BROADCAST
THE BRIDGE
Connecting IT to Broadcast

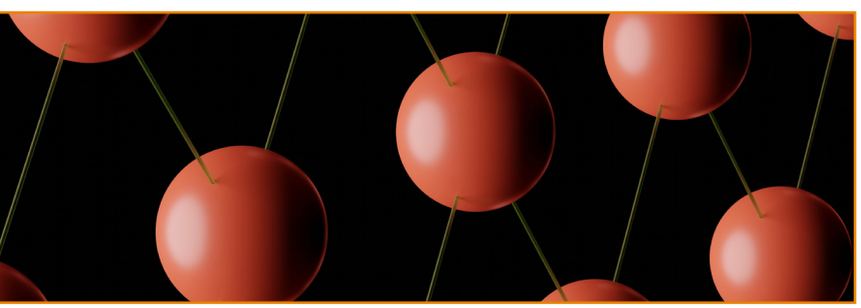
The Big Guide To OTT:

Part 6 - Internet Infrastructure

A Themed Content Collection from The Broadcast Bridge

Themed Content Collection

Contents



Series Overview

By Paul Martin. *The Broadcast Bridge.*

The Big Guide To OTT provides deep insights into the technology that is enabling a new media industry.

As OTT delivery grows, driven by both consumer demand and content provider strategy, there are many adjustments to manage. They include new production approaches, scaling content distribution, personalizing, protecting, and monetising content, and assuring audience QoE.

Content providers are delivering a mix of live, linear, and on-demand content. Business models are blending - subscription with advertising and direct-to-consumer with service aggregation. The internet-enabled OTT delivery model is driving the media industry through a giant transformation.

There are many broadcast disciplines to leverage in OTT – the concept of "broadcast-grade streaming" means streaming should match broadcast's capacity for highly consistent, highly scalable delivery of high-resolution content at low latency. There are also new disciplines for content providers to embrace, like delivering highly personalized content and building new relationships with consumers and ISPs.

The OTT technology domain builds on core broadcast distribution disciplines and adapts them to internet-based delivery. New contribution methods, ultra-low latency encoding, and high speed broadband streaming, could mean that 'streaming-grade' will become a new gold standard for content delivery. But the fixed and mobile broadband networks we rely on, and the myriad of devices we use, mean that we need to work differently to manage content accessibility and quality. So while the content may be largely the same, there are significant differences to manage between the worlds of OTT and OTA.

The Big Guide To OTT is a multi-part series. Each part tackles a different theme and there are three or more articles per part.

Available now:

Back To The Beginning
Content Origination
CX - Customer Experience
Managing Latency
Assuring Viewer QoE
Internet Infrastructure

New Parts coming soon:

Broadcast Grade Streaming
Streaming Sustainability
Quality Of Experience
Monetization & ROI
Content Delivery Networks

Internet Exchanges & The Growth Of OTT

By Paul Martin. *The Broadcast Bridge.*

Demand for bandwidth is growing at a remarkable rate. Equinix's Global Interconnection Index (GXI) Volume 6 forecasts total interconnection capacity to reach 27,000 Tbps by 2025, which is up from just 5,000 Tbps in 2020. This incredibly fast growth reflects the speed at which economies are digitizing and how much data is being exchanged between consumers and enterprises.

What is driving this? Service Providers including Telcos, Cloud & IT Services, and Hyperscalers represent just over 50% of the total capacity requirement. A further 33% of capacity is to be used by Banking, Securities & Trading, Manufacturing, and Energy sectors. All are scaling out to support the rapidly expanding digital economy. Content & Digital Media demands are expected to consume just 4.5% of the 27,000 Tbps of global interconnect capacity, mostly through CDN service providers. This percentage share of capacity usage is lower than reported in 2021 when Content & Digital Media was forecast at 10% of the total interconnect share, but interconnection through Internet Exchange Providers (IXPs) continues to be a fundamental part of the internet infrastructure used to deliver content.

