INTERNATIONAL TELECOMMUNICATION UNION

The Future of Cable TV

Industry paper on trends and implications

This document is a backgrounder to the upcoming workshop on the Future of Cable TV. Participants to the workshop are encouraged to read it and reflect on questions highlighted in the document. These questions will be discussed during the workshop.

Contents

1. Introduction

Cable TV cannot be defined any longer as a set of linear television services delivered over a dedicated wired broadcasting network. It should rather be viewed as video service delivery which is part of a comprehensive service offering, comprising other truly integrated services. Ranging from video on demand (VOD) services, internet access services, cloud storage and application services, as well as Internet of Things (IoT) services, such as smart metering at home.

1.1 Cable TV in a converged market place

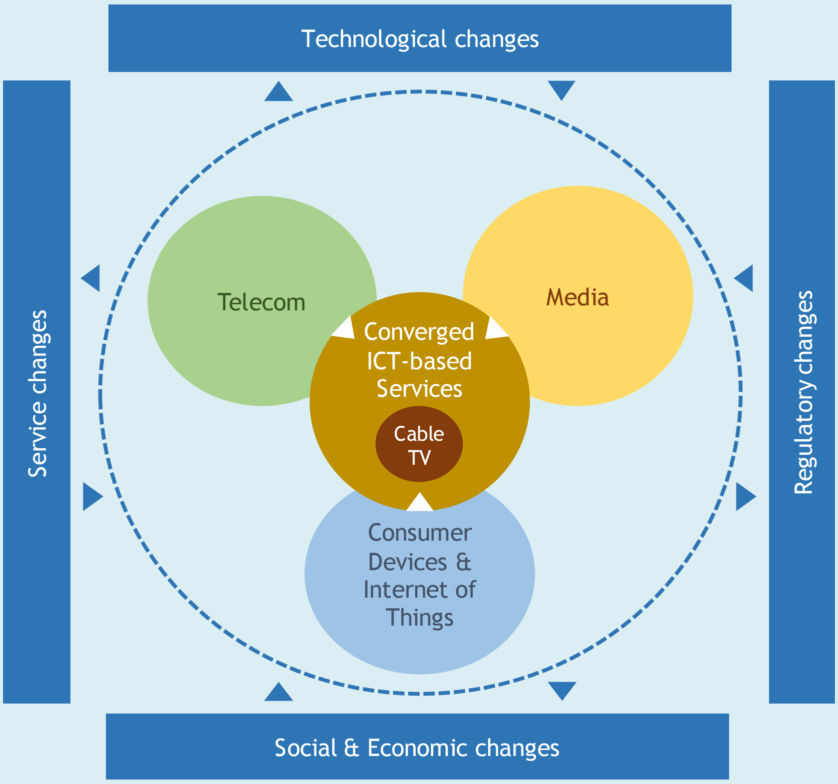
Hence, *the future of Cable TV* cannot be effectively addressed without considering the wider context of ICT convergence. Convergence is the concept that describes the trend of blurring boundaries between the traditionally distinct ICT sectors, namely: the telecommunications, media (including broadcasting) and device (or IT) industry. These blurring boundaries relate to *industry* and *service* convergence.

Traditionally, industries, especially telecom and broadcasting, were segregated in silos as their products and services were complementary and not substitutes, and companies were not integrated across different skill sets and assets. Subsequently mergers (and other forms of collaboration) between telecom and media companies were rarely observed or absent. This is different today. Converged services are offered in a market, comprising content, service and network providers, as well as device manufacturers. Labelling market actors in these categories is becoming increasingly more difficult, as industry convergence results in companies merging or collaborating closely.

Service convergence is especially spurred by technological advances, by digitalisation of data, voice and audiovisual content, as well of transmission platforms. The latter referring to the ever-widening availability of broadband internet. In addition, consumer preferences change due to different work-life patterns and increasing amounts of leisure time and activities. In turn, ICT-based services change to adapt and respond to these changing behavioural patterns.

Governments and National Regulatory Authorities (NRA) have an important role in protecting (members of) society against undesirable developments, in endorsing a proper market development and in stimulating an efficient use of spectrum and other scares resources. A solid regulatory framework, including national legislation and regulatory authorities, is necessary in achieving the objectives.

The concept of ICT convergence is depicted in Figure 1, including the interaction between the converged ICT market place and different external factors; social & economic, service, technology and regulatory changes. Figure 1, also illustrate that nowadays a Cable TV offering is part of a wider service offering.



Source: ITU

FIGURE 1: CABLE TV IN A CONVERGED MARKET

Following Figure 1, this industry paper will address the key technological, service and regulatory changes, observed globally, and where relevant, specifically in Europe (in Chapters 2 to 4). The paper will conclude with the key implications of these observed changes for the Cable TV industry and NRAs by posing several key questions (in Chapter 5). The paper intends to provide a general industry overview, inform on the latest developments and to provide discussion input for the workshop "The Future of Cable TV", to be held on the 25 and 26th of January 2018, Geneva, Switzerland.

1.2 Defining and scoping Cable TV

In this paper, Cable TV network operators are defined as providers of linear television services, part of an integrated service offering, whereby this provider either owns or fully controls the service delivery network infrastructure. Typically, Cable TV network operators would own or control (a form of) a Hybrid Fibre Coaxial (HFC) network.

However, the scope of video services includes many different services, applications and technologies. A general framework, as included in Figure 2, is presented to better understand differences.

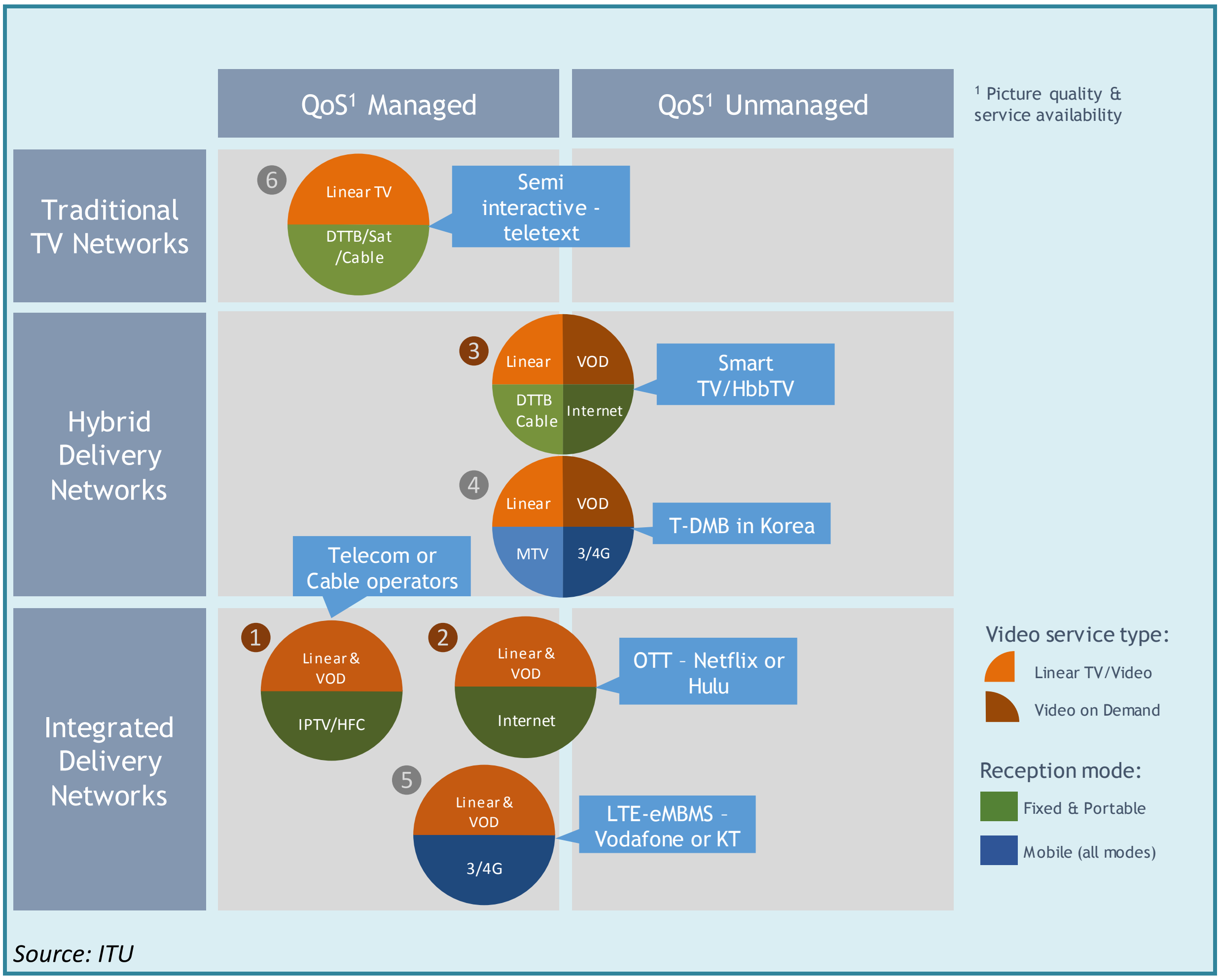


FIGURE 2: FRAMEWORK FOR VIDEO SERVICE DELIVERY

From Figure 2 it can be observed that video services can be split into two basic forms (see the top halves of circles 1 to 6):

1. Linear services: the service provider (or broadcaster) schedules the audiovisual content, plays-out and distributes the audiovisual content accordingly. Linear services are mostly distributed 24 hours a day and 7 days a week (24/7). This category also includes TV services whereby the end-user can temporarily pause and restart the broadcast or can restart the beginning of the broadcast. With this type of 'delay' features the essence of scheduled play-out remains unchanged. Nowadays this functionality sits in the cloud (i.e. storage made available via the Internet) or broadcast network (e.g. IPTV network). Linear services can be offered free of charge[1] or be payment based;
2. Non-linear services or VOD[2]: the end-user determines what audiovisual content (often from a structured content library) and when this content is to be played out. VOD services are

[1] A well-known form is Free-To-Air (FTA) television services, like the Digital Terrestrial Television Broadcasting (DTTB). It should be noted that FTA refers to the content provider or broadcaster not charging the end-user directly. They finance their business based on advertising income and/or licence fees. However, the (cable TV) network operator may charge the end-users for receiving a bouquet of FTA services.

[2] It is noted that near Video on Demand services whereby the content is played out in a carrousel (e.g. the film starts every 15 minutes) can be considered as a linear service. Such services are possible on traditional one-way broadcast networks.

often paid services and providers can dice and slice the video content in many ways and apply different payment arrangements (e.g. Pay per View –PPV or periodical subscriptions) but they leave the end-user in command for scheduling the audiovisual content. These non-linear services also include time shifting the content. Time shifting is intended to view the content at a moment at the viewer's convenience. It can include pausing and rewinding linear television services (i.e. live television) as well as playback of the content after the initial broadcast.

Linear and VOD services can be offered in many commercial arrangements and they don't differ in this aspect. However, they may differ in how service availability and picture quality are managed by the service provider, as part of the Quality of Service (QoS). It is important to note that we focus here on the service levels of the audiovisual service. Two basic forms can be distinguished (see the left and right column in Figure 2):

1. Video services with managed QoS: in this category, the *service provider* manage and offers end-users (minimum) picture quality and service availability levels. The classic example is a Public Service Broadcaster (PSB) that distributes its television service over its own terrestrial broadcast network. It is also possible that the service/content provider distributes over third-party networks. The service/content provider agrees the (minimum) service levels with the network operator in a distribution agreement or contract. Such a contract may include guaranteed service levels whereby a form of financial compensation is agreed in case of underperformance;
2. Video services with unmanaged QoS: the service/content provider does not manage service levels to end-users. An example that falls in this category is content providers offering their audiovisual content over the Internet (i.e. OTT). The Internet Service Provider (ISP) or mobile network operator offering the Internet access to the end-user, does manage service levels (such as service availability). However, the ISP or mobile operator does not actively manage picture quality and service availability, specifically for the individual service/content provider.

