A cooperative approach to content delivery

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A Netflix briefing paper 2021

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Cover illustration by Bratislav Milenkovic.

Foreword

When the COVID-19 pandemic forced us to recede into a global quarantine, the ways in which many of us connect with each other - through work, school, and entertainment - ceased in their typical forms. Where possible, we moved the essential functions of society online using our internet connections.

Online work, school, and entertainment have long been complements to their physical counterparts. But with no other option, basic needs were met for many of us with these not always perfect replacements. The pandemic highlighted how robust online alternatives can be, as many quickly scaled to meet the demand for interpersonal connection. Internet networks had to adapt to meet the growing demand for high speed broadband, by leveraging their existing capacity for a massively increased load.

The increased demands during the pandemic highlight the importance of cooperation. Together, content providers and networks have been meeting people's needs. Without both, our ability to sustain human connection, distanced productivity, or continuous learning is challenged. Both must be fostered in a sustainable way.

We saw examples of this cooperation in its finest form during the pandemic. Where the exceptional nature of the pandemic made it necessary, Netflix and other video streaming services reduced the bandwidth of streams to decrease traffic volume, and ISPs around the world quickly grew capacity to ensure continued connectivity for internet users. To get content to consumers more efficiently, Netflix and ISPs worked together to deploy additional servers into ISPs' networks as well as increase capacity in our backbone network and at local internet exchange sites in order to fulfill the growing demands for Netflix content.

An internet that can meet the needs of a globally connected population - during a pandemic and beyond - depends on such cooperation between ISPs and content providers to best provide the services they offer to their customers.

Humanity will move beyond the pandemic. But we should take the lessons we have learned about the need for a collaborative approach to online content delivery forward long into the future.

Gina Haspilaire

Vice-President, Content Delivery
Netflix

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Executive summary

Consumers buy internet access from ISPs in order to reach content and applications. Without content, consumers would have less need for internet access. Likewise, without a connected population, content providers would have no ability to service consumer requests. Put simply, online services and internet networks depend upon each other.

This complementary relationship between content providers and networks has resulted in a model of content delivery based on cooperation - a model which has promoted a virtuous circle of innovation, whereby the improvements in networks inspire new forms of content, and this in turn drives uptake of higher speed broadband plans. This model has also encouraged greater connectivity and the wider societal benefits that occur when consumers and businesses have improved access to information and services.

However, despite its strengths, there have been threats to this model. In some countries, proposals have been made that could place a tollbooth in front of the entrance to networks, blocking traffic requested by consumers unless content providers agree to pay to lift the gate. These proposals have often been a response to the myth that content and application providers do not contribute to the costs associated with building out connectivity, leaving ISPs unable to upgrade and expand broadband networks.

Against this backdrop, this report demonstrates that Netflix and other content providers are investing significantly in content delivery infrastructure and video streaming technology to deliver content more efficiently. Further, it shows that an approach built on cooperation, rather than traffic charges imposed on content providers by ISPs, is good for ISPs, content providers, consumers, and society as a whole.

Chapter one of the report explores the complementary relationship between ISPs and content providers and shows how this relationship generates significant benefits for both. For content providers, largely frictionless connectivity to a huge user base

has underpinned the uptake and usage of those services. For networks, consumers purchase internet access to reach such services.

Online entertainment services like Netflix invest significantly in content to engage and delight their customers. Netflix alone spent more than $12.5B on content in 2020. Reaching such content is a substantial portion of what consumers do with their internet connection and may prompt them to upgrade their broadband connection, generating incremental revenue for ISPs. Empirical evidence suggests that broadband customers who use Netflix are more likely to be on higher speed (and more expensive) broadband connections. For example, a study of broadband users in Italy in 2017 found that of those on ADSL (Asymmetric Digital Subscriber Line) connections, 12% were Netflix users, while for those with FTTH (Fiber To The Home), 18% were. In the UK, 77% of those with standard broadband were users of subscription video-on-demand services (such as Netflix), compared to 86% and 90% respectively of those with superfast broadband and ultrafast broadband.[1]

In markets where broadband adoption has not reached saturation, online services can encourage broadband deployment and uptake.

$1.2B

on estimated savings for our ISP partners that have opted to deploy servers within their own networks

200%

increase in the number of hours a Netflix member can stream over the last five years

In addition, in markets where fixed broadband adoption is high, video traffic is a key reason for customers to retain a fixed internet connection rather than going mobile-only.

This complementary relationship incentivizes ISPs and content providers to work together to focus on the best technical approach for consumers and this, in turn, generates value for ISPs, content providers and consumers.

Chapter two of the report explains how Netflix efficiently delivers its content. Netflix's Open Connect Content Delivery Network (CDN) moves content closer to consumers using a distributed network of local servers at the edge of, or within, an ISP's network.

This benefits ISPs by reducing the distance they must go to fetch traffic, and thus their costs. For our ISP partners that have opted to deploy servers within their own networks, this cost saving is estimated to be $1.2B in 2020.

Moving content closer also frees up long haul network infrastructure for the other types of traffic for which those links are essential - for example, live video streaming or voice calls over the internet which cannot be stored locally. This can reduce congestion, resulting in a higher quality service for consumers.

Netflix also invests in improving encoding and video compression to deliver high quality content without using unnecessary bandwidth. As a result, the number of hours a Netflix member can stream per GB of data has increased by more than 200%[2] over the last five years.

1 Ofcom, Technology Tracker 2021, 17 December 2020. Standard broadband is defined as providing a download speed of less than 30 Mbps, superfast broadband between 30 Mbps and 300 Mbps and ultrafast broadband more than 300 Mbps.

2 Based on the latest encoding profile.

Chapter three concludes with an assessment of why traffic charges imposed on content providers by ISPs will be harmful to consumers. It considers the key arguments cited by those who support traffic charges: that ISPs need funds from content providers for investment and that content providers do not contribute to the costs of delivering content.

It also discusses the main risks associated with traffic charges.

Traffic charges pose problems because there are no alternative routes to the end user. A consumer's chosen ISP has complete control over what content can travel over the connection. This creates a 'terminating access monopoly' which can pose multiple risks when combined with traffic charges.

Traffic charges can lead to double-charging where ISPs seek to charge content providers for the carriage of traffic that their customers have already paid for. Customers pay for an internet connection on the understanding that it will allow them to reach all content available on the entire internet, not just from those content providers who have agreed to their ISP's traffic fees. The problem of double charging is exacerbated when the speeds required for the content being delivered are well under the speeds paid for by consumers.

Traffic charges may also allow ISPs to leverage their own video offers. Many ISPs compete directly with streaming video services, either because they are themselves a cable TV operator, or a telco with an IPTV offering. Any degradation of quality for other video providers strengthens the competitive position of an ISP's own TV service, disturbing a level playing field.

Traffic charges can lead to perverse incentives. The only way for an ISP to force a content provider to pay for traffic charges is to ensure congestion otherwise limits an ISP's customers from receiving requested traffic from the content provider. This congestion represents powerful leverage for the ISP to force the content provider to accept the demanded cost to connect directly, and thus the ISP has little incentive to remedy the congestion.

Furthermore, allowing payments may discourage content providers from investing in moving content closer to consumers, to the detriment of ISPs and consumers alike. There is no requirement to move content closer to consumers. An uncongested long haul connection can still deliver high quality video. If an ISP imposes charges, the content provider may choose to deliver their traffic from a jurisdiction where payments are not required. For the ISP, this will likely mean that it is now paying to receive the traffic, since it may need to invest in international capacity to carry it back to their consumers from that jurisdiction.

Consumers invariably lose in this situation. They will be exposed to the risk of congestion along the path to more remote content, with possible degradation of their user experience. There is also a risk that consumers will lose access to the plurality of voices and applications that have enabled the internet to thrive.

Thus traffic charges are a backward step, with the potential to disrupt a highly productive partnership between ISPs and content providers that has been the bedrock of the internet's success to date.

Looking ahead, a cooperative model will only be sustained under two conditions. Firstly if content providers and ISPs continue to recognize the complementary nature of networks and content. Secondly, if governments acknowledge the important role that content providers play in stimulating demand for broadband services and establish supporting policy frameworks which restrict the imposition of charges by ISPs on content providers.

Content & network

1

The need for cooperation

The complementary nature of content and networks

The very essence of the internet is that it is a 'network of networks' - not a monolithic single network, but many separate interconnected networks of completely different types. The internet, for the most part,[3] has allowed anyone online to communicate with anyone else online. This flexibility has been transformative.

A consumer who purchases internet access can reach nearly any type of content from nearly any public network, anywhere around the world. Consumers can access a plethora of information and services and ultimately choose which businesses are successful. As of 2020, there were 4.7B people online.[4] There are 192M active websites globally,[5] and 3M apps available in the Google Play store.[6]

For content providers, largely frictionless connectivity to a huge user base has created incentives for investment in applications, and underpinned the uptake and usage of those applications.[7] This in turn has led to an explosion of innovation and competition.

