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Working Party on Communication Infrastructures and Services Policy

CONNECTED TELEVISIONS: CONVERGENCE AND EMERGING BUSINESS MODELS

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FOREWORD

This report was presented to the Working Party on Communication, Infrastructures and Services Policy (CISP) in June 2013. It was made public by the Committee for Information, Computer and Communications Policy (ICCP) in December 2013. The report was prepared by Mr. Rudolf van der Berg. It is published under the responsibility of the Secretary-General of the OECD.

Mr. Jonathan Levy of the United States Federal Communications Commission is thanked for his substantial contributions to the report.

TABLE OF CONTENTS

Tables

Figures

Boxes

MAIN POINTS

Connected televisions are defined, for the purposes of this report, as devices that have the capability to interact with the Internet to display audio visual content. Connected television is an important development because it permits the provision of certain new and valuable services to end-users. These services will also have implications for the activities of all of the players in the content distribution ecosystem. In addition to identifying the new services that connected television enables, the report analyses in some detail their effects on networks (i.e. the physical communication links that carry content to end-users). The impact on content producers themselves, on content distributors (such as traditional pay television companies), on hardware vendors, and on providers of support services such as advertising and programme guides is considered much more briefly. More detailed examination of these matters could be the subject of future work. The report also includes a discussion of policy implications raised by connected televisions for the actual connected television devices and for network infrastructure."

Global standards and technological advancement have enabled the development of connected televisions. The introduction of new features in peripheral devices has enabled new services. Existing players in the value chain have sometimes welcomed and at other times challenged these new services. The outcomes have varied in different countries with some services being permitted to proceed and others ordered to cease in their current guise. Tools that allow functions such as the skipping of advertising, the viewing of content outside a specific location and the overlay of other capabilities are being introduced by some service providers and challenged by others across the OECD area.

There is very wide interest in providing these services to consumers but contention between actors over financial compensation (e.g. over the division of revenue or bypass of existing business models in ways that contravene intellectual property (IPR) or regulation aimed at other policy objectives). There are outstanding legal disputes regarding what a consumer can do with content once it has reached the connected television or what a third party can do with content once it has been received. While, it is difficult to talk about connected televisions without explicitly considering the IPR regime for content this goes beyond the scope of this document except to provide some "case study" examples. This includes some instances of where the IPR holders have initiated services or where commercial agreements have been reached to provide such services. The aim here is not to resolve these issues but rather to share information of some of the factors that are being considered in relation to the use of broadband networks over which these services are provided.

Not all existing broadcast networks are capable of supporting connected televisions. Digital terrestrial television and satellite broadcasting services lack a return channel to make this a possibility. However in combination with a broadband connection they, as well as other networks, can support connected television services. All broadband technologies can support some form of connected television. Nevertheless, not all broadband technologies can support the delivery of multiple high quality streams to consumers. The "first-mile" connectivity available is the leading limiting factor.

Some caution that there will be a "data-tsunami", caused in part by connected televisions that will overwhelm networks. This document notes that the growth rate of data traffic is strong but decreasing in relative terms. It finds, therefore, that it is unlikely that, if networks continue to invest, the growth in traffic will be unmanageable. Broadband networks have evaluated technologies and business models that could manage the growth in traffic, guarantee levels of quality and allow price-differentiation between content providers. Some content providers have been reluctant so far to use these options and have worked around challenges in Internet connectivity by using technologies like adaptive bitrate streaming and deploying their own content delivery solutions in lieu of those offered by broadband networks. Other network operators are working with various parts of the value chain to create “win-win” solutions, and one network operator using speed for price discrimination for their customers is highlighted in this report. The model builds on the core Internet principle of charging customers directly for services (i.e. everyone pays for their own Internet connection) rather than models that may bring different parties into dispute where they do not perceive mutual benefit through commercial negotiations in a competitive market place.

There have been tensions between some content providers and broadband networks over the increasing growth in data traffic and this report illustrates these. Sometimes regulators have stepped in to address these disputes, including a direction that services be reinstated if they involved a cessation, as well as bringing all parties together to discuss differences. Elsewhere, market forces have resolved these issues. The Internet’s model of traffic exchange, using peering and transit, has proven very robust for delivering services to connected televisions. Its market-based approach generally leads to acceptable outcomes with disputes being relatively rare exceptions and it has a proven track record for scaling services.

INTRODUCTION

Recent OECD work has described digital content distribution as being at an inflection point. It was noted in a report on this subject that:

> "Streaming video now represents the largest component of Internet traffic. Viewers are watching a growing share of video via Internet-based distribution systems to both television sets and new endpoints such as computers and mobile devices. New entrants and services are challenging the linear broadcast paradigm and the bundling arrangements driving revenues in many content industries. Growth in digital content distribution, especially video, will be a major consideration for both wired and wireless communications networks in the coming years. The impacts on network performance and investment in each market will depend on specific usage patterns, technical choices, and business decisions. The robustness of the Internet will become an increasingly significant factor as greater percentages of content and user activity flow over them." [1]

This report further examines the distribution of digital video content, and focuses more specifically on the likely influence "connected televisions" will have on wired and wireless networks in the coming years. Connected televisions are defined here as devices that have the capability to interact with the Internet, concurrently with traditional delivery mediums. These devices could be the larger-screen "smart televisions" that are increasingly found in households throughout the OECD area but also the use of such devices in combination with others such as smartphones and tablets. The report considers how these connected devices are being used in relation to network connectivity, the robustness of the Internet and the implications this demand is having in areas such as investment in infrastructure, the exchange of traffic, network deployment and so forth. The report, therefore, focuses on one side of the television market, the distribution and the networks used for distribution. It does not examine the creation, aggregation, packaging, selling, licensing and regulation of the content itself. This could be the focus of future work and the European Commission is taking some of these areas up in their future programme of work. In April 2013, the European Commission published a green paper that raised questions in relation to a consultation they are undertaking on the subject of connected televisions (Annex 1).

Brief introduction to the industry ecosystem

Broadly speaking, there are five basic roles in a content distribution value chain or ecosystem. These are:

- **Content producers** develop original material for distribution across analogue, digital, or physical media. Although the most valuable content is generally commercially produced, the largest share of material available online is now generated by end-users (i.e. user-generated content).

- **Distributors** license content and store, aggregate, package or manipulate it for availability to end-users.

- **Networks** provide the communication links to carry content to end-users. These can be satellites, antennas or wired networks. A producer or a distributor may own a network (or vice versa), but the functions of moving bits and selling content are conceptually distinct.

- **Hardware vendors** manufacture end-user devices to display, store, and manage content. The hardware involved may be a general-purpose platform such as a personal computer or smartphone, or it may be a specialised device such as a television, video recorder or set-top box.

- **Supporting services** such as advertising, programme guides, search, analytics and tools facilitate revenue-generating business opportunities around digital content. Given that professional content depends on revenue generated from practices such as advertising and subscription, these ancillary functions are key elements of common business models, though may be complimented by income from sources ranging from public funding to revenue associated with must-carry requirements.

The actors making up the parts of the various value chains engage in both competition and co-operation inside and across these categories. Technical standards and industry co-ordination around matters such as intellectual property or protection of children may require concerted efforts of major players across the basic roles that ensure delivery of digital content. Many entities, such as the BBC, Sony, Comcast, News Corporation, Vivendi and Netflix occupy more than one role across these value chains.

This report focuses on the interactions between distributors, networks and hardware vendors. It deals less with content producers and supporting services. It will, therefore, address only a limited subset of the potential developments in the market and the questions policy makers may encounter in the future. Nonetheless, as the industry is very much an ecosystem, a change in one role as a result of technological developments, can also precipitate changes in the functions played by others. It needs, therefore, to be borne in mind that the developments in networks, hardware and distribution will significantly influence those parts of the value chain that create content and provide supporting services. Furthermore, the creation and distribution of broadcasting and cable television services, as well as the networks used to deliver content, have had associated regulation to meet public policy objectives, for example on discoverability, local content creation and accessibility. While these goals are generally of a similar nature, there are significant differences across OECD countries in areas such as the existence of cable and satellite networks, the role played by public broadcasters, promotion of cultural objectives, democratic values and so forth. There are also new questions, such as those dealing with privacy, given that the presence of a return-channel, which is necessary for connected television services, might create privacy concerns that did not exist with traditional television. The effects of convergence due to technological and commercial changes will, therefore, be different in different countries and may result in country specific issues arising around the changes in ecosystems. This could include the competitiveness of some aspects of the sector due to asymmetric regulation across different countries and their consequent ability to innovate as fast as others. Future work could examine some of these issues that go beyond the scope of this report, which is primarily focused on broadband network development in relation to the increasing use of connected televisions.

This report is split into two main parts. The first part discusses several examples of connected televisions, their history and the legal and regulatory challenges that these services faced. The second part evaluates the effect of connected televisions on networks. It examines the networks currently used for television and broadband and evaluates how they are affected by connected televisions. It concludes with an evaluation of the impact on network demand and how the market is reacting in areas such as quality of service (QoS), interconnection, content delivery networks (CDN) and download caps. Examples are provided from experiences in Korea and Norway, where there was a dispute between market players over the growth of video related traffic. Both contributions have framed these debates using the term "net neutrality", which is applicable in these national contexts. In this report, however, the term net neutrality is not used. The position is taken that the actions of market players can be described more accurately, with other terms, when considered across multiple countries that may not always use this term or do so with different interpretations.

CONNECTED TELEVISION

Introducing connected television

The term “connected television” refers to any device or application that allows the viewing of video using an Internet connection. In order to view the video some device is needed, of course, meaning that it may be more useful to think of a connected television as a device enabled with the capability to display video delivered via an Internet connection.

The definition is quite general, and encompasses at least properly-equipped home television receivers, certain game consoles, desktop and laptop computers, tablets, and smartphones. The related term “smart television” refers to an upright television screen that can be connected to the Internet. Connected television is important for at least two reasons: first, it enables new business models and valuable new services for end users; second it has implications for the relations among the various components of the content distribution ecosystem — content producers, distributors, networks, hardware vendors, and support services (as defined above). This report highlights the new connected television services and their impact on networks—the infrastructure over which distributors provide those services. The scope of the document permits only a summary discussion of the implications from connected televisions on the other components.

In brief, connected television is placing significant new demands on network transmission capacity. Depending on the nature of infrastructure (e.g., wireline or wireless, shared or dedicated), a variety of investment and pricing strategies will be adopted by network providers. While other services, such as gaming and videoconferencing also increase the demand for Internet capacity, mitigation strategies differ between these services. Some investment and pricing strategies may be useful for dealing with all of these demands, but some (e.g. content distribution networks) are most useful to support connected television delivery.

An alternative and more limited definition is given by Scheuer of the Institute of European Media Law. He states:

> “A smart/connected TV is therefore primarily a device that receives television signals via traditional broadcast distribution methods (terrestrial, cable or satellite) but which can also access the Internet. This can be achieved either through a network adapter built in to the TV set itself to connect it to either a wired (LAN) or wireless (WLAN) Internet network, or by connecting a peripheral device (set-top box, Games console, Blu-ray player) that contains such an adapter to the TV.”[2]

An earlier OECD report defined a related term, “IPTV,” and it is useful to contrast the definitions of connected television and IPTV, as well as clarify some related terms that come up in the present and other discussions of video and its delivery. The earlier report defined IPTV (for technical but not for regulatory purposes) as “video and ancillary services such as audio/text/data delivered over the Internet Protocol and offered as a channel/channels of linear and/or nonlinear programming of broadcast quality designed to be viewed on a television.” The report also refers to IPTV as “‘television’ delivered over Internet Protocol.” The term “television” was itself in quotation marks and the 2006 report offered a definition of “traditional television service” as “linear programming (one-way scheduled audio-visual programming) of broadcast quality offered as a channel/channels designed to be viewed on a television set.” The 2006 report went on to define several additional terms from the IPTV definition[3].

The major contrast between IPTV and connected television is that the latter requires the use of an Internet connection. The 2006 report notes that “IPTV does not have to be operated over a private/managed network.” However it is fair to say that many IPTV applications, whether it be a package of linear pay television services, a video on demand (VOD) service, say from the servers of a cable television company, or even the mobile video component of the United States ATSC digital terrestrial television standard, are offered over private or managed networks rather than the open Internet. Nevertheless, the 2006 report cites a service that provided cable channels via the open Internet for display on a television receiver. The reference to "ancillary services" in the IPTV definition is also important for connected television. As noted below, ancillary content delivered over the Internet can be an important component of the new services that connected television can offer.

The term "over the top" (OTT) is also used in discussions of connected television. OTT content is provided over the open Internet and not over managed facilities. As noted in the previous paragraph, IPTV could in principle be provided over-the-top. A term such as "WebTV" does not adequately describe over-the-top video services, as these may not make use of web browsers, HTTP and HTML, but instead rely on applications (i.e. apps). Perhaps it is a matter of semantics, but it is not clear whether video provided over managed facilities should be considered connected television. Services delivered over managed facilities do not necessarily require an Internet connection.

The European Commission, in connection with its *Audiovisual Media Services Directive*, offers definitions of linear and non-linear content as follows: "Television broadcasts are 'linear' services because they follow a schedule arranged by the broadcaster, while on-demand (or 'non-linear') services leave users to decide when to watch a particular programme. While these services differ in how they are made available, they are both addressed to the general public." Hence the term "non-linear" is essentially equivalent to VOD. It is also very similar to the term "unicast," which in IP networking parlance refers to a point-to-point transmission. Although a linear transmission can, in principle, be point-to-point, and some new services make use of features along those lines, in practice, they are today still more likely to be point-to-multipoint services.

The term "broadcasting" has different regulatory connotations in different countries, which will not be addressed here. However, it is fair to say that in each case there is the sense of a point-to-multipoint transmission. With regard to IP networking, the term "multicast" has a similar connotation, so the terms are roughly interchangeable. It is worth noting that "multicasting" has a specialised definition in the United States context, referring to the transmission of multiple digital terrestrial television programme streams over a single broadcast signal.

What is new about connected television?

Connected television is the latest in a long line of evolutionary developments that, over the last 20 to 30 years, have continually expanded the range of services available to video consumers, continually expanding the range of choices and degree of control on the part of the end user. In the early days of television, end users had the choice of a handful of free-to-air (FTA) terrestrial video services delivered in real time. Over the years, as additional spectrum was assigned and entry permitted, the number of FTA choices increased. However, the big increase in distribution capacity and hence end user choice came with multichannel technologies such as cable television and direct-to-home satellite service.

Some of these multichannel services offered time-shifting by retransmitting the same block of programme content at different times of the day. That being said, the first major advance in time-shifting was the videocassette recorder. In a way, this could be said to have enabled place-shifting as well, since one could carry a videocassette from one location to another and play it back in each location, provided a recorder/player was available there.

The advent of the digital video recorder (DVR), sometimes referred to as a personal video recorder (PVR) enabled much more convenient and comprehensive time-shifting, both because of the substantial digital content capacity that could be included in a compact piece of equipment and because of advances in programming capability that facilitated automated recording of content.

Additional modes of time-flexible delivery also developed. Multichannel distributors transmitted the same programming (mostly films) on different channels with staggered start times. Services such as Netflix offered rental DVDs delivered via the postal service (still a popular service today in the United States and elsewhere), and wireline multichannel distributors such as cable offered substantial libraries of video on demand (VOD) programming, without recourse to the Internet. (Of course video content transmitted via dedicated cable or fibre connections to an end user's premises could be in IP format even if it does not traverse "the Internet" or it could use a traditional cable form of modulation such as QAM). Both of these last-mentioned technologies support "binge viewing" (consecutive viewing of multiple episodes of a series, perhaps even a whole "season" at once).

There are, however, some important video services that are only enabled by connected television. And of course connected television can reduce the cost or otherwise make more efficient some previously available activities. Perhaps the most important new service that connected television can offer is place shifting, including mobile or nomadic viewing. With a connected television device and a sufficiently robust Internet connection, it is possible to stream video content anywhere. In the earliest versions of the technology, the stream originated at the end user's television receiver, where a piece of equipment such as a "Slingbox" received the transmissions, converted them to IP and then sent them out over the open Internet to another of the end-user's devices. This could be a tablet in another room of the house, a laptop in a hotel room in another country, or a smartphone in a car or at a sports venue.