Lastly, video services can be carried by different technical platforms. There are two basic forms (see bottom half of the circles in Figure 2):

1. Traditional broadcast networks: these networks are specifically designed and deployed for distributing audiovisual services. They are based on international transmission standards (such as ATSC, DVB, ISDB and DMB) and are essentially one-way networks. They can offer a semi-interactive component by broadcasting content in carousels (for example Teletext). They can be wired and wireless, including respectively coax cable networks and satellite, terrestrial and mobile networks;
2. IP-based networks: these networks route traffic (i.e. data) over routers to addressable end-user equipment. These networks are two-way (i.e. duplex) and switched networks whereby traffic is managed by IP protocols. The data can represent audiovisual services. They include networks like HFC and IPTV networks but also the Internet as offered by ISPs. Again, they can also be wireless like third and fourth generation (3G/4G) mobile networks (based on international standards like UMTS and IMT/LTE). Also, the future IMT-2020 (5G) mobile networks will be included[3].

[3] IMT-2020 (5G) aims to facilitate future developments such as Internet of Things (IoT), and more specifically in the media industry, the mass delivery of video content with ultra-high definition (8K). For more details on the IMT-2020 (5G) design criteria and implementation issues, see ITU-T Focus Group IMT 2020 Deliverables, dated

These platforms come with different end-user equipment (or one could say with different network terminating equipment). The traditional broadcast networks require transmission standard compliant receivers such as Set Top Boxes (STB) or handsets. For IP-based networks the range of end-user equipment is much wider and range from smart phones, tablets, phablets, laptop/desktop computers and game consoles. However, receivers from both platforms can be integrated into one single device, combining broadcast and IP functionality. The two most prominent examples are connected TV sets and mobile phones with broadcast receivers[4].

The focus of this industry paper is on the service and platform combinations 1, 2 and 3 (see brown labelled numbers in Figure 2), i.e. video service delivery on respectively:

1. Integrated delivery networks with fully managed QoS (IPTV and HFC);
2. Integrated delivery networks with partly manage QoS (OTT service delivery over Internet);
3. Hybrid delivery networks (Smart TV/HBBtv).

2 Technology and standard trends

This Chapter provides and overview of the key technological trends and standards for wired networks carrying video services, as part of an integrated service offering. Also, connected TV and Ultra High Definition Television (UHDTV) will be addressed as specific developments for high quality video delivery.

2.1 Increasing bandwidth capacity

As stated in the Introduction, Cable TV network operators deliver video services as part of an integrated service offering, including broadband access and value-added services based on this access. All internet traffic forecasts show that the demand for bandwidth will continue to grow, driven by high quality video delivery, increasing numbers of (mobile and fixed) smart devices and the rise of IoT[5]. Hence, not only for providing high quality video delivery, but also for the delivery of broadband access and related services, a state-of-the-art delivery network is a must-have.

In upgrading delivery networks, the most challenging business decision is to replace the existing local loop (either twisted pair of coaxial cable) for fibre or enhancing the existing local loop infrastructure. A solid business case should form the basis for such a decision, considering the costs of each option and what future services would be requiring what bandwidths. Such a business case can vary considerably between local markets, depending on factors such as the technical state of the current infrastructure, geographical population spread, smart device penetration, as well as ability/willingness-to-pay factors.

The following three paragraphs illustrate the technological advances made in the deployment of twisted pair and coaxial cable, as well as in the deployment of optical fibre.

2017. For an overview of what IMT-2020 (5G) aims to deliver over IMT-Advanced (4G), see ARCEP report "5G: issues and challenges", dated March 2017, p12-13.

[4] ISDB-T and DMB-T enabled mobile phones are widely available in Japan and Korea respectively. The ISDB-T based (NOTTV) service was however discontinued in September 2016. DVB-H enabled mobile phones were available in Europe but services have been discontinued. DVB-T2 Lite is a newly developed standard for delivering mobile television services to mobile phones and tablets. Also, Digital Audio Broadcasting receivers are integrated in mobile handsets, such as the LG Stylus smartphone.

[5] See for example ITU/UNESCO Broadband Commission report "The state of Broadband", September 2017, or Cisco's annual Visual Networking Index (VNI) Forecasts from www.cisco.com VNI online tool, December 2017 or for mobile internet Ericsson's annual Mobility Reports, June 2017.

2.1.1 Enhancing twisted pair

The most commonly applied technology in copper wired (or twisted pair) access networks is xDSL, where 'x' stands for the various forms of Digital Subscriber Line technology. The family of xDSL technologies includes a wide range of standards and profiles, enabling higher traffic speeds over local loop copper wire. Table 1 shows an overview of the main xDSL technologies and their specifications.

TABLE 1: MAIN xDSL TECHNOLOGIES

	VDSL2	ADSL2+	SHDSL	HDSL
Transmission mode	Asymmetric & Symmetric	Asymmetric	Symmetric	Symmetric
Pairs of copper	1	1	1 & 2	1,2 or 3
Frequency band	12MHz to 30 MHz (down & up data)	0,14MHz - 2.2 MHz (down/data)		196KHz
Modulation	DTM	QAM	TCPAM	CAP /2B1Q
Bitrate (down/up)	Up to 200Mbits/s bidirectional	12 Mbit/s up to 24Mbits/s and 1 Mbit/s up to 1,4Mbit/s	Up to 5,7Mbit/s (single pair)	2Mbs bidirectional
Reach	<2.5 km	<1.5km	<3Km	<3.6km
ITU standard	ITU-T G.993.2 (Nov 2015)	ITU-T G.992.5 (Jan 2009)	ITU-TG.991.2 (Dec 2003)	ITU-T G.991.1 (Oct 1998)

From Table 1 it can be observed that only VDSL2 is prepared for high quality video services like UHDTV (see also Section 2.3.2), requiring speeds of 40 to 50 Mbit/s. For improving the performance of xDSL, bonding, vectoring and phantom mode techniques are applied[6]. Only bonding and vectoring are briefly outline below to illustrate the possibilities.

Channel bonding may be used to combine multiple wire pairs, increasing available capacity or extending the copper network's reach[7]. Channel bonding is applicable to any physical layer transport type (e.g. VDSL2, ADSL2, SHDSL, etc.). The xDSL bonding, allows a network operator to aggregate multiple xDSL lines, into a single bi-directional logical link, carrying Ethernet traffic. This transport is transparent to the subscriber who sees a single connection. Table 2 shows the performance improvements that bonding over copper lines (two pairs) can achieve.

[6] Transmission technologies are to move closer to the theoretical channel capacity given by the Shannon theorem, either by reducing noise and/or applying modulation schemes.
[7] Defined in ITU-T G.998.x

TABLE 2: BONDING GAINS AND DISTANCE

Distance (in metres)	**Gain**
0-1,000	40 Mbit/s to 80 Mbit/s
1,500	30 Mbit/s to 60 Mbit/s
2,250	10 Mbit/s to 20 Mbit/s
3,150	5 Mbit/s to 8 Mbit/s
> 3,750	Minimal to none

Vectored VDSL2 is a technology that offers a new alternative for further improving copper line performance by reducing the noise or crosstalk, by anti-phase signalling[8]. Vectoring is particularly beneficial with short cable lengths (< 1 km) and is applied on sub-loops and local loops. Crosstalk is the main reason why lines in the field perform significantly lower than their theoretical maximum. Vectoring may re-utilise existing resources at the street cabinet or Digital Subscriber Line Access Multiplexer (DSLAM) infrastructure. Consumer equipment needs some adaptations/replacement as stipulated by the ITU-T G.993.5 vectoring standard.

Vectoring is a CPU intensive process and it needs to measure constantly noise in all lines together and is therefore limited to a certain number of lines that can make part of the vectoring process (a few hundreds of lines). The most important aspect of vectoring resides in the fact that all lines should be part of the vectoring system. If not, performance drops considerably. For example, at a loop length of 400 metres and only 60% of the lines controlled, performance could drop up to 60%. This full control over all lines, may have implications for regulatory provisions addressing the unbundling of the local loop[9].

2.1.2 Enhancing coaxial cable

The main advantage of HFC networks is that they are capable of high asymmetric data traffic rates. The DOCSIS specification is a set of ITU recognized standards (ITU-T Recommendations) allowing asymmetric high-speed data transfer on existing cable TV systems[10]. It uses efficient modulation, coding and multiplexing techniques[11]. The DOCSIS standard is used in Europe, USA and Japan with different specifications and different frequency band use[12]. Broadband and broadcast capacity may be shared on the same cable and operators should balance network capacity between the different services. Operators could also choose to convert broadcast service delivery to be facilitated in an all-IP based network structure to provide all broadband services[13]. The evolution of DOCSIS and its future development is shown in Table 3.

[8] Defined in ITU-T G.993.5.

[9] Unbundling requirements aim to provide access for third parties to local loop infrastructure.

[10] ITU-T J.83 (12/2007 and annexes A, B, C, and D) distinguishes between European and US implementations. See also the Recommendation ITU-T J.222 (2007) DOCSIS 3.0.

[11] Quadrature amplitude modulation (QAM), Orthogonal Frequency-Division Multiplexing (OFDM) and low-density parity-check (LDPC) codes.

[12] European Cable TV network operators use a modified version of DOCSIS 3.0 (i.e. EuroDOCSIS) that reflects the standard 8 MHz channel raster applied in Europe. EuroDOCSIS provides higher downstream rates than in the USA or Asia, where 6 MHz channels are typical. Also, EuroDOCSIS commonly uses DVB-C for downstream broadcasting.

[13] From DOCSIS 3.0 and onwards, IPv6 is also supported.

TABLE 3: DOCSIS 3.X SPECIFICATIONS

	DOCSIS 3.0 standard	DOCSIS 3.0 phase 1	DOCSIS 3.1 phase 2	DOCSIS 3.1 phase 3
Download speed	300Mbit/s (54-1002 MHz)	1Gbit/s (108-1002 MHz)	5Gbit/s (300*-1152 MHz)	10Gbit/s (500*-1700MHz)
Upload speed	100 Mbit/s (5 – 42 MHz)	300 Mbit/s (5-85 MHz)	1Gbit/s (5-230* MHz)	2Gbit/s* (5-400* MHz)
No. of channels (down/up)	8/4	24/12	116*/33*	200*/55*
QAM scheme (down/up)	256/64	256/64	≥1024/256	≥1024/256
*To be determined				

The bandwidth performance, as shown in Table 3, are based on the result of applying more efficient signal modulation, error handling and encoding. In addition, a more efficient spectrum use is applied in the higher frequency ranges. However, full duplex communication is nowadays restricted, and the upload speed is considerably lower in comparison to the download speed[14]. In 2016 several commercial DOCSIS 3.1 deployments were completed in the USA, Europe, Australia and New Zealand.

It should be noted that DOCSIS 3.1 employs many of the technologies as applied in the DVB-C2 standard for downstream broadcasting services[15]. Spurred by the arrival of the HEVC (or ITU-T H.265) encoding technology (see also Section 2.3.2) and many network operators following an all-IP strategy, it is debated whether DVB-C2 should still be applied within a DOCSIS deployment or that the DVB-C2 (PHY) should be consolidated in the DOCSIS standard.

