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Third-Party Service Providers' Options for Reselling Cable Services and Cable Access

The Dutch situation

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Customer	KPN

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Summary

Situation

KPN has an obligation to offer third parties access to its regulated copper network and its DSL transmission networks. Although cable networks in the Netherlands are subject to the market analyses process under the Telecommunication Act, an obligation to offer access to the coaxial network or to the transmission and service platforms has not been imposed.

KPN's Request

KPN has asked TNO to provide an overview of the possibilities of reselling cable services by third-party service providers and of access to cable networks and transmission and service platforms for third parties.

Research questions

The basis to address these questions is a firm and in-depth understanding of cable networks. In addition, the impact of the third-party access on the cable capacity must be known. We therefore have defined the research questions as follows:

- What is the technical design of cable networks, of their transmission and service platforms?
- What is the capacity of a cable network and how is it used and managed?
- What are the technical options for reselling cable services and third-party access?
- What is the impact of reselling cable services and third-party access on the cable capacity?

Approach and sources

In order to address these questions, TNO has performed desk research and predominantly used publically available sources, like technical standards, reports of industrial meetings, press releases. TNO has combined this information with her own background expertise in cable infrastructures.

Conclusions

From the technical viewpoint, the Dutch cable networks have the possibility to offer a number of wholesale service and access options:

i) Reselling the cable services,

ii) Access to the DVB narrowcast and EuroDOCSIS services and transmission platforms for managed VoD and best effort Internet services.

iii) Access to the DVB broadcast services and transmissions platforms for managed radio and television services,

iv) Shared frequency access at the (regional) head end and the HUB,

v) Full unbundled local loop at the multi-tap of the last amplifier.

To rate the above technical options, we have to take into account the extra frequency spectrum that they demand.

Considering the frequency spectrum demand, we can conclude that:

i) Reselling the cable services does not require extra frequency spectrum from the cable network,

ii) Access to the DVB narrowcast and EuroDOCSIS services and transmission platforms does not require additional frequency spectrum from the cable network because extra capacity can be created by segmentation of the optical nodes,

iii) Access to the DVB broadcast services and transmission platforms require extra frequency spectrum for the third-party provider's services,

iv) Shared frequency access requires extra frequency spectrum from the cable network,

v) Full unbundled local loop does not require extra frequency spectrum from the cable network.

Extra cable frequency spectrum is an obstacle to deliver the above wholesale service and access options. In practice, the available frequency spectrum is allocated to end-user services. Therefore, if spectrum is needed for the services of a third-party provider, the cable operator has to either reduce its own service offer, invest in more efficient transmission technology or upgrade the cable network to expand the cable spectrum.

The options *i)*, *ii)* and *v)* do not require the allocation of spectrum for third-parties' services and therefore they are more obvious than options *iii)* and *iv)*.

1 Introduction

KPN has an obligation to offer third parties access to its regulated copper network and its DSL transmission networks. Although cable networks in the Netherlands are subject to the market analyses process under the Telecommunication Act, an obligation to offer access to the coaxial network or to the transmission and service platforms has not been imposed.

KPN has asked TNO to provide an overview of the technical options for third-party service providers *i)* to resell the services of cable providers, *ii)* to deliver their own services via the cable services and transmission platform of cable operators and *iii)* to deliver their own services with their own services and transmission platform using frequency spectrum of the cable network. This paper gives such an overview.

The basis to address these questions is a firm and in-depth understanding of cable networks. In addition, the impact of the third-party access on the cable capacity must be known. We therefore have defined the research questions as follows:

- What is the technical design of cable networks, of their transmission and service platforms?
- What is the capacity of a cable network and how is it used and managed?
- What are the technical options for reselling cable services and third-party access?
- What is the impact of reselling cable services and third-party access on the cable capacity?

In order to address these questions, TNO has performed desk research and predominantly used publically available sources, like technical standards, reports of industrial meetings, press releases. TNO has combined this information with her own background expertise in cable infrastructures.

The feasibility of reselling cable services, of access to the cable services and transmission platforms or to access to the cable frequency spectrum depends on several factors. These can be technical or practical in nature, but there are economic factors as well. In this paper, we examine the technical, practical and elementary economic considerations; advanced economic, costs, commercial and market analysis are not in scope.

This paper is organised as follows. In section 2, we first give a technical overview of the network and the transmission and service platforms of a cable infrastructure. To deliver wholesale access services, cable providers have to allocate part of their access network capacity to the third-party services. The availability of network capacity and the impact of allocating capacity to the third parties is discussed in section 3. Subsequently, in section 4 we give a brief description of the technical options of reselling of cable services and of third-party access to cable frequency spectrum, cable transmission platforms and cable service platforms. To conclude we assess the cable capacity needs of the different access options in section 5.

2 Cable architecture and technology

In this section we give a concise overview of the common design and architecture of cable infrastructures. Successively, we will discuss the hybrid fibre coax (HFC) network, the overall architecture of cable infrastructures, the HFC transmission platforms and the service platforms.

2.1 The HFC network

To deliver communication services, Dutch cable networks have been upgraded to two-way hybrid fibre coaxial (HFC) networks.

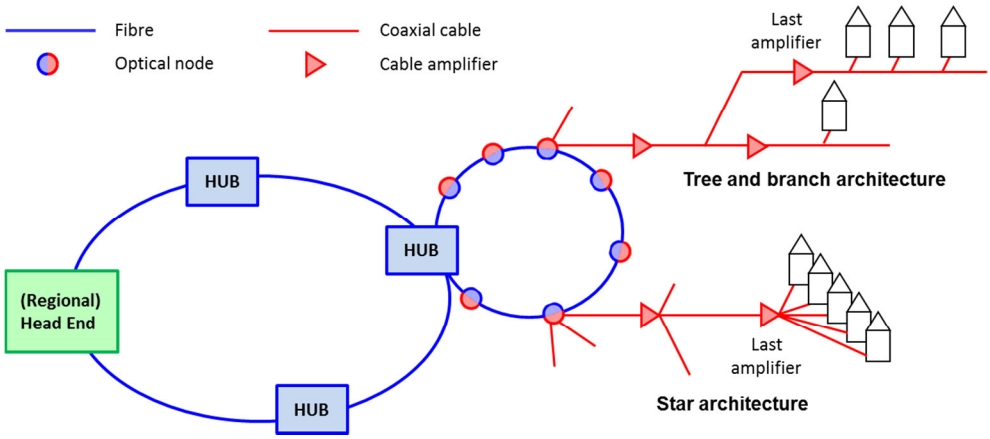

Figure 1: Topology of an HFC network. Source: TNO

The basic purpose of the HFC network is the distribution of radio frequency (RF) signals from the network to all connected homes (downstream) and the aggregation of radio frequency signals from each home back to the network (upstream). For this distribution and aggregation of signals a branching coaxial network with a fibre backhaul connection to a HUB is used, as shown in Figure 1. A so-called optical node that transparently converts the optical RF signal to an electrical RF signal and vice versa, is placed at the interconnection point between the fibre backhaul and the coaxial network. Typically, a the coaxial network connected to an optical node covers some 800 - 1200 homes in the Netherlands.