Currently, content providers may stream from their own web sites or license others, including multichannel distributors such as cable or satellite companies, or free-standing aggregation sites such as Hulu to stream their content. Hence it can be a substitute for traditional distribution platforms such as FTA, cable, or satellite television. Although Netflix began by distributing DVDs through the postal service (and still does so extensively), it also has a very popular video streaming business. Today, various distributors, e.g., Cablevision in the United States, offer "cloud DVR" services. Rather than subscribers having a physical DVR on their premises, they have dedicated cloud capacity maintained by the distributor. Although this procedure may raise issues of copyright law, which varies across countries, it certainly is more technically efficient than a network of physical DVRs.

When a content provider stores video "in the cloud" on its own initiative (i.e., not pursuant to an instruction from an end user to record it), this provides an efficient basis for place shifting and time shifting along with it. With cloud content, it is possible to begin viewing on one device and then pick up on another or to access a live programme in progress and then shift back to the beginning. This is more efficient and provides more functionality than either recording content on a DVR for future viewing or the type of "catch up television" service that can be provided as part of the video on demand offering from, say, a cable television operator providing the on demand content using its dedicated facilities.

Connected television also enables, or at least substantially facilitates, the targeting of advertising to individual locations. This potentially benefits advertisers because it increases the likelihood that the message is delivered to a receptive audience. On the other hand, it is important to recall that some connected television services, in particular those that entail recording point-to-multipoint broadcasts, make it possible to skip over advertisements (e.g., the Dish Networks “Hopper” product). In many cases, video streams delivered “on-demand” can disable the fast-forward feature and hence defeat attempts at advertisement skipping.

Connected television can also enable the delivery of various valuable services ancillary to the basic provision of video. This could be additional information about the actors or other personnel involved in the video, opportunities for e-commerce, posted reviews and commentary, or even real-time reactions delivered via social media. In some cases, this content may display on the same screen as the primary video content; one standard that supports this functionality is Hybrid Broadcast Broadband Television, or HbbTV, used frequently in Europe. In other cases, this content may appear on a “second screen” (e.g., a tablet or smartphone). Social media applications designed to be used in conjunction with video consumption are increasing in popularity. These include commentaries via Twitter and similar platforms as well as ancillary information regarding the actors, writers, plot, fashions, etc. in the programme content. Zee TV is one prominent example of the latter. These applications can “connect” members of the audience for a particular video programme even if the programme itself is not necessarily being viewed via connected television. However, as a complementary service to the video content, social media applications can strengthen the viewer’s connection, thus possibly increasing or maintaining the size of the audience and also offer monetisation opportunities from increased ad revenue to sales of ancillary merchandise.

THE IMPLICATIONS OF CONNECTED TELEVISION FOR CONTENT PRODUCERS, DISTRIBUTORS, NETWORKS, HARDWARE VENDORS, AND SUPPORTING SERVICES

Introduction

Connected televisions are, in the first instance, pieces of end-user hardware. However, the services they enable affect all other aspects of the content distribution ecosystem. Connected television increases the value of content to its producers and opens up the possibility of "cutting out the middleman," bypassing traditional distributors and delivering directly to end-users. It challenges distributors, both because of the potential for competition in their core business but also because, to fend off that challenge, traditional distributors need to add connected television services to their own offerings. The substantial increase in demand for Internet capacity, sparked by connected television services, induces network providers to invest in new capacity and to consider revisions in their pricing plans. Hardware vendors wrestle with the range of functions to include in their connected television devices and with questions of standardization. Supporting services are also challenged; whether it is advertisers considering how to target their messages and measure the implications, or programme guide providers competing for space on connected televisions and struggling to integrate content from multiple sources in their search functions. The implications of connected television on networks is considered below in some detail. This section briefly examines the implications of connected television for the other segments of the ecosystem.

Impact on industry ecosystem

Content producers

End users value flexibility in the time and place at which they view video content. It appears that they also value the ability to switch seamlessly from one device to another, e.g., to begin watching a sporting event on the main "home television" receiver and then switch to a mobile device while riding in a vehicle to another location. This flexibility makes the content more valuable, both because of the convenience and because it may well increase the total size of the audience. This can translate into higher license fees for content producers. Moreover, since a significant fraction of the subscriber fees paid to distributors go to compensate the distributor for its efforts and infrastructure investment, connected television offers content producers the opportunity to capture some of that revenue by distributing directly to the end user via network facilities that are already paid for in significant part by the end user. As discussed below, direct distribution of content, particularly if it achieves high volume, may require some infrastructure investment by the content provider itself (e.g., content distribution networks). Perhaps the most prominent United States example of the use of connected television for direct content distribution is Netflix, which offers a large number of movies on its streaming service and has even produced popular original content, e.g., the series *House of Cards* and *Orange is the New Black.*

In either case – in respect to Internet distribution as a complement to traditional distribution or as a substitute for it - important issues of intellectual property rights and digital rights management arise that are beyond the scope of this document. One example of the type of controversy that can arise is the Aereo service in the United States. Aereo holds itself out as a service that rents individual FTA television antennas, housed in a central facility in each market where it operates, to customers. For a monthly fee, Aereo then streams FTA television services to subscribers' connected television devices. In the United States, broadcasters have sued Aereo for copyright infringement, but the courts have not yet ruled on the merits of the case. Aereo successfully defended against broadcasters' request for preliminary injunction, which would have required Aereo to suspend service while a court decision on the merits of the broadcasters' complaints is pending.

Distributors

Directly-distributed content has the potential to cut the revenues of traditional distributors because it could attract audiences away from their own content packages. This is true both for content that is exclusive to connected television and for content that is available both via the traditional platform and via connected television. At the margin, if enough valuable content is available via connected television, then some end users may cancel or cut back on their traditional pay television service (become either "cord cutters"or "cord shavers").

Even for those who maintain their traditional pay television service, watching some content via connected television will affect the stream of advertising revenues that the pay service earns. The advertising effect could also be present *vis-à-vis* FTA television content. If an end-user chooses connected television to access video programming that had been transmitted via FTA television, the end user might well see a different menu of advertisements, and this could reduce the distributor's revenues. Given that, for widely-viewed content, point-to-multipoint distribution will remain very efficient, another effect of connected television on traditional distribution may be to narrow the range of traditionally-distributed content to that which is most popular, leaving very narrow niche content solely to connected television distribution.

Hardware vendors

A connected television, by definition, includes a piece of hardware. The crucial component that makes it "connected" is its processor, which provides the capability to receive IP video and deliver it to the screen for display. In practice, technological developments in the screen have encouraged the development of connected television. As television displays evolved from cathode ray tube to LCD and plasma technology, the resolution and picture quality improved immensely. These developments were beneficial for traditional television and connected television. Perhaps the key point for connected television is that these new technologies made it possible to produce smaller, thinner, portable, and mobile devices with high-resolution displays. This made mobile and nomadic video possible. Mobile means constantly on the move, e.g., in a moving train or bus. Nomadic means available at different places, e.g., one's back yard or a "hot spot" at the local coffee shop, not necessarily in constant motion. In the home, particularly with respect to television receivers intended for group viewing, the much larger screen sizes made possible by LCD and plasma technology are of particular importance, for connected television but also for traditional distribution.

The processor that enables connected television can be built into the device itself (this is the case with respect to laptop and desktop computers, tablets, and smartphones and many of the more recent "upright screen" television receivers) or it can be in a peripheral device, either specifically designed for connected television or a multipurpose device. The Slingbox, described above, is an early example of a special purpose peripheral device; it does not receive video content via the Internet but it does convert video delivered to the television receiver via traditional means into an IP stream and transmit it over the Internet to other devices under the control of the owner. The TiVo box provides DVR functionality, a programme guide, an interface with a pay television service, and access to the Internet for applications such as Netflix. Other peripherals designed to process IP streamed video and deliver it to a display include "Apple TV", Roku, and Chromecast. Until recently the Boxee Box was also available and offered a cloud DVR service along with streaming to a connected television, but this provider was recently purchased by Samsung.

Some multipurpose peripheral devices also enable connected television. These include game consoles such as Microsoft Xbox, Nintendo Wii, and Sony Playstation and some DVD and Blu-Ray players. Connected television capability can also be integrated with digital television set-top boxes; in the United Kingdom YouView offers a set-top that connects to a FTA television antenna and to the end user's broadband service. Traditional pay television services, such as cable can also include connected television features in their set-top boxes. For example, in France, the cable operator Numericable integrates Twitter access into its set-top box, thus facilitating "second screen" social media activities. Broadband providers in France, frequently include a digital terrestrial television receiver in their end user equipment in order to permit subscribers to receive FTA television service as well as whatever IP video their broadband connection can support. In some cases this is limited by the available DSL speed. Another broadband provider, Orange, facilitates connected television by having an "appstore" for its Livebox product that permits access to some video streaming applications.

Whether it be functionality integrated into a smart television or a peripheral device designed to be connected to a video display, the general trend is towards increasing functionality, with DVR capability, a programme guide and a search function, Internet access (with some pre-loaded applications), wireless connectivity, and, often the ability to control these functions remotely using an application installed on a smartphone, tablet, or other device.

The choice of what applications to include pre-installed on a connected television device is, of course, up to the service provider deploying it rather than the manufacturer. Similarly with the "Orange appstore;" it is not the manufacturer but the service provider (or maybe the appstore provider) that makes the decision. This can bring up competitive issues, as recent trade press coverage of Comcast's apparent deliberations over whether to include Netflix as an application on its set-top box interface illustrated. In some European countries, HBO is offering its HBO Go service on a standalone basis (rather than, as is currently the case in the United States, offering it only to pay television subscribers). Likewise, Netflix has signed contracts with three European pay television operators to offer its service via the operators' set-top box.

Supporting services

Advertising remains a key component of video programming revenues. As viewing patterns become more diversified, both in terms of when and where the content is viewed, this presents a challenge for audience measurement, which is a key input to advertising pricing and purchase decisions. Measuring time shifted viewing on traditional television receivers (say, those equipped with set meters or people meters) is relatively straightforward, and firms such as Nielsen now offer a variety of measures, from live viewing to live plus three days to live plus seven days. Measuring viewing on tablets, laptops, or smartphones is a greater challenge. As mentioned above, when video is streamed to a particular device rather than "broadcast" on a point-to-multipoint basis, it is possible to target the advertising to the individual recipient. This has implications for how advertising messages are created and how they are bought and sold. As such, advertisers and audience measurement entities are clearly being affected by the advent of connected television. The same is true for providers of programme guides, although it is important to acknowledge that the programme guide may be created or its configuration determined not by an independent programme guide entity but by the maker or purchaser (say, a cable television company) of connected television hardware.

Competition and peripheral devices and services

Digital video recorders

Cloud-services and set-top boxes enable many new "connected television" functions. The introduction of novel technological capabilities such as these, often challenge existing business models and, therefore, can affect the competitive dynamics of a value chain. As a result, they are frequently brought to the attention of regulators and courts to assess their consistency and legality in relation to regulation and law. The overall nature of these effects goes beyond the scope of this present report not least because of the different regulation and legal requirements framing communication services across OECD countries. Some historical and contemporary examples can, however, be provided given the implications these changes have for policy makers and regulators.

The videocassette recorder (VCR) was one of the first peripheral devices for television sets. For the first time, consumers could time-shift and place-shift the viewing of television services. VCRs also launched a new market for content, both in video rentals and sales. In 1976, some, though not all, content producers in the United States, initiated a lawsuit in relation to the introduction of VCRs. They argued that because the device could be used for copyright infringement, a manufacturer was liable for any infringement committed by its purchasers.[4] In 1984, the United States Supreme Court ruled 5-4 in favour of the manufacturers of VCRs. Nonetheless, despite widespread take-up of VCRs in all OECD countries from around that time onwards their legal status often remained unclear. The copyright law of Australia, for example, deemed recordings of broadcasted content for personal use to be illegal until 2006, when the law was amended to reflect community use over many years.

The further development of technological capabilities around recording devices and their access has meant that these issues are contemporaneous with connected televisions. The digital video recorder as part of a set-top box and cloud-based video recorders are currently facing challenges in and outside courts. In Belgium, public and commercial broadcasters requested compensation from cable and IPTV companies for the use of DVRs. The reasons given by the Belgian broadcasters were that the new technologies enabled users to time-shift, to skip commercials and that the pay-per-view catch-up television services saw less than forecasted uptake, because consumers preferred a recorded version over paying for a streaming version. The broadcasters said that their product was not the distribution of an individual programme with advertising, but of an evening of programmes and advertising, a model they argued would be rendered less effective by the use of DVRs.[5] In 2013 a law was proposed in the parliament of the state of Flanders in Belgium, that would require prior authorization of broadcasters for any functionality offered by a television service provider added to the linear broadcast. This would include recording, fast forwarding, skipping through commercials, overlays, sidebars and other functionality.[6]

In January 2012, in the United States, Dish Networks introduced a feature called "PrimeTime Anytime". When enabled, this feature would automatically record the four major broadcast channels during primetime hours and store eight days of recordings. In May 2012, Dish added a function that allowed viewers to automatically skip the advertising when watching recorded PrimeTime Anytime content from the previous seven days, but not for content recorded on that day. For consumers, the feature meant the service would look and feel like there were no commercial breaks in the content. In 2013, Dish added a Slingbox feature to its DVR, enabling its users access via the Internet to content received over their home satellite dish and on their DVR. Both features were challenged in lawsuits by broadcasters. An injunction on contractual and copyright grounds was not successful, however, in an initial court case and the litigation progressed to a district court.[7]

In 2009, also in the United States, Cablevision introduced a networked DVR or cloud DVR for its customers. Instead of requiring a DVR in the household of a customer, the recording was done in a datacenter of Cablevision when the user requested this to be undertaken. The recording was then sent to a user on request. This capability saved Cablevision the cost on the acquisition of millions of DVRs, their hard-disks, maintenance and replacement. Each recording was done for each customer individually. If 10 000 customers recorded the same programme, the same number of copies would be on the system. This service was challenged in the courts but was upheld to be legal after an initial defeat. The grounds were that the service, though provided by Cablevision, was under the control of the user. It stored individual copies for each user and they were only accessible for that user. As a result it was not assessed to be a public performance, which would have been in contravention of the law.

In 2012, in Australia, a similar case on a cloud DVR service met with a different outcome and was ruled against by the court. In this case, Optus a major fixed and wireless network provider enabled its customers to record up to 15 free-to-air digital channels on a cloud DVR. This content could then be accessed by an app on a smartphone or computer as soon as two minutes after being recorded. This latter feature was particularly contentious for actors with business models that relied on the sale of rights for live events such as sport. They said this capability contravened their ability to sell exclusive rights separately to free-to-air and Internet providers. Telstra, the leading rival to Optus, in providing fixed and mobile communication services in Australia had, for example, purchased the Internet rights to the largest codes of football in that country (Australian Rules and Rugby League) for its Internet customers on fixed and mobile networks. Though Optus was initially successful against the legal challenge to the service, based on the provision of the Copyright Act of 2006 that had legalized personal recordings on VCRs, it was ruled against on appeal. The Court argued that Optus had made the recording, either alone or with the subscriber, and it was not doing so for private and domestic use and, therefore, did not fall under the exception of the Copyright Act.[8] The outcome also led to the closure of similar over-the-top cloud DVR companies in Australia, such as MyTVR and Beem.tv.

Cloud DVR services have not only come up against concerns such as time-shifting but have also given rise to issues around geographical coverage. In an endeavor to meet existing regulatory requirements, the aforementioned MyTVR in Australia, when in existence as a service, limited the acceptance of subscription only to users that lived in the geographic area covered by the applicable free-to-air services. A consideration here was that under the Broadcasting Services Act, 1992, an individual person must not control television-broadcasting licenses whose combined license area exceeds 75% of the population of Australia. The intention of this clause, when introduced, was to prevent media concentration. In other cases, cloud DVR services have limited their geographic coverage in an endeavor to abide with the rights sold to free-to-air broadcasters for specific geographical areas.