2.1.3 Deploying optical fibre

Optical fibre, with its unsurpassed data traffic speed of 100 Gbit/s on a single strand of glass fibre in operational settings, is considered particularly suitable for backbone networks (for trunk and long distance inter-city transmissions). However, as fibre deployment costs are dropping, both in CAPEX and OPEX terms, optical fibre is expanded into access networks. In IDI developed countries[16], fibre is increasingly applied for residential access. In these fibre deployments both active and passive fibre is used. The main differences between the two are shown in Table 4.

[14] In laboratory settings, full duplex on HFC has been demonstrated using DOCSIS 3.1, for example by AT&T and Nokia.

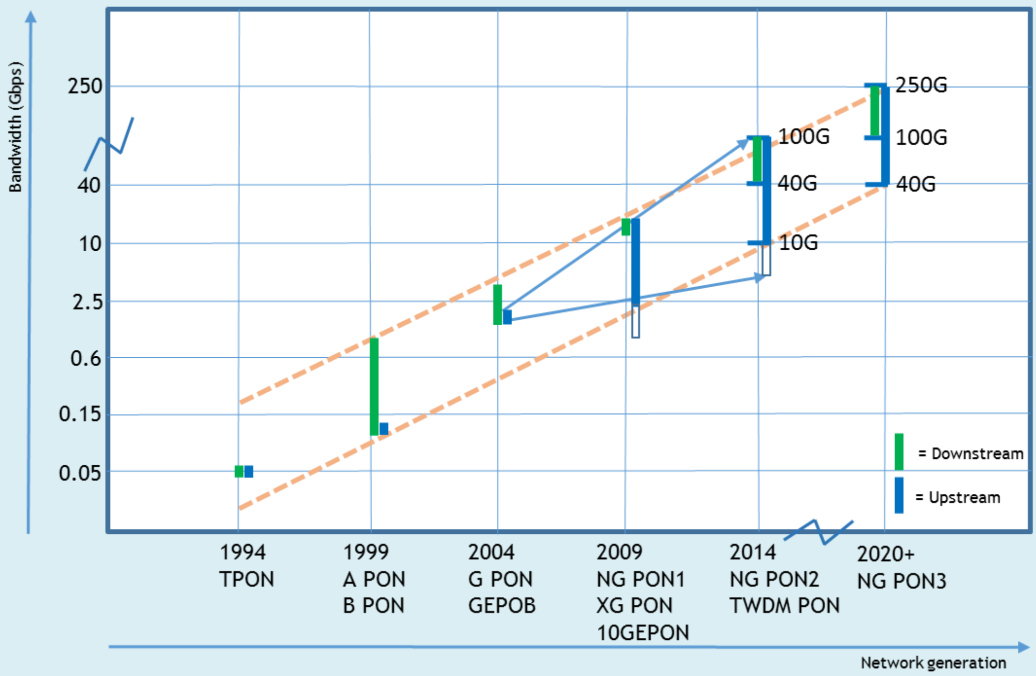
[15] Such as OFDM (Orthogonal Frequency Division Multiplexing and LDPC (Low Density Parity Check) coding for Forward Error Correction (FEC).

[16] IDI developed countries are defined in ITU's annual reports "Measuring the Information Society", see the ICT Development Index (IDI), June 2017.

Table 4: Main specification of Optical Fibre

	Active Optical Fibre	Passive Optical Fibre
Main Data traffic management components	Amplifiers, routers, switch aggregators	Splitters
Powered components	Ends and middle	Ends
Subscriber line	Dedicated	Shared
Suitable Distances	Up to 100 Km	Up to 20 Km
Typical Application	Business/core network	Residential
Building & Maintenance costs	High	Lower

Figure 3 illustrates a forecast and its expected range of the available bandwidth of Passive Optical Network (PON) technology for both upload and download traffic.



Source: ITU

Figure 3: Trend of bandwidth and traffic speeds for PON

Today the deployment of fibre infrastructure is based upon the standards Gigabit Passive Optical Network (GPON), New Generation Passive Optical Network (NG PON 2) and 10-Gigabit-capable passive optical network (XG PON). They may coexist on the same physical line as they use different spectrum ranges. Gigabit PONs such as G-PON (ITU-T G.984.x series) and 1G-EPON (b-IEEE 802.3) have been standardised and are now being deployed worldwide. The performance specifications of the XG and NG PON are shown in Table 5.

Table 5: Main specification of XG PON and NG PON

	XG PON	NG PON2
ITU standard	ITU-T G.987.1 (03/2016)	ITU-T G.989.2 (12/2014) and (04/2016)
PON Wavelengths	1 down/up	Up to 8 down/up
Bandwidths	10 Gbps/10 Gbps	10 Gbps/10Gbps per pair or 10Gbps/2,5 Gbps[17]

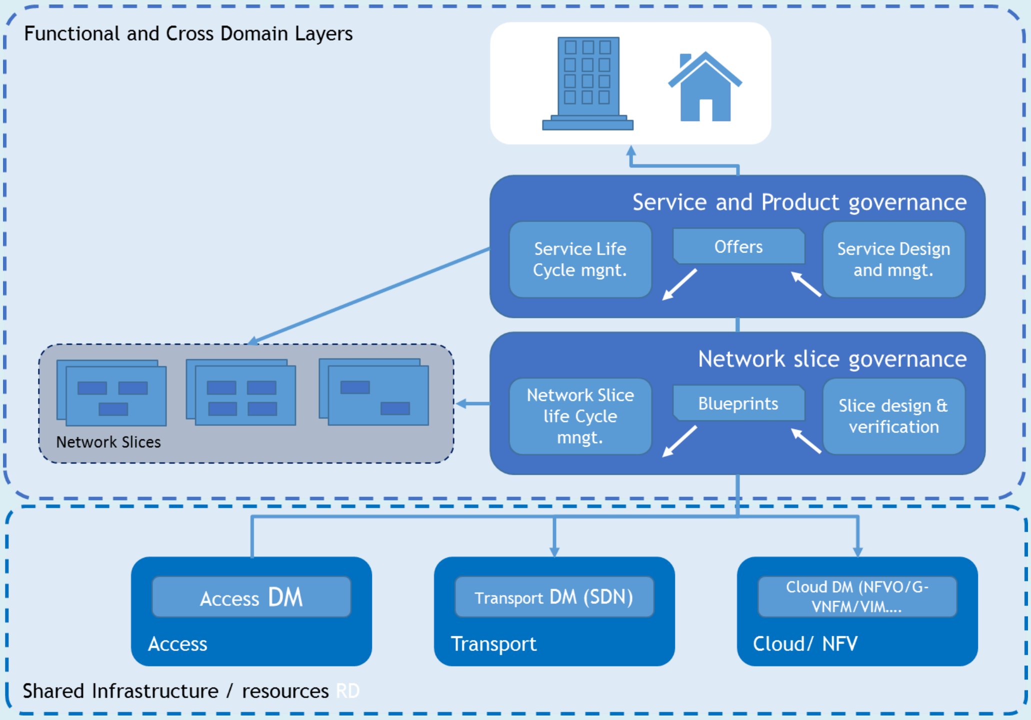
2.2 Future network concepts

In future network concepts, wired and wireless communications[18] will use the same integrated network protocols[19]. Future network concepts provide a holistic network management view, on a common resource pool independent form the underlying transport technologies. The following two key network management aspects are included in these new concepts[20]:

1. *Network Function Virtualisation* (NFV) and *Software Defined Networks* (SDN) allows networks functions and components, like Evolved Packet Core (EPC), PDN gateway (PGW) and the policy control resource function (PCRF), to operate in a virtualised environment independently from proprietary hardware. These functions and components could share commodity type hardware resources in cloud based environments. It will allow operators to deploy new services and technologies in a more rapid, flexible and scalable manner, thus reducing costs;
2. *Network slicing* allows operators to create parallel networks according to the required service in the same network infrastructure. For example, a network slice could be dedicated to Machine-to-Machine (M2M) traffic while another slice could be dedicated to public safety services or digital radio and television services. Using network slicing, it is possible to run these slices over the same physical infrastructure with adjustable network parameters concerning security, QoS, latency and throughput for each instance/slice. This slicing principle can be applied on network core components, antennas, base stations and consumer equipment. Software upgrade of a network instance/slice becomes easier, as the new software upgrade can be tested in parallel in a virtual server environment, by taking a snapshot of the running configuration and hence not effecting the operational slice.

Figure 4 provides an overview of virtualisation of network functions for different service offerings and consumer domains, sharing common resources.

[17] NG PON 2 is supporting up to 80Gbit/s symmetrical bandwidths through channel bonding.
[18] Including new satellite networks such as High Throughput Satellite (HTS) systems using multiple spot beams for providing higher network speeds.
[19] The concept of Future Network is defined by ITU-T Y.3001.
[20] It is noted that these network management aspects are also part of the design criteria for IMT-2020 (5G). See for example, ITU-T Focus Group IMT 2020 Deliverables, dated 2017.



Source: Ericsson technology review 2016

FIGURE 4: NETWORK FUNCTION VIRTUALISATION AND SLICING

For the development of IoT services, such as smart metering, smart cities and connected vehicles, the above described network management aspects are critical. Allowing the deployment of a wide range of IoT services and their use both in stationary and mobile settings. Also, the economic sustainability of new IoT services is dependent on the industry's capacity to leverage existing network infrastructure and collaboration between the different industry stakeholders.

NFV and SDN developments clearly facilitate outsourcing of network functionality and management to third parties, and more specifically to third parties with system integration skills. In this way network costs shift from investments (CAPEX) to operational costs (OPEX). It may as well result in Cable TV network operators moving away from network ownership and management. A similar trend as was observed in the telecom industry several years ago, when incumbent telecom operators outsourced their network assets and management.

2.3 Connected TV and UHDTV

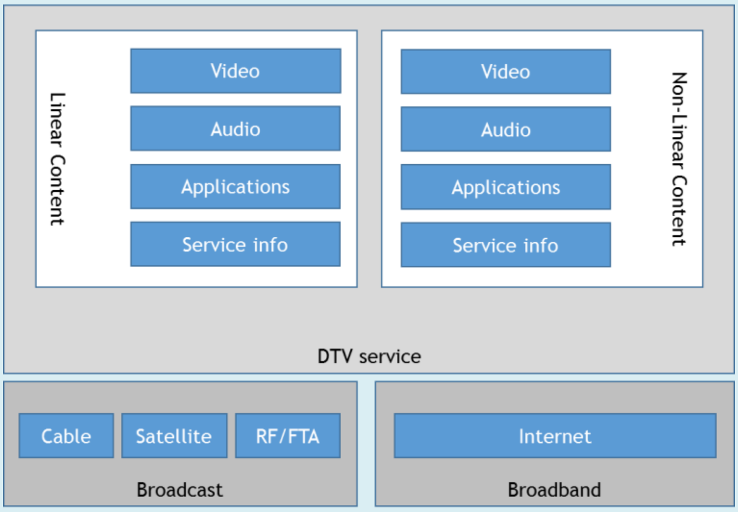
This section addresses connected TV and Ultra High Definition Television (UHDTV) as specific developments for high quality video delivery in a converged market place.

2.3.1 Connected TV and the IBB concept

Connected TV sets are either:

1. Integrated connected TV sets, whereby the functionality to access the Internet is built into a single device or set (i.e. the smart TV set), or;
2. TV sets with an external device, often connected to the TV set through the USB port, which provides access to the internet (i.e. TV sets with dongles, such as the Chromecast from Google, the Roku stick or Amazon's Fire TV stick).

The combination of broadcast and broadband technology is considered a natural development because this combination has the potential advantage of providing both efficient mass content delivery and personalised services. At the same time, combined use of broadband may bring complexity of the system and its usage due to its very wide capability and flexibility. Hence Integrated Broadband Broadcasting (IBB) systems are more than an addition of another delivery channel. Figure 5 shows an overview of the principle of IBB systems.