Interconnection is only one of the content delivery models used by D2C (Direct to Consumer) OTT operators. This article reviews how Internet Exchange Providers support the fast-growing OTT industry with multiple connectivity models.

The Internet Exchange Provider

Internet Exchange Providers play a central role in the growth of OTT video services.

They provide 3 specific ingredients essential for OTT video delivery. First, they operate data centers that house the network edge points of service providers and network operators. Second, they provide an interconnect platform that provides peering and interconnection services for service providers and network operators. Third, they provide network services to manage network expansion, network assurance, and data security. Each point is fundamental to the success of OTT video services in the years ahead.

The Data Center

Internet services are far more than best-efforts for data delivery to consumers and businesses. They are treated as critical national infrastructure. Telcos have had carrier-class data centers running with 5 to 6 "9s" availability for many years already. Internet Exchange Providers (IXPs) operate to the same standards given the importance of their facilities to the delivery of internet-based services.

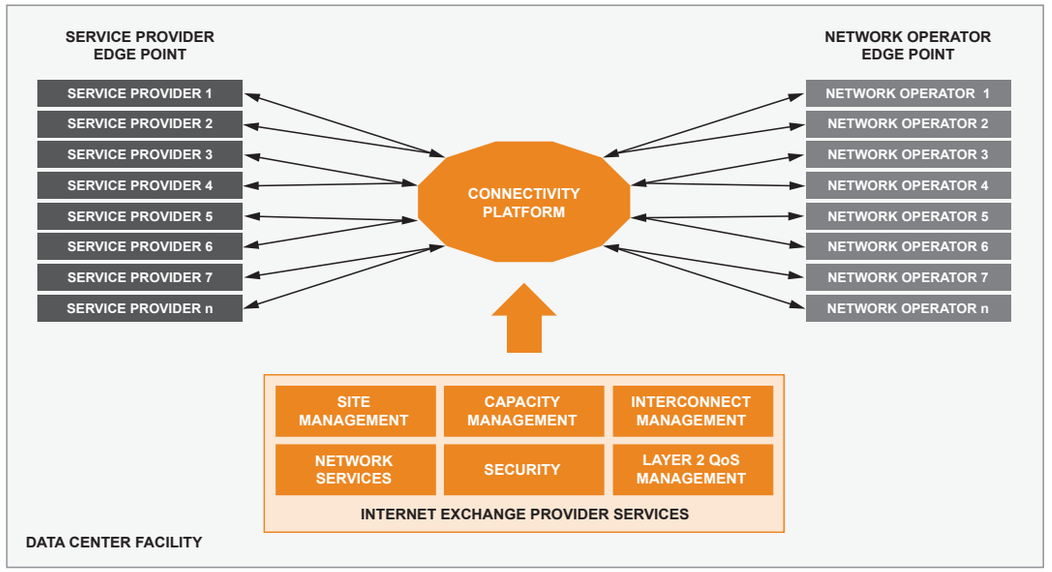


Figure 1 – The role of the Internet Exchange Provider.

Capacity of a data center is defined by the space and power of the facility. A very large facility today can have over 70,000 sq ft of space available and in excess of 20 megawatts of power. Internal connection bandwidth of the largest data centers can reach many Terabits and beyond.

IXP customers require geo-redundancy and geo-expansion. IXPs cater for this through their site strategies which require capacity expansions in existing sites and nearby sites. Interconnectivity naturally creates dense points of presence as optical network circuits converge on a single place. IXP building strategy is a primary factor for expanding connectivity.

Connectivity

There are two grades of connectivity. Public known as "peering" and private known as "interconnection" or "Private Network Interconnection (PNI)".
The Peering Network, or internet exchange capacity for general use, typically ranges from 1GbE up to 400GbE for a single user. Peering is treated by CDN Service Providers as a valuable way to connect with smaller ISP network operators. To meet with larger ISPs, CDNs interconnect. The very largest CDNs, which are often the private networks of the biggest content providers like Netflix, YouTube, Facebook and Amazon use peering or interconnecting for the smaller ISPs, with private edge caches deployed inside the largest ISPs.