For networks, consumers purchase internet access to reach such content and applications. And as those applications become more advanced, demand for bandwidth has grown. The networks have found great value in providing access to information, entertainment, and each other.

The relationship between content providers and networks is complementary and the complementary relationship between ISPs and providers of video content is particularly strong. Services like Netflix rely on networks to distribute content to consumers and ISPs benefit from increased demand for connectivity.

3 For example, some governments block access to certain sites in other countries, and many ISPs block illegal content.
4 Statistica, Worldwide Population as of October 2020, Statistica 2021.
5 Netcraft, September 2020 Web Server Survey, 23 September 2020.
6 AppBrain, Number of Android apps on Google Play, 14 October 2020.
7 See, for instance, Plum, The open internet – a platform for growth, 2011; TRPC, Fostering an Open Internet in Asia, January 2017.

$12.5B

spent on content in 2020, driving demand for high speed internet connections

Investments in video create demand for connectivity

Streaming entertainment - which is often on-demand, personalized, and available on any screen - is expanding rapidly. Consumers appreciate the freedom, flexibility, and rapid innovation streaming entertainment services afford. Access to high speed and reliable internet and internet connected devices have enabled these streaming services to become popular. Watching video is now a substantial portion of what many consumers do with their high speed broadband connection. Video streaming represents 58% of traffic. (YouTube is 16 percentage points of this, and Netflix 11 points).[8] This high level of usage is only brought about because of substantial investments in content that consumers want to watch.

Investment in video content

Netflix is one of the world's leading entertainment services. The strength of our global content offer is fundamental to our success. Great content grows engagement among our members, which we believe drives word-of-mouth, improves retention and grows memberships. In 2020, we spent over $12.5B[9] on streamed content. We invested in both Netflix originals and second-run movies and TV shows across many different genres (scripted series, films, documentaries, comedy, unscripted TV, kids and family, anime, etc). These movies and TV shows come from producers all around the world, and their stories are shared with the world.

Historically, television has been bound by a linear program schedule and often a reliance on advertising, which put a premium on airing content that will appeal to the widest audience during times likely to attract the most viewers. But online business models, such as Netflix's, depend on consumers consistently finding exciting content to watch, not just at prime time, but whenever the consumer wants. This gives streaming service customers the opportunity to discover new content and enables streaming services to make significant investments in innovative programming from creators that historically may have had difficulty reaching a global audience.

Netflix is not the only company investing in video content. Unlike traditional broadcasters, which were reliant on exclusive access to spectrum or dedicated cables, streaming services are able to offer their service via an internet connection. These lower barriers to entry for content delivery mean that diverse and competitive players can offer innovative and compelling content. We, like other major providers of online entertainment services, are all operating in a dynamic and thriving sector where a wide range of players are incentivized to continually innovate and invest in their services and the audiovisual ecosystem in order to win consumer attention. Many other major entertainment

8 Sandvine, The Global Internet Phenomena Report, May 2020. Note that these figures relate to a period when many were at home due to COVID-19. However, figures for total streaming and for Netflix were broadly similar in 2019, though YouTube was lower (9%).

9 See Netflix 2020 Quarterly Earnings Fourth Quarter Earnings, Financial Statements. Cash spending on content can be derived from the cash flow statement. The sum of Additions to Streaming Content Assets and the Change in Streaming Content Liabilities equates to cash spending on streaming content.

companies like Disney and NBCUniversal are investing in their own streaming services, as are Amazon and Apple, in order to compete with providers of user generated content, video games, and other online services for a share of consumers' time and spending.

Creating demand for faster broadband

Video - and in particular higher definition video - prompts consumers to upgrade their broadband connection, generating incremental revenue for ISPs. The FTTH Council, for instance, has seen video growth as a driver of fibre to the home (FTTH) adoption.[10] Ofcom, the UK's communications regulator, has found that: *The main drivers of residential demand for higher speeds have been an increase in the use of video-on-demand and gaming, and the simultaneous use in a home of multiple devices.*[11]

A report for BEREC (the association of European regulators) made a direct link to revenue: *Content developers and providers of Over The Top (OTT) services such as the various third-party video streaming services ... are important [in] driving increased demand for bandwidth but are not typically directly involved in the delivery of that bandwidth, but ... could certainly influence the operators' ARPU.*[12]

And operators quite explicitly use video streaming to persuade customers to take higher speed plans, as the examples on the next page show.

There is empirical evidence that broadband customers who use Netflix, for example, are more likely to be on higher speed (more expensive) connections. A study of broadband users in Italy in 2017 found that of those on ADSL connections, 12% were Netflix users, while for those with FTTH, 18% were[13]. (Note that there was no material difference between ADSL and FTTH usage rates for YouTube, suggesting that it is not simply streaming video that drives purchase of higher speed connections, but rather HD and UHD video like that provided by Netflix). In the UK, 77% of those with standard broadband were users of subscription video-on-demand services (such as Netflix), compared to 86% and 90% respectively of those with superfast and ultrafast broadband.[14]

Thus video on demand, in common with other forms of entertainment (such as gaming and streaming live sports) is a key driver of demand for higher speed broadband.

Encouraging broadband uptake and broadband deployment

In markets where broadband adoption has not reached saturation, video streaming services can help to encourage uptake, with benefits to domestic users (who can now interact with the new users) and to businesses (who can implement new processes). According to the Commonwealth Telecommunications Organisation: *OTT applications stimulate broadband adoption and thus economic growth and tax receipts.*[15]

10 IDATE for FTTH, FTTH Forecast for EUROPE, March 2019.
11 Ofcom, Promoting competition and investment in fibre networks: Wholesale Fixed Telecoms Market Review 2021-26. Volume 2: Market assessment, 8 January 2020
12 Decision Analysis, SPC Network, Strategy Dynamics & Greenwood Strategic Advisors for BEREC, Study on the determinants of investment in VHCN – a System Dynamics approach. Volume 1: Technical Report, November 2019
13 Those using Netflix at least once per week. Trevisan, Martino et al., Five years at the edge: watching internet from the ISP network, April 2020.
14 Ofcom, Technology Tracker 2021, 17 December 2020. Survey participants were asked which of these fixed broadband services does your household have: standard broadband (download speed of less than 30 Mbps); superfast broadband (download speed is 30 Mbps or higher and less than 300 Mbps); ultrafast broad broadband (download speed is 300 Mbps or higher).
15 CTO, Over The Top (OTT) Applications & the Internet Value Chain, 22 May 2020.

ISPs using streaming as a prompt to upgrade to higher speeds[16]

maxis

Maxis Fibre

30 Mbps

RECOMMENDED FOR:

- Light browsing & streaming video
- Single user on up to 2 devices
- Single storey or condominium

Maxis Fibre

100 Mbps

RECOMMENDED FOR:

- Full HD streaming & browsing
- 2-3 users on up to 5 devices
- Double storey or condominium

KCOM

Standard Fibre Unlimited

30 Mbps

RECOMMENDED FOR:

- For doing all that you love online without any data worries

Superfast Unlimited

75 Mbps

RECOMMENDED FOR:

- Ideal for homes where streaming the latest Netflix series is the perfect night in

AT&T

Standard Fibre Unlimited

18 Mbps

RECOMMENDED FOR:

- HD video streaming
- Sharing videos and photos
- Online gaming

Superfast Unlimited

25 Mbps

RECOMMENDED FOR:

- Streaming on multiple devices
- Sharing videos and photos
- Online gaming

Telstra

Standard Evening Speed

25 Mbps

RECOMMENDED FOR:

- 1-3 people browsing
- Streaming in SD
- Online gaming

Standard Plus Evening Speed

50 Mbps

RECOMMENDED FOR:

- 5-7 people streaming in HD
- Responsive online gaming

16 ISP websites [accessed 20 October 2020]. This is a brief summary of broadband packages offered by third parties and not a detailed breakdown.

The ITU has reported that: *Demand for OTTs results in both new subscribers for broadband services and existing subscribers upgrading their subscriptions for greater speed and bandwidth.*[17]

In addition, in markets where fixed broadband adoption is high, video traffic is a key reason for customers to retain a fixed internet connection rather than going mobile-only.

Increased uptake of broadband, and higher speed broadband in particular, is clearly good for ISPs but it also has spillover benefits to society as a whole. Many governments have invested substantially to improve the availability of broadband, believing in its economic and social benefits. But by itself, availability has no value - it is consumer uptake that matters. If online content providers drive uptake of beneficial broadband, then that helps realise the value of governments' investment in availability.