Source: ITU

FIGURE 5: IBB CONCEPT

The establishment of a unified IBB standard means that content owners and application developers can write once, for any smart TV set and deploy their services across countries. Unfortunately, there is no global IBB standard (yet). The broadcast industry, together with the TV set producers, developed standards and TV-apps for implementing the IBB concept on connected TV sets. It is important to note that with these solutions the remote control of the TV set is the main navigating tool. There are three standards defined and they have a growing number of applications and users:

1. *HbbTV*: The standard(s) is developed by the 'HbbTV Association'[21] and published by European Telecommunications Standardisation Institute (ETSI). The HbbTV Association was established in 2009. Hence the standard has been available for over eight years and with the migration from analogue to digital broadcasting its application is on the rise. A wide variety of HbbTV services and applications have been deployed, including service like VOD, catch-up, start-over, information services, Electronic Program Guide (EPG) and shopping services. Several commercial and public broadcasters have developed HbbTV-based services, including leading European broadcasters (like Antenna Hungária, ARTE, M6, NPO, NRJ, RTVE, TF1 and ZDF) but also Freeview in Australia[22];
2. *Hybridcast*: The Japanese public broadcaster (NHK) launched the new integrated broadcast-broadband service "Hybridcast" in September 2013. Hybridcast enhances a broadcasting service with broadband, like the other systems. NHK started with offering the HTML5-based

[21] A Switzerland based not-for-profit organisation, for more details see https://www.hbbtv.org/
[22] Freeview is an industry association of all FTA broadcasters on the digital terrestrial television platform in Australia intended to compete, with a unified marketing and programming effort, against subscription television.

application for providing detailed and useful content such as latest news, weather, sports, and financial information;

3. *ICon*: The South Korean public broadcaster (KBS) launched iCon, or Open Hybrid TV (OHTV) in the country in March 2013. ICon is the first terrestrial hybrid TV service in South Korea. The service includes EPG, program search, video clip search, voting, etc. The standard also aims at integrating digital (terrestrial) television services with broadband interactivity, like the two previously discussed standards.

Nowadays, most television broadcasters have extended the IBB concept, to also provide apps for smartphone and tablets to facilitate '*second screen*' functionality (like participating in games, surveys, providing feedback and more detail background information), whilst watching the main television screen.

The TV dongles (like Chromecast, Roku, Fire TV) have a different approach to the implementation of the IBB concept. The basic idea is to move interactive content from the small screen to the big screen (i.e. the TV set) and to introduce a second screen on the television screen. The latter, allowing multiple viewers to introduce a second screen with interactive content on the main television screen (for example to display additional information on the football game or documentary). With these TV dongles, the navigation tool is the individual smart phone (of each viewer).

These TV dongles use their own proprietary TV-apps to arrange for navigation and interactivity. In other words, these dongle providers compete with the three industry standards as listed above. Subsequently, the dongle providers must negotiation with (FTA) broadcasters to have their dongle capabilities embedded in the broadcasters' TV-apps, as to allow for a seamless experience between the broadcaster's content and the interactive content brought in by the dongle.

2.3.2 UHDTV and encoding

The application of the High Definition (HD) format is currently the industry standard. For future developments, the uptake of Ultra High Definition (UHD) should be considered; UHDTV 1 and 2. Table 6 provides an overview of the different picture formats[23].

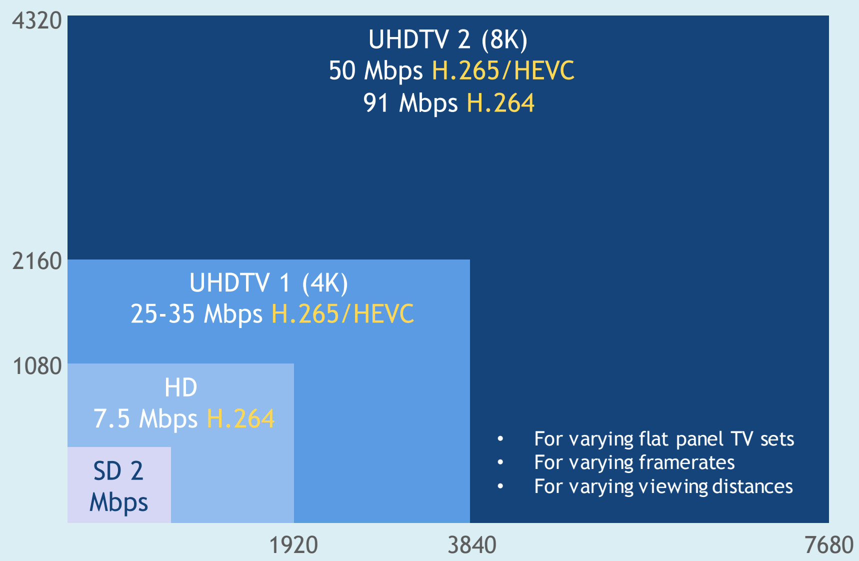
TABLE 6: DIFFERENT PICTURE FORMATS

Format	Alterative Name	Picture Ratio	Picture Resolution (in Megapixel)
HDTV	2K	1920 x 1080	~ 2
UHDTV1	4K	3840 x 2160	~ 8
UHDTV2	8K	7689 x 4320	~ 32

The technological challenge to deliver UHD services is to increase transmission capacity (see Section 2.1) and video encoding efficiency. Video encoding is used to reduce the amount of data to be transported over any transmission platform, whilst maintaining the *perceived* picture quality. Especially for terrestrial platforms encoding efficiency is key because spectrum is scares (and hence transmission capacity). Also for OTT delivery, encoding efficiency is critical as broadband capacity varies significantly between regions and countries. Figure 6 shows the picture ratio and required

[23] See ITU-R Recommendation BT.2020: Parameter values for ultra-high definition television systems for production and international programme exchange, October 2015.

capacity (net bit rate) for SD, HD and UHD services with the application of either the ITU-T H.264 (or MPEG-4 AVC) or ITU-T H.265 (or HEVC) standard[24].



Source: ITU

FIGURE 6: HD AND UHD NET BIT RATE REQUIREMENTS

From Figure 6 it can be observed that the required transport capacity is high for UHDTV services, even with the most efficient encoding technology available today (ITU-T H.265). With the current 2nd generation DVB standards a practical net bit rate can be realized of approximately 40 Mbit/s in the case of DVB-T2[25]. This would entail that one UHDTV 1 service can be carried in one multiplex, which equals to one frequency (of 8 MHz wide) per site. For DVB-C2, depending on the modulation scheme, a maximum net bit rate is available between 51 Mbit/s (256-QAM) and 80 Mbit/s (4096-QAM) in an 8 MHz channel[26]. For DOCSIS 3.1 the spectral efficiency is assessed to be between 57 and 64 Mbit/s for 8 MHz bandwidth[27]. Consequently, on a cable system with either DVB-C2 or DOCSIS 3.1, one UHDTV 2 service can be carried in one 8 MHz channel (with ITU-T H.265 encoding)[28].

OTT providers, like Netflix, are offering 'UHD' services over broadband internet (mainly in Europe and the US). It should be noted that the growth of these UHD services will be dependent on bandwidth availability. The bandwidth requirements are stated to be 15 Mbit/s, being twice the average bandwidth available to many US broadband households today. In addition, it can be claimed that 15 Mbit/s is not enough to provide a true UHDTV/4K service. 40-50 Mbit/s is more an acceptable rate

[24] Is noted that not only picture ratio or resolution determines the required bit rate but also colour definition and framerate.
[25] The net available bit rate is dependent on the system variant selected and in its turn, depends on the required reception mode/robustness. The given value is a practical value, as for example applied in the UK.
[26] See DVB document A147, DVB-C2 implementation guidelines, August 2015.
[27] See Arris document, the spectral efficiency of DOCSIS 3.1 system, 2014.
[28] In comparing the DVB-T2 and DVB-C2/DOCSIS 3.1 figures, the spectrum availability should be considered which tends to be far more restricted for terrestrial systems. Especially in Europe, where the 700 MHz band is vacated for IMT/LTE mobile systems.

for true UHDTV/4K, under the assumption that at the receiver side ITU-T H.265 is used (see also Figure 6).

This trend for higher picture resolution is mainly driven by the production of flat TV panels for viewing at home. The sales forecasts for UHDTV sets are promising, despite the lack of content and distribution. The absolute UHDTV sales numbers are still relatively low when compared to the current global sales of around 250 million sets (all TV sets). However, for the device manufacturer investments in R&D and production lines are already sunk costs and with dropping price levels consumers seems to be bound to adopt UHDTV.

For smart phones and tablets, the required bit rate for *perceived* high picture quality is significantly lower due to the smaller screen size. Consequently, in the mobile industry lower picture ratios are applied. Table 7 shows an indication of the required bit rates for the various picture ratios, ITU-T H.265 encoded[29]. As noted before, the required bit rate is subjective and dependent on the type of content ('talking heads' or 'football'), colour definition and framerate.

TABLE 7: TYPICAL BITRATES FOR ITU-T H.265 ENCODING AND DELIVERY AT MOBILE DEVICES

Picture Ratio	Typical Bitrate (Kbit/s)
640 x 480	250
960 x 540	600
1280 x 720 (SD)	700
1920 x 1080 (HD)	1,000

Also for the mobile environment, next to technologies such as eMBMS[30] on LTE networks, ITU-T H.265 encoding is critical for OTT delivery of high picture quality services. Consequently, mobile handsets should be available supporting either ITU-T H.265 and/or eMBMS. As eMBMS requires a LTE-Advanced (LTE-A) network, the handset requirement is really LTE-A[31].

3 Service and business trends

This Chapter provides an overview of the key service and business trends for HFC, IPTV and OTT-based video delivery, as part of an integrated services offering.

3.1 OTT QoS on-par with HFC/IPTV

HFC and IPTV networks are in terms of system architecture and transmission protocols practically the same. The key difference between the two network types is the physical layer. HFC networks are developed on coaxial network, whereas IPTV networks have twisted pair (or copper) networks as their basis. Coaxial cable or twisted pair is used to terminate the traffic at the consumer premises (i.e. the last mile), whilst in the core network fibre is commonly used in both network types.

IPTV primarily uses the User Datagram Protocol (UDP) based multicasting Internet Group Management Protocol (IGMP) for live television broadcasts. For on-demand content, like VOD, the

[29] Source: KBS, the public broadcaster in South Korea.
[30] eMBMS is a broadcast function within an LTE network whereby dynamically a part of the available bandwidth can be switched from unicast to broadcast mode, in selected cells of the network.
[31] LTE-A allows for bandwidth aggregation, necessary for having enough capacity for eMBMS-based services. Furthermore, the introduction of eMBMS entails for the handset that software must be downloaded to a LTE-A enabled device.

unicasting Real Time Streaming Protocol (RTSP) is applied. HTTP (Hyper Text Transfer Protocol) is also used to communicate with the network servers for data transfer. Compatible video compression standards include MPEG-2, MPEG-4/ ITU-T H.264 and HVEC/ ITU-T H.265.

With IPTV network deployments, network security and QoS are tightly managed by the service provider, who also controls the network. Management of QoS is accomplished by actively managing the traffic volumes allocated to each service category (i.e. television, VOD, voice and data). As the network operator and service provider are commonly one entity (e.g. the cable network operator or the incumbent telecom operator), the service provider can guarantee the QoS to its end-users/clients. In technical terms, these QoS levels are geared around video picture quality and service availability.