The current HFC networks mostly have a frequency arrangement with an 85 - 862 MHz downstream band and an upstream band from 5 - 65 MHz. The 120 - 862 MHz part of the downstream band is used for analogue television and digital services like digital television, video on demand and internet. For each of these services, 8 MHz spectral frequency channels are allocated. The 85 - 107.5 MHz part of the downstream band is used for FM radio. The upstream band typically can be used from about 25 up to about 65 MHz; low frequencies cannot be used because of too much ingress of distortion signals [1], [2].

Some of the downstream channels distribute the same signals to all homes in the service area of the head end. These channels are used for analogue and digital broadcast services. Some channels are used to distribute signals locally, to the

homes connected to a specific optical node, or even a specific coaxial branch that emanates from a specific node. In an adjacent optical node or coaxial branch the same radio frequency (RF) channels can be used again to distribute other signals; the channels can be reused like in a mobile cellular network. This reuse is called narrowcasting, and the part of the network where the same narrowcast signals are distributed is called a segment. Narrowcasting in a segment is used to deliver personalized services like (broadband) internet, telephony and VoD.

This hybrid broadcast-narrowcast architecture is implemented with optical transmitters with different optical wavelengths and optical passives such as optical combiners and splitters [3].

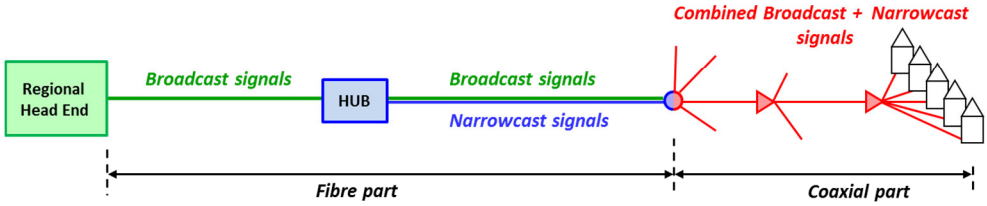

Figure 2: The HFC broadcast and narrowcast service architecture. The red part shows the coaxial part of the network that carries both broadcast and narrowcast signals. Source: TNO

The digital (DVB-C, [4]) and analogue radio and television broadcasting signals are generated in the head end, and distributed via the HUBs to all optical nodes using optical transmission; see Figure 2. The narrowcast signals are generated in the HUB or the (regional) head end and combined on a per cable segment basis, and conveyed to the optical node as well. In the optical node, the combined broadcast and narrowcast signals are converted to an electric signal and distributed to the homes.

The capacity available for broadcasting is simply determined by the number of 8 MHz frequency channels allocated for broadcasting. The capacity for narrowcasting, though, is determined by the number of frequency channels allocated and by the size of the coaxial segments.

2.2 The overall cable infrastructure

To deliver services over the HFC network, cable providers have an infrastructure with the cable-specific service platforms for television, video on demand and internet services, core and metro networks to transport the services in digital to the cable transmission systems that generate the radio frequency signals for the HFC network. Figure 4 gives a schematic overview of this part of the cable infrastructure.

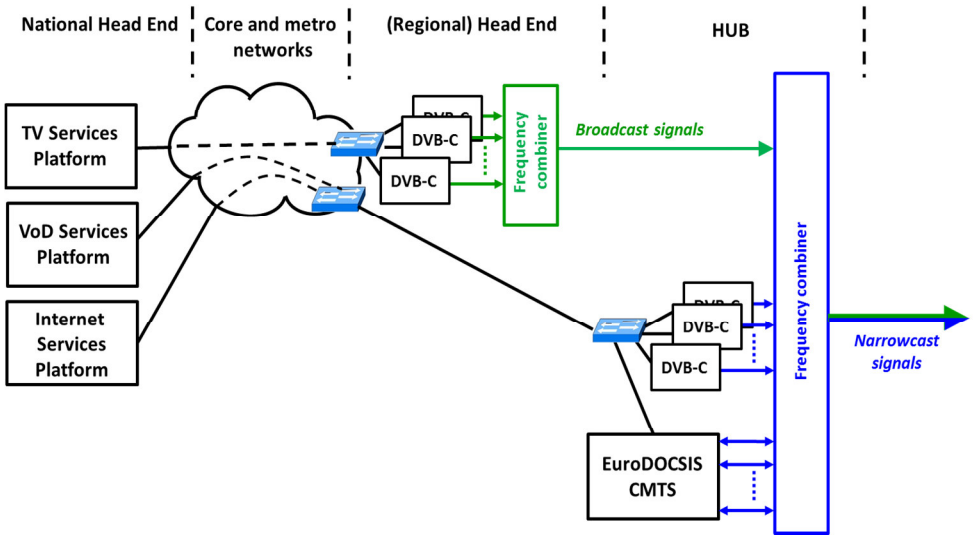

Figure 3: Schematic diagram of the service platforms, core networks and DVB-C and EuroDOCSIS transmission systems to deliver cable services. Source: TNO

2.3 Cable transmission platforms

2.3.1 The DVB-C broadcast platform

To convey the digital broadcast services via the HFC network, cable providers use dedicated DVB-C transmitters located in the (regional) head end with a capacity of 35 or 52 Mbps. Each transmitter feeds an 8 MHz channel and can carry a number of television programmes.

2.3.2 The DVB-C narrowcast platform

For the digital narrowcast services via the HFC network, cable providers use dedicated DVB-C transmitters located in the HUB with a capacity of 35 or 52 Mbps. Each transmitter feeds an 8 MHz channel and can carry a number of television programmes.

2.3.3 The EuroDOCSIS transmission platform

Broadband internet access and managed telephony services are delivered via EuroDOCSIS[1] technology. EuroDOCSIS basically provides packet/IP-based services on cable networks, i.e. from the CMTS[2] in the HUB or (regional) head end to the customer modems and vice versa. This technology uses 8 MHz frequency channels with a capacity of 35 or 52 Mbps per channel downstream whereas it uses 6.4 MHz channels with either a throughput of 30 or 20 Mbps, or 3.2 MHz channels with 15 or 10 Mbps throughput upstream.