How such a service would be regarded in other countries is a point for consideration. In France, for example, certain players could technically propose services for a Network Personal Video Recorder (NPVR) or Cloud PVR option that could bring new features for viewers (not available within the current PVR) to mainly *i)* watch and record several TV programmes without constraints; and *ii)* watch their recorded programmes on any device (e.g. television, PC, smartphone, tablet). However, under French copyright law, it is a common principle that reproduction of a copyrighted work requires the prior authorisation of the copyright holders, unless the said reproduction falls into one of the exceptions granted by the law, in particular the exception for private copying.

Live television online

Aereo, initially launched in New York in 2012, is one of the best-known examples of a cloud live television and DVR service operating in specific geographical locations. The service was immediately challenged in the courts by broadcasters, but with the support of some cable companies such as

Cablevision. In addition, the earlier Cablevision ruling was significant for Aereo. Until now, the service has been upheld in the courts. With the two courts, which have considered challenges to date, taking the view that this is not in violation of the law.[9]

One attribute that differentiates Aereo, from a service such as MyTVR, is the use of a dedicated antenna for each customer accessing the service in the Cloud. The similarity, between Aereo and other Cloud DVRs, is that it enables subscribers to view live as well as time-shifted over-the-air television on Internet connected devices. With Aereo, however each subscriber has an individual antenna, no larger than a coin located in a datacenter. Hundreds of thousands of such antennas are co-located at these facilities. From here the television programme is streamed to the individual user's "connected television", wherever the user is or when the user records something to a storage facility. Customers subscribe to the service for a monthly fee. The service was initially only available in New York City. In 2013, Aereo announced plans to expand across 22 cities in the United States.

In April 2013, a company called FilmOn launched a similar service to Aereo's offer in Switzerland. They aim to make free-to-air satellite television available via the Internet to their customers. The company says that when users access their website or via an app on a smartphone they will receive content via their own unique satellite dish or micro antenna. They take the position that under Swiss law reception and distribution of any receivable free-to-air signal is allowed. This legal position, they say, enables local platforms including Swisscom IPTV and UPC Cablecom to receive and distribute channels, including the United Kingdom's domestic channels such as BBC1, BBC2, ITV and Channel 4 or France's France 2, 3 or Italy's Italy 1 and so forth.[10] A user can either opt for a free or advertiser supported service streamed at SD or pay for a HD stream.

Unlike the Swisscom service, which is aimed at their customers in Switzerland but can be viewed abroad, the FilmOn offer is available to any user that accesses the website or downloads the app. This means, for example, that a user in France could watch the BBC, whether in France or another European country while travelling. A viewer from Italy could watch France 2 and so forth. FilmOn says it "will respect a broadcaster's control over where their content is available by ensuring the service respects international boundaries where they are already in force."[11] This would likely mean the user from France might not be able to view the BBC service when travelling in, for example Australia or Japan.

In Europe a number of nascent linear and cloud DVR services have emerged. In Sweden, a company called Magine, currently offers live online television and cloud DVR services in that country, as well as in Germany and Spain. It offers around 30 channels of live television, with DVR and catch-up television. It has contracts with these channels and is licensed to carry the content. In some ways it resembles traditional broadcast television. As it broadcasts over the Internet, however, it can be used on any type of connected device and at any location. It uses an app that can be installed on smart televisions of LG and Samsung and apps installed on laptops, phones and tablets. One of the features it offers is that it enables a user to seamlessly switch from live to on-demand. For example, when a user selects a programme that has already started, the user can go backwards to any moment in the programme. On many set-top boxes, this would currently not be possible, because the set-top box only records what the user is watching and therefore can go back only to the moment the channel was launched.

Standardisation

Historically, many providers of cable and satellite services have required the use of a proprietary set-top box. Sometimes this box was paid for when joining the network or rented by the subscriber and in other cases any charge was not broken out in the overall monthly fee. Over the years many consumers have expressed the view that they would prefer to have an alternative choice of equipment as they do with other communication services. They have witnessed the innovation in non-proprietary set-top boxes in terms of their ease of use and potential lower cost over their lifetime.

While it is not always possible to have service without the use of a set-top box this is starting to change where users have effective competition. Some consumers would prefer to have the option to receive television through a set-top box that is independently purchased via a retail channel or to use standardised interfaces on digital televisions. Some cable companies and network operators are also looking into the possibilities of doing away with the set-top box as it requires a significant capital investment up front and continuing service expenditure over the years. In some countries there are rules on being able to receive DTT or analogue cable without a set-top box, but generally not pay-television services.

There are technical developments to integrate IPTV protocols directly into television sets without the need for set-top boxes. One example is the trials being undertaken by Samsung and TeliaSonera in Estonia. Nonetheless, there is very little standardisation towards ‘connected television’ platforms. Every device and every channel requires separate co-operation between both broadcasters and device manufacturers, sometimes with additional help from the broadband networks. This is hindering competition in all three markets.[12]

A further challenge, without widespread standards, is that smaller channels have difficulty getting their apps pre-loaded on smart televisions. At the same time, smaller television manufacturers have difficulty developing smart-television applications or getting developers to develop for their platforms. Moreover smaller networks neither get the content nor have the ability to develop apps when these are not available from the broadcasters. At times, even the largest manufacturers of smart televisions have had challenges in introducing these services into the market. A notable dispute took place in 2012 between Samsung and Korea Telecom (Box 2).

This is not to say there are no standards. There are, such as HbbTV of the European Broadcasters Union, used in Germany, France, The Netherlands and other countries and similar standards, that are just not yet widely accepted. As a result broadcasters do not provide easy access to APIs and content, and often only allow their in-house developed apps access to their services. There is no default standard yet, because all players likely believe they can dominate part of the market and, therefore, are less likely to accept a competing standard.

A key question in this area is the application provider entry conditions and innovation, which is worthy of more detailed discussion, though it is still early in the development of this market to draw conclusions. Certainly some connected televisions come pre-loaded with some applications of some service providers and not others in those same markets. These applications appear to be the result of commercial negotiations between the actors involved rather than as selected by consumers and introduced by them onto the device. Any concerns may be mitigated by the greater use of standards that enable choice or by capabilities or devices that enable bridges between services or the use of over the top services.

In all these considerations, the degree of competition among ISPs or other actors in a market is of crucial importance. This includes any future vertical competitive issues that could arise in the interactions of ISPs and content/application providers. These would include possible incentives of ISPs vertically integrated into content provision to behave anti-competitively with respect to competing independent content providers and possible anticompetitive discrimination by ISPs among competing independent content providers. While this issue goes beyond the scope of the document it can be noted that some communication regulators have acted to ensure some types of content are available to all players in a market where it was deemed that these providers would not otherwise be able to compete (e.g. Ofcom and the United Kingdom's “Premier League” football competition).

IMPLICATIONS OF CONNECTED TELEVISION FOR NETWORKS

Networks for television

The use of connected televisions requires different capabilities than for networks that have traditionally been employed to deliver video services. Connected television requires a network that can support non-linear content and interactivity. Not every network can be adapted to support the use of connected televisions such as satellite and DTT and require supplementary connectivity if they are to provide two-way communication. The connected television functions will work around the media received via traditional broadcasting.

The use of digital television broadcasting (DTT) has almost entirely replaced its analogue equivalent in OECD countries. By the close of 2013, analogue terrestrial broadcasting will be replaced by DTT in all OECD countries, except for Turkey and Mexico. These two countries will make the switch in 2015 and this change is expected in Chile in 2017. DTT is very flexible for both a broadcaster and users. A broadcaster needs relatively few antennas to reach millions of potential users. For those users, DTT can be built into a new television or be received via a set-top box.

Depending on local conditions DTT may need an external antenna for better reception indoors. The number of channels on DTT is dependent upon the available spectrum and the encoding used. For example, in the United Kingdom, Freeview offers 50 TV channels, and 24 radio stations plus 4 HD channels, with more channels to be added in the near future.[13] Each of these service providers may have one or more channels. DTT only supports linear broadcasting and no on-demand services. The technology does not support non-linear content and does not have an integrated return channel, for non-linear or interactive features. As a result another communication channel, such as a broadband connection is necessary to incorporate this functionality into a connected television.

Satellite television makes use of a device in geostationary orbit. For reception a user needs a dish and an adequate line of sight to a satellite positioned above the equator. Satellite services support a large number of television channels, often giving users access to hundreds of free-to-air and pay-television channels in standard and high-definition. Like DTT, satellite television does not support non-linear content and interactivity, because it does not support return channels. There are satellite services that include non-linear content and interactivity, but to enable this they make use of a separate return channel over a dial-up or broadband connection. There are broadband satellite networks with speeds up to 12 Mbit/s, which can support connected television services, though data usage is often limited by caps that are generally low relative to terrestrial fixed broadband networks.

Cable television networks have evolved from being shared antenna networks to comprising hybrid-fibre coaxial cables that can provide Internet access. These networks carry a radiofrequency signal over which a number of analogue and digital television channels are modulated. An attribute of cable networks is that the signal in the coaxial cable is well shielded from external "noisy" influences. This gives a cable network operator a very wide spectrum to modulate their signal over, thus enabling a large number of channels to be carried. In order for this to function, with the many hundreds of channels that typify services today, fibre needed to be brought closer to the user's premises. These channels do not only carry analogue and digital television, they also carry IP-protocol signals in both directions. The IP-protocol is used to provide broadband Internet access as well as services such as broadcast linear IPTV, Video on Demand, VoIP and video-conferencing.

The Data Over Cable Service Interface Specification (DOCSIS) is a standard that enables the addition of high-speed data transfer to an existing cable television network. Up to 1 000 end-users may be connected to a single cable head-end, though often the number of end-users connected is between 100 and 300. Using DOCSIS 3.0, released in 2006, a cable network can carry between 40-50 Mbit/s digital content per analogue television channel of 6-8Mhz.[14] In a typical installation, four (or more or less) channels are bonded for an Internet download speed of 160-200 Mbit/s and three channels are bonded for Internet upload speeds of 120-150 Mbit/s. This speed is shared between all users. The number of users that share download bandwidth can, however, be reduced by assigning them to a different set of bonded download channels. In using DOCSIS 3.0 only three channels can be used for upload by all users. This is a result of choices made in the past. Theoretically a cable connection using DOCSIS 3.0 can share 5 Gbit/s downstream, if it was used only for IP-connectivity and not for analogue or digital television.

DOCSIS 3.0 allows for the use of channels to broadcast variable bitrate IPTV and Video-on-demand and for these to be mixed in with Internet broadband channels. The design goal for DOCSIS 3.1, which is scheduled for release in 2015, aims at a 50% increase in capacity. It will have a theoretical capacity of 2 Gbit/s upstream, and 10 Gbit/s downstream, if the cable will solely be used for IP-traffic. Some networks do not use VOD over DOCSIS to deliver video-on-demand to some of their customers, but instead use a dedicated digital television channel. This allows the delivery of VOD without the need for a DOCSIS 3 tuner. This still requires the customer to have an IP-connection to a set-top box, but the content is not sent using the Internet Protocol. This is an example of a connected television service without the use of IPTV.

Digital subscriber line (DSL) is a technology, which provides Internet access by transmitting digital data over the copper wires of traditional telecommunication networks. DSL networks can support the delivery of television using IPTV. They can offer up to 100 Mbit/s symmetrical data transfer depending upon the type of DSL used and the technologies applied (theoretically even more). The maximum up and download speed is dependent upon the distance of the customer premises from a digital subscriber line access multiplexer (DSLAM). The IP television streams share this bandwidth with the other applications used over a network. On a DSL network a DSL provider will often use a form of management to guarantee that the IPTV stream is not influenced negatively by other applications.

There is an increasing number of fibre to the household (FTTH) networks across the OECD area and they commonly use IPTV to deliver television to their subscribers. Users of these networks can share, or use individually, between 100 Mbit/s and 10 Gbit/s, depending on the topology and technology used. Some fibre networks, notably Verizon FiOS in the United States and Reggefiber in The Netherlands, use a similar technology to that of cable networks to deliver television in the premises of consumers and may deliver a mix of analogue and digital television. The technology is essentially the same as used by cable networks, except that the fibre terminates in a residence instead of at a cable modem termination system. The signal is carried over a separate colour on the fibre, next to the two colours that carry the upstream and downstream IP-packets.

Given constraints, due to the spectrum limitations associated with 3G networks, mobile operators have been cautious in promoting mobile television. There have been a few notable exceptions but they generally involved over-the-top options for customers. In the United Kingdom, for example, “3 UK” as far back as 2006 offered their customers the ability to use a Slingbox on some tariff plans. More recently there have also been a number of devices, such as those sold by EyeTV, that when connected to a smartphone or tablet, enable users to receive over-the-air television signals, thus not using mobile spectrum or incurring charges from their operator. For LTE a new standard for multicast has been developed, which might be introduced on networks in 2013, Enhanced Multimedia Broadcast Multicast Services (E-MBMS).

While mobile network operators are increasingly seeking the rights for content, such as live sporting events, their experience with mobile television is mixed. There are currently a number of OECD countries, Japan, Korea and United States, where broadcast television can be received on mobile telephones and other devices. In Japan, all mobile operators offer their customers access to mobile broadcasting, using 1Seg-technology. Many smartphones are available and for telephones that do not have a native receiver, such as the iPhone, an adaptor with an app is available. Korea uses DMB technology, which has become widespread due to rapid diffusion of mobile devices. DMB is also used in vehicles such as trains and automobiles, but authorities prohibit watching DMB television in automobiles by drivers in consideration of traffic safety.

In August 2012, in the United States, “Dyle mobile TV” launched in selected markets. The Dyle application enables live broadcast programming utilising the ATSC-Mobile DTV standard. The company works with EyeTV to provide the receiver and, as such, any use does not become part of the user’s data allowance or incur data charges. Samsung has developed a mobile telephone to access the Dyle services. Dyle is operated by a joint-venture of 12 major broadcast groups including Cox Media, Hearst Television, as well as Fox and NBC. The Dyle service does not offer interactivity and there is no need for an Internet connection when viewing live television. There are, however, a few times when a user needs a data connection to run the Dyle TV application. This includes registering in order to automatically renew a device’s access to the service and to update the programme guide.

Around 2006, in Europe, several mobile operators introduced DVB-H, a version of the digital television standard DVB-T for handheld devices. However, only Nokia supported the standard in its devices and consumer uptake of mobile television was limited. All European countries have now ceased DVB-H broadcasts and the spectrum has, in many cases, been returned for alternative use.

Consumption of audio-visual content on mobile devices is growing across the OECD. Some networks are reporting that considerable amounts of traffic volume on LTE networks is for video usage from platforms such as YouTube and Vimeo as well as their own branded services, more so than on 3G networks. There are, however, few official data to inform the breakdown of on-net and off-net video traffic. It does show that LTE is a better fit for online video and as a result users employ it more to access video. A growing number of video streaming services, including Netflix, allow a user to shift the viewing of audio-visual content from a television to a mobile device. In other words, they can begin watching on one device and location and continue with another device and location. Nonetheless, a significant amount of this usage, while using smartphones and tablets, will be over a Wi-Fi connection to a fixed network.