The Interconnection Network is defined as private network connection between two participants. A typical threshold at

which a service provider will move to an interconnection model with a network operator is around 1-2Gbps of traffic. As noted above, this area of the industry is growing very quickly. To accommodate fast and frequent capacity growth, IXPs provide API-driven, automated interconnection via a central service.

Alongside this growth in throughput, security has taken on a renewed urgency. Starting in 2017 efforts were accelerated to resolve one of the longstanding weaknesses of the internet: the independent validation of IP address ownership. This problem has been an issue for OTT streaming services, creating a weak spot for content to be pirated and services to be disrupted. To validate IP addresses in a centralized manner, IXPs provide a Route Server service which redistributes the routes and verifies they are matched with the central encrypted lists which are held securely be the regional internet authorities. IXP members can peer with the IXP-hosted Route Server instead of having individual clearing relationships with all other IXP members. The Route Server creates efficiency for an ever-larger set of network interconnections. CDNs carrying OTT video streams routinely use IXP Route Server security services. Internet Service Providers are also now validating their IP address ranges and those of their peers through the same centralized model.

IXP capacity is growing rapidly to keep pace with the demand. Consumers request content and content providers make it available. Network Operators expand core and access network bandwidth. IXPs expand the interconnection points to support the demand on all sides. From the early 1990s to c. 2007, internet usage grew quickly but did not exceed 100 Exabytes delivered per year. From 2007 to 2016 total data delivered grew 10x to reach about 1000 Exabytes. Cisco forecasts 3500 Exabytes will be delivered in 2023 which complements the faster-than-average 4x growth in interconnect capacity forecast by Equinix. But by 2023 we will still only be near the beginning of the Media Industry's transformation towards a fully OTT-centric delivery model. A key data point to note is that approximately 5-10% of household-name broadcaster viewership is through OTT platforms that use the internet for content delivery. This leaves a long way to grow.

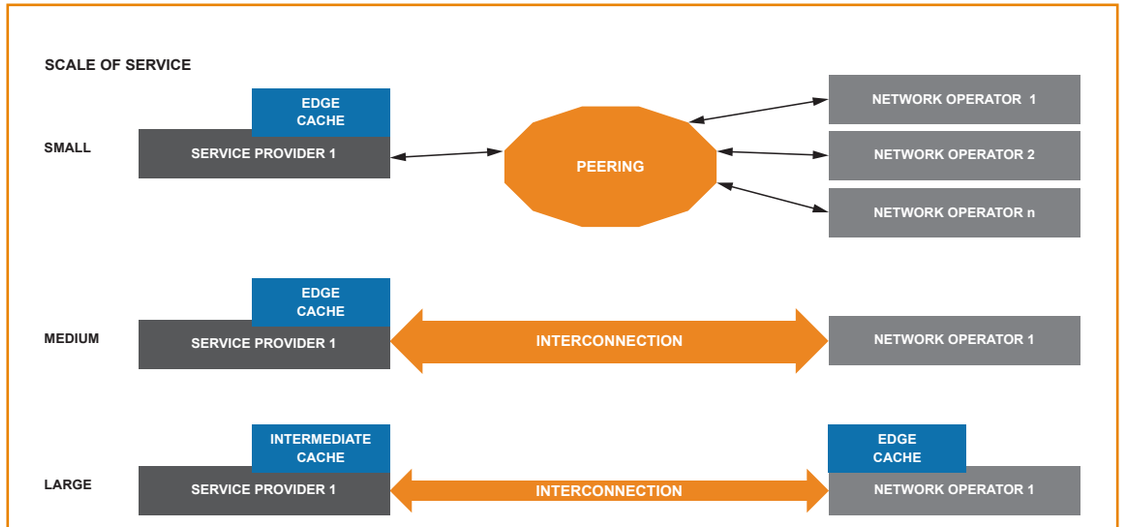


Figure 2 – Modes of connectivity as OTT service throughput grows. Mixing modes for a single service provider is normal.