Efficiency benefits of a cooperative model

This complementary relationship incentivizes ISPs and content providers to work together to focus on the best technical approach for consumers and this, in turn, generates value for ISPs, content providers and consumers. In addition, capabilities of the network inspire new forms of content, which in turn encourage uptake of faster and more robust broadband. Video, for example, is a key reason for users to upgrade their fixed broadband speed or take fixed broadband in the first place.

In the vast majority of cases, this virtuous circle results in a cooperative model of deployment where content providers and networks work hand-in-hand to deliver content more efficiently, reducing costs for both parties. As we discuss in the next section, Netflix invests substantially to deliver its traffic in such a way as to make it easier for ISPs.

This cooperative model works best when neither side seeks to charge the other. For instance, Netflix (like many other online content providers) does not try to charge ISPs.

Similarly, the vast majority of ISPs around the world do not charge content providers for delivery of their traffic, though as discussed in Chapter 3, a few wish to change this.

Today's approach is the result of decades of thoughtful development by content providers and ISPs. It is also an approach that ultimately provides benefits for consumers.

We now turn to a description of how Netflix (and others) deliver their content.

17 International Telecommunication Union, Economic impact of OTTs on national telecommunication/ICT markets, 15 June 2020.

Cooperation in practice

2

Netflix Open Connect

Moving content closer

In the early days of the internet, content would typically sit on a single server, and then travel over multiple networks to reach consumers. ISPs either had to build out significant infrastructure to reach the content, or else they relied on arrangements to enable the exchange of traffic across different networks.

Two types of arrangements evolved.

The first type is transit, a paid connection through a network to the parts of the internet not available via a direct connection. Like internet access purchased by end users, a transit provider can link (directly or indirectly) to all other networks on the internet, and their associated customers.

The second type is direct interconnection whereby two parties connect to one another, but only for the purposes of exchanging traffic destined for their respective networks (as opposed to all of the possible end points on the internet that can be provided by transit). Interconnection may be settlement-free or paid. In settlement-free interconnection, based on a mutual benefit, no money is exchanged between the parties. This was the basis of all interconnection in the early days of the internet, and is still the most common arrangement.

In these cases, there could be vast distances between content and the user requesting it. Therefore, as the internet grew and became more international, some of these arrangements became less practical for a number of reasons.

First, building and maintaining international networks is costly, as it involves laying infrastructure over long distances - overland and underwater. In some cases, this connectivity doesn't exist and would need to be built from scratch. In other cases, delivering traffic to a location will require passing through multiple networks.

90%

of internet traffic destined for consumers is carried by CDNs

$75B

is invested annually into infrastructure by online service providers to bring content closer to consumers

Second, remote content must travel through more routers (the internet's switches) on its journey to the consumer. Each one of these routers has a chance of being congested by high traffic loads, which can lead to packet loss[18] - the discarding of certain elements of the data being transmitted. Packet loss above a certain level results in a poor experience for the consumer, for example in the form of buffering and/or degraded video quality. In extreme cases it may render the service unusable.

Third, geographic distance leads to delay (latency) in the time it takes a packet of data to reach the consumer. This is less of an issue for video streaming (where there is less interaction and the data flows steadily[19] down to the consumer). However, it can significantly degrade other applications. Loading a web page may involve multiple round trips for data between the consumer and the server with the content.

The solution to these problems is to move a copy of the content in question closer to the consumer, using a distributed network of local servers, i.e. a Content Delivery Network (CDN). This reduces the geographic distance content must be carried, shrinking an ISP's costs. CDNs also minimize the number of routers and networks content must travel through, minimizing opportunities for congestion.

According to UK regulator Ofcom: *The local delivery of content can result in better delivery times to the consumer, which may translate to a better quality of experience, and so is often a preferred option for content providers. This approach further reduces transit or backhaul connectivity costs,*[20] *and can also improve the customer experience by reducing the likelihood of data congestion in these parts of the network.*[21]

Many companies now operate such CDNs. Large content providers operate their own in-house CDNs. Smaller content providers make use of independent CDNs such as Akamai, Fastly and Lumen (formerly Level 3). Using a CDN provides the ability to quickly and efficiently deliver traffic across the internet and is an important enabler of market entry and innovation.

CDNs are very widely and heavily used, and one study found they carry approximately 90% of internet traffic destined for consumers.[22] Analysys Mason estimate that in the period 2014-17 online service providers invested $75bn annually in infrastructure that brings content closer to consumers.[23] These investments reduce costs for ISPs.

Netflix initially relied on independent CDNs, but today operates its own CDN, called 'Open Connect'.

18 A data packet is a small unit of data.

19 Strictly speaking, video is served in chunks, which fill a buffer at the user end. As the user watches the video and depletes the buffer, a new chunk will be sent. However, this is all invisible to the user.

20 These are costs for the long-haul distribution of traffic, which may be borne by an ISP and/or a content provider

21 Ofcom, Connected Nations 2016, 16 December 2016

22 Craig Labovitz, Internet Traffic 2009-2019, 26 February 2019. A range of 60-80% was reported for Brazil in 2018: NIC.br, A importância dos Sistemas Autônomos e dos Internet Exchanges/PTTs, 23 August 2018. An earlier Ofcom study reported 83% of fixed network traffic came from CDNs in 2017. Ofcom, Connected Nations 2017 - Data analysis, 15 December 2017.

23 Analysys Mason, Infrastructure Investment by online service providers, December 2018.

The long haul

Why the early structure of the internet could not scale to meet the demands of today's internet usage

SINGLE SOURCE
When a user requested video content, it was served from a single location

CONGESTED DELIVERY
This server may have been a huge geographical distance from the user and traffic growth would mean expanding this long distance capacity

HUGE EXPENSE
Securing global connectivity would come at a high cost to Internet Service Providers (ISPs) who would have to purchase or build these backhaul connections

Long way round
Data would be forced to travel through many routers and networks

Traffic jams
Each router could be congested by high traffic volumes

Lost in transit
Congestion would lead to 'packet loss', causing quality to degrade

$1.2B

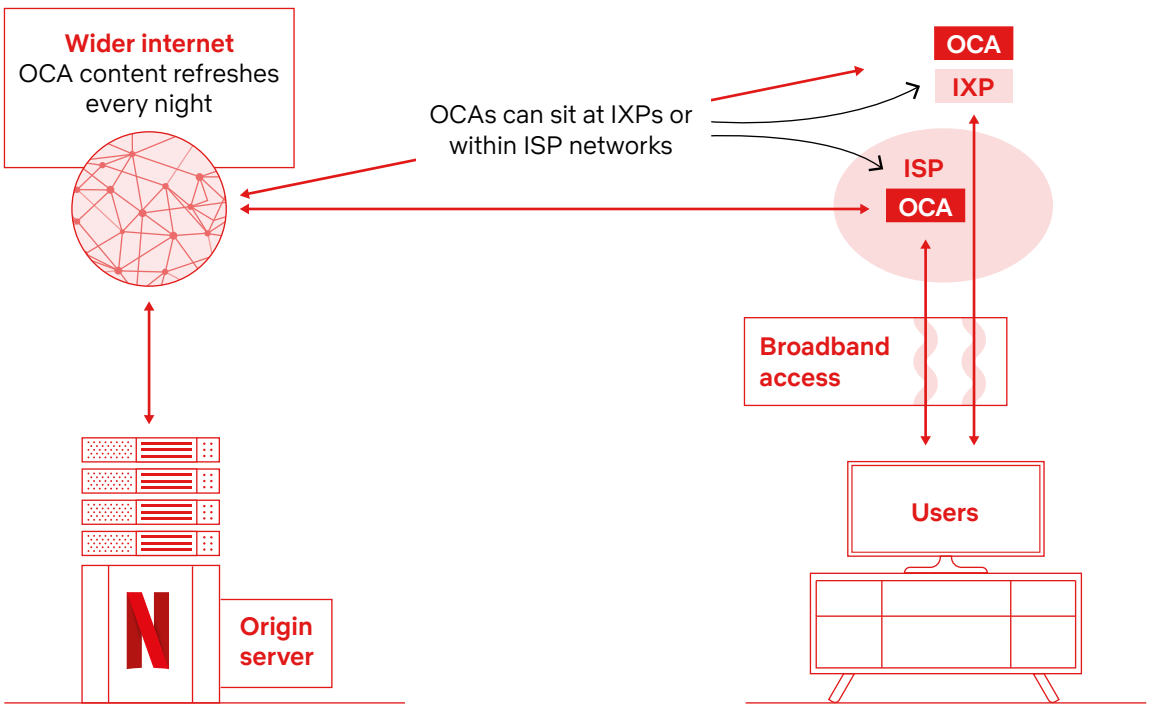
The amount of money Open Connect saved ISPs in 2020

Description of Netflix Open Connect

As of early 2021, Netflix has over 200 million paying customers around the world, using tens of thousands of combinations of device and network configurations. Open Connect is a key part of ensuring that these customers can reliably access high-quality video streams as efficiently as possible. Netflix also uses other techniques, such as sophisticated video compression and file versioning to reduce the size of video files, which we discuss later.