Audio-visual content on the Internet

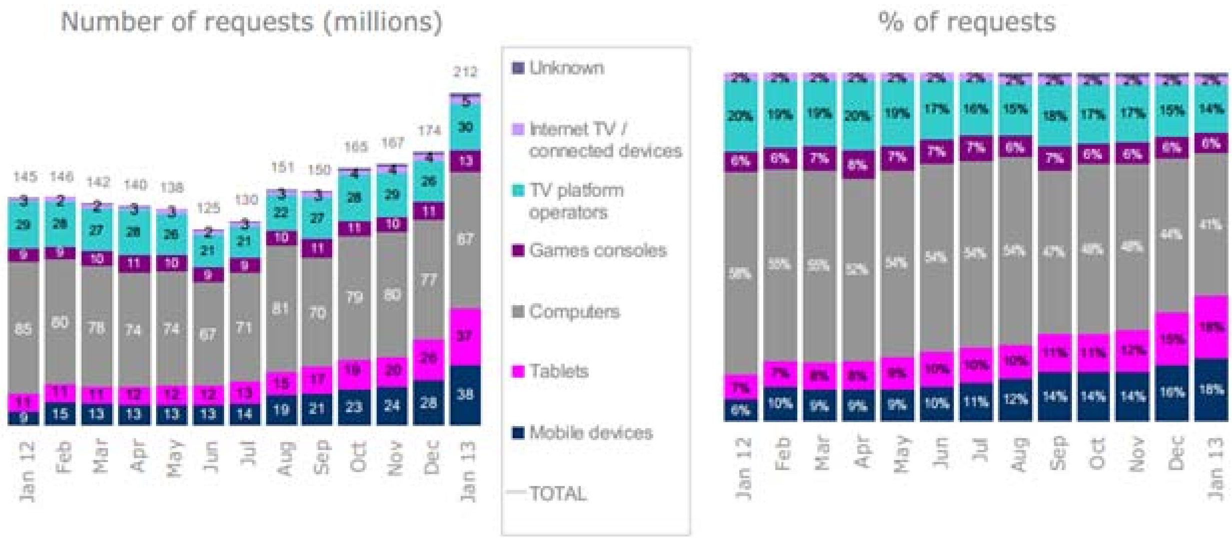
The distribution of television and video content over the Internet was foreseen in some of the earliest browsers for accessing the World Wide Web. The use of video, however, was severely limited by the lack of processing power in connected devices and by the bandwidth of access lines (e.g. dial-up Internet or 256 Kbit/s low speed broadband). At the time, due to bandwidth restrictions users needed to download a file before playing it. Technological advances in software such as RealPlayer, Quicktime and Windows Media Player made the playing of live video or video embedded in webpages possible. In the late 1990s, some broadcasters such as CNN offered access to video-clips as part of their programming. However, it was only after 2000 with the wider availability of broadband that video became an important driver of Internet traffic.

Prior to 2004, the sharing of video was cumbersome for consumers until the arrival of services such as YouTube, Youku, Tudou, Vimeo, Dailymotion and Rutube. There were some earlier services but they did not achieve significant acceptance by the market. All these sites functioned with Adobe’s “Flash Video”, which was included in a larger number of browsers than competing video systems, such as Quicktime and

Microsoft Windows Media Player. Part of the attraction and consequent growth of some sights over others, was reported to have been because of their ease of use and that operators of the sites did not review the content before being uploaded.

A key element of effective business models with video sharing has proven to be significant network effects (i.e. viewers are attracted by content and publishers by viewers). By 2012, YouTube had around three billion views per day and 800 million users. That being said, some sites, that focus on a particular location or language, such as Dailymotion (French), Rutube (Russian), Youku and Tudou (China) or that focus on professional or high quality, have also become significant players in those markets.

Figure 1. Use of BBC iPlayer



Source: BBC, February 2013.

As early as the mid-1990s some live broadcasts of events over the Internet were trialled. On 18 November 1994, the Rolling Stones broadcast a concert over the Mbone network, an experimental multicasting network, which needed experimental software. In 1998, KPN experimented with Snelnet, a pilot of a DSL network in Amsterdam, which offered broadcast television channels, catch-up television called “DelayTV” and a music video juke-box, which all proved popular with their users. One of the first providers of IP-television was Kingston Communications in Hull, United Kingdom, which offered broadcast television using the Internet Protocol over its own DSL-network in 1999.

It was not until the introduction and expansion of broadband access networks that progress began to be made. It made it possible for users to stream the content and watch it while it was downloading. Eventually this led to developments such as broadcasters offering full access of their programming after it had been released, so-called “catch-up” television. Services like Hulu, BBC iPlayer and many others from private and public broadcasters have seen considerable take up and acceptance by the market. The BBC iPlayer experienced over 200 million requests for television content in January 2013. Notable in these data is the enormous growth in the use from mobile devices and tablets. These devices represented 13% in January 2012 and 36% in January 2013. Even though the relative size of some categories declined, the number of requests is increasing on all platforms (Figure 1). The growth in use of iPlayer via Internet television and television platform operators is relatively stable. This may be explained by the limited user interfaces of some televisions or that mobile and tablet apps opened up new (mobile) uses for iPlayer, which are not possible with a traditional television.

By 2012, most broadband networks offer IPTV, in some form, as part of their service. On DSL and fibre networks, it is often the primary distribution technology; on cable networks it is a secondary technology. The country with the highest IPTV subscription rate is France (Figure 2). In this country IPTV is generally an inseparable part of a triple play offer on fixed broadband networks and prices for a bundle of services are among the lowest in the OECD area.

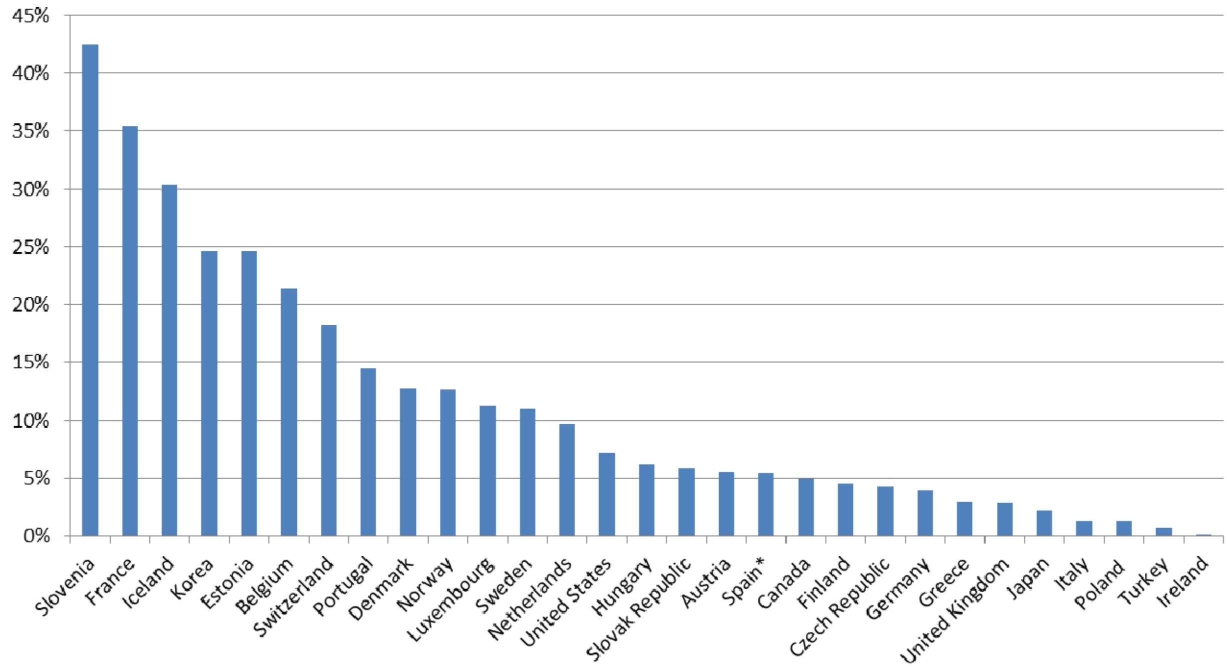


Figure 2. IPTV subscriptions as a percentage of households (2012)

Source: OECD, European Audiovisual Observatory, Screen Digest.

The technology behind connected television

The technology underlying connected televisions consists of two main elements. One element is the way content is encoded and transmitted to the consumer. The second element is the data and apps that allow interactive applications built around the content. Together, they create the experience for the consumer of connected television services. For both elements there is a global push towards standardisation.

Digital content compressed using encoding technologies to transmit over digital networks as original uncompressed content requires large network bandwidth or storage space. For example, uncompressed HD frame, consisting 1920 pixels horizontally and 1080 pixels vertically, requires bandwidth of 50 Mbits. At 24-30 frames per second, this might result in 1.5 Gbit/s of data or 11.25 Gbyte for a minute of video.[15] If this needed to be stored, a Blu-Ray disc could only hold four minutes of content. For transmission, an advanced optical network would be required, operating at 10 Gbit/s, to be able to carry out this function for individual premises. Some video is now shot at 60 frames per second, which is said to be more natural to the eye. In the case of 3D the same image has to be caught from two slightly different angles, again doubling the bandwidth required for transmitting 3D content. The successors to HDTV are 4K and 8K, which have four and 16 times the pixels of HD content.

Digital content can be compressed by the use of algorithms that look for repeated segments, for example a red rectangle can be described as “100x100 pixels red”. More regular patterns enable higher compression rates.

In audio-visual content a large compression factor can be achieved because the difference between two images in a stream is not too large. The human eye cannot follow all changes in a sequence of 24-30 images per second. This enables the use of “lossy encoding”. The term "lossy" compression is a data encoding method that reduces the size of data by discarding some of it without compromising an objective (e.g. loss in image quality is only minimal).[16] Encoding is a trade-off between image quality, file-size, bitrate, processing power and energy use. Scenes with faster movement require a higher bitrate for a given quality, or show less quality than slow moving scenes at an equal bitrate. Video is often compressed using variable bit-rate encoding thereby allowing a constant quality, but saving space on media. The quality of an encoding is dependent upon the purpose the encoding is intended for as well as skill of the encoder and the technical development in encoding that is applied. It is, therefore, difficult to say, whether an encoding is fit for purpose, based on the bitrate alone.

Working together, video compression standards are created jointly by the ISO/IEC Moving Picture Experts Group (MPEG) and ITU-T Video Coding Experts Group (VCEG). Advances in chip-design and encoding algorithms have enabled the release of a new standard for compression roughly every 10 years. Though it is possible to do decoding in software, it is mostly done by specialised parts of video chips. H.262/MPEG 2 was approved in 1994 and is known for its use for DVD’s and digital broadcasting.[17] The standard H.264/MPEG4 AVC was approved in 2003 and is more commonly used for Blu-Ray discs and HD-broadcasting, because it can achieve roughly twice the compression at similar quality. In January 2013, the High Efficiency Video Coding (HEVC) standard, aimed at the successors of HDTV, known as 4K and 8K was finalised. It will achieve a similar increase in compression capability. A 100 MB video encoded in H.262 would be 56 MB in H.264 and 33 MB in HVEC.[18] The exact bitrate of audio-visual content will depend on the application. Furthermore some broadcasting systems, such as DTT may use statistical multiplexing to dynamically change the bitrates of the emitted channels based on what is being broadcast on that channel and other channels. A football match could be broadcast at a high bitrate to increase quality, while other channels are at the same moment broadcast at a lower quality and lower bitrate (Table 1).

Table 1. Bitrates in Mbit/s of Internet streaming services

Medium	Mbit/s
4K	25 (HEVC)
8K	90 (HEVC
BBC iPlayer	0.8 and 1.5
Blu-Ray	Up to 40, typically 20-30
DTT UK Freeview (SD and HD)	Variable between 3 and 17
DVD	3-9
Netflix	0.375, 0.500, 1, 1.5, 2.6 (HD), 3.8 (HD), 5 (Super-HD), 9 (3D)
Swedish public broadcaster live streaming	5
Youtube	Up to 52mbit/s[i]

[i] Maximum streaming rate attained by author on high bandwidth connection, during off-peak hours.

The same video compression standard can be used for all types of audio-visual applications; video-conferencing, digital (satellite) broadcast, cable IPTV, physical media online streaming or download. There are different profiles that allow the parameters of the encoding to be adjusted to best suit the application. The encoded video is combined with audio, subtitling, digital rights management and other data in a container or wrapper, which specifies the various parameters of the video and its metadata, so that the player knows how to display the content. Well-known formats are Integrated Services Digital Broadcasting (ISDB), Advanced Television Systems Committee (ATSC) and Digital Video Broadcasting (DVB) for satellite and terrestrial broadcasts, QuickTime and Flash for online content and DVD and Blu-Ray for physical formats. The use of a single compression standard for all applications allows for extension of connected television services to devices. The same compression standards are used for physical media, broadcast and streaming, which the device's video chip can handle. The device only needs to be able to work with the different container formats, which is limited to a software update.

When content is sent over the Internet a provider has two choices. They are either using a progressive download or streaming that content. While this may not always be obvious for users it is an important distinction for content providers and networks. A progressive download is when the full video file is sent to a user. That user can view the file from the beginning of the data received but can only skip forward as far as the file has downloaded. In contrast, a streaming file only sends the data concurrent with it being viewed. Users can skip forward in a stream and the video delivery picks up from the point specified by the viewer.

The advantage of a progressive download is that it is a relatively simple mechanism, where the server does not have to be aware of the user's stage of viewing and maintain the stream. This enables a less expensive and more robust system serving more customers at lower costs. It makes use of TCP and HTTP and does not have the potential disadvantage of being blocked by a firewall. Compared to streaming, which uses UDP, it is also less influenced by short network fluctuations, as long as the average download speed is above the average bitrate of the file and when bandwidth is not sufficient, a viewer can wait for the whole file to be downloaded. Progressive download using TCP also fits the “burstiness” of other Internet traffic, scaling down when other traffic is scaling up, thereby consuming a fairer share of bandwidth. For streaming using UDP to function effectively, the download speed associated with that data always has to be above the bitrate of the stream. UDP also lacks a mechanism to dynamically scale its traffic to take only a fair part compared to other streams. Therefore, streaming does not tolerate well the “burstiness” of a network.

A further advantage of a progressive download is that when it has finished it does not use up resources anymore, leaving these for other users. The benefits of streaming is that a user can skip through a file and that no more bits are sent than are necessary for viewing, which is important for users with bandwidth caps. Streaming can also support live broadcasts, whereas using a progressive download cannot perform that role. Streaming is sometimes not supported by firewalls such as those used by a business or corporate user.

The technology associated with streaming and progressive downloads has changed dramatically over the years. Progressive downloads have gained the ability to skip through a file, without the need to download the full file, known as “progressive download streaming”. Streaming has also progressed to make use of adaptive bitrate streaming. In this case, the bitrate of the stream is adjusted depending upon network conditions.[19] Adaptive bitrate streaming is different from variable bitrate streaming. For adaptive bitrate streaming, the file is encoded with different maximum bitrates. Netflix uses up to 8 different maximum bitrates, with different quality levels. Within this maximum bitrate, the content may be encoded using variable bitrate or constant bitrate encodings.

Before 2012, YouTube made use of progressive download streaming. In 2012 it switched to adaptive bitrate streaming. This allows YouTube to automatically select the best quality of the stream, based on the device, network and screen-size used and it can scale up or down, depending upon network conditions or whether the user has selected the full-screen option. The streaming client, in the browser or app will notify the streaming server of improvements or deteriorations in streaming quality and screen size changes. This way it can adaptively scale up to 52 Mbit/s and higher. For the streaming provider the implication is that it needs to have multiple versions of the same content in various qualities, optimised for various devices. Netflix encodes every film into 120 different versions, based on screen size, aspect ratio, device type and other elements.

For live streaming, such as in the case of linear broadcast television or live events, it can be expected that many users will access the same content at the same time. Traditional broadcasting networks, satellite, DTT and cable are all optimised for all viewers watching content at the same moment. It requires higher upfront costs to broadcast content in this manner, but every additional viewer reduces the average cost per user. For example, 500 channels could be broadcast, at the same time, with viewers selecting the content that most appeal to them across these channels. For IP-networks, IP-multicast was developed to allow a similar use and save bandwidth in the core network by sending streams once, instead of multiple times.

Though multicast was part of the earlier mentioned experimental Mbone network, in the early nineties, it has not seen a large take-up on the Internet. Many Internet exchange points (IXPs) enable the exchange of multicast traffic between networks, but at the world’s second largest IXP in Amsterdam (AMS-IX), traffic is less than 1 Mbit/s. This would not support, for example, a single SD-stream. To further place this in context, the AMS-IX handles 2 terabit/s peak traffic. Multicast is more popular on managed IPTV networks of ISPs for traditional linear broadcasting. This makes more effective use of network capacity in the core of the network. The term “managed network” is sometimes used in relation to multicast and connected television services (Box 1).