As with HFC/IPTV networks, broadband internet networks are also IP based. However, OTT delivery differs from HFC/IPTV as it transmits streams using HTTP, the protocol which has been used for decades to transport web pages over the internet. In turn HTTP is based on Transmission Control Protocol (TCP), a connected transport protocol. A TCP connection can be easily managed through firewalls, Network Address Translation (NAT) systems, home and office networks. It also enables anyone with sufficient web hosting capacity to broadcast audio and video content to a worldwide audience over the open internet.

HTTP has traditionally been used as a transport solution for VOD media embedded into web pages, especially on Adobe Flash-based sites, such as YouTube. However, this solution does not stream in real-time, but instead relies on progressive downloading media files. The browser downloads the file from the HTTP web server and when it has a sufficient amount of data, starts to play the content while it continues to download the rest of the file. The main drawback of this approach is the length of time it takes to fill the initial buffer. Another issue associated with HTTP is streaming quality, which depends on the IP connection. Content streaming may be subject to stalling if there are fluctuations in bandwidth, leading to frame freezing. Consequently, it was nearly impossible to use this solution to broadcast live television services.

However, with the arrival of new streaming solutions it is now possible to stream high quality live broadcasts over HTTP. The two main technical components, when it comes to effective OTT delivery, are Adaptive Bitrate (ABR) and Content Delivery Networks (CDN). ABR technology is used to stream videos securely and smoothly across multiple networks[32], whereas CDNs are used to deliver content to various browsers, set-top boxes, mobile devices, etc., quickly and in a cost-effective manner.

For OTT service delivery, service provisioning and network operations are commonly separated and the QoS management is more challenging. In the case of OTT service delivery, the network operation is carried out by third parties (Tier-1 network operators and ISPs) and these entities only guarantee the QoS of the data delivery (i.e. the availability and bandwidth of the ‘data pipe’) and not per service (i.e. video service).

Recent developments show however that OTT service (or content) providers (like Netflix, Hulu or Amazon Prime Video) agree with ISPs that their services have priority over other traffic, as to ensure that a minimum broadband speed is made available to their subscribers[33]. Under these agreements a financial compensation for the ISP is agreed. In this way, the OTT content providers can offer their

[32] ABR streaming ensures that video streaming continues, provided a minimal bandwidth is available and that at any given time video is delivered at the best possible quality.
[33] It is important to note that for ISPs guaranteeing QoS per service, net neutrality regulations should be considered (see Section 4.2).

subscribers packages with different picture quality levels (e.g. 'Silver' for HDTV/2k and 'Gold' packages for UHDTV/4k).

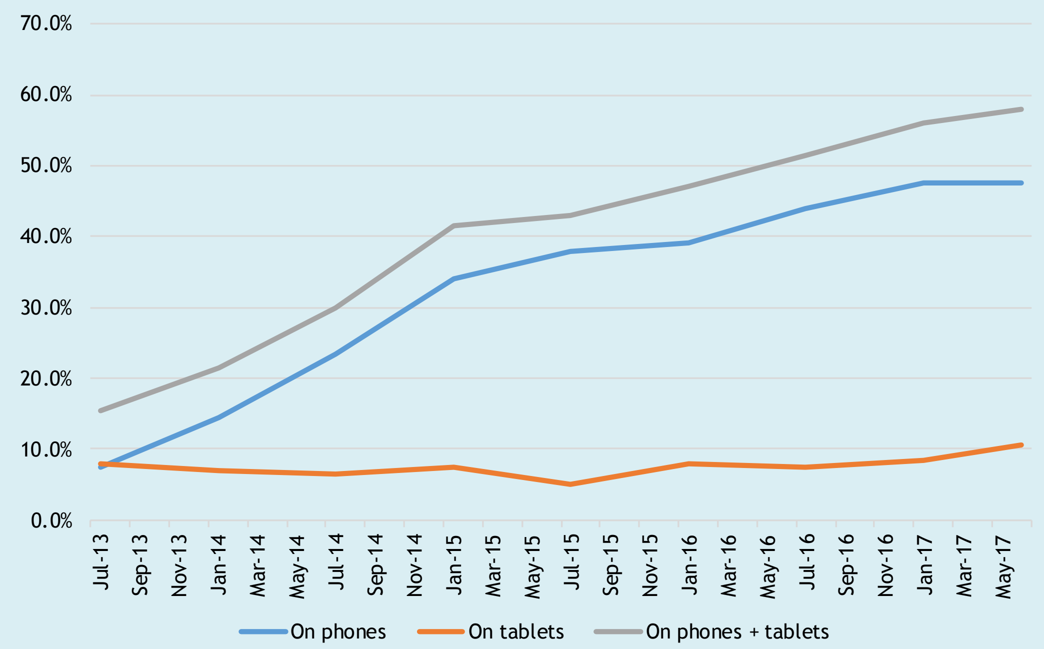
It could be easily argued that these content providers move towards audiovisual services with managed QoS and that these services are no different from television services over HFC/IPTV networks. This trend is also depicted in Figure 2, HFC/IPTV and OTT-based video delivery are in the same segment.

3.2 Service anywhere and anytime

With the widespread availability of broadband Internet (see Section 2.1) and powerful connected devices, users can consume their VOD and linear TV services anywhere and anytime. These developments gave also rise to OTT delivery (see Section 3.1) and redistribution concept like the Slingbox[34].

The trend of consuming video services anywhere and anytime, is reflected in video downloading or streaming by consumers on connected devices. Figure 7 shows, of all videos played on connected devices (i.e. desktops, smartphones, tablets and connected TV sets) the share of time played on mobiles and tablets. The share of time played on mobile phones has steadily increased over the past four years (July 2013 to June 2017). In June 2017, smart phones made up most of all video plays on connected devices, about 48%, whilst tablet plays made up about 11%. The rest of the videos played are on other connected devices, such as connected TV sets and desktops.

[34] The Slingbox or the Sling-enabled Digital Video Recorder (DVR) from DISH Network, streams a (paid) television service, received at home, over the internet to anywhere in the world where the end-user logs in with any IP connected device.



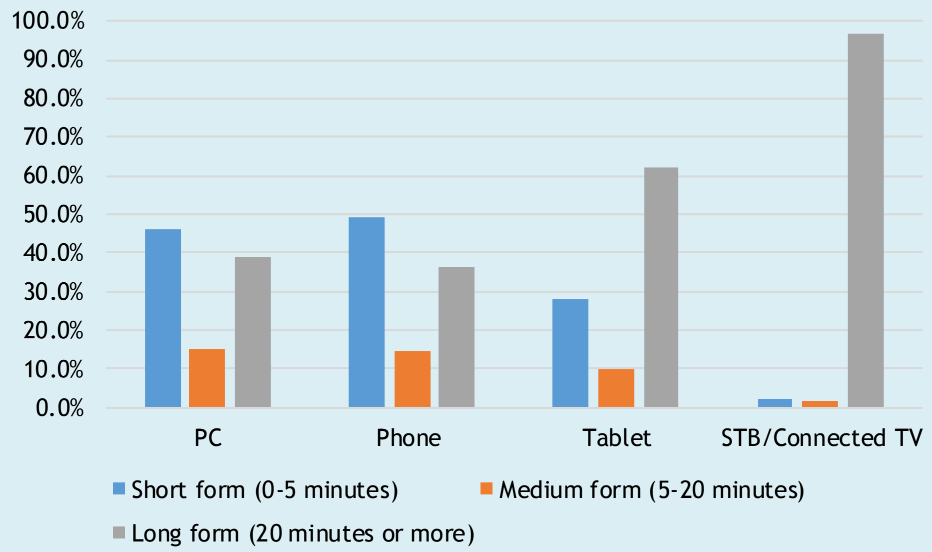
Source: OOYALA Global Video Index Q2 2017, adapted

FIGURE 7: SHARE OF TIME PLAYED ON MOBILES AND TABLETS

In addition, it is important to recognize the different types of video services played on the various connected devices. Video services can be broken down into the following sub-categories:

1. Short form (0-5 minutes): video clips, streamed or downloaded (like offered on YouTube);
2. Medium form (5-20 minutes): video clips, streamed or downloaded;
3. Long form (20 minutes or more): live television (like sports, news, etc.), catch-up TV, including full episodes of television shows and films (like offered on Netflix or Hulu).

Figure 8 shows the share of time watched (or streamed) by device type and the video length (or streaming session duration).



Source: OOYALA Global Video Index Q2 2017, adapted

FIGURE 8: TIME WATCHED AND VIDEO LENGTH BY DEVICE TYPE

Figure 8 shows that for (linear) television and film services (like Netflix and Hulu), having streaming sessions of over 20 minutes, the connected TV set is the key delivery platform. In contrast, mobile smartphones are mostly used for short form video (49% of all videos watched on mobiles are short form video).

The anywhere-and-anytime trends shows that Cable TV network operators cannot offer their services without having a clear mobile strategy, whereby service delivery on mobile devices is truly integrated.

3.3 Multi-screen and media meshing

As described in Section 2.3.1, Integrated Broadband Broadcast (IBB) concepts are used to introduce a second screen in the home. Offering second-screen mobile phones and tablet apps are part of contemporary service offerings of broadcasters and OTT service providers. Nowadays, second screen should be read as 'multi-screen' as the number of connected screens per households are steadily on the increase. In IDI developed countries[35], the number of internet connected devices (with screens) stands currently on an average of between 6 to 7 devices per household[36].

For understanding this trends of having more screens per household and the impact it has on the industry, it is important to differentiate between *media-stacking* and *media meshing*[37].

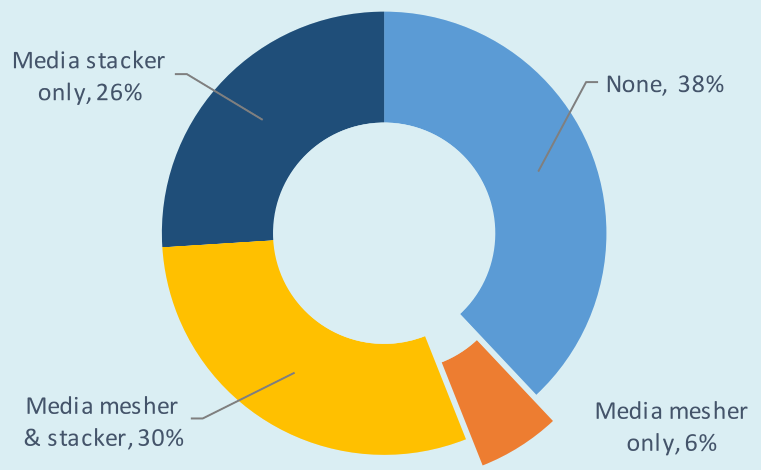
[35] See footnote 16.
[36] In the UK 7.4 devices (YouGov survey 2015), in Australia 6.4 devices (Nielsen Regional TV audience measurements 2016) and in the US 7 devices (Sandvine Global Internet Phenomena report, 2016).
[37] Media stacking entails the consumption of different forms of media at the same time. In theory, media stacking can result in more media consumption, but could also cannibalise revenues. Media meshing is using two or more media forms 'simultaneous' as to complete the service experience. For example, playing along on your tablet with a TV game show.

Over the years, consumers have become more and more multi-taskers, spending (near) simultaneously time between various services or devices. This phenomenon of *multi-tasking* is not new. Early research has already shown this multi-tasking trend between different media like television, computer and music, especially under young people.

With the availability of more screens the multi-tasking has increased. However, with concepts like IBB one new aspect has been introduced; *media meshing*. Media meshing is conducting activities or communicating via other devices while watching television. But these activities are then related to the television program being watched. The simplest form could be discussing with friends a television program being watched, using a chatting application on a smartphone. More elaborate forms are television program *embedded* applications (i.e. IBB), allowing the viewer to comment, interact or vote on program events, using the 'second screen' on a tablet or smartphone.