[1] European version of DOCSIS (Data Over Cable System Interface Specification)
[2] Cable Modem Termination System

The EuroDOCSIS channels are shared by different users which brings the risk of service degradation due to congestion. Therefore, to assure a sufficient voice quality for telephony services, EuroDOCSIS has arrangements in place to handle telephony with priority over Internet traffic. Each customer gets one or a number of virtual connections between the CMTS and the modem, the so-called service flows. In addition, mechanisms are implemented to manage the packets of each service flow. For the Internet and telephony connections, separate service flows are configured. For the Internet, a service flow with a minimum bit rate guarantee is used, and thus a best effort plus connection is delivered. In the case of telephony, a service flow with a guaranteed real-time variable bit rate (rt-VBR) is applied.

Currently, EuroDOCSIS 3.0 is the latest and therefore most advanced technology deployed. An important feature of EuroDOCSIS 3.0 is the bonding of upstream channels and of downstream channels. By bonding two or more channels, the maximum bit rate of the internet service is not limited by the capacity of the individual EuroDOCSIS channels, but by the number of channels that are bonded.

Since the EuroDOCSIS platform is a shared system, the capacity is overbooked by default, but to warrant a good internet service, the capacity is managed. The load of each EuroDOCSIS port serving a single frequency channel is monitored, and when a certain threshold is surpassed, the cable operator expands the capacity, either by adding extra frequency channels or by splitting the coaxial segments. When the EuroDOCSIS and network capacity thus is properly managed, the cable provider can warrant the Internet service bit rates at all times and for all customers.

For the Internet access services, the CMTSs are connected to a national service centre with a connection to the Internet. Customers must have a dedicated cable modem to terminate the EuroDOCSIS connection and to provide Ethernet connectivity. This modem, and more specifically the EuroDOCSIS network side interface of the modem, is managed by the cable provider. Usually, the cable modem is provided by the cable provider as an integral part of the Internet service.

Cable telephony is a service delivered on top of the EuroDOCSIS service. For telephony, a dedicated PacketCable platform is needed in combination with a service flow with a real-time VBR service. Customers must have a cable modem with a multimedia terminal adapter to connect a telephone.

For comparison, in DSL networks, VoIP traffic generally receives a higher priority than best-effort Internet to ensure that the telephony service does not deteriorate in situations of congestion. A managed service lane is created on the DSL connection for telephony and possible other premium services but not for the Internet service. In analogy with this DSL network design, one can consider the EuroDOCSIS service flow with a real-time VBR service as a managed transmission service, and cable telephony as a managed telephony service.

2.4 Cable service platforms

In the current cable infrastructure, radio and television services are delivered as an analogue service and as a digital service. Digital television is delivered with DVB technology but with distinct platforms for linear (broadcast) and non-linear (VoD and catch-up television) television.

2.4.1 Analogue services

National and foreign analogue radio and television channels are all received in the head end. The channels are broadcasted from the head end to all homes using FM and phase alternating line (PAL) modulation for radio and television, respectively. In the case of FM radio, the 87 - 107.5 MHz FM band is used, whereas the PAL television channels are transmitted in eight MHz frequency channels in the frequency range from about 120 up to 862 MHz. Regional and local analogue channels can be inserted in the regional head or possibly in the HUB.

For analogue services, no transmission platform is used. The radio or television signal is used to modulate the assigned transmission frequency. The RF radio or television signal is combined with the other broadcast signals and injected into the HFC network for distribution.

Cable network operators leave some specific frequency channels unused for internal use by the customers. For instance, to replay programmes from a customer's analogue video recorder, one or more VCR channels carry no cable signal. Similarly, often a frequency channel is reserved so that hospitals or retirement homes can distribute their own television programmes.

Due to technical and historical reasons, the analogue services and cable connection are tightly linked. Cable providers can connect or disconnect a customer by connecting or disconnecting the coaxial drop cable that serves the customer in the street cabinet.

2.4.2 Linear digital radio and television

2.4.2.1 The digital radio and television platform

All radio and television channels are received in the national head end where they are processed and multiplexed into so-called transport streams. Each transport stream contains all programmes for a single DVB-C transmitter. The transport streams are conveyed to the DVB-C transmitters by the core network. Figure 3 in paragraph 2.2 provides a schematic overview of this infrastructure architecture.

Similar to the cable telephony service, the DVB system architecture for television services provides protection of the television services. By creating dedicated connections with fixed bandwidth and a limited number of television channels, the television programmes cannot be distorted by external processes such as congestion on the Internet access connection. Therefore, the cable DVB-based television service can be considered as a managed television service.

The details of processing and multiplexing the digital radio and television channels are schematically illustrated in Figure 4. For linear radio and television, all channels are received and processed at the head end. The channels are transcoded to an appropriate bit rate and several channels are multiplexed in a transport stream with a capacity of either 35 or 52 Mbps. To protect the content, either the television channel or the full transport stream with a number of channels is scrambled using a control word [5].

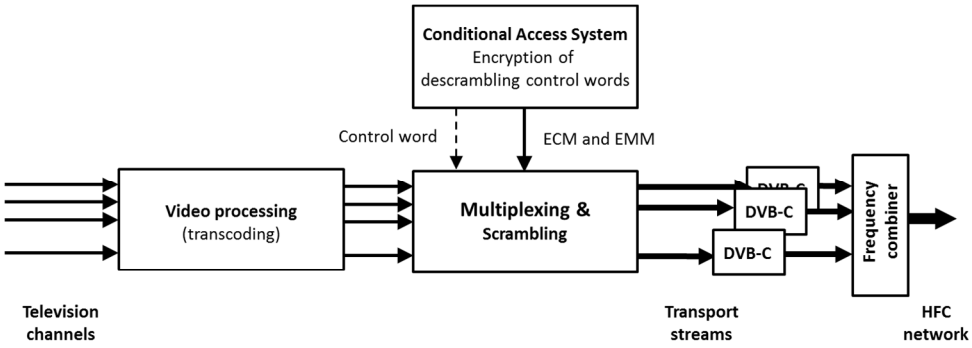

Figure 4: Schematic illustration of the cable digital television platform. Source: TNO

2.4.2.2 The conditional access system

Cable-based TV platforms use a single standardized common scrambling technology [6]. However, to deliver the control word to authorized customers in a secure manner, different proprietary solutions are used. This technology to deliver the control word to authorized customers is called the conditional access system (CAS).

This conditional access system provides key management technology to convey the control word for descrambling the individual channels or transport streams in a secure manner; see Figure 5. The control word is encrypted first with a service key. Thus encrypted, it is safely broadcast to all homes using an entitled control message (ECM). Secondly, the service key is encrypted on an individual basis with a unique user key and the encrypted service key is broadcast in an entitled management message (EMM).