Box 1. Distinction between managed and over-the-top connected television

Some commentators have made a distinction between managed and over-the-top connected television services and this wording has featured in some regulatory decisions. The term “managed” refers to a service offered by the broadband network operator. This network operator manages the service by providing dedicated bandwidth for the service and creating a special QoS class, by using multicast or by having the facilities closer to the end-user. Over-the-top (OTT) connected television is perceived as being unmanaged, because the network operator does not provide facilities to the OTT service provider to improve or guarantee the quality of experience. OTT is felt to provide inferior performance and service quality and, therefore, is not regarded by some as “true television”. Some regulators use this distinction to differentiate in the regulatory treatment of services. At the same time, some network and OTT providers use the distinction to support their views on which treatments that should be applied to services.[20]

A key question that can be asked, in relation to any distinction, is whether it makes a difference for consumers or if they expect the Internet access service they pay for to be able to deliver a quality acceptable for their requirements relative to a video service bundled with that subscription. OTTs such as the Swedish Public broadcaster, Netflix, Lovefilm and others have found the use of an unmanaged Internet sufficient for their customers. That being said, it should be underscored that the vast majority of linear television is still handled by broadcasting technologies such as DTT, satellite and cable). Even when broadband ISPs have tried to make managed services commercially available, they have found few distribution networks willing to make use of these services. A further factor that blurs such distinctions, including between OTTs, is that some of the OTTs have more far reaching distribution networks as well as making differing levels of uses of CDNs.

The rising use of connected televisions may in the long term decrease the reliance on multicast broadcasting, whether it is on IP-networks or traditional broadcasting networks. An increase in linear broadcast channels and on-demand use of audio-visual content decreases the number of consumers simultaneously watching the same content. By way of an example, on average 300 to 1 000 households are connected to one cable headend. A cable network may offer up to 500 channels. There is a high probability that not all channels are in use even if all viewers were at home watching television. Cable networks have adapted by moving to switched digital video, where less popular content is not broadcast, until requested by a user. This frees up capacity for on-demand services and other broadband Internet services.[21]

An increasing number of cable and IPTV networks are offering second screen services for tablets, mobile phones and laptops and integrated with social media services. This content is streamed in multiple versions, to facilitate different screens and quality, which decreases the average number of viewers per individual content stream. A cable or IPTV network may not need as many different versions of the same content as a service such as Netflix, but they do need multiple versions, for SD, HD, 3D, and different aspect ratios. Some networks have moved to cloud based digital video recorders, which create separate streams when a user watches content that they recorded earlier. Depending on the implementation it may also mean that when a user presses pause, the live stream is paused and recorded in the cloud and then replayed when “play” is pressed, creating a separate stream.

ISPs are increasingly making video-on-demand, catch-up television and live television available on more devices and with greater flexibility in terms of where content is consumed. On the one hand, devices such as mobile phones and tablets can be used as remote controls, search devices and as a way to schedule or directly record content for later use. Much of this functionality can be employed whether or not a user is at their residence. On the other hand, some network operators offer live television to watch on tablets and mobile phones streamed directly from the servers of the IPTV or cable-television company, instead of from the user’s set-top box as does a Slingplayer. In the United States these services are known as “TV Everywhere”. Most cable and IPTV companies only allow their customers to use these services at a location associated with that subscription. In April 2013, however, Time Warner Cable and Swisscom started to offer services that are available outside a single location such as a user’s residence. The customers of these two networks can access their services when they are on other Internet networks. This can include uses such as when travelling out of a local region or abroad.

A conclusion that can be derived is that the impact of multicast is declining over time. The impact is decreased by an increase encoding efficiency through new codecs and variable and adaptive bitrate streaming. This allows video providers to tune their service to best fit the network of the receiver.

The effects of audio-visual content and services on networks

From the outset of the introduction of broadband networks, ISPs have pointed to their utility for enabling the transmission of audio-visual content. In 1998, the staff of the aforementioned ADSL trial undertaken by KPN in The Netherlands, for example, actively worked together with public broadcasters to provide access to real-time and on-demand content. One of the challenges noted in that trial was the lack of available audio-visual content.[22] Nonetheless, traditional telecommunication carriers could see cable network operators enabling their coaxial networks for Internet access and they were able to offer their existing video services in parallel with new services.

Today, most major broadband providers offer a bundle of services that include video. While they do not raise issues related to some services, such as traffic generated by their own managed IPTV services and VOD-services, some have expressed the view that the increase in traffic generated by connected televisions in relation to OTT services are either challenging for network management or that they are not being fairly compensated for carrying this traffic. Other operators take a different view saying that the level of traffic increase is not at issue or that they view any increase as being beneficial in relation to their business model. Further views are expressed by other players in the ecosystem around connected televisions from consumers to OTTs.

After briefly mapping the ecosystems around connected televisions this document now turns to their effects for networks and, in the following section, their implications for business models. From a network perspective the relevant components of a network could be categorised as being made by:

- first mile connectivity
- middle mile connectivity
- backhaul, core and interconnection connectivity

In the case of **first mile** connections almost all wired and wireless broadband network technologies have advertised speeds that can support streaming SD and HD content via the Internet. The ability to do so in practice, however, depends on a number of factors. In the case of shared topologies, such as 3G and 4G wireless as well as cable and satellite networks it will be dependent upon the number of simultaneous users. For DSL networks as well as 3G and 4G wireless networks, the distance to the DSLAM or antenna also has an influence on the speeds that can be achieved. In relation to point-to-point topologies such as DSL and fibre, the number of streams, or the highest quality that a connection can receive, is dependent upon the speed of the line and the bitrate of the content. DSL networks can reach speeds up to 8 Mbit/s (ADSL), 20-28 Mbit/s (ADSL2+) or up to 30-100 Mbit/s (VDSL2+),[23] depending upon line length between the DSL-modem and the DSLAM, where up to 4 km from the exchange, 4 Mbit/s can be supported. DSL networks are capable of providing connected television services, but for high quality and multiple streams to one connection VDSL2+ with fibre-to-the-curb is necessary.

On a shared topology such as wireless and cable estimating the usefulness is a more complex matter, because it also depends on the number of other users and how they make use of that network. Cable is particularly difficult to predict, because in theory it can flexibly allocate up to 5 Gbit/s to between 100 to 1000 connections. Some of that bandwidth is used for broadcasting streams of the most watched content to all connections. The remaining bandwidth can be dynamically allocated to IP-data and switched digital video. When two users share the same 40 Mbit/s DOCSIS channel and both will try to watch a 10 Mbit/s stream, while other users are using 30 Mbit/s, the system may reallocate one or both to another channel. Managing a cable network is therefore a statistical exercise. If a large enough proportion of users are not using the cable network, or watching linear multicast content, then there is enough bandwidth available for HD on-demand streaming for some. Whether cable networks can sustain a demand at a peak time (e.g. a popular sporting final or the release of a popular new television show), when all connections are trying to stream on-demand content, is less clear and will depend on the number of users on a node, the average bitrate of the streams, the total bandwidth available for IP-traffic and so forth.

Wireless networks can support SD and HD streams, however when the number of concurrent users rises, the bandwidth available per user decreases. This can only be improved by increasing the number of base-stations in a network. This is not possible for a satellite network. Early roll-outs of LTE in Germany, for example, experienced a large take-up of video services which could account for as much as 85% of traffic during a day, which was significantly more than on 3G networks.[24] The main conclusion that can be drawn from these data is that users are making greater use of various services, including video, by taking advantage of superior LTE capabilities. Given that adoption of this technology is not yet universal in Germany and that deployment was commenced in rural areas, the role that 4G/LTE will play in large-scale consumption of audio-visual content in that country remains to be seen.

Data caps, as part of a bundle of services, are more common with wireless networks than fixed broadband networks and are, as a rule, much lower than for fixed networks. These caps are common on both terrestrial wireless and satellite networks. As a result, even if the speeds of wireless networks support video they are generally regarded as a complimentary service due to the limitations relating to usage. In the United States, for example, the Federal Communications Commission has reported that Exede Satellite Internet reached sustained download speeds of 12 Mbit/s and even exceeded them in some circumstances.[25] Users report that speeds may vary during the day.[26] This would support streaming video or progressive downloads and users have reported Netflix to function. The plans, however, only allow between 10 and 25 GB of traffic during daytime (05:00-23:59), which is 33 to 75 hours of Netflix at the lowest quality setting. Data caps and their rationale will be discussed in the next sections.

Middle mile networks carry the traffic to and from a first mile network. Almost all networks use fibre-optic technology to bring the signal to the user. How close the fibre is to a consumer and how short the loop length is in the first mile to that user determines in a large part the maximum speed needed to offer services. In shared topologies, like Passive Optical Networks and Cable networks as well as wireless the bandwidth needed is dependent upon the speed of the last mile technology, which for LTE is 300 Mbit/s - 3.3 Gbit/s per site, for GPON is 2.5Gbit/s (shared over 32 users) and for HFC networks is 5 Gbit/s (though modern cable networks use RF modulation and would describe this bandwidth in Mhz).[27] More users on a node will not increase maximum demand but rather it will only decrease the average available bandwidth per user.

When operators use point-to-point networks, the maximum demand needed in middle miles is determined by the number of users and the highest broadband speed attainable, as well as the peak usage profile. For lower broadband speed networks, such as ADSL and ADSL2+, the maximum speed needed on a node is directly correlated to the number of users and less to their use, as during peak hours 70% to 90% of users will be online and will experience lower performance rates if there is not enough bandwidth available. For VDSL a typical node size is 200 users with 50 Mbit/s per user.[28] This would require around 10 Gbit/s, which is a very common speed for Ethernet backhaul.[29]

In point-to-point fibre networks, where users can get up to 1 Gbit/s and the loop lengths and number of nodes are similar, in theory 10 users can use a full 10 Gbit/s interface. To date, a relatively small number of network operators have rolled out VDSL2+ and often not to all their customers. Reaching all their customers will require large investments. In these networks the maximum bandwidth needed is very much dependent upon the number of simultaneous users and the bandwidth each of them requires. A conclusion that could be drawn is that, in principle, all networks will support 'connected television services' in the first mile and in the middle mile, though investment may be necessary to support higher speeds in the future. On shared topologies the mix between multicast and unicast traffic and the number of users on a node will for the most part determine the quality that can be delivered.

In relation to the widespread and increasing use of connected televisions the traffic of individual nodes in a network will be combined at a city or regional level. This is where ISPs currently split their networks between multicast and unicast traffic. The unicast traffic from a city or regional level will then have to be aggregated at one or more further levels above that, depending on the size of the country. It is at these levels that the effects of 'connected televisions' will be most felt in respect to network resources. The networks have been designed to handle the multicast traffic, which is operator controlled. The unicast traffic, however, depends upon an end-user and how they use the network. This is independent of whether it is the ISP's video-on-demand service or a third party and this determines if traffic will have to be carried over backhaul links. Backhaul often functions on multiples of 10 Gbit/s, though recently 100 Gbit/s has become available in some markets.[30] A medium-sized city or region with 200 000 connections could theoretically consume as much as 1 Tbit/s watching 5 Mbit/s streams.

Backhaul, core and interconnection networks carry traffic between regions and across countries to the interconnection locations that connect the network to other Internet networks. Part of this traffic is unicast traffic from the ISPs own VOD-content and its Content Delivery Network. Other traffic is exchanged between the ISPs network and its transit providers. This traffic is paid for by the ISP on a per megabit(s) per month peak capacity basis, irrespective of traffic balances and the direction of traffic. Where it is economic, ISPs will take a decision to bypass an upstream transit provider by peering directly with other ISPs and content providers. For the largest peering partners, this is often done on a direct basis (private peering) and for the smaller peers, it is common to do this through an indirect connection (public peering) via an Internet Exchange Point (IXP). At the larger IXPs in Europe, such as in London (LINX), Amsterdam (AMS-IX) and Frankfurt (DE-CIX) speeds of 100 Gbit/s per connection are available.

In many ways the difficulties of scaling a broadband network is not unlike the scaling of an electricity or water distribution network. Theoretically the end nodes all have a capacity that is significantly higher than their normal usage profile, to allow for peak usage per home. The core network has to be scaled based on peak usage around extreme events. For "Connected Televisions" the difficulty for a network will be to estimate how many users will stream in parallel and what quality streams they wish to watch. Such a moment in the United Kingdom, for example, could be on New Year's Day, when according to the BBC the use of iPlayer is highest. Variable and adaptive bitrate streaming from a content provider would try to fit as much quality as possible in the stream, whereas the design of the network puts a limit on the maximum throughput. A well-designed network will need to be able to balance this. This is in some ways no different than an electricity or water network that needs to plan for so called "television pickups", which in the United Kingdom can be as large as 2800 Megawatt in a matter of minutes, straight after a World Cup penalty shoot-out, or the average use of seven million households in that country. Electricity networks have to plan for this pick-up and time the activation of extra capacity correctly or else the network would fail and this will be a consideration for ISPs in relation to connected televisions.

CONNECTED TELEVISION POLICY ISSUES

Connected television is first and foremost a piece of end-user equipment, so a discussion of policy implications of the foregoing should begin there. This document has focused on the implications of connected television on one other portion of the industry ecosystem enumerated in the Introduction, the network infrastructure that carries content to the end-user. Connected television has been and is likely to continue to be responsible for significant increases in network traffic. Indeed, it may be the single most significant source of increased demand for transmission capacity. This section considers end-user hardware and network infrastructure, as the other portions of the ecosystem — content producers, content distributors, and supporting services are beyond the scope of the document. The purpose is emphatically not to make specific policy recommendations, but to highlight issues for consideration. It should not be presumed that government intervention is appropriate in any particular case.

There are certainly some devices the sole purpose of which is to deliver Internet video to a video display, but in general, end-user video equipment is evolving to provide and integrate a multitude of functions. These include but are not limited to "connected television (video delivered via the Internet), applications to access video from particular connected television providers (e.g., Netflix, Hulu), linear video from traditional sources (e.g., a multichannel pay television provider such as cable or satellite, or over-the-air television), ancillary content (including social media), DVR and storage capacity, a programme guide/search function, and a local area wireless network.

Many providers of cable and satellite services require the use of a proprietary set-top box. For example, the United States requires cable television operators (although not satellite companies to provide subscribers upon request with a security module that can be attached via a standard interface to end-user equipment, whether it is a "smart television" or a connected television device such as a TiVo box. Other examples include telecommunication and cable operators that actively compete on set top box features in France, Poland and in the United Kingdom. This requirement can limit the range of choice available to end-users and constrain competition in the provision of set-top boxes. On the other hand, pay television providers, including satellite companies in the United States, have commercial incentives to offer the various capabilities enumerated above and they do so. Because set-top boxes represent a significant capital investment for pay television operators, some may eventually conclude that it makes business sense to do away with proprietary set-top boxes. To date, the satellite companies have not chosen to do this in the United States.

If the pay television markets were characterised by robust competition and relatively low switching costs from one provider to another, then there would probably be no need to consider proprietary set-top box issues. However, many countries do not have such robust competition. And the increasing prevalence of "triple play" packages of voice, video, and data services probably has the effect of raising switching costs. Hence, policy makers may wish to consider the costs and benefits of measures to foster competition in the set-top box market.

This leads naturally to the question of standardisation. It comes up in connection with non-proprietary set-top boxes because manufacturers of such equipment and of television receivers that wish to integrate services from a pay television provider with connected television and other services need specifications for the security module that permits subscriber access to pay television services. However, as the essence of connected television is accessing video over the Internet, given there are a large number of current and potential suppliers of Internet video, and because the current trend is toward integrating multiple functions into connected television devices, the question of standardisation is relevant here as well. Hybrid Broadcast Broadband Television is an example of a standard; it addresses display of ancillary content on the screen along with video. There may also be the potential for standards with respect to video streaming that could reduce the cost of connected television equipment and make it easier for new content providers to enter.

A related topic is Application Programming Interfaces (APIs). These specifications for the interaction of software programs are necessary for the design of, for example, connected television equipment that can display the content delivered by a particular provider over the Internet. An important issue here is incentives for innovation. It is worth examining the extent to which standardisation or transparency with respect to the APIs chosen by content providers or connected television equipment manufacturers would facilitate the introduction of new and valuable end-user applications. New entrants to the content provision business generally wish to make it simple for connected television equipment to display their content. This could happen either through having the entrant's application pre-loaded on the connected television device or through making it easy for end-users to download the application to the connected television device. Either way, standardisation/transparency could be valuable.