The definition of multi-tasking should therefore be redefined to include media meshing and media-stacking. The business significance is that media-stacking can more quickly result in cannibalising revenues between services or products. Whereas media-meshing would increase customer retention or revenues.

In this light, Ofcom's 2013 research on media staking and meshing shows some useful insights. Six in ten UK adults are multi-taskers when watching television services. However, most of these multi-taskers are media-stackers, as illustrated in Figure 9. Only six percent of all adults are media-meshers (only).

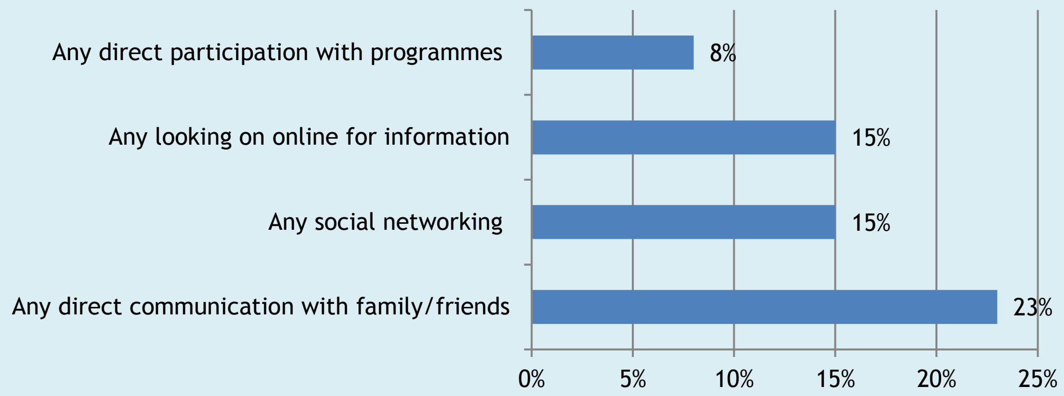


Source: Ofcom

FIGURE 9: MULTI-TASKER TYPES IN THE UK

From the perspective of a Cable TV network operator or broadcaster the media meshing activities are of special interest as they can potentially result in new revenues stream or extra customer loyalty by having users directly participate with the program or service. Of the reported media meshing activities, the majority constitute chatting, talking or searching information about the television program being watched.

Although related to the television program these activities are only loosely related. Only a small percentage of media meshing involves activities that are directly related to the program. Figure 10 shows an overview.



Source: Ofcom

FIGURE 10: MEDIA MESHING ACTIVITIES

The activities directly related to programs, as included in Figure 10, are activities like participating with a program (e.g. voting or entering a competition) or participating, using a program specific application (e.g. for on a tablet).

Although true media meshing activities constitute still a small percentage it can be expected that these interactive service offerings will continue to rise. Driven by the increasing number of sold connected TV sets (and dongles) and the further adoption of IBB standards. From a business perspective, the key challenge for Cable TV network operator will be to push media meshing beyond merely improving customer retention, but also as a mean to generate new profitable revenue streams.

3.4 OTT and traditional viewing

In this paper 'traditional' viewing is considered to include linear TV viewing (see Section 1.2) and pay-tv subscription packages, the latter to also include additionally priced linear TV services (such as sports channels). The impact of OTT on pay-tv subscription packages is often referred to as 'cord-cutting' (i.e. additionally priced services are discontinued). This Section discusses the impact of OTT on both, linear TV viewing and pay-tv.

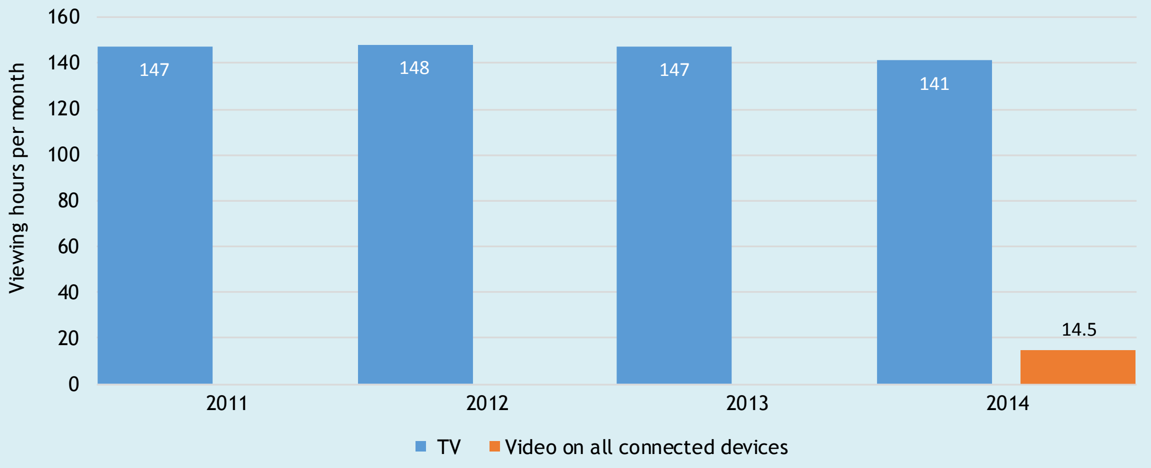
3.4.1 OTT and linear television

The impact of OTT on linear television viewing is widely analysed and debated. Undoubtedly, the impact is significant. However, data also shows that the impact is often slower than was anticipated.

For example, in 'OTT homeland' the United States, with high uptake levels of services like Netflix and Hulu, any significant impact only showed after more than five years[38]. In 2014 the percentage of OTT

[38] Netflix started as a DVD-by-mail service in 1998, and began streaming in 2007. With broadband penetration increasing in the US, also the number of subscribers and the VOD viewing hours started to increase.

subscribers stood at 40% in the US and the monthly TV viewing time started to significantly decline only then[39]. This slow impact is illustrated in Figure 11.



Source: Nielsen US

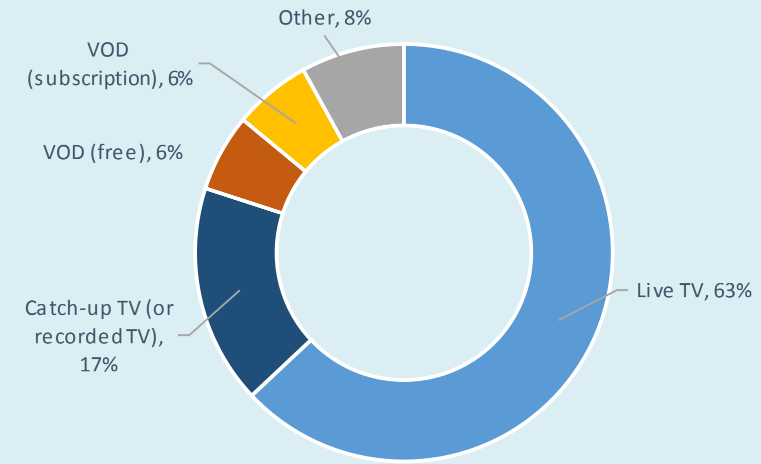
FIGURE 11: MONTHLY TV VIEWING HOURS PER MONTH IN THE US

Figure 11 shows that all VOD services consumed on all connected devices (i.e. connected TV, mobile, tablet and desktop) together, is still relative small compared to the TV viewing hours per month.

This relative slow impact on traditional live TV viewing was also measured in Europe, for example by the European Broadcasting Union (EBU) in 2015. The viewing time between live and time-shifted viewing stood at 95.5% for live viewing as compared to 4.5% for time shifted viewing (same-day and time-shifted viewing after 7 days or more)[40]. 2017 data from Digital UK and RTL Germany also shows that still around 80% of viewing is either live or time shifted of recorded TV (i.e. catch-up TV) via traditional delivery. Figure 12 shows the viewing percentages for the various forms of video consumption, as reported by Digital UK in 2017.

[39] It is noted that this number includes all providers of OTT video services, such as Netflix, Amazon Prime Video and Hulu. It also noted that growth has continued. For example, in July 2017 Netflix reported 104 million subscribers worldwide, of which 52 million are outside the US and across 130 countries. Compared to 50 million global subscribers in July 2014.

[40] For all audiences. Young audiences showed similar results; 94.5% over 5.5%. Source: EBU Media Intelligence Service, Audience trends television 2015.



Source: Digital UK, 2017

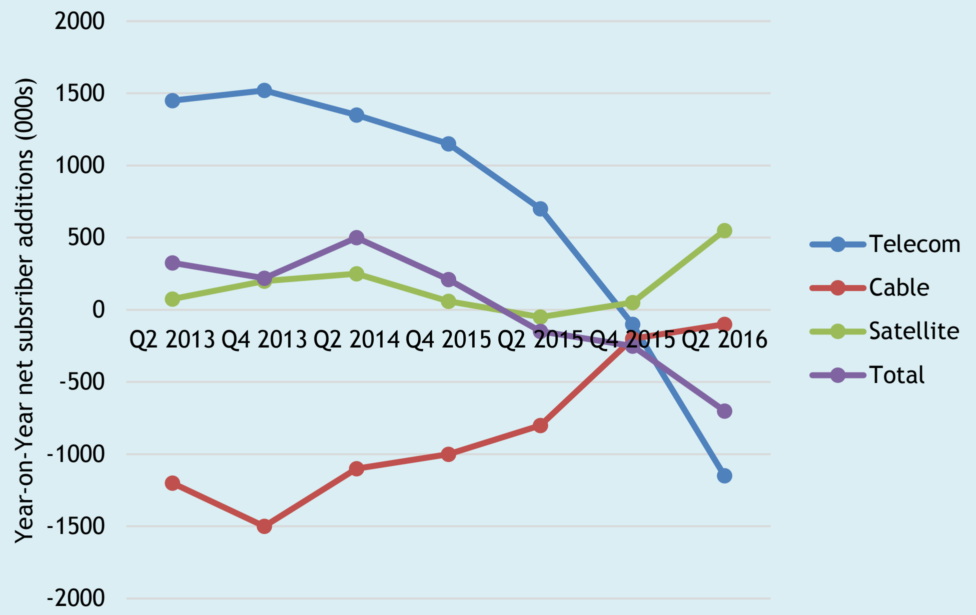
FIGURE 12: VIEWING TIME PERCENTAGES PER VIDEO TYPE

Figure 12 also shows that of all VOD viewing (as opposed to live TV viewing), by far the most popular form is catch-up or recorded TV. Hence, linear TV can still form a nucleus based on which other VOD-like and interactive services can be developed. The continued popularity of live TV may be the very reason why OTT providers, like Netflix, are agreeing distribution deals with Cable TV network operators[41]. Finally, it should be noted that although linear TV will continue to play an important role, it strength seems to be for event-based TV content, like live sports and news, and to a lesser extent for drama series and soaps.

3.4.2 OTT and pay-tv

Cord-cutting due to the rise of OTT services is also much debated in the industry. However, measuring the impact is dependent on the definition used (e.g. is cord cutting the cancelling of the whole service package or only parts of it) and the aggregation of different type of companies (e.g. only cable companies or cable, telecom and DTH companies all together). Nevertheless, most reports show a clear negative impact on subscribers and revenues of mainly telecom and cable companies. Figure 13 shows the cord-cutting impact on the year-on-year net subscriber additions for the telecom, cable and satellite providers in the US.

[41] In the US over twelve pay-tv operators incorporate the Netflix service in their Set-Top-Box (STB), such as Comcast integrates Netflix into its Xfinity X1 STB. In Europe, UPC offers the Netflix app on its Horizon STB (for example in the Netherlands and Switzerland). In September 2017, Netflix and the Orange Group have renewed their service distribution agreement and to extend this agreement to all 29 countries Orange is present.