Open Connect CDN is a combination of local servers (called Open Connect Appliances - OCAs) and backbone infrastructure. Since the launch of Open Connect in 2011, Netflix has spent over US$1B to develop and deploy over 14,000 OCAs across 142 countries.

Illustration of Open Connect architecture



In order to bring content as close as possible to the consumer, OCAs are either deployed within ISP networks or at public Internet Exchange Points (IXPs), physical locations where many networks come together to exchange traffic. Each OCA deployment stores nearly all of the Netflix catalogue, including each title in the various formats and video qualities. Content is refreshed overnight as new content is released or becomes more popular.

Open Connect will directly interconnect with any ISP to hand off traffic at one or multiple IXPs. The interconnection predominantly supports the flow of traffic from Netflix to the ISP, with each side upgrading the capacity as needed to support user requests for content. Unlike interconnection among ISPs, where traffic is exchanged in both directions, traffic is primarily content destined for the ISP's users that have requested it, so it is flowing in one direction.

OCAs within an ISP's network are provided by Netflix to the ISP free of charge on a non-discriminatory basis. In most cases, the ISP takes full ownership and control of the equipment. Installing an OCA within the ISP's network allows the ISP to place it wherever in its network is most beneficial, avoiding costs that might otherwise be incurred fetching content over long distances to bring it into its network. To date, over 1,000 ISPs have taken ownership of and installed OCAs. For our ISP partners that have opted to deploy servers within their own networks, the cost savings for 2020 is estimated to be approximately $1.2B.

If an OCA is hosted at an IXP, then Netflix retains ownership and pays for its own power consumption, colocation fees, cross-connect fees and so on. Netflix has placed OCAs in more than 80 IXP locations in over 25 countries, where Netflix will peer with any ISP.

This investment by Netflix can have spillover benefits when a content provider like Netflix builds out its CDN to an IXP, ISPs and other content providers may be encouraged to also have a presence at that IXP. Multiple content providers and ISPs coming together at a single IXP location can generate significant efficiencies for all concerned.

Cost savings calculation

Estimate of costs per year =

Volume of traffic x Distance traveled x Price per unit of traffic

In turn the price per unit of traffic depends upon the cost of leasing long haul capacity.

The cost savings estimate reflects the savings that ISPs that take OCAs within their networks realize as a result of significant localization via the Open Connect Appliances and the resulting reduction in long haul internet backbone costs. It is important to note that even partners that are unable or unwilling to take OCAs within their network still realize savings as a result of localization of content within IX sites. Without the Content Delivery Network (CDN) content would be handed off at the source of the data (a handful of cloud storage regions) and the ISP would then carry the content to their end users.

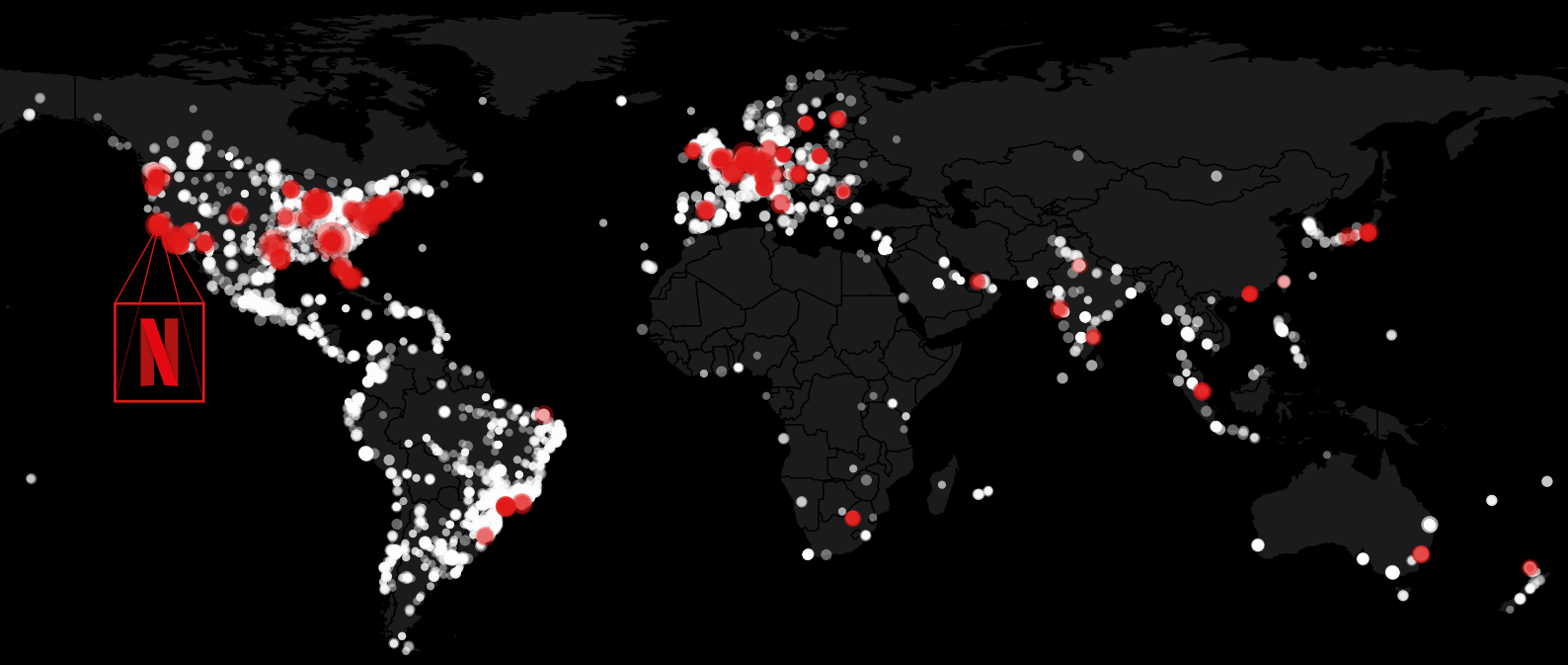
Bringing content closer

Netflix's investment in a new world of content delivery

OPEN CONNECT

Netflix now stores its content close to every member
- no matter where in the world they are.

Open Connect is Netflix's Content Delivery Network.
It's made of more than 14,000 Open Connect
Appliances (OCAs) spread across 142 countries.



KEY

Netflix headquarters
in California, USA

Netflix OCAs
Located within public
Internet Exchange Points

OCAs gifted to Internet Exchange Points
(ISPs)

25
100
Number of content caches per server

Note: Data as of 2020

Benefits for ISPs from Open Connect

Cost savings

Having content delivered by Open Connect provides various cost savings to ISPs.

First, they avoid 'transit charges'. While many ISPs will freely exchange traffic with other ISPs in their own region by directly interconnecting with each other,[24] to exchange traffic with more distant networks they generally rely on (and pay) transit providers. Further, they have to 'meet' the transit provider at an overseas location if transit is unavailable in their own country. In this case, the ISP will need to pay not only the transit charge, but also the costs of expensive international backhaul capacity to reach the transit provider.

However, Open Connect allows ISPs to avoid these costs, by passing the traffic directly to the ISP rather than via a transit link.

According to TeleGeography: *While the increase in broadband users and access rates will continue to drive traffic growth in access networks, much of this growth may be managed locally within a network and may not lead to proportional increases in traffic on international links. Thus, CDNs and caching will continue to have a localizing effect on traffic patterns and dampen international internet traffic growth.*[25]

French ISP Altice has noted that embedded Open Connect OCAs have: *Advantages both for the ISP and Netflix, minimizing the Internet traffic, while improving the quality experienced by customers, respectively.*[26]

Second, if an ISP hosts multiple OCAs, it also avoids some cost for their own core network capacity. Traffic can be delivered to the consumer from a nearby server, rather than having to travel across the ISP's core. UK broadband provider Sky has cited CDN caching as a key source of cost saving as video demand grows.[27]

Case study: Brisanet

Brisanet is a regional ISP that operates in the Northeast region of Brazil. Netflix traffic represents about one fifth of Brisanet total traffic.

Localizing the traffic has helped the company to significantly reduce transport traffic within Brisanet's network and thus reduces costs for augmenting transport capacity.

Localizing traffic has also improved the quality of experience for consumers. After installing Open Connect servers, Brisanet has received very positive feedback from their customers via their call center.

24 See the appendix for a more detailed discussion.
25 TeleGeography, The State of the Network, February 2020.
26 Altice Labs, InnovAction #2, January 2018.
27 Sky, Sky Core Network - Positioning for Massive Video Demand, 20 Feb 2018.