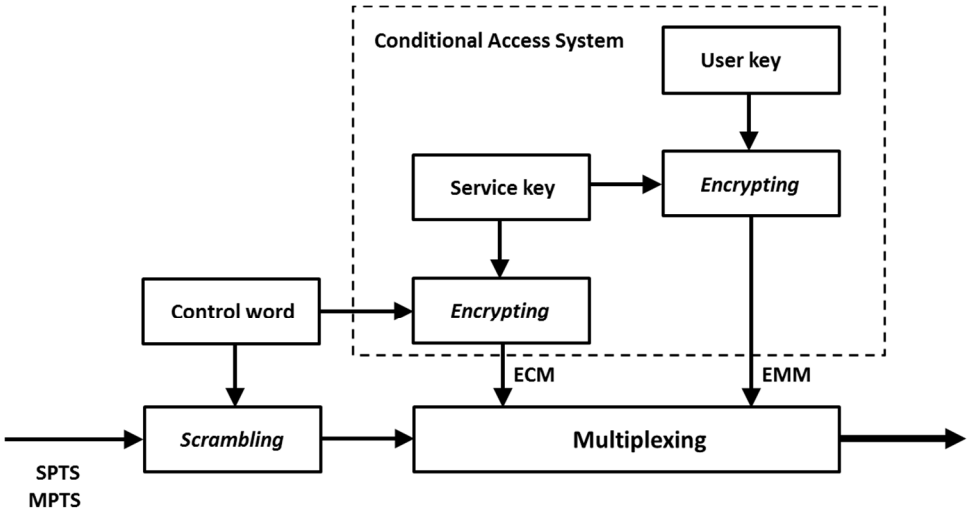

Figure 5 Conditional access system and scrambling. Source: TNO

To provide the digital television service, each customer needs a unique user key. This user key is implemented in hardware in a smart card with a unique identification code printed on the outside. Cable providers have the information from

the supplier of the smart cards necessary to associate the user keys and control words with the card identification codes.

Authorized customers can decrypt the service key with the user key on their smart card, and using the service key they can decrypt the control word. Unauthorized customers receive the encrypted service keys as well, but cannot decrypt them.

As mentioned earlier, the conditional access system is not standardized. There are various manufacturers of conditional access technologies on the market, such as Irdeto, Nagravision and NDS. The customer side of the conditional access system as indicated in Figure 5 can be integrated in the digital receiver, the set-top box, or it can be implemented in a so-called conditional access module (CAM module). Both set-top boxes and the CAM modules have a slot for a smart card.

Modern television sets have an integrated digital receiver that support the so-called common interface standard and have a slot for a conditional access module with a smart card. By inserting the CAM module with a smart card of the conditional access technology used by the cable provider, the digital services can be provided and the television channels can be shown on the screen without an external set-top box.

To provide the digital services, the card identification code is administratively linked to a customer. Next, with the unique user key associated with the card identification code, cable providers can provide digital channels or packages of radio and television channels to each customer on an individual basis.

2.4.2.3 The electronic programme guide

To select a television channel, customers can zap through the digital channels, choose a channel number with the remote control, or consult the electronic programme guide (EPG). The EPG is generated by the customer's digital receiver, STB or television set. It receives all relevant programme information in a standardized format via the cable broadcast, multiplexed in a digital transport stream [7].

2.4.2.4 The digital receiver

As indicated, in order to receive digital television services from a cable operator, customers need a digital receiver. Although many components of the DVB broadcasting technology are standardized and are subjected to compliancy tests, this does not warrant full interoperability of every digital receiver and cable operators' digital television platform. From a business viewpoint there are several options:

- The cable operator develops a dedicated receiver that he supplies to his customers,
- The cable operator specifies all requirements to interoperate with its television platform and offers manufacturers the possibility to test and certify the interoperability of their receivers. The requirements for interoperability and a list of the receivers that successfully have passed the test are communicated to vendors and customers. Customers must buy a receiver, but if they buy a certified one, proper interoperability is guaranteed.

2.4.3 Non-linear digital television

VoD and catch–up TV content are stored on servers at a regional network level. Cable operators may have a dedicated content delivery network. The servers have a connection to dedicated DVB-C transmitters in the so-called EdgeQAMs[3], with a capacity of 35 or 52 Mbps each. Each of the DVB-C transmitters feeds a frequency channel of a specific coaxial narrowcast segment.

Like the DVB-based radio and television service, the non-linear digital television service can be seen as a managed service.

The programmes on the servers are already scrambled using a control word. Customers who order a programme receive the control word using the same conditional access technology used for broadcasting. The scrambled programme is narrowcast in the cable segment serving the customer.

In order to select VoD and catch-up television content, a catalogue of all programmes that are available from the content servers is needed.

VoD and catch-up television typically require a bit rate of a few Mbps, with possibly different bit rates for different content types, such as for instance catch-up television and HD video on demand. T
he capacity to deliver VoD and catch-up television per coaxial segment is limited to a fixed number of 8 MHz channels and therefore to a limited number of simultaneous programmes.

To watch VoD and catch-up programmes, a digital receiver with a return channel is needed for interactivity (selection of programme, start, stop, pause etc.) For this interactivity an IP connection is used, either with an embedded EuroDOCSIS modem or possibly with an external modem.

As for digital receivers for broadcast services, not all receivers for interactive services and conditional access modules are interoperable with the service platforms of cable operators. To address this issue, the same equipment policies are used as those for digital receivers for basic broadcast services.

From the technical point of view, cable operators can deliver non-linear television services via their EuroDOCSIS platform as well (i.e. IPTV). However, the EuroDOCSIS platform does not support a warranted quality of service for video services, and therefore this option can be considered as an unmanaged non-linear television service.

[3] An EdgeQAM is a module containing a number of DVB-C transmitters to convert a transport stream to an RF DVB-C modulated signal carrying the transport stream.

3 Cable frequency spectrum, network load and capacity

For the delivery of services, the network must have a sufficient capacity. In this section we consider the network capacity and the way it is managed.

3.1 Frequency spectrum

The current 5 - 65 MHz upstream and 85 - 862 MHz downstream band plan of a cable network is a system design choice, albeit that historically it is defined by the terrestrial FM radio (87 - 107.5 MHz) and television bands (Band IV/V from 470 - 862 MHz). The maximum edges of the upstream and downstream band are not chosen by individual cable operators, but are a long-term choice made by the international cable industry. As such, most cable transmission equipment available in the market only supports these maximum band edges and therefore there is no immediate benefit to build cable networks with an upstream and/or downstream frequency edge that is not supported by the transmission equipment.

In the network, the frequency band plan is implemented using active components such as electric amplifiers, optical transmitters and receivers. The frequency range of these components is restricted using filters.

As a rule, the available frequency spectrum is allocated to services, and therefore it is considered a scarce resource[4].

Because of the limited power budget[5] of the optical transmitters and the amplifiers, the network load is restricted by *i)* the number of carriers (analogue and digital) and *ii)* their signal level. Increasing the load beyond a specific level will lead to degradation of the services. In practice, the load of a cable network is optimized for the lengths of the fibre and coaxial links, the number of branches at the optical and coaxial branching point and the power budget of the active components.