Contention

While network bandwidth continuously grows to meet demand, network contention – caused by the dynamic ebbs and flows of consumer and business demand on the network – is a perennial problem. To avoid contention network operators must build capacity ahead of the demand. If this does not happen, traffic must be prioritized to limit the impact of contention. As a rule, peering points and internet exchanges are less susceptible to capacity shortfalls because they are built for peak aggregate traffic, with headroom to manage serious facility outages. But the fundamental concept of multi-tenancy that applies to telecoms networks, CDNs and service provider networks means that capacity can be oversubscribed.

Individual networks can have capacity shortages when overbooked or when demand reaches unexpected levels. This typically would only happen at peak time as otherwise the network's peak capacity is generally available at all other times. In 2020 the world's shift to homeworking, homeschooling and daytime video streaming highlighted network robustness because they are built for evening peak use. At the Internet Exchange level, individual service providers can reach maximum capacity on their network ports. But CDNs, IXPs and ISPs generally build enough headroom in to their capacity so they can handle the loss of an entire facility, thereby minimizing the chance of capacity shortages.

In the end however, we are in an accelerating growth phase for internet traffic. Therefore, the chance of capacity shortages occurring in a multi-tenant service provider environment is an ever-present risk. While service providers and network operators will aim to build to stay ahead of the demand curve, the demand is coming around that curve very quickly, often too quickly for individual media companies seeking to innovate and expand their streaming video services. Which is why we see headlines on a routine basis about streaming records being broken with associated customer experience impacts as network capacity buckles under the pressure, and why we can expect these problems to continue until we reach "full-scale" streaming.

Edge Deployment

OTT operators are one of the biggest consumers of internet bandwidth with their specialist use case of video streaming. One of the ways the biggest OTT operators avoid contention is to deploy private, dedicated capacity inside ISP networks. As IXPs are observing, the trend towards deploying capacity inside ISP networks to get even closer to the consumer is growing, driven by the largest video streamers. There is a trend towards services being more distributed towards users, as the internet's fundamental pull system progresses towards its ultimate state of caching and processing ever closer to the consumer.

For a network operator the benefit of deploying caches deeper in the network is the saving in backhaul bandwidth. Opencaching and 5G both support this business objective.

Opencaching is focused on standardizing edge cache communication protocols so that ISPs can utilize their own infrastructure for multiple tenants or individual tenants. This could ultimately enable the placement of open-standard edge caches into many local telephone exchanges. 5G places smaller cellular masts closer to consumers, creating infrastructure that can ultimately be used for content processing, storage and streaming. This continuous push towards the consumer is critical to achieve maximum total throughput for minimal additional investment in the core network.

As a result, network operators are starting to work more as infrastructure providers with IaaS (Infrastructure as a Service) offerings. IXPs now have the opportunity to deploy their own network management services on top of network operator infrastructure. And network operators themselves can deploy their own network services on top of other network operators' infrastructure.

While network operators can expand their networks and deploy processing and storage capacity ever deeper in their networks, the IXPs will maintain a critical position of consolidated interconnection between many service providers and many network operators. There are various scenarios where OTT Operators will not want to (or will not be able to) deploy cache capacity inside ISP networks, so peering and interconnection will continue to be valid options for the long-term. In the end, the IXP's many-to-many relationship position is unique and will persist and grow in order to provide secure, resilient and scalable networking services over the years to come.

Considerations For OTT Operators

Live Streaming events are driving larger and larger audiences. Individual OTT Operators are normally able to quite accurately predict their patterns and levels of viewership, even for live events.