Netflix Open Connect is uniquely able to help ISPs take advantage of these benefits because we have a defined, limited catalogue of content. Netflix is able to better optimize the upload content to OCAs during off-peak hours, which avoids burdening the ISP or other parts of the internet during periods of the day where there is the highest usage. This means the connectivity needed to fill these servers is often without any cost to the ISP, as network capacity is built (or acquired) for peak capacity. Netflix is uniquely able to pre-position copies of all content in advance. Many content providers store a copy of a file only after it has been requested by a user, which may occur during peak hours. Furthermore, because the volume of Netflix traffic is limited, an OCA deployment can offload up to 100% of traffic from a single location.

Increased revenue from consumers

Aside from these immediate cost benefits, the improved quality of experience for the consumer has benefits for ISPs. Consumers who are happy with their experience of the services they receive over their broadband connection are unlikely to change their broadband supplier. By preventing buffering and instability, CDNs help broadband networks retain their customers.

A survey of broadband users found that slow speed/buffering and poor stability were the two main reasons that would influence broadband consumers to change their supplier.[28]

Network operators recognise the quality and cost benefits of CDNs. According to UK ISP TalkTalk: *Caching helps manage capacity, customer experience and costs … Netflix, for example, is located at over 60 locations around the UK, avoiding bandwidth costs in the core network and serving content to end customers with lower latency response times.*[29]

GSMA, the global association of mobile operators, has said: *By having content closer to the subscribers (using CDNs), the expected delays are shorter, and this means better quality of experience. Also, by having visibility on the services and the locations where those services are being used, the operator can spend less on network optimisation, prioritising the most important areas of high-value services. Users with better QoE [Quality of Experience] directly translates to less churn.*[30]

In addition to these advantages, CDNs are more resilient, since if one element fails, traffic can be redirected to other servers, reducing the risk of downtime.

Case study: Telecentro

Telecentro is an ISP in Argentina. Thanks to Open Connect, the company was able to significantly reduce its costs for international transit and improve performance. Because of that, their customer base grew faster as they were perceived as a very high quality broadband ISP in the market.

28 Huawei / Strategy Analytics, Unlocking Value for Residential Broadband Services with Quality Broadband Network, October 2017.

29 TalkTalk, Capital Markets Day, 5 March 2019.

30 GSMA, América Móvil and VIAVI Solutions – Creating Business Value through Content Delivery and Analytics, 17 December 2019. Text in brackets added for purposes of clarification.

Greater control

Open Connect provides ISPs with unparalleled control over how they receive Netflix traffic. Video-on-demand traffic has a largely predictable daily pattern, rising to a maximum in the evening. This allows content providers and ISPs to better predict and account for peak traffic. ISPs have full control over where they receive traffic, whether at one of the many IXP locations where Netflix is present or through placement of OCAs within their network. ISPs can fully determine which of their customers are served from which OCA, enabling better network planning and resilience.

ISPs are also able to determine when the content on OCAs is refreshed with the latest Netflix films and series. This allows them to ensure content is refreshed at off-peak times, so it does not contribute to peak capacity needs. This can help to minimize costs and provide greater network stability.

Encoding

Open Connect is not the only tool Netflix uses to ensure a good user experience. It also seeks to use the least amount of data to deliver a given picture quality.

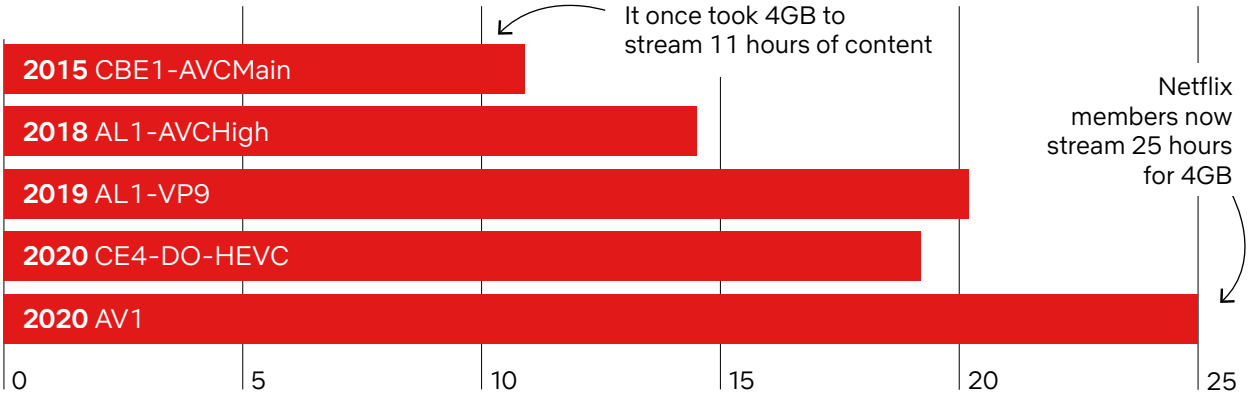
Delivering quality video to Netflix's members without using unnecessary bandwidth allows a good experience even on intermittent connections or those with limited bandwidth. But efficient encoding is applied to all Netflix's streams, and this has a benefit for ISPs too, since it minimises the traffic flowing across their networks.

There are also benefits to members beyond just picture quality. If less of a household's broadband capacity or wifi capacity is used for a given Netflix stream, then the freed capacity can instead be used for other applications.

There are two aspects to creating more efficient video streams. The first is that Netflix encodes multiple versions of the same video file, customised to the capabilities of different devices (including legacy ones) and the available bandwidth on a member's internet connection. The multiple encoding versions adapt to the device and available bandwidth automatically, allowing the resolution to go up depending on what a device is capable of and/or congestion on the broadband connections to viewers' homes. This is efficient since there is no benefit to sending a heavy, ultra high definition video stream to a device with a lower resolution screen or an internet connection that can not handle it.

The second is a drive to improve video compression. Successive generations of video compression formats allow the same quality of visual image to be delivered with less and less bandwidth. Netflix invests continually to deploy the most effective compression. It also optimises compression for different content types - using less data to deliver less complex video. For example, a video of a news anchor can be encoded using significantly less bandwidth than a car chase.

In the past five years, Netflix's encoding has more than doubled the data efficiency of streaming



Hours of streaming per 4GB of data

As a result of these efforts, Netflix streams are increasingly efficient. The number of hours a Netflix member can stream per GB of data has increased by more than 200%[31] over the last five years.

Netflix is also working alongside a number of companies including Samsung, Intel, Cisco, and Hulu in the Alliance for Open Media, a collaborative effort to offer open, royalty-free and interoperable solutions to make media technology more efficient. These solutions seek to provide superior quality for all users, on all devices, and on all platforms. The Alliance's efforts have resulted in the launch of video encoding technologies that have dramatically improved the efficiency of high quality video streaming across the industry.

Conclusion

These encoding improvements and deployment of Open Connect offer substantial benefits to ISPs, including cost savings, the stability of services they provide, and increased revenues. ISPs may see significant reductions in transit costs from moving content closer and ISPs who deploy servers in multiple locations may also see a reduction in the need for infrastructure to connect those locations. Maintaining international connectivity is costly as it involves infrastructure that spans long distances. Long distance connections have more opportunity to become congested by high traffic loads, which can lead to a poor experience for the consumer. Delivery through Open Connect "opens up the pipes" of an ISP to reduce the chances of congestion impacting Netflix or other application quality. The increased quality of video delivered via a CDN can lead to reduced churn for the ISP.

31 Based on the latest encoding profile.

Threats to the ecosystem

3

Understanding traffic charges

In recent years, one of the key changes to which the internet has adapted has been the increase in video traffic.

Improving access networks, rapidly falling costs of transmission and substantial investment in CDNs by video providers now enable subscribers to reliably watch high quality video on a range of devices.

As we have seen, the growth in video (supported by CDNs) has had benefits for consumers, content providers, ISPs and society as a whole.

However, these benefits rely on a somewhat unstable equilibrium of mutual cooperation to invest in efficient delivery. There is no requirement to move content closer to consumers. An uncongested long haul connection can still deliver high quality video.[32] Thus a relatively small disincentive to bringing content closer to consumers may prompt a content provider to stay further away. However, this would cause additional costs for the ISP, and increase the likelihood of congestion on back-haul networks.

It is important not to inadvertently create incentives that would undo the cooperative approach that has led to the investments in moving content closer by way of Content Delivery Networks. Despite these risks, some governments and ISPs have considered charging content providers for access to networks. This is likely to harm consumers, through double charges for connectivity, less competition, and ultimately poorer performance. In this chapter we consider the (flawed) case made for traffic charges, and then turn to the damage they may cause.

The case for traffic charges

The most frequent argument in favor of traffic charges is that ISPs are in urgent need of further funds for investment to support increasing traffic volumes and to fund wider broadband deployment.