Experience with computers, tablets, and smartphones makes clear the importance of access to applications, including which are pre-loaded and how easily others are accessible (e.g. via an "App Store"). Accordingly, it is worth considering how market forces are likely to operate in this area and whether any actions are needed to ensure reasonably easy entry into the business of providing connected television content.

The other area relevant for this document is network capacity, both with respect to pricing and investment. First, consider wireline service providers (e.g., cable television companies, telecommunication companies offering DSL or fibre to the home service) and the facilities that they own and use for delivering service to customers (roughly speaking the first mile and middle mile categories mentioned above). These companies generally provide two more traditional categories of video service in addition to the "over-the-top" services considered to be connected television. They use some of their capacity for a bundle of linear channels and they may offer video on demand content that resides on their own servers. These two categories may be delivered using IP but would not count as connected television because they do not reach subscribers via the open Internet. As end-user demand for capacity increases, broadly speaking the response of ISPs with respect to their own capacity is reasonably clear—reduce shared capacity by building fibre further out into the network, so that the number of households sharing, say, coaxial cable in each "node" is reduced. With respect to DSL, the procedure is similar, with the object of shortening the copper wire loop length by extending fibre. This permits more efficient versions of DSL to operate. Fibre-to-the-home-architectures generally have enough capacity to handle even extremely high residential demand.

With respect to wireless providers, the "first mile" is of course wireless, although for backhaul the wireless providers use wireline capacity. To expand first-mile capacity means one or both of the following—build new cell sites and/or expand the amount of spectrum available for wireless broadband. Hence another important policy issue is ensuring that adequate spectrum is available for wireless broadband, including possibly reallocating spectrum from other less valuable uses to wireless broadband. The importance of this mechanism will vary from country to country, depending on how demand for wireless service is growing and how spectrum is currently deployed in the country.

In this context it is important to recall that sometimes the wireless "first mile" is not traversed over wireless broadband company spectrum. Increasingly, end-users are employing local "Wi-Fi" networks instead to connect to the Internet. Apart from their own self provisioned Wi-Fi, it is frequently provided by local entities, mostly businesses such as hotels and coffee shops but also sometimes by local governments. Wireline ISPs, such as Comcast and Verizon in the United States, are increasingly providing access to far-flung groups of Wi-Fi "hot spots" as part of the wireline broadband service.

Investment and pricing decisions are clearly influenced by the degree of competition among ISPs. In general, the wireless broadband space is characterised by greater competition than the wireline. Some countries have just one wireline infrastructure; a few, such as Korea, have several. Much of the United States is served by two wireline infrastructures, one based on the telephone network and one based on cable television operators. Clearly, the degree of competition is a relevant factor for considering questions of ISP regulation. This document has illustrated various end-user pricing methodologies that have been used to recover the cost of wireline networks, with the intention of charging more to end-users who have stronger demand for the service. ISPs have tried to do this by charging according to download speed tiers and sometimes by resorting to download limits (although this is better understood as tiered pricing as most wireline ISPs do not impose flat ceilings on downloads). Aside from any question of price regulation, all OECD countries consider transparency in billing and descriptions of service offerings to be critical components of any service.

Some believe broadband service is a "two-sided market" and the potential exists for ISPs to impose charges on content or application providers in addition to end-users. To the extent that application providers might wish to ensure fast delivery of their content, ISPs might have the scope to charge them a fee. One way of describing "network neutrality", a topic that this document does not consider, is in terms of a requirement that ISPs cannot charge content providers a price for priority service. However it is important to note that content providers can and have incurred other costs in order to improve the quality of their service, principally by building or contracting for Content Distribution Networks (CDNs). By caching content at multiple sites, the content provider can shorten the path that content must travel to reach an end-user, thus increasing quality and reducing the resources needed for transport of the content over the Internet. Hence if a policy maker is concerned that content providers should have tools available to increase the quality of its service but is concerned, for example, about encouraging investment in new applications, and hence does not want to put new content providers at a disadvantage relative to incumbents with respect to delivery of their application over the Internet, CDNs may be a way to balance these concerns.

One other aspect of the relationship between content/application providers and ISPs is relevant here. To the extent that an ISP is vertically-integrated into content/application provision, it is important to be alert to the possibility that the vertically-integrated ISP may have the incentive and the ability to behave anti-competitively with respect to independent content/application providers.

As noted above, the purpose of this analysis is not to recommend particular regulatory actions or to suggest that regulatory intervention in any specific area is needed. Rather it is to highlight issues and questions that may be raised as connected television continues to develop, expand, and place additional capacity demands on the Internet.

EXPECTED CHANGES IN NETWORK DEMAND AND THEIR IMPLICATIONS

The effect of increasing video traffic over networks has been described by the terms “data tsunami” and “exaflood”. The terms suggest that networks will succumb in a dramatic manner to the amount of data sent. Some believe that growth in data use will exceed the capacity increases in networks and, therefore, will cause widespread problems in the functioning of those networks. One indicator that is frequently pointed to is that the use of Netflix can make up to 30% of peak traffic on an ISP’s network in a country where it operates. There are few independent sources for data on traffic growth over networks. Those sources that are available show robust growth but offer data that enable a more considered view of network capabilities and traffic growth.

Data from Internet exchanges (mostly in Europe) and from Cisco’s Visual Networking Index show a year on year reduction in growth rates for Internet traffic even though overall growth rates remain positive. For example, whereas global traffic according to Cisco grew eight times from 2007 to 2012 it will only grow three times in the period 2012 to 2017, a growth rate of 29%. In 2012, the growth of traffic at the Amsterdam Internet Exchange was 29% and in 2011 the total growth of peak traffic across European IXPs was 41%.[31] While both average and peak demonstrate strong growth rates they are lower than in previous periods. This growth needs to be considered in the context of the phenomenon known as Moore’s law. This predicts a 41% year-on-year growth in the development of optical components in networks.

There are few independent studies on the potential costs of increased video traffic. One of the few was work undertaken by Ofcom, in 2007, to assess the impact of the BBC’s iPlayer in the United Kingdom. One assumption made in this work was that viewers would watch 34 billion minutes per year by 2011. This proved remarkably prescient as in 2012 the BBC reported that viewers watched 36.5 billion minutes.[32] Ofcom calculated that in 2007 prices, the costs of iPlayer would have a net present value of between USD 604 million (GBP 399 million) and USD 1 258 million (GBP 831 million) over a five year period, based on the then current price for a 155 Mbit/s ATM connection from BT of USD 39 000 per month under wholesale bitstream access.

The author’s of the Ofcom report assumed their estimate was on the “high side” as they did not include any potential decreases in the prices for bandwidth. Furthermore, they said the bandwidth needed to support iPlayer could be used for other or even competing services, such that the full cost might not necessarily be allocated to iPlayer alone. In 2008, one media source reported that ISPs in the United Kingdom, such as Carphone saved up to 80% on their bandwidth costs by moving away from BT and providing their own Gigabit Ethernet backhaul network. As a result it was reported that BT effectively cut its prices in half in 2008 to meet increasing competition.[33] The absolute figures are not as critical as the general indication of trends in bandwidth prices and these are reflected in official reports.

ISPs have different views on “connected television” and the potential effects on their networks and business models. Some networks like Swisscom openly welcome OTT-television. Swisscom has stated, in its investor presentations, that it sees the provision of OTT-services as being global, but that business users and consumers want the best local networks to access these global services. Like most providers, it sees the margins for traditional services provided by them and increasingly by OTTs as declining and suggest investment in high-speed access is the most appropriate strategy to respond to this trend. Swisscom’s CEO has said the company welcomes OTT-television and increased use of video, including their own offerings, as it will stimulate customers to use the higher-speed access services they sell. He also sees their television service becoming an included part of any Internet broadband subscription, not a separately priced service in a bundle.

In respect to mobile services Swisscom's strategy reflects the high fixed costs of establishing networks but the low marginal cost of delivering traffic including video traffic. This is reflected in its NATEL branded mobile tariff options that offer unlimited voice, text and data services (Table 2). The key differentiation of service is by speed rather than the amount of data used by a customer. Users are able to select the speed that best fits their requirements. If they wish to watch live television or YouTube at an optimal speed the company recommends "infinity M". If they wanted to upload HD video then Swisscom would recommend "infinity L". There are no "bit caps" on the Swisscom NATAL LTE consumer services with the only restrictions being applied for commercial use (e.g. direct marketing or call centres) or in association with machine-to-machine services.

Overall Swisscom says their customers and investors have welcomed this approach. In respect to their customers they say that speed is an easier concept to communicate to users, especially those that do not well understand measurements such as Gigabytes and that their customers prefer the certainty of a fixed price for data usage. The company says that investors have also welcomed the pricing model given that it is popular with consumers and has enabled the company to gain market share. It says that investors also welcome that the model has the benefit of making OTTs video the potential drivers of their revenue growth. Meanwhile the model builds on the incentives that already exist for an access provider and CDNs to co-operate (i.e. in March 2013 Swisscom and Akamai reached such an agreement).[34]

Table 2. Swisscom LTE mobile broadband service (NATEL)

infinity XS	infinity S	infinity M	infinity L	infinity XL
				+ Saving data via the internet
			+ Uploading HD videos + photo albums	
		+ YouTube + Live TV + Route planner + Streaming music		
	+ SBB[35] + Facebook + News and Weather + E -Mail			
E-Mail without attachment				
Download (up to): 0.2 Mbit/s	Download (up to): 1 Mbit/s	Download (up to): 7.2 Mbit/s	Download (up to): 21 Mbit/s	Download (up to): 100 Mbit/s
Upload (up to): 0.1 Mbit/s	Upload (up to): 0.5 Mbit/s	Upload (up to): 1 Mbit/s	Upload (up to): 2 Mbit/s	Upload (up to): 10 Mbit/s
USD 39.10/month (CHF 59)	USD 49.70/month (CHF 75)	USD 65.60/month (CHF 99)	USD 85.50/ month (CHF 129)	USD 112 /month (CHF 169)

Source: OECD, Swisscom (USD conversion using PPP)

The approach adopted by Swisscom takes what many think is a key challenge for the industry and makes it a potential "win-win" strategy for their investors and OTTs. It also charges users of video services for an LTE infrastructure, with upfront high fixed costs, that provides them with superior service while offering lower prices for users that only wish to use voice, text, Internet surfing and so forth. While not entirely the same, there are also operators that are allowing MVNOs to offer extremely competitive prices with their 3G infrastructures while charging a premium for their new 4G networks. At the same time some are varying prices depending on whether a customer is in a 3G or 4G cell.

Many ISPs, however, have had a more circumspect view on the undoubted increase of online video being generated by their customers. They have flagged, tested or adopted a range of different strategies to deal with traffic increases and endeavour to strengthen revenue. The following sections will discuss some of these strategies used by ISPs and by content providers to decrease costs, offer improved services to their customers and to increase revenues.

The use of quality of service

The Internet is a general-purpose network and provides a "best effort" performance level. Some have taken the position that in order for audio-visual services to function effectively the network would have to supply a guaranteed Quality of Service (QoS). In return they would see this as a service for which they should be compensated for by OTTs. This is different from the Swisscom model that asks users, rather than OTTs, to pay directly for increased network performance associated with wishing to use video at higher speeds. In addition, while Swisscom's offers entail differentiated speeds they still only offer "best effort" functionality to customers consistent with how the Internet itself functions.

Proponents of introducing QoS argue that payments would stimulate the development of networks and offset the costs of delivering audio-visual content. They say QoS could be provided either by reserving dedicated bandwidth or by giving different priority classes to traffic (e.g. gold, silver, bronze). Standards are available for QoS delivery, such as DiffServ. In practice many ISPs forego the use of these standards and mostly rely on dedicated bandwidth to guarantee the quality of VoIP, IPTV and VOD. Nonetheless, there are some networks that do use DiffServ for their own services.[36] However, ISPs are generally believed to have been unsuccessful in selling QoS mechanisms to OTT providers of audio-visual services over the Internet. The Internet model for traffic exchange does permit this in commercial transit and peering relationships.

Content providers have generally not been positive about differentiated quality for general or overall Internet traffic. There are several practical arguments why they are not willing to pay for QoS. One of the main concerns they have is that an entity selling a QoS solution may not control part of the chain. In other words they may own a local access network but not transit nor the home network. Both the transit network and the home network may be congested. Making use of QoS would require the direct interconnection with all networks, or a reliable way of cross-network QoS, something that has been researched, but has proven to be difficult in practice. What is more, the end-user may have a different opinion of what traffic is important and may assign those priorities in home routing equipment, thereby influencing the QoS service offered by the local access network.

A further consideration is that content providers deal with multiple and competing ISPs, who have different network performance characteristics. A content provider may judge that a network with a lower performance record, will upgrade regardless of the content provider buying QoS services, in order for the ISP to remain competitive with other networks. Or to put it differently, by paying extra for QoS mechanisms, they may feel it will not provide the correct incentives for networks to invest in extra capacity. OTT content providers may believe that paying for QoS might also lead to a situation where monopoly power could be exercised in respect to termination.

As an alternative, OTT content providers have been able to offer greater quality of experience through the use of adaptive bitrate streaming and buffering of their clients. Instead of paying for dedicated capacity, the bitrate of audio-visual content is tweaked to fit the available bandwidth. As this is an end-to-end relationship between the content provider and the client software, the influence of home networks, first mile, backhaul, core and transit networks can be factored in when offering services.

For their part, some ISPs have experimented with different approaches in this area. In the United Kingdom, a small ISP called Plusnet, openly managed traffic on its network for some time, before ceasing to do so as backhaul bandwidth became more affordable. It would inform its users that certain games, BBC iPlayer and other applications were prioritized on its network with the aim of providing higher performance with these applications, particularly for the BBC iPlayer. They said this was done because of the costs they incurred for backhaul in the United Kingdom. In this case it was the ISP managing the traffic to better fit what it thought its customers wanted. It informed its customers of this management via its blog.

Some networks have taken another approach to managing traffic caused by video on their networks. They use caches that transcode and resize the video before it is received by the user and send it to the user at a lower quality, size and bitrate. The customer does not necessarily know that the content has been altered. Content providers dislike these transcoders, because they cannot control the video streaming settings. The content provider cannot scale their delivery with the actual performance of the network. The presentations of the providers of such caches also promote the fact that they can strip-out advertising and insert alternative advertising. The content provider and the original advertiser may not be aware of this action. Whether such practices are permissible in different jurisdictions is, however, a question for consideration. The content is not owned, nor purchased by the ISP, but it does alter the content and may even charge third parties for undertaking this action.

Interconnection between audio-visual content providers and ISPs

As might be expected many ISPs would like to charge OTT-television providers when they become a significant part of traffic to the users of those networks and, at times, vice versa. The Internet's model of commercial negotiations for Internet traffic exchange has proven to be remarkably successful in terms of scaling the Internet. In a previous OECD report these commercial negotiations were described as: "Transit agreements are commercial contracts in which a customer (which may itself be an ISP) pays a service provider for access to the Internet; these agreements are most common at the edges of the Internet. Peering agreements are the carrier interconnection agreements that are within Internet exchange points (IXPs) and allow carriers to exchange traffic bound for one another's customers; they are most common in the core of the Internet". A survey of 142 000 peering agreements, conducted for this report, showed that the terms and conditions of the Internet interconnection model are so generally agreed upon that 99.5% of interconnection agreements are concluded without a written contract (and without payment, which is known as settlement-free peering).[37]

Transit is paid for by the ISP on a per megabit(s) per month peak capacity basis, irrespective of traffic balances and the direction of traffic. Where it is economic, ISPs will take a decision to bypass an upstream transit provider by peering directly with other ISPs and content providers. For the largest peering partners, this is often done on a direct basis (private peering) and for the smaller peers, it is common to do this through an indirect connection (public peering) via an Internet exchange point (IXP). At the larger IXPs in Europe, such as in London (LINX), Amsterdam (AMS-IX) and Frankfurt (DE-CIX) speeds of 100 Gbit/s per connection are available. If two parties derive benefit from a direct interconnection arrangement they are free to do so and this is best left to the market. There have, however, been a number of cases where such parties take actions in an endeavour to influence the outcomes of such negotiations.