As noted, the band plan of an HFC network is a system design choice. To change this band plan operators have to:

1. Replace active components or possibly only the filters in the components so that they operate according to the new frequency band plan,
2. Reengineer the network as mentioned above to maximize the network load for this new band plan. For example, to extend the downstream frequency band, a larger power budget is needed, which either requires components with a higher output level or shortening the length of the network links to reduce attenuation.

[4] About 90 channels of 8 MHz in the 85 - 862 MHz band are in use for television and broadband services. The FM band (87 - 107.5 MHz), a band for the FM/TV diplex filter (107,5 - about 120 MHz), at least two 8 MHz channels for customer VCR recorders and a 8 MHz channel for retirement homes' and hospitals' (among others) own television services are not used for these services.

[5] In cable networks, linear optical lasers and electrical amplifiers are used; however, for higher signal output levels, the components will produce non-linear distortion products that deteriorate the overall performance. The power budget indicates the maximum signal output power of a component that can be used without service degradation due to the non-linear nature of the component.

From the technical and engineering viewpoints, the HFC network comprises three subsystems:

1. an optical broadcast subsystem,
2. an optical narrowcast subsystem, and
3. a coaxial subsystem.

Each of these subsystems can carry a limited load only, because of the limited power budget of the active components.

3.2 Cable capacity

The capacity for narrowcasting can be expanded by reducing the size of the coaxial segments. Such segmentation is implemented at the optical node. At this point the optical broadcast and narrowcast signals are combined while a number of coaxial branches emanate from this point. In case of segment splitting, an additional optical backhaul for the narrowcast signals is created and the coaxial branches are (re)distributed over the available optical backhauls. This type of splitting is illustrated in Figure 6.

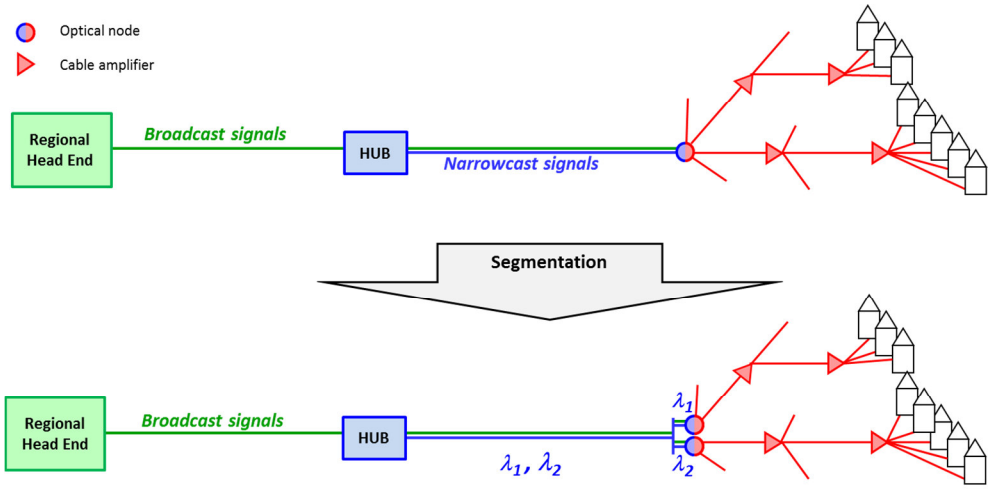

Figure 6: The principle of cable network segmentation. Source: TNO

As an alternative option, the capacity of the narrowcast platform can be increased by expanding the narrowcast frequency band, provided the maximum load of the narrowcast subsystem is not fully used. Expansion of the frequency spectrum for narrowcast services thus can be realized only at the expense of the frequency spectrum for broadcast services, unless the total cable frequency spectrum is expanded as well.

4 Cable wholesale services and access options

In this section we give a technical overview of the wholesale services that cable providers could offer. We can distinguish four types of wholesale services:

- Reselling the cable retail services,
- Access to the television and VoD services platforms,
- Access to the transmission platforms,
- Access to the HFC network.

Figure 7 gives a schematic illustration of the three access options. In practice, each option can be realized in multiple ways. In the following subsections we discuss each of the options in more detail.

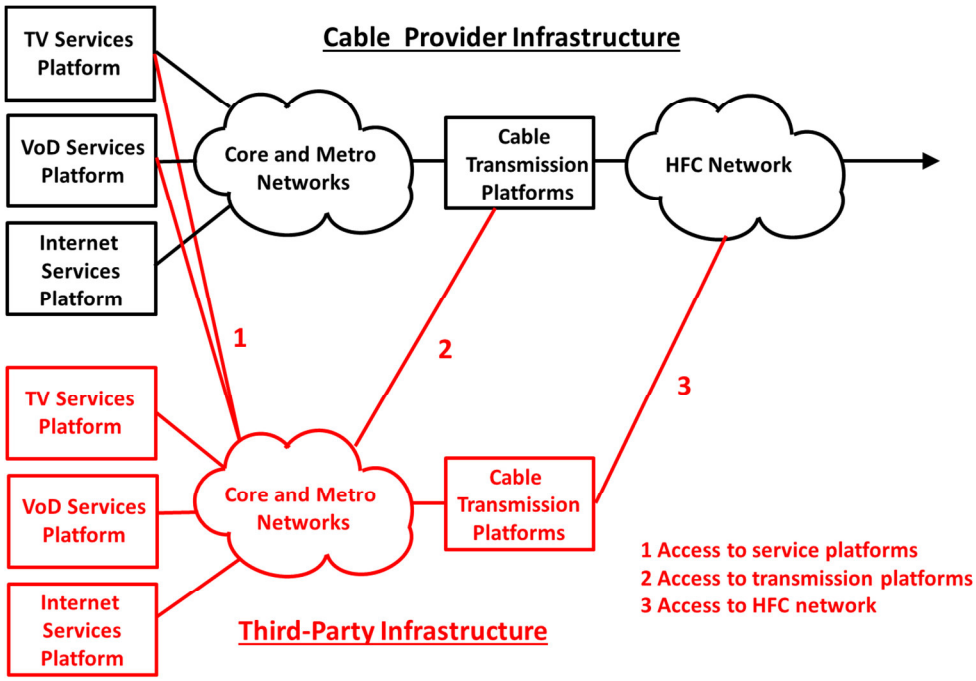

Figure 7: Schematic overview of the different infrastructure access options. Source: TNO

4.1 Reselling cable services

4.1.1 Analogue radio and television

The analogue radio and television channels are an inseparable part of the cable connection. Reselling the cable provider's channel offer thus is a straightforward option to deliver analogue services by a third-party provider. Such a resell of the complete analogue service offer has no technical impact on the network, but it requires changes of the provisioning, support and administrative processes and the IT systems.