Past claims that traffic charges are essential have proven unfounded

These arguments are not new. For example, in 2012, ETNO, the European association of incumbent telecoms operators, argued that: *Today there is a huge disproportion amongst revenues and a clear shift of value towards players (Over the Top players - OTT) who are not contributing to network investment. Traffic and revenue flows need to be realigned in order to assure the economic viability of infrastructure investment and the sustainability of the whole ecosystem.*[33]

32 Latency may be increased if there is an international leg, but this is relatively unimportant for video. However, if the transit link is congested, then there is a risk of packet loss and lower quality video.

33 ETNO, ETNO paper on Contribution to WCIT, 7 September 2012.

ETNO went on to propose the end of settlement-free interconnection (the collaborative exchange of internet traffic between ISPs and content providers) and the introduction of a 'sending party network pays' principle - that is, traffic charges. This proposal was not adopted, but even so the internet continued to function perfectly well - traffic charges were not necessary for investment or sustainability.

In the US there has been a 'natural experiment' in the significance of charges to content providers for investment. When Charter Communications (a US cable operator) merged with Time Warner Cable and Bright House Networks in 2016, the merger was subject to a number of conditions, including an obligation to offer settlement free interconnection with video providers.[34]

While this restriction has since been removed, we might have expected to see a degradation in the performance of Charter's broadband, relative to other ISPs that were not restricted to settlement-free interconnection over the time period in which payments were prohibited. In fact, Charter has had one of the best performing cable broadband networks in the US, according to the FCC[35] and the ISP Speed Index.[36] The lack of paid interconnection (charges by an ISP to a content provider for a direct connection) has not fed through to poor performance for consumers.

Thus both in the case of ETNO members and of Charter, traffic charges have not been necessary to fund improved broadband.

Indeed, in recent years there has been a surge in investment in fibre broadband globally. Much of this has been purely commercial, and has not needed traffic charges as a justification.

Traffic charges are a poor mechanism to support investment

Even if new sources of funds were necessary to support broadband investment, traffic charges would be a poor mechanism. This is because any payments received by ISPs would be 'untied' - that is, there would be no requirement for the funds to be spent on broadband infrastructure. ISPs may have many uses for their cash - the purchase of sports rights for an IPTV service, acquisitions, returning cash to shareholders and so on. These are all perfectly legitimate - but funds received from traffic charges may be spent on these, rather than on the broadband upgrade that was the purported purpose.

Better interventions are available to support widespread broadband deployment

While traffic charges are not an appropriate tool to support network investment, we are not suggesting there is never a case for external support. For example, there is a clear social case for supporting the provision of good-quality broadband in rural areas where it may be commercially unviable to deploy. However, there are many available interventions to support rural broadband, and indeed many countries already have such interventions in place. For example, in the United States some states are providing funding to support broadband deployment in unserved and underserved areas through grant programs that fund a portion of the cost of deployment in these communities.[37]

Traffic charges would be an untargeted and inefficient way to support rural broadband. They also carry significant dangers.

34 US Department of Justice, Justice Department Allows Charter's Acquisition of Time Warner Cable and Bright House Networks to Proceed with Conditions, 25 April 2016.
35 FCC, Ninth Measuring Broadband America Fixed Broadband Report, 3 August 2020
36 https://ispspeedindex.netflix.net/country/us
37 The Pew Charitable Trusts, How States Are Expanding Broadband Access, February 2020

200%

The number of hours a Netflix member can stream per GB of data has increased over the last five years

Dangers of traffic charges

The termination monopoly

The termination of traffic - final delivery to a consumer - is the last great telecom monopoly. If a given user requests a video stream while connected to a particular ISP, the video provider has no option but to send that stream via that ISP.

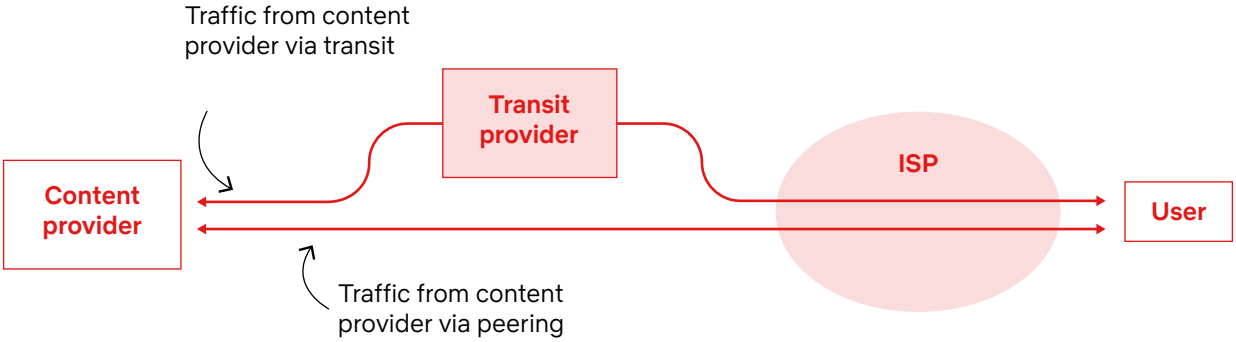
This remains true even if the user has access to other networks. It is clearly not possible for the video provider to request that the user disconnect from their home wifi and switch to 4G, to watch the video in question.

The danger of termination monopolies is one of the reasons regulators have been so active in the regulation of voice termination rates on both fixed and mobile networks over many decades. Without this regulation, there would have been a real risk of excessive pricing by telcos.

The termination monopoly for internet traffic is relatively benign if a consumer's ability to reach any content of their choice is not impacted by that ISP. However, if ISPs charge for the termination of internet traffic then consumers' ability to reach content may be restricted to those content providers that are able to pay. Furthermore, restricting consumers to only a subset of content, not a broad spectrum of content they might not otherwise encounter, deprives society of a rich content portfolio.

The risk of a termination monopoly is exacerbated in markets where consumers face challenges switching ISPs - either due to limited competition, long-term contracts, or high switching costs. But even in markets where there is competition among ISPs, a content provider can only reach consumers through their chosen ISP.

Theoretical alternate routes to the consumer



Alternate routes to consumer often not realistic in practice

It is sometimes argued[38] that such termination monopolies are unproblematic because content providers have various routes to a given ISP. For example, the content provider might have a direct connection to the ISP via peering[39] and an indirect connection via transit, as shown on the previous page. (Alternatively, they might have CDN servers on-net - that is within the ISP - and transit).

However, this is often more the illusion of choice than the reality. The ISP ultimately controls all of these routes into its network and can modulate the quality and potentially the pricing of both these routes. (The ISP might charge the transit provider for paid interconnection, for example). Thus, this apparent choice of route for the content provider invariably leads back to the access provider, who is at best competing with itself.

Further, transit links are unlikely to have the capacity to absorb traffic redirected from direct interconnection or a CDN. Ofcom (in 2017) found that for UK fixed networks, transit represented just 5% of their traffic,[40] and transit capacity is presumably provisioned accordingly.

As we have seen, Netflix alone might represent 11% of an ISP's traffic. Thus if Netflix were to switch its traffic to transit from Open Connect, 16% of the relevant ISP's traffic would be flowing through circuits designed for 5%. (Even this assumes that routes are available through all the ISPs' transit connections, which is far from certain). This would lead to massive congestion and consequently a catastrophic degradation of quality for Netflix's services. Netflix's competitors, likely still delivered via CDNs within the ISP's network, would be largely unaffected.

This congestion would also create some problems for the ISP, since other services arriving via transit would also be affected.

38 See, for instance, Laure Jaunaux & Marc Lebourges (Orange Regulatory Department). Externalities between on-line contents drive telecom operators' incentives to provide quality open internet through neutral network, 14 January 2019.

39 Peering refers to a direct connection to exchange traffic between two networks, generally at zero cost.

40 Ofcom, Connected Nations 2017 - Data analysis, 15 December 2017.

Fast times

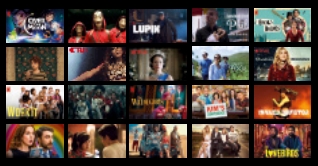
As broadband speeds get faster, Netflix streams take up less and less of a member's purchased bandwidth. Netflix recommendsjust 5 Mbps to stream a high-definition movie on Netflix on a fixed line connection. That means a Netflix member with a high speed broadband connection has enough bandwidth to stream multiple HD videos at the same time

25 Mbps

5 films

100 Mbps

20 films



1000 Mbps

200 films

Potential for leveraging into video markets

The threat of this termination monopoly is not simply a matter of the price paid for termination. Many ISPs compete directly with streaming video services, either because they are themselves a cable TV operator, or a telco with an IPTV offering. By 2024, 45% of Western European households are expected to take TV from a telco or cable operator.[41] ETNO has noted that "Operators supplying traditional pay-TV within Western Europe continue facing strong competitive pressures from OTT services [such as Netflix and Amazon]."[42]

Thus for any ISP with its own TV service, any degradation of quality for other video providers strengthens the competitive position of that TV service. This risks providing an incentive to take advantage of the terminating monopoly in a way that is detrimental to consumers.[43]

Potential for double charging

ISPs seeking to charge content providers for the carriage of traffic have almost universally already charged their consumers for carriage of that same traffic. Both mobile and fixed broadband products include data allowances (often 'unlimited' for fixed). Consumers have paid for these data allowances on the understanding that it will allow them to reach the entire internet, not just those sites that have agreed to pay to be distributed by their ISP. Further, if consumers have paid for traffic, to also charge content providers would appear to be a double-charge.