In New Zealand, for example, the largest ISP wanted to charge transit to the national radio broadcaster instead of entering into a peering arrangement. The broadcaster responded by routing traffic via the West Coast of the United States, such that the ISP had to pay to backhaul the traffic to its New Zealand customers. They were also said to have offered a superior stream to local ISPs that peered within New Zealand, compared to the stream fed through the United States. On the one hand, the ISP had significant market power in relation to termination while, on the other hand, the broadcaster had desirable content including the games of the national Rugby team.

Box 2. Net Neutrality policy and connected televisions in Korea

This section has been contributed by Sunghyun Na, Research Fellow, Korea Information Society Development Institute.

Changes in communication markets occur at an increasingly rapid pace and they sometimes raise concerns about what may be perceived as unreasonable traffic management practices, especially if they potentially undermine the openness of the Internet. Korea, which has among the world's best network infrastructure, is faced with growing demands for reasonable traffic management. The country has an advanced Internet environment in which more than 80% of Internet subscribers connect to fixed networks at speeds of 50 Mbit/s and higher.[38] At the same time, its Internet usage per capita is 62 GB per month on fixed networks, more than twice that of the United States, which is 30 GB. With this as background it is perhaps not surprising that issues around the rapid growth in traffic have come to the fore.[39]

In this regard, the Korea Communications Commission (KCC), a regulatory agency for the ICT industry, unveiled 'Guidelines on Net Neutrality and Internet Traffic Management' in December 2011, based on the views and information presented at a 'Net Neutrality Forum' and through a public consultation. This guideline presents basic rules – transparency, no blocking, and no unreasonable discrimination – and allows traffic management to a reasonable extent, for example, traffic management to secure network security and reliability, and to resolve temporary network congestion, and as required under the law. MSIP (Ministry of Science ICT and Future Planning, a successor of KCC) as part of its follow-up measures, plans to develop 'Instructions on Transparency of Traffic Management and Reasonable Use and Management of Networks' through consultation with ISPs, content providers, and other key players. MSIP expects reasonable traffic management to take root within the range of industry self-regulation by presenting specific standards for traffic management information disclosure and by providing guidance to the extent of reasonable traffic management.

In February 2012, a dispute between KT (the largest ISP in Korea) and Samsung Electronics (one of the world's leading equipment companies) occurred in Korea. Around 2010, Samsung Electronics, in an effort to build an ecosystem along the lines of other manufacturers in this sector, refreshed its product line-up into smart-television supporting Internet connections and web browsing, and now almost all of its television products in the market also have those functions. KT argued that the fast spread of connected televisions could lead to a "traffic explosion" and without adequate preparation, including additional investment in networks, this could severely impair services, and KT requested consultation with connected television manufacturers including Samsung Electronics. However, Samsung Electronics showed a lukewarm attitude towards KT's request for consultation by saying that it only manufactures devices and the issues raised by KT are related to content providers, who directly or indirectly provide content for users. As a result of KT's requests not being met, the company blocked the Internet connections for smart televisions for five days in February 2012, a decision that affected the Internet access of 24 000 Samsung Electronics "Smart TV" users.

This type of dispute between a telecommunication operator and manufacturer has been rare. It harks back to the Hush-a-phone Case (1956) and Carterfone Case (1968), where a vertically integrated telecom operator objected to use its service together with a certain device. In response, KCC warned against KT's blocking of Internet access, citing that it was a violation of the Telecommunications Business Act, in particular, violation of users' interest and unreasonable discrimination, and independent with KCC's decision, KT offered non-monetary compensation for damages experienced by customers due to the blocking of their service. Following the dispute, it is known that KT and Samsung Electronics have been working closely together to look for mutually beneficial approaches.

Box 3. Net neutrality in Norway: Background and results

This section has been contributed by Frode Sørensen, Senior Advisor at the Norwegian Post and Telecommunications Authority.

The Norwegian guidelines for net neutrality were launched in 2009, prepared by a working group led by the Norwegian Post and Telecommunications Authority (NPT). These guidelines have often been referred to since then, for example by the European Commission in connection with their engagement in net neutrality.[40] This Box sets out the background to the Norwegian experience.

The net neutrality debate came to Norway in 2006. The media reported incidents[41] that tended to indicate that some Internet service providers had begun to throttle traffic-intensive applications such as streaming and p2p file sharing. Net neutrality was already a known concept, especially after the FCC had established principles for the open Internet in 2005 in the United States.[42]

Against this background, NPT began a study of net neutrality, that later led to the Norwegian guidelines for net neutrality. The incidents reported by the media tended to indicate a move away from a best effort Internet, which treated all users equally, and NPT wanted to prevent such a situation from developing. The reported incidents were resolved without NPT having to take action, but the situation was a reminder that the Internet would not necessarily remain neutral and that it would be important to follow developments closely.

The incidents can be looked upon as a reaction from Internet service providers to the growth of Internet traffic, although traffic growth has been rapid throughout the lifetime of the Internet. NPT believes it is legitimate for Internet service providers to manage traffic on the Internet, but this should be done in a neutral way. An important criterion for such neutrality is that any limitation to traffic volume should be done independently of the application that is the source of the traffic.[43]

NPT has formulated the following objective for work on net neutrality: "The overall goal for net neutrality is to ensure that the Internet remains an open and non-discriminatory platform for all types of communication and content distribution".

The Norwegian model

The Norwegian model for net neutrality can be described as co-regulation. Co-regulation is a form of self-regulation under the active leadership of the regulator (in this case NPT). In this way, NPT has been able to set clear goals for the guidelines that were developed, while at the same time the various parties in the industry have been able to balance each other's views. In 2008, NPT set up a working group consisting of three main groups: *i)* Internet service providers, *ii)* content and application providers; and *iii)* consumers, represented by the consumer associations.

The Norwegian guidelines for net neutrality were launched in 2009.[44] Parties that have not formally endorsed the guidelines also seem to follow them in practice. Since then, the working group that developed the guidelines has acted as a reference group that has met once a year to discuss developments in the industry and whether the guidelines are functioning as intended. So far, the conclusion from these meetings has been that the guidelines function as they should and that no update is necessary as yet.

In recent years, some European countries have chosen to establish statutory net neutrality; both the Netherlands and Slovenia have done this. Other countries also have ongoing discussions by policy makers, such as in Belgium and France. In Norway, however, the co-regulatory approach has so far made it unnecessary to regulate net neutrality by law. This model has worked as a useful tool for achieving the goal of neutral Internet services for Norwegian end users.

At the same time, there is no guarantee that this state of affairs will continue, and in the proposals for amendments to the Electronic Communications Act it can be noted that the "Norwegian Post and Telecommunications Authority and the ministry are following developments and will if necessary consider regulatory measures if it proves that a voluntary arrangement is insufficient to ensure good development in line with the overall goals".[45]

The Norwegian guidelines

The Norwegian guidelines for net neutrality consist of three principles that prescribe 1) transparency regarding users' Internet access service and any specialized services,[46] 2) non-blocking; and 3) non-throttling of specific applications and content, except for reasonable traffic management.[47] When the effects for these guidelines are considered, it is relevant to look at conditions in other countries.

The well-known breaches of net neutrality, in the United States, are Madison River's blocking of voice over IP in 2005 and Comcast's throttling of p2p file sharing in 2008.[48] It was claimed, at one stage, that the need for net neutrality was specific to the United States but it gradually became known that several European providers of mobile Internet access blocked voice over IP so as to prevent loss of income by their own mobile telephone services.[49]

The most common restrictions in Europe are blocking or throttling of p2p traffic and voice over IP. Data published by BEREC[50] in 2012 shows that among European Internet users, at least 21% experience restrictions in the use of p2p applications in the fixed network. In the mobile network, at least 36% experience restriction of p2p traffic and at least 21% experience restrictions in the use of voice over IP.

Given that video streaming is in the process of taking over from p2p file sharing as the most traffic-intensive application,[51] it is not improbable that this will be the next application that could be throttled or blocked. Today, when connected television seems to be a new trend, such restrictions would have negative consequences for innovation in future television services. Or, one can aim at net neutrality and let the Internet economy blossom.

The case in New Zealand occurred in the 1990s but as traffic drivers have shifted from audio to visual the more recent cases generally involve video. Notable examples occurred in Korea (Box 2) and Norway (Box 3). In Korea, Samsung introduced a video on demand service integrated into its television sets that made use of the consumer's broadband connection. Access to this service was blocked by Korea Telecom. In Norway, Nextgentel, the largest ISP, decided to significantly reduce capacity to the national public broadcaster NRK. The broadcaster had reportedly declined to pay for the additional capacity NextGenTel said was required to carry the traffic requested by its customers. NRK reacted by putting a notice on its website stating that the decrease in performance was due to a decision by NextGenTel. In reply to customer complaints NextGenTel than reinstated the original capacity between the two networks.

As noted, Internet traffic exchange is done under a system called peering and transit. Peering is generally cheaper as it saves both networks on transit costs. For the most part, content providers are very open to peering and will actively expand their network to new IXPs and datacenters, if it makes financial sense to peer there. In early 2013, according to the PeeringDB, Google was present at more than 70 public peering points, Microsoft at 52, Facebook at 22 and the BBC at eight.[52] Like all other networks, these entities would pay transit where they can either not provide their own infrastructure, due to regulatory constraints, or where this is a more economical option. For their part, ISPs also welcome peering where it makes sense for their networks but also seek transit payments where they believe they are providing greater value to the other network. This enables global connectivity and the ability of each of over 44 000 Autonomous System (AS) on the Internet not to have to negotiate with every other network on the Internet. In other words, without transit the BBC would have to negotiate with 44 000 networks and vice versa.[53]

This does not mean that ISPs and content providers should necessarily peer with or pay transit to any other particular network. This has to be a commercial decision. A peering agreement costs money in operational and capital expenditure. Connecting to smaller networks can, for example, be more expensive than the savings in transit. Netflix in its peering policy defines a minimum of 2 Gbit/s peak traffic and a minimum 10 Gbit/s interconnection for private peering, though it is open to public peering with any network connected to the same IXP.[54] The decision to peer or not should therefore be evaluated on a case-by-case basis.

There are networks that do not enter into a peering arrangement with a particular AS even where it would make financial sense based on the savings in transit. One case has been demonstrated, from the historical example, in New Zealand. Here, the ISP argued that the content provider should pay for peering (sometimes known as paid peering) or buy transit from it. A challenge from the perspective of the content provider is that paying for peering creates a termination monopoly, where it will continuously have to negotiate with the terminating network over the costs of peering. In the case of transit, there is a market and competition that forces prices down. Therefore many networks refuse to pay for peering and prefer transit. The same argument might be made by an ISP, in relation to a content provider having monopoly power over a different part of the value chain (e.g. exclusive sporting broadcast rights). A point for consideration is whether in the New Zealand case the action to stream at a lower speed, across the Pacific, was the equivalent of an ISP providing less bandwidth to its interconnection with the content provider. In ther words, in this case, both parties had some degree of market power that they attempted to exert over the other.

These debates are being actively played out across OECD countries. In January 2013, Iliad Free, one of the largest ISPs in France set as a default for their customers, software that specifically blocked advertising to sites that carried Google advertising. Customers could unblock this function, if they so wished and understood how to do this or if it was happening. This was reported to be as the result of a dispute between Free and Google in which Free requested Google to pay transit to reach their customers for services such as YouTube. The blocking of advertising was seemingly aimed at disrupting Google's business model and bringing the company to the negotiating table. After intervention by the authorities Free set the function to not block this traffic unless activated by users.

The nature of peering and transit disputes is that they generally only penalise each network involved or more specifically their customers. At the same time, while some tactics are readily identifiable others not so evident except in terms of performance. Even then, the nature of the best effort from Internet is such that a consumer may not know where the cause of degradation of any performance they experience lies. In the case of Iliad and Google some users of Free say that YouTube has a low quality in the evening. It would appear that Free is reluctant to expand capacity to those points in their network where they exchange traffic with Google. In an interview the owner of Free stated that there will be no expansion of the peering bandwidth to Google until Google pays Free the increased costs they are experiencing in traffic increases.[55]

This dispute is currently being investigated by ARCEP, the French communications regulator. For regulators such cases are challenging. In general, a network, whether it is primarily a content provider or an ISP, is free to decide when and how it wants to increase peering capacity. Customers may have taken reduced quality in consideration when choosing the network. In a competitive market customers could switch operators, though in practice the switching costs may be deemed high by consumers and in the case of bundles, the bundle may be less attractive at other ISPs. It could also be considered as a point for discussion when an action taken by one network could be considered as discriminatory in that this policy or practice is not applied to other networks.

In the most competitive markets peering and transit disputes can still occur but they tend to be more evident in countries where there is less developed competition. The case of New Zealand has been mentioned but, around the same time, Australia was emerging from a duopoly in the provision of telecommunication infrastructure. In these types of markets, by not peering or buying transit locally, established networks force other ISPs and content providers to buy transit from them to reach customers in that country. If networks refuse to buy transit locally from these networks, but buy it from another transit provider, the traffic will be routed via an international link out of the country, to be exchanged elsewhere with the network.

This puts a financial cost and an additional latency on the traffic. The Australian ACCC tried to remedy this in 1998 by requiring Telstra to peer with the three largest operators, at that time, in the country. The effect was that these four networks only peered with each other and refused to peer with any other networks in Australia, thereby putting an even larger portion of traffic out of reach for local peering agreements. Some believe this impaired the development of the market and as a result the deployment of independent infrastructure, such as new national backbone and under-sea cables, for many years. When this independent infrastructure did emerge the very tight bandwidth caps evident in Australia, were dramatically expanded in more populated areas.

An alternative solution for a regulator might be to require networks to buy domestic transit from an operator who does not hold market power. In such a case the incumbent can refuse peering. The other ISP or content provider can, however, also refuse to buy transit from the incumbent and go to a third party, without an additional punishment on their traffic by it being routed outside the country and back again.

There are variations known on this refusal to peer. One is where networks (ISPs or content providers) that refuse to buy a paid peering and opt for transit instead see their traffic routed via a saturated transit connection. This will deteriorate the performance of the services offered. Another is where the transit connection itself will not be saturated, but will appear saturated only for traffic to and from the specific network. These practices are difficult to detect and it is even harder to distinguish between intentional impairment and configuration errors.

Another justification used to not peer between two ASs, or that a network is flooded, is that the traffic is unbalanced. In many peering relationships and especially with connected television services, one network is likely to send more than it receives. What is unclear in this case is why the traffic from, for example, the content provider to the ISP has to be balanced. Historically, the case was made that networks that could not reach a 2:1 or 3:1 ratio were too small to peer with larger Tier 1 networks. With the advent of large content providers the argument has reversed, now end-user ISPs argue that networks exceeding a 2.5:1 ratio should pay for peering. This position was used, for example, in France, where there was a dispute on this between Cogent and France Telecom, which led to a decision by the French Competition Authority, which upheld the peering agreement and peering ratios both parties had agreed on. SFR, a major mobile operator in France, has a similar peering policy.[56]

The technical merit behind such ratios is not self-evident and many players take a different view.[57] To carry 500 Mbit/s in one direction, a 655 Mbit/s or 1 Gbit/s connection is needed irrespective of whether the traffic in the opposite direction is 10, 100 or 499 Mbit/s. The same equipment would be needed in a network to carry traffic; as for the core of that network there is no asymmetric networking equipment, supporting higher speeds in one direction. Accordingly, there would be no difference in costs. A further consideration is that it is unclear how ISPs would make their traffic balanced, with most ISPs currently only supporting asymmetric up and download levels of, for example, 20:1 on ADSL2 networks. An alternative response from a content provider could be to strictly limit the traffic it sends to the ISP, such that it is always in balance. The result could be that traffic would dwindle to close to zero, because most of the traffic from an ISP consists of control messages controlling the flow of incoming data. When there is less incoming data there is also less outgoing data.