Source: Company reporting, Jackdaw Research Analysis, adapted

FIGURE 13: CORD-CUTTING IMPACT ON SUBSCRIBERS IN THE US

Service bundling and multi-play offerings are commonly applied by telecom and cable operators to combat cord-cutting. However, not only cable and telecom operators are bundling services but also relatively new players like ISPs and OTT providers are following this multi-play strategy. Although still in its infancy, VOD services are bundled by 'traditional' ISPs. They are providing TV services bundled with home broadband and fixed-line telephone services.

4 Regulatory and policy trends

In this Chapter, key regulatory and policy trends are addressed, directly relevant for Cable TV network operators and other providers of video services.

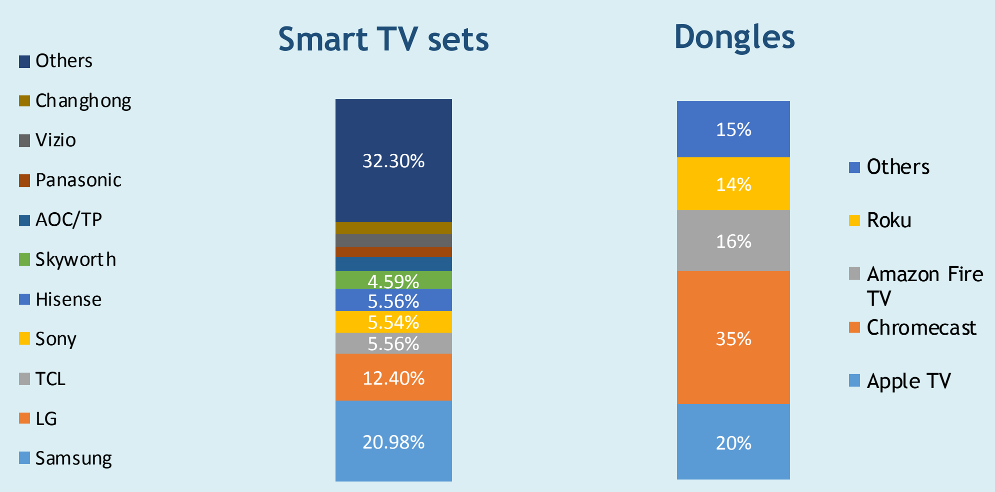
4.1 Eco-system access and connected TV

In the market of VOD and television services, display devices are critical for enjoying the services and they range from smartphones to connected TV sets. These devices are 'smart' as they are more than just a piece of hardware. Device producers are basically platform or *eco-system* providers. A platform for consumers to access the services through an integrated single user interface. The eco-system also enables content providers to make their content available in a unified manner. Both consumer and supplier are also serviced and billed in this single eco-system.

With the significant increase of connected TV sets, new elements in the eco-systems are added by the TV set manufacturers. Clearly with these eco-systems the device manufacturers would like to move up the value chain and add recurring revenues (for example by having revenue sharing with content providers or providing subscription based services) to their more cyclic revenues stream of 'selling boxes'.

The first step in their strategy is to gain market share quickly and hopefully set or dominate the industry standard. Dominance in a market obviously gives rise to competition concerns that may require regulatory intervention. Content or service providers may possibly be blocked from an (dominant) eco-system, for device manufacturers to gain (unfair) market advantage. The device manufacturer may favour its own (subscription based) service over third party service providers.

However, there are some other factors for National Regulatory Authorities (NRAs) to consider when assessing these risks. With VOD and multi-channel television offerings becoming common place, practically anywhere in the world content diversity will increase significantly[42]. Standardisation and an open platform for TV-apps also reduce the risk of market power abuse, as compared to a situation of having proprietary TV-apps. Competition at the device market itself or intermodal competition will also help reducing the risks of market power abuse. Figure 14 shows the number of competitors and their market shares in the connected television market, showing fragmented market shares.



Source: Statista, Strategy Analytics, 2016

FIGURE 14: GLOBAL MARKET SHARES OF SMART TV SETS AND DONGLES

Like in the mobile device market, market shares can change quickly. In such volatile markets, regulatory measures can be quickly misdirected (at the wrong party).

4.2 Net neutrality and audiovisual services

Net-neutrality is a topic that is currently attracting considerable regulatory attention. Network operators should manage all data-streams according to the same rules, i.e. not introducing any form of preferred or discriminatory treatment of content by technical or financial measures. Capacity management as such is often necessary and justifiable, if it is based on technical grounds and applied on a non-discriminatory basis. Deliberate blocking or throttling audiovisual streams of third parties is not acceptable.

A recent example is the discussion on *zero-rating* content services on mobile devices: the transmission of selected audiovisual services which are not counted towards customers' data plans. In the United States T-Mobile charges reduced or no additional costs for its 'Music Free' audio-

[42] Content diversity will increase after the worldwide migration process from analogue to digital broadcasting and the increasing number of OTT service providers.

content service and ‘Binge On’ video-content service at a standard resolution (640 x 480 pixels). Customers pay an additional $ 25 per month to receive videos in high definition. The lawfulness of these services was questioned as it was felt that throttling video streams and charge customers extra to not throttle video runs, is a violation of the principle of net neutrality.

The Federal Communications Commission (FCC) was accepting T-Mobile’s free music and video services because all service providers are treated equally, T-Mobile provides little streaming video of its own and users do not encounter serious barriers for opting-in or opting-out.

Conversely, the FCC held a different opinion on zero-rating schemes offered by AT&T and Verizon. In December 2016, the FCC accused these operators of a potential violation of net neutrality rules and hindering competition because these operators were not able to prove that they offer the same conditions (and rates) to affiliated service providers and unaffiliated third parties. Under those conditions, unaffiliated service providers are seriously disadvantaged in reaching AT&T-customers, Verizon customers respectively[43].

In Europe, T-Mobile is also offering zero-rating music services: ‘Music Freedom’. European regulators have different views on the possible violation of net neutrality regulation, but in the Netherlands, the competition authority ACM forced T-Mobile to stop the Music Freedom service in December 2016. As it was supposed to violate Dutch regulations on net neutrality. However, T-Mobile (and Vodafone-Ziggo) successfully appealed to this decision. In April 2017, the Court decided that the Dutch regulations are not in line with the European Open Internet Access Directive[44] and, hence, are not valid.

The above discussed regulatory disputes illustrate that apart from anti-competitive behaviour and reducing user choice, the allocation of the limited capacity available for different services is a key issue in the net-neutrality discussion. By loading the available capacity with own audiovisual services, network operators could hinder the introduction of other services because of capacity constraints.

Perhaps a less discussed case of net neutrality is broadband access providers (ISPs) blocking internet traffic generated by smart or connected TV sets. It is important to point out that the example as discussed in Section 4.1 (i.e. access to eco-systems of connected TV sets), is really the reverse side of net neutrality. In Section 4.1 content providers are possibly blocked from an eco-system for device manufacturers to gain (unfair) market advantage. But in the often-cited case of Samsung’s connected TV sets in South Korea, the device producer was asked by KT (the largest ISP in South Korea) to block OTT-apps (i.e. services that require high network capacity) from smart TV sets[45].

Samsung, like other TV set manufacturers, introduced smart TV sets supporting internet connections and web browsing. KT argued that a mass-uptake of connected TV sets would result in a large increase of internet traffic volumes. This would severely impair KT services and result in large network upgrade investments. Samsung, on the other hand, argued it was only producing devices and that the matter raised by KT was merely related to content providers, who provide the content. Because of KT’s requests not being met, the company blocked the internet connections for smart televisions for five days in February 2012.

The KCC (the ICT Regulator at that time) had to intervene and ruled that KT’s blocking of internet access was a violation of the Telecommunications Business Act. The blocking constituted a violation of consumer interest and unreasonable discrimination.

[43] However, in April 2017 the FCC announced plans to roll back net neutrality rules put in place in 2015.

[44] Regulation (EU) 2015/2120 of the European Parliament and of the Council of 25 November 2015.

[45] See OECD paper ‘Connected televisions, convergence and emerging business models’, 22 January 2014.

This South Korean case illustrates that other net-neutrality disputes can emerge with the mass introduction of connected TV devices. More likely to happen when considering the future uptake of connected UHDTV sets, pushing up bandwidth requirements for ISPs (see also Section 2.3.2).

4.3 Local audiovisual content requirements

Local audiovisual content requirements typically originate from television or radio stations to broadcast a minimum percentage of local (or otherwise prescribed) content over their networks. Similarly, must-carry obligations require Cable TV network operators to carry local television services on their platforms. These obligations are based on the rationale that, if no such requirements were applied, the level of local content delivered over media networks would be below what is regarded as being in the public interest (e.g. to preserve national identity or languages, or to support local production industries). Also from a business perspective local content requirement are important. As audiovisual content production is often the single largest cost category for service providers, the impact of any regulatory content requirements can be significant on the business case for these providers.

In a converged regulatory environment, it makes sense to apply local content requirements to linear content providers in a technology-neutral manner. Meaning that linear TV services, regardless whether they are delivered over IPTV, HFC, the Internet or mobile platforms, are subject to the same obligations as 'traditional' broadcasting platforms (e.g. DTTB or satellite).

However, in relation to non-linear platforms, the relevance of local content requirements is less clear. Non-linear platforms raise two key challenges for the effectiveness of local content requirements. First, due to a lack of natural capacity constraints (as non-linear platforms are not limited by the number of hours in a day), there is a potentially indefinite and constantly expandable amount of overall content that can be made available on non-linear platforms. Accordingly, while it would be theoretically possible to require a *proportion* of all content made available on non-linear platforms to be local content, content providers would have to constantly adjust their local content offerings every time they expand their content libraries, ensuring ensure that they fall within the requirements.

Second, due to the greater degree of control that consumers have over the content they consume in a non-linear environment, local content requirements are less effective at ensuring that consumers are exposed to local content. To illustrate, it is much easier for consumers to bypass local content in an on-demand content library than it is when that content is the only option available to them on a given channel at primetime hours.

At the same time, the technical features of non-linear platforms create greater commercial incentives for carrying local content, thereby reducing the need for regulatory intervention. In contrast to linear platforms, which have a finite capacity per channel (limited by the number of hours in a day), content service providers are encouraged to only carry the most profitable content and leave out less-profitable content.

There is an increasingly blurry divide between content service providers such as Netflix, Amazon or the Apple iTunes Store and content generated by individual users and delivered over Internet-based platforms such as social media networks (i.e. user-generated content). While it may be difficult to conceive of a user irregularly uploading family videos on Facebook or YouTube as providing an audiovisual service (and therefore being subject to regulatory obligations), certain user-generated content may reach large audiences and may even generate revenues to the point where it becomes difficult to distinguish it from a commercial content service provider. For example, many individually-run channels on YouTube achieve millions of views and are able earning advertising revenues through the YouTube Partner Program.

In Europe, the regulatory cornerstone for regulating audiovisual services is the Audiovisual Media Services Directive (AVMSD)[46]. The AVMSD is currently under review as to better cater for the convergence trends in the audiovisual market domain. In May 2016, a proposal for the update of the AVMSD was presented by the EU Commission[47]. In April 2017, the EU Council agreed a general approach for amending the Commission's proposal, as to progress the revision of the Directive towards adoption. The EU Council's agreement included the following key aspects:

1. The scope of the Directive to include 'social media' services, including services based on user generated content;
2. The 'country of origin principle' to be maintained and facilitated[48];
3. Advertising ("Commercial Communication") rules more relaxed by applying the 20% hourly advertising limit only for the time window of 07:00 to 23:00;
4. Relaxing the rules for product placement and sponsoring, under the encouragement of self- and co-regulations;
5. On-demand service providers, including providers of OTT services such Netflix and Amazon, to provide at least 30% local content ("European Works") and give 'prominence' in their content catalogue to this local content[49].