This problem is best illustrated when the speeds required for the content being delivered is well under the speeds paid for by consumers. The average global fixed line broadband speed is 87.84 Mbps[44] and this is much more than is needed to watch video. A Netflix member should theoretically be able to watch 17 simultaneous HD streams (of 5 Mbps each) with a connection of this speed.

Perverse incentives

The only way for an ISP to force a content provider to pay for traffic charges is to ensure congestion otherwise limits an ISP's customers from receiving requested traffic from the content provider. This congestion represents powerful leverage for the ISP to force the content provider to accept the demanded cost to connect directly, and thus the ISP has little incentive to remedy the congestion.

This potential leverage has caused concern to regulators in the context of ISP mergers,[45] and, in the past, ISPs have been known to use congestion in this way.[46]

41 Digital TV Europe, Rise of IPTV to benefit Telcos, 23 May 2019.

42 ETNO, The state of digital communications 2020, 28 January 2020.

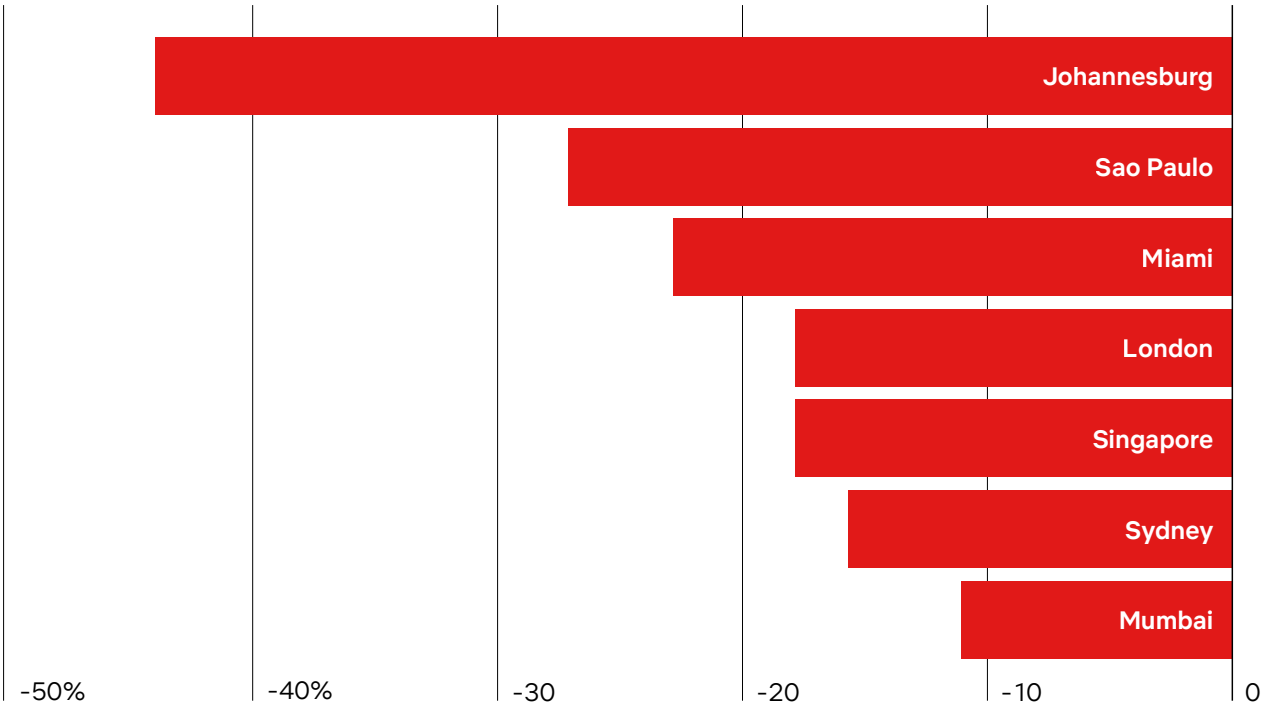
43 For a detailed discussion of these issues, see David Evans, Comcast's Acquisition of Time Warner Cable Would Result in an Economically Significant Increase in the Magnitude of Terminating Access Fees for Online Video Distributors, 6 April 2015.

44 Speed Test Global Index, https://www.speedtest.net/global-index, Accessed on 3 December 2020. The global average download speed for October 2020 was 87.84 Mbps.

45 See for example ¶550 onwards of European Commission, Case M.7000 - LIBERTY GLOBAL / ZIGGO, 30 May 2018

46 A number of such interconnection disputes are discussed in Daniel A. Lyons, "An Antitrust-Informed Approach to Regulating Internet Interconnection." Journal of Science & Technology Law 24, no.2 (2018): 229-276

Transit price CAGR, 2017-20[47]



If an ISP does impose charges for interconnection or on-net CDNs, then this gives content providers two choices: pay those charges, or deliver their traffic via offshore methods (e.g. via transit or non-localised interconnection). Transit prices have had a long-run trend of brisk decline, so in financial terms this can be an attractive option for content providers. This would result in backbone and transit links being used for content that can be more efficiently delivered, both in terms of cost and capacity, by means of local content servers.

While traffic charges by an ISP may force such an outcome, it is clearly suboptimal. For the ISP itself, it will likely mean that it is now paying to receive the traffic, since it may need to pay transit charges to the relevant transit provider. Moreover, if the ISP is buying its transit at a remote location, then it will need to invest in international backhaul capacity also. Avoiding such costs is one of the key reasons more than 7,000 ISPs around the world use Open Connect to receive traffic. Larger ISPs may tolerate these increased costs in order to force through traffic charges, but there is still risk to consumers.

Consumers invariably lose in this situation. They will be exposed to the risk of congestion in transit links, with possible degradation of their user experience. Increased latency may also cause problems (though less so for streamed video, which is not latency-sensitive). There is also a risk that consumers will lose access to the plurality of voices and applications that have enabled the internet to thrive.

47 TeleGeography, Global IP Transit Prices Keep Doing What They Do Best, 8 September 2020.

Conclusion

A cooperative model is win-win for consumers. At the heart of the internet's value is the fact that it is an adaptable network of networks which enables the communication and sharing of information and content between people, irrespective of location.

In recent years, one of the key changes to which the internet has adapted has been the increase in video content. In order to support this increase in traffic, content providers like Netflix have worked hand in hand with ISPs.

In Netflix's case we invest significantly in content, which drives demand for broadband internet access. We invest in delivery infrastructure (OCAs and backhaul infrastructure) and compression technology. In both cases, we have not only innovated on existing industry standards, but also actively participated in standardization activities to ensure constantly improving efficiency across the industry as a whole.

We have made these investments in delivery because we want to give our members the best experience possible no matter what the available bandwidth is or the capability of their viewing device.

And our investments have also reaped significant benefits for ISPs - increased revenues, greater broadband takeup - and for many ISPs Open Connect has enabled them to avoid the costs of expensive international transit. It has also generated benefits to society. The availability of high quality video gives consumers a reason to go online in the first place and to upgrade their broadband connections, promoting greater connectivity.

Looking to the future we are keen to continue to work in partnership with ISPs in this way to ensure that content is delivered to our members in the most efficient way possible. However a cooperative model will only be sustained if content providers and ISPs continue to recognize the complementary nature of networks and content. In addition, if governments acknowledge the important role that content providers play in stimulating demand for broadband services and establish supporting policy frameworks which restrict the imposition of charges by ISPs on content providers.