It is conceivable that a third-party service provider would not want to resell a cable provider's entire analogue offer. Technically, it is possible to add or remove television channels. Channel(s) can be removed by placing an RF band filter in the coaxial drop cable. However, the spectrum adjacent to the pass-through band will be damaged, and cannot be used any more for other cable services. Moreover, the analogue channels may first have to be reallocated to new frequencies to properly isolate these channels with a filter. This reallocation of analogue television channels will affect all customers still watching analogue. They will have to retune their television set.

Adding an analogue channel requires access to the frequency spectrum of the broadcasting platform, and as such this will have implications for the use of the cable network as discussed in subsection 4.4.1

4.1.2 Reselling linear and non-linear digital television

Cable operators already distribute a large package of digital television channels. In addition, they offer non-linear programmes using their platform for VoD and catch-up television. For these VoD and catch-up television services, an Internet connection is needed in addition to the cable connection.

Third-party service providers could resell cable operators' broadcast channels. To distinguish its own customers from those of a cable operator, the third-party service provider must have its own smart cards. For the conditional access system, there are two options. Either the third party could make use of the conditional access system of the cable provider or use its own conditional access system.

The use of a third party's own conditional access system is called 'simulcrypt' and it is commonly used in satellite broadcasting. In this solution, the third-party provider receives the code words from the individual channels or the transport stream and encrypts them himself using his own service key. The service key again is encrypted using the customer's user key. The third-party EMM and ECM messages are multiplexed in the transport stream together with those of the cable operator.

A third-party service provider could wish to add or remove broadcast television channels. Furthermore, the provider could prefer to define different packages of television channels. The possibility to remove television channels, to change the packages or to add channels depends on the implementation of the scrambling in the television platform. If each television channel is scrambled separately with its own control word, changing the packaging is possible. If, in contrast, the transport stream is scrambled, service mutation is only possible at the level of the transport stream that contains a number of television channels. The possibility to add a channel is similarly affected, and possibly limited, by the scrambling mode.

To add a channel, the third party will have to make a request to the cable operator to extend its offer with the desired channel. If this request is not honoured, the third party could add a channel itself using access to the DVB broadcast platform of the cable provider as discussed in subsection 4.2.1.

Using its own conditional access system will give a third-party provider control of the selection of the television channels from the cable provider's offer and of the definition of own packages, either at the level of single television levels or at the level of transport streams containing a number of channels. When using the cable provider's conditional access system, the third party will depend on the cable provider to provide the digital services and to change the service packages.

Video on demand and catch-up television programmes are scrambled on a per programme basis prior to the storage on the network servers. As such, the conditional access system does not limit the possibility to resell these programmes. For reasons of content rights, it may not be suitable to share a content storage system and a catalogue. Instead, a third party could arrange its own servers to store the content and its own catalogue that are interconnected to the VoD platform of the cable provider. However, this option to connect a third party's own servers and its own content catalogue, possibly in combination with an own conditional access system, cannot be considered as resell option anymore, but has to be considered as an implementation based on access to the cable provider's non-linear television platform as discussed in subsection 4.2.

To receive the programmes, the customer will need an interactive digital receiver. The third-party provider could choose to use any receiver that is certified by the cable operator. If there are no certified receivers on the market, the third-party provider should make an arrangement to use the cable provider's receivers.

4.1.3 Reselling cable Internet

Cable providers offer consumer best-effort Internet access services with a number of service profiles. Any third-party provider could resell this cable Internet access service using the same broadband service profiles. In principle, the third-party provider can choose to provide an own cable modem or that of the cable provider.

4.1.4 The Belgian implementation of the reselling of cable services

In July 2011 the Belgian regulatory authorities decided to impose a wholesale obligation on the Belgian cable providers [8]. In the following years, the details of the wholesale offer were discussed and negotiated among stakeholders [9][10].

The final reference offer includes a wholesale resell obligation for analogue and digital television services [10]. Cable operators are obliged to provide a reference offer consisting of all analogue and digital radio and television channels that are distributed. The reference offer includes a formal procedure to add or remove channels from the reference offer or to make technical adaptations. This formal procedure involves all stake holders: cable operator, third parties and the regulator. The offer includes the programme data for the EPG. The third parties' analogue offer is not differentiated from the analogue package of the cable provider; there are no analogue channels added or removed.

For digital television services, third-party providers will have to install their own conditional access system, possibly shared with other third-party providers. Third parties can choose from the reference offer which television channels to resell, and

can define their own packages of programmes. For the customer equipment's interoperability, the cable network operator provides a specification of the digital receiver and the conditional access system. The certification has to be assigned to an independent and positioned certification office, or, for the conditional access system, to the vendor.

4.2 Access to the television and VoD services platforms

4.2.1 Access to the television services platform for managed linear television

From a technical viewpoint any third-party service provider can access the television services platform of a cable provider to deliver its own managed television service with its own channels and its own picture quality (bit rate). Using the cable provider's conditional access system or using simulcrypt, third-party service providers can serve their own customers as explained in subsection 4.1.2

Depending on whether cable providers scramble individual television channels or transport streams with a number of television channels, the minimum capacity a third party can have will correspond to either a single television channel or to a number of television channels.

For services delivered via access to a cable operator's broadcasting platform, the same interoperability of the digital receiver is required as for reselling a cable provider's digital television offer; see subsection 4.1.2.

The television channels of the third-party provider require transmission capacity of the DVB broadcast platform. If there is no room for the extra television programmes in the existing DVB-C transport streams, then the cable provider will have to allocate 8 MHz frequency channels in the broadcast network, and add DVB-C transport streams.

Cable providers can provide access to their national or regional network sites in order to transport the television channels of the third-party service provider to the television head end.

4.2.2 Access to the non-linear television platform

As explained in subsection 4.1.2, a third party could arrange its own servers to store the content and have an own catalogue and interconnect these with the VoD and catch-up television platform of the cable provider.

The service demand of the third-party provider's customers requires transmission capacity of the non-linear television platform and of the narrowcast network. The capacity of both can be expanded, the first by adding equipment and the second by segmentation and/or adding one or more 8 MHz frequency channels.

4.2.3 The Belgian implementation of a wholesale obligation for VoD and catch-up television

The Belgian regulatory authorities consider the cable system for the delivery of VoD and catch-up television services as rather complicated for third parties. Unless there is a demand from a third party, cable providers should not make preparations for a

wholesale offer. Instead, third-party providers are granted the possibility to offer VoD and catch-up television services via the EuroDOCSIS broadband platform. Cable providers are not allowed to impose unreasonable restrictions for VoD services.

