIS – 2.0 – further enhances QoS and security aspects.

Again the principle here is customer identification, the packaging of traffic to and from that subscriber within some form of “tunnel” e.g. a label switched path, the application of service parameters according to a service contract and the delivery of that to and from the selected ISP.

One of the main challenges associated with layer 3 solutions is scalability. It must be ensured that the network can handle the additional routing and switching load caused by the incremental processing that needs to be carried out. High-performance routers are required on the network since applying complex policies consumes far more processing power and memory than traditional destination-only routing. However, the solution can scale. For example a single gateway router can be used on the metro-sized network to manage service flows via PBR and interconnect with ISPs. However, to handle tens thousands of cable modem subscribers without service degradation, PBR functionality must eventually be distributed to the network edge, preferably in an integrated DOCSIS CMTS and IP switch/router environment.

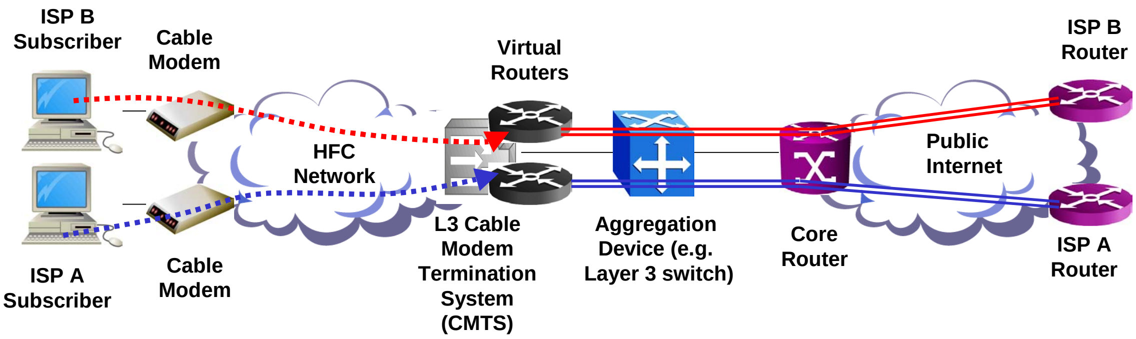


Figure 3: Use of Layer 3 Solution to separate multi-ISP traffic

This arrangement has several advantages including the fact that MPLS can be used to provide QoS and Traffic Engineering (TE). IP address renumbering is not necessary. Independent routing of traffic is maintained again through the use of “virtual routers”. Another advantage of these types of solution is that the interconnecting ISPs do not have to make significant changes or upgrades to their networks and do not need to take any extra steps in provisioning their clients.

4 Conclusions

This paper illustrates that various technical solutions DO exist for cable operators to provide “bitstream” type services to third parties. This can be demonstrated and confirmed both by the fact that all major cable data equipment vendors provide comprehensive solutions for accomplishing this but also by the fact that “open access” is a commercial reality in a number of countries (e.g. in Europe NTL in the UK, outside “open access” can be found above all in Canada, Israel, and some operators in the US). It is fair to note that the inherent structure and architecture of a cable network may render these solutions more complex than in the case of DSL though as technology develops these complexities may diminish.

From the expenditure point of view, again, regulatory remedies do come at a price. The implementation of one of the technical solutions described earlier would require an additional investment but of course, the cable operator as well as any PSTN operator would be able to reflect these costs in any cost-oriented wholesale offer. As in the case of PSTN operators found to have SMP, NRAs would need to carefully consider the proportionality of requiring a cable operator to provide wholesale broadband access when SMP is found.

Overall, it follows from the principle of technological neutrality that PSTN and cable network operators must be treated in the same way if found dominant, i.e. an obligation to provide BSA may be imposed equally on both types of operators if such an obligation is considered proportionate and justified in the light of the Art. 8 FWD objectives.

In the context of the Common Position reached by the European Regulators’ Group on Bitstream Access, the situation regarding cable will also have to be taken into consideration where this is appropriate.

5 Glossary & Abbreviations

ADSL - (Asymmetric digital subscriber line) allows broadband data services to be carried on conventional copper pair telephone cables, with a higher data rate on the downstream link

ATM - Asynchronous Transfer Mode. Network technology based on transferring data in cells or packets of a fixed size. The small, constant cell size allows ATM equipment to transmit video, audio, and computer data over the same network, and assure that no single type of data hogs the line. ATM creates a fixed channel, or route, between two points whenever data transfer begins.

Bandwidth - Bandwidth is the difference between the highest and lowest frequencies available for network signals. It is also used to describe the amount of data that can be transmitted in a fixed amount of time.

CMTS - Cable Modem Termination System, a system of devices located in the Cable Head-end that allows cable television operators to offer high-speed Internet access to home computers. The CMTS sends and receives digital cable modem signals on a cable network, receiving signals sent upstream from a user's cable modem, converting the signals into IP packets and routing the signals to an Internet Service Provide for connection to the Internet. The CMTS also can send signals Downstream to the user's cable modem. Cable modems cannot communicate directly with each other; they must communicate by channelling their signals through the CMTS.

DHCP - Dynamic Host Configuration Protocol is a TCP/IP protocol that enables a personal computer or workstation to get temporary or permanent IP addresses from a pool on a centrally-administered server.

DOCSIS - Developed by CableLabs, Data Over Cable Service Interface Specification defines interface standards for Cable Modems and supporting equipment.

HFC - Short for Hybrid Fiber Coax, a way of delivering video, voice telephony ,Data and other interactive services over Coaxial and Fiber optic cables.

IP - Internet Protocol. The Internet Protocol provides a connectionless service between networks. The protocol provides features for addressing, type-of-service specification, fragmentation, reassembly, and security.

L2 - Layer 2. This is also referred to as the OSI (Open Systems Interconnection) Data Link Layer. It provides the means for synchronizing the bit stream flowing to and from the physical layer and for the detection of errors due to transmission problems.

Latency - In networking, the amount of time it takes a packet to travel from source to destination.

MPLS - Multi Protocol Label Switching. MPLS has been developed to speed up the transmission of IP (Internet Protocol) based communications over ATM (Asynchronous Transfer Mode) or optical networks. The system works by adding a much smaller “label” to a stream of IP datagrams allowing “MPLS” enabled ATM or optical switches to examine and switch the packet much faster.

PPPoE - Point-to-Point Protocol over Ethernet. PPPoE is a specification for connecting the users on an Ethernet to the Internet through a common broadband medium, such as a single DSL line, wireless device or cable modem.

QAM - Quadrature Amplitude Modulation. Modulation technique using two amplitude modulated RF (Radio Frequency) carriers that are out of phase by 90 degrees. Information transfer is achieved using a mixture of phase and amplitude changes.

QPSK - Quadrature Phase Shift Keying. Phase shift keying in which four different phase angles are used.

QoS - Quality of Service. The performance of a communications channel or system is usually expressed in terms of QoS (Quality of Service).

Router - A router is a device that determines the next network point to which a packet should be forwarded towards its destination. The router is connected to at least two networks and decides which way to send each information packet based on its current understanding of the state of the networks it is connected to.

VPN - Virtual Private Network This is a private network link, which is carried on a public network through the use of tunnelling. It is likely that the communication will utilize encryption techniques.