Glossary of terms

CAGR

Compound Annual Growth Rate

Cache

A temporary local copy of information that originated elsewhere. Thus for CDNs, a copy of files to be delivered to consumers, stored in a local server

CDN (Content Delivery Network)

A distributed system of servers, designed to enable the efficient and reliable distribution of content over the internet

CP (content provider)

An internet business whose focus is delivering content (rather than - say - e-commerce) to consumers. Netflix, CNN and YouTube are examples

FBB

Fixed broadband

Hop

One step in a packet of data's journey across multiple servers

ISP (Internet Service Provider)

A company providing internet connectivity to consumers (consumers or businesses). May provide fixed broadband, mobile data or both

IXP (Internet Exchange Point)

A location where many networks meet to exchange traffic, avoiding the need for multiple bilateral connections

Latency

The lag between a packet of data being sent and reaching its destination

OTT (Over The Top)

Describes services delivered over another network without being integrated with it. YouTube, Facebook and Netflix are examples (since they are not provided by telcos operating broadband networks)

Packet loss

When a router is sent more data than it can handle, it discards a certain amount of data. This is known as packet loss. Typically the data in question will then be requested again from the source server

Router

A switch on the internet, that receives packets of data and sends them onwards down the appropriate link

Server

A computer that stores and transmits content

TCP/IP

Transmission control protocol and internet protocol. The two foundational standards for data transmission that underpin the internet

Appendix

The Internet (TCP/IP) protocol enables easy physical interconnection between two networks that both use it. However, there is also a commercial aspect to interconnect - does money flow between the two parties and what extent of connectivity is provided?

Transit and peering

There are two primary categories of interconnection, namely transit and direct interconnection (with some variety under each heading). We discuss these below.

Transit

Transit is typically used by an ISP (or content provider - CP) to reach the parts of the internet not available to it via other types of connection, such as interconnection. The ISP buys transit from a transit provider, who in turn links (directly or indirectly) to all other networks on the internet, and their associated consumers.

For destination ISPs and CPs on its own network, the transit provider passes the traffic on directly. For other destinations, it will connect with other transit providers, who will in turn pass the traffic on to the destination in question. Since essentially all ISPs and CPs are connected to at least one transit provider, connection via such providers enables universal connectivity.[48]

While transit provides universality, it has two major disadvantages. Firstly, it comes at a cost. The ISP or CP must pay in relation to the amount of traffic carried via the transit link.[49]

Secondly, it may lead to inefficient traffic routing. An ISP may have to procure transit from a provider that is not based in their own country, but (say) in the US. If so, all traffic sent by the ISP will have to travel to the US, even if it is destined for a consumer in the ISPs' own country. This is known as traffic tromboning. It is expensive, since both the sending and the receiving provider must pay for pricey international capacity. It is also technically poor, since the long journey introduces latency and the potential for packet loss.[50]

48 It is also possible to buy partial transit, where the transit provider offers connectivity only to certain destinations

49 Transit is typically priced on a 95th percentile basis - that is, based on 'near peak' bandwidth demand, but setting aside the busiest 5% of periods

50 While tromboning is becoming rare in larger internet markets, it remains a significant problem in some smaller markets. See, for instance, UN ESCAP, An In-Depth Study of the Asia-Pacific Information Superhighway in CLMV Countries, March 2020

Illustration of transit

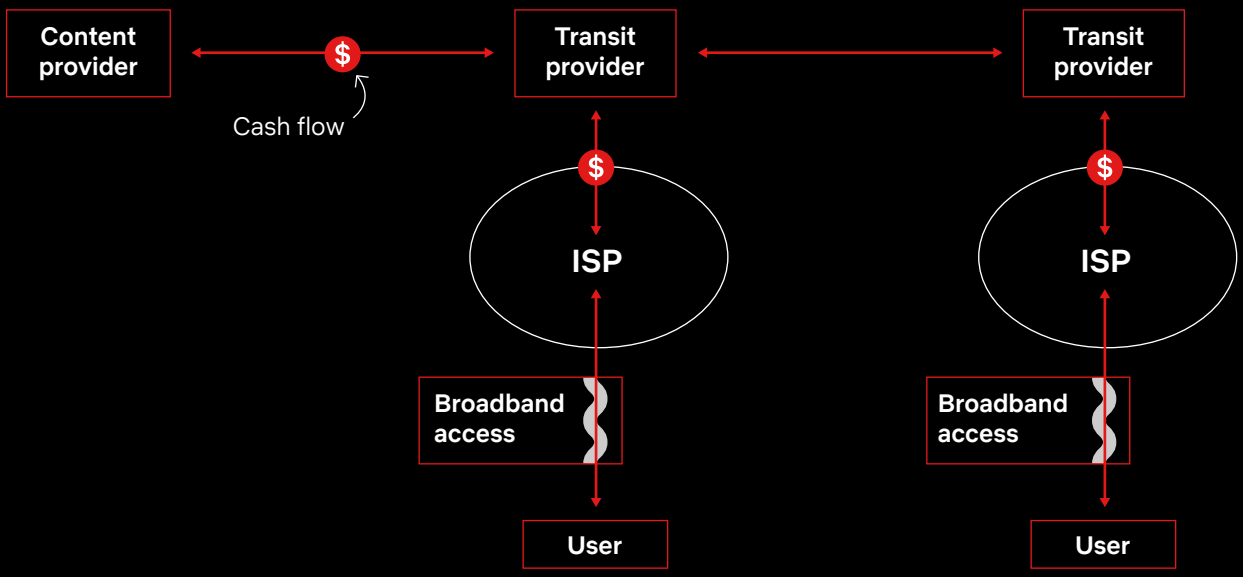
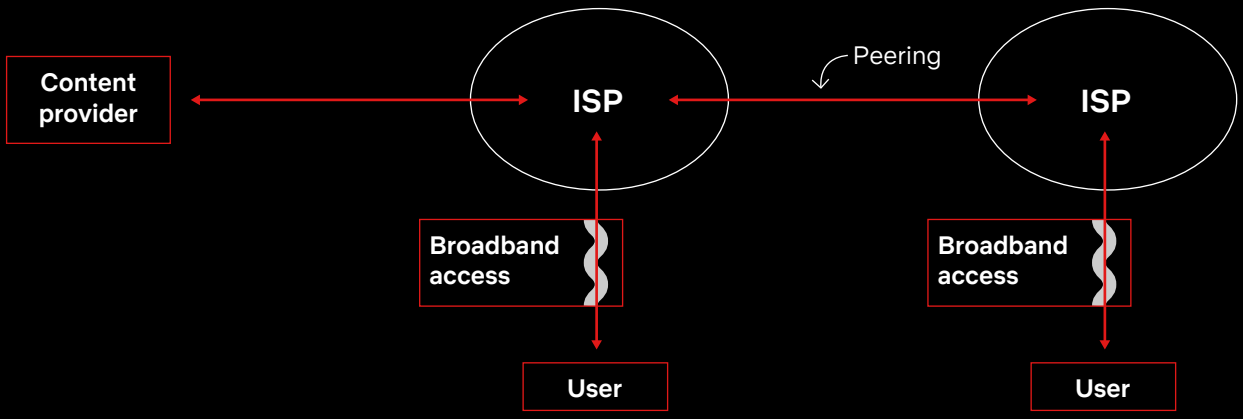


Illustration of peering



Direct interconnection

The main alternative to transit is direct interconnection through peering. When two networks peer, they connect, but only for traffic destined for their respective networks. For example, ISPs X and Y might peer, and the traffic flowing over the link would be any traffic travelling from ISP X's consumers to ISP Y's consumers, and vice versa.[51]

ISPs may peer, but so too can ISPs and content providers. In this scenario the traffic flowing would primarily be the content destined for the ISP's users.

There are a range of types of interconnection. It may be public or private. Public interconnection takes place via an Internet Exchange Point (IXP), a physical location where many networks come together to exchange traffic. This is efficient for connecting with many different peers. Private interconnection takes place via a direct physical connection between two networks. This may be lower cost and more reliable if a large volume of traffic is being exchanged.

Peering may also be settlement-free or paid. In settlement-free interconnection, no money is exchanged between the peers. This was the basis of all interconnect in the early days of the internet, and remains very common. Generally interconnection links are mutually beneficial, and so both parties gain even if they are unpaid. Further, if there is no payment then contracts can be far simpler. Indeed, interconnection based on a handshake (i.e. without a written contract) is very common.

That said, networks often have certain criteria that they apply to certain peers, to avoid being gamed. For example, a network with expensive international connectivity might be reluctant to peer with a purely local network, since it would pick up the lion's share of the cost of transmitting traffic between the two networks' customers.

Sometimes networks only offer interconnection if traffic flows are roughly balanced - that is, there is a similar volume of traffic flowing from peer X to peer Y as is flowing in the opposite direction. This does ensure that the two parties are imposing similar traffic costs on each other. However, this is not necessary for settlement free interconnection to be merited. Asymmetric traffic may create value for both parties, even if costs are not balanced. For instance, YouTube may send a lot of traffic to a small ISP, but that ISP gets great value from making YouTube available to its consumers

While settlement-free interconnection is common, there is also paid interconnection, where one party pays the other. This may arise where one party gets much less value out of the interconnection (and so requires compensation), or where one party has leverage, and can simply insist on payment.

51 'Partial interconnection' is also possible, where peers only agree to connect certain subsets of their customers, similar to partial transit


NETFLIX