4.3 Access to the transmission platforms

With their own cable compatible services platforms, third parties could choose to deliver their services using the DVB-C and EuroDOCSIS transmission platforms of the cable operator as indicated in Figure 8. The figures illustrates the different options. Either third parties have their own network to the transmission systems (1 and 2), or cable operators provide additional connectivity services via their core and metro networks (3)

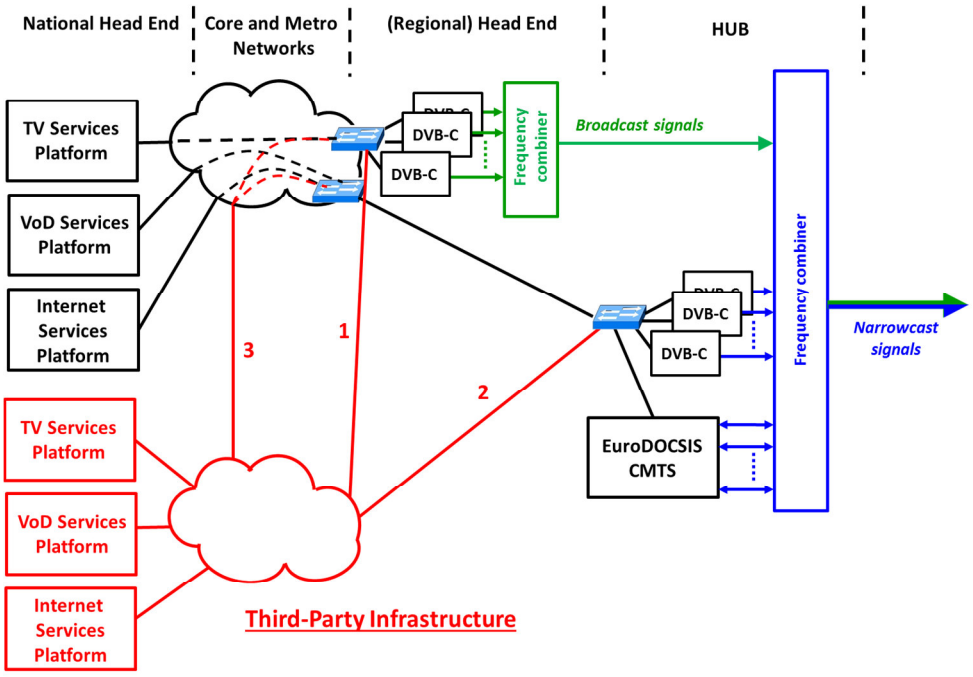

Figure 8: Access to the DVB-C broadcast narrowcast modulators and to the EuroDOCSIS CMTS. There are different options as pointed out in the text. Source: TNO

4.3.1 Access to the DVB-C modulators

For television and VoD services, third parties can connect to the DVB-C modulators in the (regional) head ends or in the HUBs respectively, as indicated by links 1 and 2 in Figure 8. Alternatively, if cable providers can provide an optical connection from a point in their network to the DVB-C modulators, third parties can interconnect at this point. This latter possibility is indicated by link 3 in Figure 8. With the additional optical connection, third parties can interconnect at a number of regional or at a single national point to deliver and collect their traffic.

4.3.2 Access to the EuroDOCSIS platform for best-effort Internet services

Using the EuroDOCSIS platform, third-party service providers can offer a retail Internet service with the same bit rate profiles as the cable operator or with their own profiles albeit that the maximum up- and downstream bit rate depends on the number of bonded frequency channels.

Using cable providers' national and regional networks, access to the EuroDOCSIS platform can be offered at the sites of the CMTSs, or at a regional or even national level, as shown in Figure 8.

Customers of third-party service providers will create extra IP traffic. However, the EuroDOCSIS cable platform is designed to cope with the growth of broadband traffic demand. A concern for cable providers is that the traffic of third parties' customers should not negatively affect the characteristics of the composite traffic of all users.

4.3.3 Access to the EuroDOCSIS platform for television and telephony services

For television and VoD services, a third party could consider an IP-based television service delivered via the EuroDOCSIS internet connection. For managed linear and non-linear television services, a managed network service over EuroDOCSIS is needed, which currently is not supported for television services. Moreover, delivery of linear and non-linear television potentially could change the traffic characteristics and the total traffic volume of the EuroDOCSIS service.

In the current market, Dutch cable providers already offer linear and non-linear (streaming) television services to tablets and smartphones. Moreover, Netflix has entered the market with an over-the-top video service.

Telephony is provided with a dedicated service flow with a real-time VBR scheduling of the voice packets. Because of the small traffic volume associated with telephony, cable operators can deliver a telephony wholesale service. In addition, third-party service providers need access to the PacketCable[6] soft switch of the cable provider, or they have to install or connect their own PacketCable soft switch. Since telephony requires very little bandwidth, the impact on the cable capacity will be limited.

4.3.4 The Belgian implementation of a wholesale broadband access obligation for the EuroDOCSIS platform

The Belgian regulatory authorities have imposed an obligation for Belgian cable providers to offer wholesale broadband access services [10]. The wholesale offer encompasses a limited number of broadband profiles, two of which can be defined by third parties. The maximum bit rate of third parties will be equal to, or less than, retail service with the highest bit rate of the cable provider. The broadband profiles with a lower bit rate include a monthly volume cap.

[6] PacketCable is the standardized technology for telephony services for a (Euro)DOCSIS network.

4.4 Access to the HFC network

In telephony networks, there are two variants of loop unbundling: full unbundled local loop and shared access. In the first case, third-party service providers get full access to the copper wire pair that serves the customer. For shared access third-party service providers get access to the higher frequency part of the spectrum; the low frequency band remains in use by the incumbent telecom provider for (POTS or ISDN) telephony services. In the following section we will consider the cable equivalents of full unbundled local loop and of the shared local loop.

4.4.1 Shared access from the cable

In a cable network, shared access would entail access to one or more 8 MHz channels in the downstream spectrum, optionally combined with access to the upstream spectrum. For such shared access, cable providers have to clear these channels up to the hierarchical network level where the signals are combined. Hence, shared access for narrowcast services can be offered at the HUB whereas shared access for broadcast services can be offered at the head end, as shown in Figure 9.