With the above listed amendments, the AVMSD revision aims to close the regulatory gap between non-linear and linear services. Although the revision includes social media and video sharing platforms in its scope now, a distinct regime remains for VOD and linear TV. The new article 13 (Chapter IV) for VOD services includes now a minimum 30% local content requirement (as opposed to no % in the current AVMSD). However, for linear TV services it remains to be 50% (Article 16 remained unchanged). Moreover, TV services have an additional requirement for a 10% share for "European independent works" (Article 17 also remained unchanged). Also, although advertising, program sponsoring and product placement rules are more relaxed for the audiovisual services in scope of the new AVMSD (Chapter III), separate additional provisions remain in place for linear TV services for advertising and teleshopping (Chapter VII).

Considering the trend of media meshing between linear TV and on-demand services (see Section 3.3) and the penetration of connected TVs (see Section 2.3), this distinction between linear and non-linear may become untenable. Also, if NRAs consider non-linear and linear services to operate in the same *relevant market* any imbalance in the regulatory burden between these service categories may inflict market distortions[50].

[46] Directive 2010/13/EU of the European Parliament and of the Council of 10 March 2010. It is noted that this Directive distinguishes between (a) general provisions for all services in scope (Chapter III), (b) provisions for on-demand services only (Chapter IV) and (c) provisions for television broadcasting (Chapters V to IX).
[47] COM (2016) 287 final, Proposal for a Directive of the European Parliament and the Council, amending Directive 2010/13/EU, 25 May 2016.
[48] The country of origin principle means that a service provider needs to respect only the rules of for example host country A, but can deploy its service in all EU countries. However, a receiving country B with stricter rules than those set by the Directive cannot restrict the service from the service provider in country A by applying these stricter rules, except in specific circumstances as defined in the Directive.
[49] In the Commission's proposal, see footnote 47, 20% of European Works was proposed which was raised to 30% by the EU Council.
[50] NRAs generally define *relevant markets* in resolving (ex-post) regulatory disputes, for example between OTT and Cable TV network operators, or for identifying market parties with *significant market power* (SMP), resulting (ex-ante) in specific licence conditions for parties with SMP.

5 Implications for industry and NRAs

In this Chapter, against the background of the trends as described in this industry paper, several questions are posed as to provide input for discussion. These questions address the implications of the identified trends for the Cable TV industry.

First some industry-wide questions are raised (see Section 5.1 below), followed by more specific questions which are grouped together according to the trends as addressed in Chapter 2 to 4 (see Sections 5.2 to 5.4 below). The questions can be related to the sessions as included in the program of the workshop "The Future of Cable TV", to be held on the 25 and 26th of January 2018.

5.1 Industry-wide implications

Session 1: Enabling Environment for Sustainable Growth and Deployment of Cable TV.

Background:

1. Cable TV services as part of a wider converged market place and competing with other video and integrated services (see Introduction);
2. The identified trends as described in this industry paper (see Chapters 2 to 4).

***Question 1**: What would be the key technological and service developments that Cable TV network operators should embrace as to improve their competitive stance in the converged market place? Especially considering the rise of OTT and mobile service offerings from market players outside the traditional industries of telecommunications and broadcasting.*

***Question 2**: In what way can NRA's, international bodies like ITU and other stakeholders (e.g. EBU, CEPT, ETSI) help in addressing the challenges of the Cable TV industry? For example, in terms of regulations, licensing or standard setting.*

5.2 Technology implications

Session 3: Evolving Technology: Innovation Driving Growth of Cable TV.

Background:

1. Existing infrastructure (twisted pair and coaxial cable) can be significantly enhanced but reaching its limits. Optical fibre deployment is relatively expensive but offers unparalleled speeds (see Section 2.1);
2. Transmission standards DOCSIS 3.1 and DVB-C2, in combination with ITU-T H.265 encoding, provide efficient solutions for carrying UHDTV services (see Section 2.1.2 and 2.3.2);
3. Continuing growth in the demand for broadband capacity, driven by high quality video delivery (UHDTV), smart device (including smart TVs) penetration and the rise of IoT (see Section 2.1). Partnering with OTT service providers may also require more broadband capacity (see Section 3.4.1);
4. Future network concepts, enabling integrated and uniform service delivery across multiple platforms (wired and wireless networks) and consequently facilitating multi-play strategies (see Section **Error! Reference source not found.** and 3.3);
5. Consumers are increasingly media meshers and consume their (video-based) services anywhere and anytime, predominantly on IP-based networks (see Section 3.2 and 3.3).

***Question 3**: Do Cable TV network operators need to replace their existing coaxial-based local loop with fibre given the forecasted demand for more broadband capacity, and especially considering the uptake of UHDTV?*

***Question 4**: Is the deployment of future network concepts necessary for provisioning of competitive multi-screen/play offerings and may this entail outsourcing of network assets to third parties (with system integration skills)?*

***Question 5:** DOCSIS 3.1 and DVB-C2 provide both efficient solutions for the transmission of high quality video. Is there a need for both or should they be integrated in all-IP based networks?*

5.3 Service and business implications

Session 2: Market Trends and Business Models.

Background:

1. OTT service providers agreeing distribution contracts with ISPs (including Cable TV network operators), ensuring QoS for their (UHDTV) services. Hence, OTT delivery of audiovisual services is developing to be on-par with HFC/IPTV-based delivery (see Section 3.1);
2. Consumers are increasingly media meshers and consume their (video-based) services anywhere and anytime, whereby service integration across mobile platforms seem to be critical. Especially, considering the continuous growth in mobile video watching (see Section 3.2 and 3.3)
3. The impact of OTT on linear TV services is significant but is slower than previously anticipated. In addition, the largest portion of non-linear video watching is catch-up or recorded live TV content. However, the strength of linear TV seems to be for event-based TV content, like live sports and news, and to a lesser extent for drama series and soaps (see Section 3.4.1);
4. OTT service providers partnering with Cable TV network operators as to integrate their services (see Section 3.4.2).

***Question 6**: OTT delivered services are perceived by consumers to be on-par with HFC/IPTV delivered services or is there still a unique selling point to be derived from HFC/IPTV-based service delivery?*

***Question 7**: Are integrated service offerings across multiple platforms critical in surviving in the long-run? Will linear TV remain a key element of this service offering, based on which also VOD services can be developed?*

***Question 8**: Non-linear watching is dominant under young people. Can it be expected that they will carry their video consumption pattern into adulthood, or at that time, they would like to be entertained by professionally produced linear TV content? Or in other words, is linear TV dead or will it continue to exist? And if so, for what share of all video watching?*

***Question 9**: OTT service providers seeking partnerships with Cable TV network operators illustrates the strength of linear TV or OTT providers merely seeking market access, by accessing the eco-system/STB of the Cable TV network operator?*

5.4 Regulatory and standard setting implications

Session 4: Setting International Standards for Sustainable Growth of Cable TV

Background:

1. Device producers, including TV set manufacturers, are *eco-system* providers and these systems can potentially block or hamper market access for third party content providers. However, the market for connected TVs (including dongles) is fragmented and market shares can change quickly. Resulting that regulatory intervention may be misdirected (see Section 4.1);
2. Regulators rule differently in net neutrality disputes, including cases about zero-rating of audiovisual content in data bundles. Mass deployment of UHDTV connected TV sets may give rise to new disputes. UHDTV deployment may significantly increase the network cost for ISPs, who may in response try to limit this impact by pricing, throttling or even blocking this UHDTV traffic (see Section 4.2);
3. Local content requirements for non-linear services are more difficult to enforce than for linear TV services. Considering the trend of media meshing and the uptake of connected TVs, the distinction between non-linear and linear is blurring for the consumer. The revision of the AVMSD is aimed at changing the European rules to better facilitate for these convergence trends (see Section 2.3, 3.3 and 4.3);
4. A global standard for IBB (or TV apps) is absent, fragmenting the market for audiovisual services and potentially locking consumer into proprietary solutions (see Section 2.3.1);
5. Transmission standards DOCSIS 3.1 and DVB-C2, in combination with ITU-T H.265 encoding, provide efficient solutions for carrying UHDTV services (see Section 2.1.2 and 2.3.2);
6. Future network concepts, enabling integrated and uniform service delivery across multiple platforms (wired and wireless networks) and consequently facilitating multi-play strategies (see Section **Error! Reference source not found.** and 3.3).

Question 10*: Should NRAs be closely monitoring (potentially) unfair practices of locking-in customers in TV ecosystems, and if so, should they be proactive in protecting consumers against these practices? Or alternatively, is the promotion of global standards sufficient?*

Question 11*: Are the different net-neutrality regimes and dispute resolutions hampering service innovation and network investments? Can it be expected that the forecasted future growth in IP-based video delivery, result in new net neutrality disputes?*

Question 12*: Are the current proposals for the AVMSD revision sufficient in helping the audiovisual industry to compete better in the converged market place? Are key elements missing or should rules be changed or removed in the AVMSD revision?*

Question 13*: Is a different direction or approach needed of standardisation bodies in setting standards in the areas of IBB and network operations (including DOCSIS and DVB-C2)? Are critical standards missing or being developed too slowly?*

Glossary of Abbreviations

A/V	Audiovisual (service)
ABR	Adaptive Bitrate
ATSC	Advanced Television Systems Committee
AVMSD	Audiovisual Media Services Directive
CDN	Content Delivery Network
DMB	Digital Multimedia Broadcasting
DOCSIS	Data Over Cable Service Interface Specification
DSLAM	Digital Subscriber Line Access Multiplexer
DTH	Direct-To-Home (broadcasting)
DTTB	Digital Terrestrial Television Broadcasting
DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting-Cable
DVB-T2	Digital Video Broadcasting-Terrestrial 2nd (generation)
eMBMS	Evolved Multimedia Broadcast/Multicast Service
EPC	Evolved Packet Core
ETSI	European Telecommunications Standardisation Institute
FTA	Free-To-Air
GPON	Gigabit Passive Optical Network
HBBtv	Hybrid Broadcast Broadband TV
HEVC	High Efficiency Video Coding
HFC	Hybrid Fibre Coaxial (network)
HTTP	Hyper Text Transfer Protocol
IBB	Integrated Broadband Broadcasting
IPTV	Internet Protocol Television
ISDB	Integrated Services Digital Broadcasting
ISP	Internet Service Provider
IMT	International Mobile Telecommunications
ITU	International Telecommunication Union
KBS	South Korean public broadcaster
LDPC	Low-Density Parity-Check
LTE	Long Term Evolution
LTE - A	Long Term Evolution - Advanced
MPEG-4	Moving Picture Expert Group Advanced Video Coding
NAT	Network Address Translation
NFV	Network Function Virtualisation
NG PON	Next Generation Passive Optical Network
NRA	National Regulatory Authorities
OFDM	Orthogonal Frequency-Division Multiplexing
OHTV	Open Hybrid TV
OTT	Over-The-Top (services)
PCRF	Policy Control Resource Function
PGW	PDN gateway
PON	Passive Optical Network
PPV	Pay Per View
PSB	Public Service Broadcaster/Broadcasting
QAM	Quadrature Amplitude Modulation
QoS	Quality of Service

SDN	Software Defined Networks
SMP	Significant Market Power
STB	Set Top Boxes
TCP	Transmission Control Protocol
UHDTV	Ultra-High Definition Television
UMTS	Universal Mobile Telecommunications System
VOD	Video-On-Demand
xDSL	(x) Digital Subscriber Line
XG PON	10-Gigabit-Passive Optical Network