The use of content delivery networks and caches

The use of content delivery networks (CDN) has appeared in the last decade as a way of reducing the costs of traffic for both content providers as well as ISPs, while at the same time increasing quality. In 2011, the largest CDN in the world was likely to be Akamai, then serving up to 9 Tbit/s of network traffic in 84 countries through 1800 nodes.[58] There are, however at least 50 global and regional competitors. Some transit networks, like Level 3, offer their own CDN services, to make their transit services more attractive and several ISPs and telecommunication operators have their own ‘Carrier CDNs’ or have partnered with CDNs such as Akamai (e.g. Orange). This has created a very dynamic market, where providers of audio-visual content are faced with several options.

A CDN does not have its own content; rather it provides facilities for others to deliver their content. It often has servers, peering agreements and network connectivity in a large number of countries. This allows it to distribute "visitors" to sites over a wide platform, instead of all customers coming to a single webserver in a single country. The net result is that latencies are shorter because the content is served closer to the user and that the aggregate interconnection capacity is higher, as well as enabling sudden peaks in demand to be distributed across the infrastructure of the CDN. For ISPs the benefit of interconnecting with a CDN is that the CDN is often located at a local IXP, which saves on transit fees and its customers getting a better overall service.

Audio-visual content providers sometimes select multiple CDNs through which they deliver their content. Making use of middle ware providers, such as Cedexis and Conviva, they can select CDNs that perform best at that moment for their traffic to a specific customer. The middle ware providers provide knowledge on the average performance of the receiving network, so that the right streaming speed and quality can be selected. It is not in the interest of an audio-visual content provider to overload the receiving network, because customers may receive an unsatisfactory performance and stop watching the service.

Some of the largest content providers, notably Netflix and Google, are rolling out additional facilities to increase the speed and responsiveness of their services, by deploying custom designed servers in ISP networks. Google calls this Google Global Cache and Netflix calls it Open Connect. These servers are located in locations close to users, so that the ISP does not have to use backhaul and core capacity to carry the traffic. The ISP will receive a number of servers and routers and will only have to provide local network connectivity and power. Some say the savings in networking equipment do not offset the energy costs though, for example, a Netflix Open Connect server can serve up to 15 Gbit/s from 550 Watt. The servers are managed by Google or Netflix and populated with their most demanded content. Netflix say that they could achieve far greater efficiencies by self-supplying, instead of using a CDN and ISPs could save between 80% and 95% of backhaul traffic. Netflix does make use of three third party CDNs, but can save costs by doing part of the distribution itself.

Netflix has also announced that only networks that peer with it or make use of Open Connect can get access to its 5 Mbit/s Super-HD and 9 Mbit/s 3D content. This makes sense from its point of view, because it saves Netflix on transit and third party CDN costs. It works together with networks like Cablevision, Clearwire, Virgin Media, British Telecom, TDC, Telmex and Telus. Not every network is, however, content with this initiative by Netflix. TimeWarner cable objected publicly, stating that its network was capable of carrying this traffic, but that it did not want to be forced to use Netflix's Open Connect.[59] TimeWarner also operates a CDN and is a transit provider.

On a national level broadcasters and ISPs may often work together in bringing on-demand content to a user. The models chosen depend very much on the location. In some cases, it is the ISP who provides the infrastructure on which the broadcaster places content and, in other cases, it is the broadcasters' infrastructure which extends into the ISPs network. A notable example in France is the ISP Free, which offers catch-up television for the largest number of channels. Free offers its users the option to buy a premium pass (for a day or a month), which enables them to enjoy a guaranteed quality of service to access audiovisual content, even when its infrastructure reaches peak capacity. Without this pass, access is provided by using the "best effort" principle.[60]

Some ISPs have established their own CDNs, located deep in their networks, in order to sell a better delivery quality to content providers. The reaction of content providers has been mixed. TDC, for example, mentioned in a presentation that it so far had not found any outside party willing to use its CDN.[61] Other ISPs have been more successful, but Netflix has said that the costs of integrating these solutions into their infrastructure exceeded the benefits it had with its current CDNs and Open Connect. With several thousand ISPs worldwide, it can be seen why this may be the case. In addition, content providers are sceptical of

ISPs that do not allow other CDNs deep in their networks; the performance of the ISPs CDN may be overstated, because of this technical advantage. By not using it, the content provider may forego a current gain, but also may not face lock-in and may see the ISP change the CDN policy in the longer term, because there are not enough customers for its CDN.

The use of download limits

Until recently, the use of download limits (data caps) on fixed networks was decreasing in the OECD area due to competitive pressure. There has been a slight uptake, in some countries, but at the same time an expansion in the size of caps in others. In some statements the caps are mentioned as a way of more equally sharing a network amongst users and not over-burdening a network. However, some advocates and critics alike, contend that the caps are also related to the increasing use of 'connected televisions'.

In May 2013, Deutsche Telekom announced it planned to start offering new customers revised tariffs which it said were to take into account increasing data usage on its fixed network. It said the new tariffs may not come into effect until 2016, however, depending on traffic growth and would not be applied to existing contracts. The new plans are marketed by speed and volume and will be discussed in the following section. In terms of volume, the baseline offer started at 75 GB, which the company said would be sufficient for 10 films in standard resolution, plus three HD movies, plus 60 hours Internet radio, plus 400 photos and 16 hours of online gaming as well as general surfing. The company said it planned for the use of DT's own IPTV service not to be counted in the allocated data allowance and that the baseline offer is at an advertised speed of 16 Mbit/s rising in gradated tiers of data and speed to 400 GB and 200 Mbit/s respectively.

From the perspective of some ISPs, data caps are tools to manage and price demand for network resources. This faces scrutiny from some critics, however, if an ISP's own IPTV or cable service is treated differently to an OTT. Their other concern is that caps may discourage users from making greater use of their services even if all traffic is managed in the same manner.

In response to data caps Netflix enables its customers to use settings that affect the quality and data use associated with streamed services. From the Netflix website they indicate there are three settings to choose from:[62]

- Good quality (uses up to 0.3 GB per hour)
- Better quality (uses up to 0.7 GB per hour)
- Best quality (uses up to 1 GB per hour, up to 2.8 GB per hour if watching HD, or up to 4.7 GB per hour if watching 3D)

Netflix also as different default settings in different countries:

- The default setting in the United States is "Best".
- The default setting in Canada is "Good".
- The default setting in Latin America is "Best," except in Brazil where it is "Good".
- The default setting across the United Kingdom and Ireland is "Best".

The critics of broadband caps note that during peak hours, those that go over caps by the end of a billing period, are not using the network significantly more than other users in a way that incurs costs to the network. During peak hours all users, whether they are heavy or low users, are adding equally to the total peak load of the network. It is during off-peak hours where they make greater use of a network. However, unlike electricity usage during off-peak hours, the use of increased data during off-peak hours on the Internet does not result in extra operational expenditure.[63] It is the peak use that defines the costs of the network and all users add equally to the peak level. An analogy would be that a driver who drives a large number of kilometres adds one vehicle to the morning rush hour, just like any other vehicle in rush hour, indifferent of how many kilometres these vehicles drive during the rest of the day. It is also unclear why reducing speeds or charging extra is only relevant at the end of a billing period. If broadband caps had a measurable effect, they would work on a day-to-day basis.[64] For some proponents of this pricing model it may, therefore, be viewed as a way to introduce a “second best pricing” scheme (i.e. if more optimal conditions cannot be met an alternative model is utilised).

The use of operator provided IPTV or other services is sometimes excluded or not counted in total usage. This traffic generally traverses the same network components as OTT video, except for the interconnection. Here transit may have to be bought, but video providers are generally willing to peer as described earlier. At the same time, some content providers may be willing to enter into commercial arrangements that relate to service pricing, particularly with respect to the possibility of reducing the direct cost to consumers for access. Where this is most evident are in business models that are the result of a network operator providing access to a service, which is not counted towards usage (i.e. if a user has a bit cap these data are not metered). In some countries, mobile operators provide access to services such as Facebook (e.g. in Indonesia) or Google search capabilities (e.g. in India) without these data being metered on the same basis as other services. While the financial arrangements, if there are any, are not disclosed it is clear that the market is exploring different business models and this may be increasingly evident in relation to video services.

According to an article in the *Wall Street Journal*, the sports channel ESPN has been in negotiations with Verizon Wireless to not count the traffic to and from ESPN to the caps of Verizon Wireless customers. ESPN would compensate Verizon Wireless for the use of the network.[65] This would be an alternative way of financing the traffic generated. However, the article noted "no such arrangement is imminent, and ESPN is not sure if the economics would be attractive for both parties"?

One conclusion that might be drawn is that data caps on fixed networks are much less about network management or increasing traffic, due to connected televisions, and more about legitimate price discrimination. In early 2013, the President of the United States National Cable and Telecommunication Association, Michael Powell, said that broadband caps were not about network capacity but about pricing fairness.[66] He noted the high upfront fixed costs of rolling out broadband networks and that the ability to set discriminatory rates provided a way of meeting those costs. In economic terms it is about charging those customers that value a product more than those that value a product less.

From a policy perspective, the aim should be to give ISPs the greatest flexibility possible to price access services. At the same time, there needs to be effective competition and the absence of market power to provide market discipline for these prices. While consumers widely accept data limitations on mobile networks, where they may have a wide choice from multiple MNOs and MVNOs, they are more circumspect where they have an effective monopoly or duopoly in the pricing of fixed network services. It is also the case that consumers show more acceptances for mobile caps because they can shift consumption to self-provisioned Wi-Fi networks. Data collected by Mobidia, from direct monitoring through an app downloaded by Android users, suggest cellular traffic typically accounts for one-third (or, in many cases, less than 20%) of overall smartphone-originated traffic (Table 2).[67]

Some say that wireless services provide competition to fixed networks and for certain services that is no doubt the case. For 'connected television' services this seems less likely. Clearly, most smartphone users see them as complimentary if two thirds of smartphone use is undertaken on fixed networks using Wi-Fi. In relation to data caps, the question needs to be asked as to whether a 2 GB or 3 GB capped mobile service, common in many OECD countries, can effectively substitute for a 200 GB or 300 GB capped service, levels that are common in those countries with fixed broadband data caps. This is especially the case if the mobile service is not complimented by the home provision of Wi-Fi. The issue is not whether there are caps but whether there is effective competition, also taking into account that some of the fixed and mobile offers will be from the same providers in some areas.

Some cities, regions and countries are moving to a structurally separated model for fixed broadband services and the creation of a virtual monopoly for wholesale broadband access for retail service providers. While regulators will oversee those monopolies, the question can be asked as to whether models associated with price discrimination in a direct relationship between the entities setting those prices and customers, disciplined by competition, are the correct ones for wholesale monopolies. To be sure, the entities that own and manage these networks need to recover the high upfront costs associated with their construction and generate returns appropriate to how they were funded. Nonetheless, if these services have a low marginal cost and the direct relationship with the market is severed, the increasing use of connected television services could be constrained. If wholesale offers dictate retail pricing structures, in the absence of competition, they could limit the ability of the market to promote innovation including in pricing.

There are business models and technical tools that enable local access networks and OTTs to better manage and meet challenges that arise from the increased traffic generated by connected televisions. In that respect, the model chosen by Swisscom for its LTE mobile network will be watched closely by all stakeholders to see if it does provide a "win-win" approach for infrastructure providers, investors, OTTs and consumers.

Table 3. The use of Wi-Fi as a percentage of Android traffic on cellular mobile devices in selected economies

	Cellular	Self-provisioned/ private Wi-Fi	Managed public Wi-Fi	Managed public Wi-Fi as % of total Wi-Fi
Brazil	19.2	78.9	2	2
Canada	22.9	75.2	1.9	3
France	20.6	77.1	2.3	3
Hong Kong, China	27.5	71.3	1.2	2
India	47	51.7	1.3	3
Italy	29.2	69.2	1.6	2
Thailand	27.9	67.2	4.9	7
United Kingdom	18.3	80.4	1.3	2
United States	31.6	66.4	2	3

Source: Mobidia

Summary of findings

In the coming years, the use of 'connected televisions'will undoubtedly increase across the OECD area. Previous OECD reports and this report have described many of the main trends such as:

- increasing broadband availability and higher broadband speeds

- decreasing bandwidth requirements for high quality video due to better encoding algorithms
- increasing chip set speeds, and decreasing costs
- increased use of CDNs and caches rather than expensive transit arrangements
- multi-platform strategies by broadcasters to deliver their content on any device (smartphones, tablets, smart TVs etc), any time (linear or catch up), and anywhere (at home or outside using mobile networks, and
- new devices changing the dynamics of connected television.

Data provided by the BBC’s iPlayer demonstrate that once practical devices such as tablets become widely available, as they did in 2012, the demand for connected television services is clear and increasing (Figure 1). The devices that will be used most in future for connected televisions are unclear, however. Few would have predicted the take up of video services on smartphones and tablets only a few years ago given the initial poor response to mobile television services.

In the future, televisions may be a single screen but more likely they will be a combination of screens with different devices interacting in concert across a residence and other locations, such as vehicles, through the use of hand held devices and other devices embedded in the vehicles. While there will still be a role for traditional broadcasting, including for live events such as sport and news, the emerging options for greater connectivity and storage mean that consumers will dictate when and where they choose to consume content.

The available evidence suggests that all current wired broadband technologies can support “connected televisions” though, of course, some end-users may not be able to, because in their situation the required 1 to 5 Mbit/s is not available. Not all networks will, however, be able to stream high quality HD to multiple devices on the same connection. Some networks will see contention issues or, in other words, be constrained depending on how many users are accessing the same services. If ISPs do not invest in new capacity the result will be, in a competitive market that customers will over time migrate to other networks where such investment does take place. On the other hand, in situations where there is little competition, customers and content providers will optimise the available bandwidth. The content providers will invest in better encoding for streaming and other technical solutions such as pre-loading of content during off-peak hours, if such a possibility exists. Their customers will also adapt their consumption patterns.

For traditional broadcast networking technologies, the trend to individualised viewing will over time likely mark the end of the usefulness of multicast technologies. If a broadband connection can support streaming for on-demand viewing, there is little reason why it cannot replace satellite, DTT or cable in those areas where it is available. It will likely take considerable time before spectrum could be entirely reassigned, through tools such as incentive auctions, but with policy makers aiming for the maximum practical availability of broadband, there may be a time when the traditional over the air broadcasting services are no longer necessary. It is not a question of whether these business models continue to exist but rather that they can be delivered more effectively through other means.

In the future, it is unclear whether today’s traditional broadcast television will be delivered over-the-top or whether it will be a part of any broadband bundle and retransmitted by an ISP. Discussions over content rights will be a key consideration in determining outcomes along with technological and commercial developments. Companies such as Aereo and FilmOn have demonstrated some of what is possible but also that not all industry players agree with new business models, which they argue do not provide fair compensation for the value that is being brought to the market.

The available evidence demonstrates that the use of connected televisions will generate considerable new traffic but also that there are tools available to different industry players to meet this demand and that prices have declined significantly for both equipment and bandwidth. It is true that networks will have to invest if they want to be able to serve higher quality content, such as 4K and 8K video services. One of the best ways to encourage investment is by establishing effective competitive and open markets. There are different business models that support investment in these markets. Liberalisation of communication markets has given all players the freedom to choose their business models and the way they manage investment and increase shareholder value. Competitive markets will show which players adjust or emerge to meet consumer demand and participate in the growth of connected televisions.

ANNEX 1

European Commission green paper: Preparing for a fully converged audiovisual world[68]

In April 2013, the European Commission published a green paper that raised questions in relation to a consultation on the subject of connected televisions. The questions include (paraphrased):

- What factors impact the availability of premium content (across the European Union)?
- How will the funding of content change?
- Is there a need for a mandatory technical standard for "connected television"?
- What broadcasting/broadband networks are most useful for "connected television"?
- How will spectrum allocation have to change in light of "connected television"?
- Is there a market distortion in the regulation between linear and non-linear services?
- Is the country of origin principle still a valid principle?
- How do rules on e-commerce affect "connected television" services?
- How is the prominence of broadcasters and related media plurality changing with the advent of "connected television"?
- How will advertising be affected by "connected television"?
- How will children be protected when "connected television becomes reality"?
- How are "connected television" services going to meet the needs of people with disabilities?

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