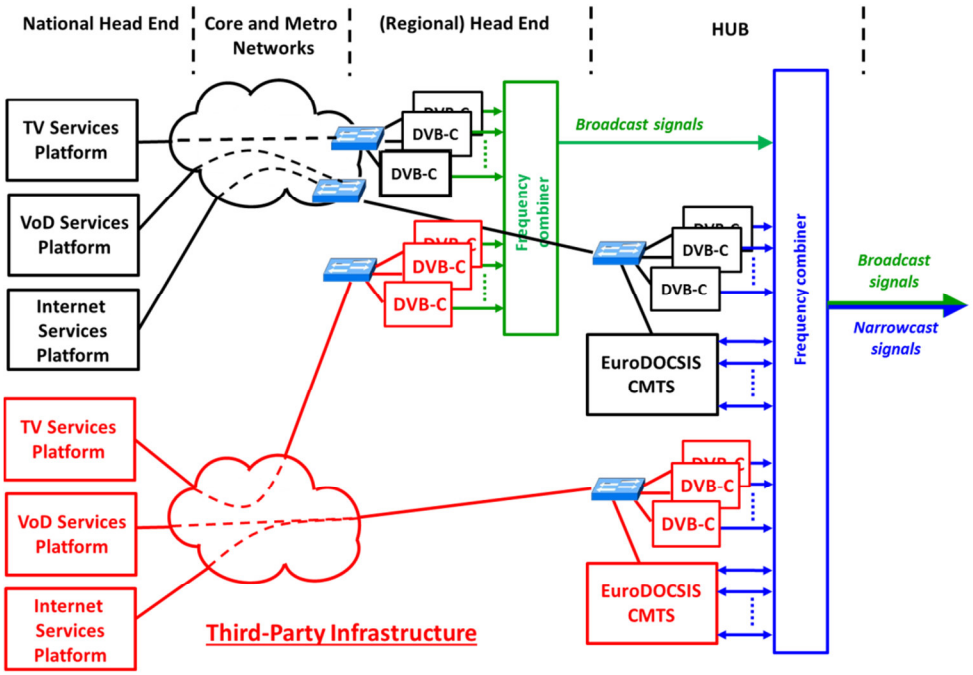

Figure 9: Schematic illustration of the shared access through cable. Source: TNO

Given the availability of frequency channels on the HFC network, third-party service providers can install their own EuroDOCSIS, DVB or PAL broadcast systems and/or a dedicated VoD and catch-up television platform.

To protect the overall performance of the HFC network, the signals from the transmission platforms of third-party service providers must fall within a specified spectrum mask that specifies the frequency channel and the signal level of the signals.

To house third-party providers' necessary systems, cable operators should provide colocation or adjacent location facilities at the HUBs and at the head end.

4.4.2 Full unbundled local loop from the cable

In most European cable networks, because of the tree-and-branch topology, full unbundled local loop is not feasible. It would make it impossible for individual customers to choose their own provider[7].

In the Netherlands, however, most cable networks have a star architecture, with each home connected with an individual drop cable to the multi-tap in the street cabinet, instead of a branch-tree architecture connecting the homes to the last amplifier. Therefore, full unbundling of the local loop at the last amplifier is technically possible in the Netherlands. Cable providers have to disconnect the coaxial drop cable from their own multi-tap[8], and hand the drop cable over to a third-party service provider. Figure 10 shows this option.

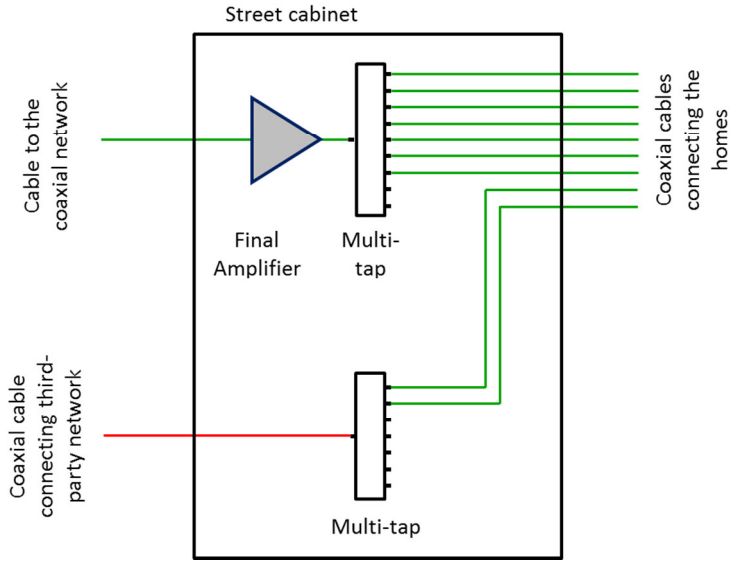

Figure 10: Full unbundled local loop at the final amplifier. Source: TNO

In the Dutch situation, the street cabinet for the last amplifier is rather small (h x w x d = approximately 80 cm x 60 cm x 15 cm) and, generally, the available space is just sufficient for the amplifier, multi-tap and cabling, see Figure 11. The amplifier is powered via the coaxial network from the optical node. For safety reasons, the voltage is low and therefore the power available at the final amplifier is limited, and possibly not sufficient to power additional electronic equipment.

[7] Only if all customers connected to one branch would collectively decide to choose a different cable service provider, full unbundling would be possible. For example, in Sweden there are different cable providers with their own coaxial network in the same service area. The owners or administrators of apartment buildings and flats can negotiate a collective arrangement on behalf of the residents.

[8] The multi-tap is a passive cable network component that splits the output signal of the final amplifier into a large number of signals to feed all the homes served by the amplifier.

Figure 11: Typical Dutch street cabinet housing the final amplifier (top) and two multi-taps (bottom right) with coaxial drop cables to the connected homes. Source: TNO

A third-party service provider could build its own network using a coaxial drop cable of the cable operator. To do so, the third-party provider has to build a network to all street cabinets that it wants to serve, and may have to install a cabinet for its own equipment and arrange electricity. In this new roll-out, the third-party provider can choose for today's state-of-the-art EuroDOCSIS technology, however, the provider can also opt for an all-IP technology using for instance a microCMTS or EPON over Coax (EPoC) technology [11].

5 Cable frequency spectrum and services for third parties

Cable is a shared medium with limited resources in terms of frequency spectrum for broadcast and narrowcast services. As pointed out in section 3, the amount of frequency spectrum is a design choice, and can therefore be changed; however, such an upgrade requires investments.

As a rule, the frequency spectrum of a cable network is fully used to deliver services. Therefore, if spectrum is needed for the services of a third-party provider, cable operators have to either reduce their own service offer, or invest in more efficient transmission technology or in expansion of the cable spectrum by upgrading the cable network as pointed out above.

Considering the wholesale options of section 4, we can conclude that:

1. Reselling the cable services does not require extra frequency spectrum from the cable network for the third-party provider service offer,
2. Access to the DVB narrowcast and EuroDOCSIS services and transmission platforms does not require extra frequency spectrum from the cable network because extra capacity can be created by segmentation of the optical nodes,
3. Access to the DVB broadcast services and transmissions platforms requires frequency spectrum for a third-party provider's services,
4. Shared frequency access requires extra frequency spectrum from the cable network,
5. Full unbundled local loop does not require extra frequency spectrum from the cable network for a third-party provider service offer.

The Belgian obligation encompasses *i)* reselling of cable services, *ii)* access to the DVB narrowcast services platform for video on demand services and *iii)* wholesale broadband access to the EuroDOCSIS transmission platform, which respectively correspond with options 1 and 2 of the above list. The Belgian obligation does not impose wholesale options 3, 4 or 5.

6 References

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