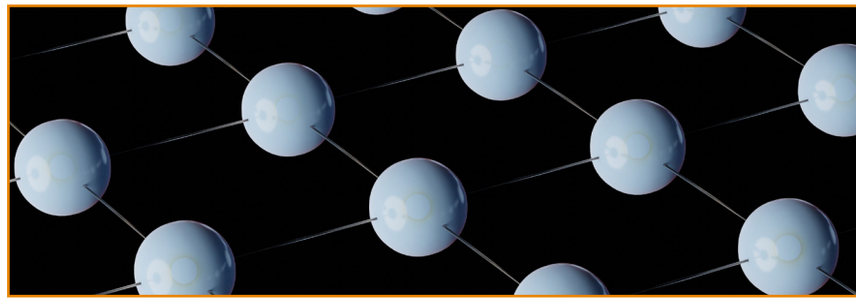
As audience sizes grow, OTT Operators will increasingly use advanced forms of caching to improve and maintain quality of experience for their audiences, particularly for live events that drive the biggest audiences and the biggest commercial returns.

Because of the risk of unexpected multi-tenant capacity shortages and its effect on a customer's QoE (Quality of Experience) the largest OTT Operators are building their own CDNs, which provide dedicated capacity, lowest-possible-contention, and perfect access to big data sets for service and consumer analysis. For ultimate control, an OTT Operator does need a private environment.

IXPs see that video streaming from caches deployed inside ISPs is growing year on year, led by the major video service providers like Netflix, YouTube and Facebook. These three digital giants, plus Amazon, drive about 50% of peak evening internet traffic between them in countries where they are present.

As Brenden Rawle, Senior Director of Business Development EMEA at Equinix states: "Technological innovation is continuing apace across industries, with digital media services being no exception. The rise of digital media services is transforming the way we consume and interact with media content, and demand for high-quality, real-time content delivery is only increasing. Our focus at Equinix is to enable networks, content and digital media businesses, and large enterprises, to securely exchange internet traffic and connect distributed infrastructure and digital ecosystems worldwide. From a single peering exchange point, content and media providers can connect to multiple network carriers, content delivery networks and internet service providers, to deliver their streaming video services to viewers all over the world in real time, thus meeting expectations."

The next wave of streaming giants are the national and international broadcasters, whose OTT services are becoming increasingly strategic and are the focal point for future investment in programming, advertising and customer engagement. When prime-time TV audiences move to OTT platforms – we can imagine a concurrent audience of 20 million in a country with a population of 60 million – then the national household-name broadcasters will represent a significant proportion of total internet usage. And they will rely even more heavily on the carrier-class Internet Exchange infrastructure.



Telco Access Networks & The Growth Of OTT

By Paul Martin. *The Broadcast Bridge.*

Telco fixed access networks are "the last mile" to homes and commercial buildings. They play a key role in the delivery of OTT Video, and are undergoing big changes to support its growth.

Telco fixed access networks were originally built in the 19th century to deliver telegraph services, evolving during the 20th century into telephone services. Today they provide vital telecommunications services supporting all aspects of a nation's life including government, business, education and entertainment. Companies in this sector include the likes of British Telecom, Telecom Italia and AT&T. Over the last 30 years, the voice-first PSTN network has evolved to support data services over broadband, and today telcos are deploying new data-first access networks.

In contrast to Telco networks are "Cable networks" – think Virgin Media, Comcast and UPC. These businesses were created to support video and data delivery. This article focuses on the Telco fixed access networks which generally serve the vast majority of any country's population with broadband and voice services. So, what are the technology evolutions or revolutions underway in telco access networks, and how do they support the growth of OTT Video?

Telco Access Network Technology

Today there are two primary types of Telco access network technology:

1. "Legacy" that includes some level of copper network and includes solutions like ADSL (Asymmetric Digital Subscriber Line), VDSL (Very high bit-rate DSL) and FTTC (Fiber To The Cabinet)

2. "Next-gen" that is fully fiber-based and is called FTTP (Fiber to The Premises) or FTTH (Fiber To The Home)

The future of OTT Video delivery needs next-gen access networks. These networks will deliver greater bandwidth and reliability. For legacy networks, the copper cable itself is the limiting factor for both these performance metrics. Over recent decades there have been multiple upgrades to the electronics attached to the copper network which have increased bandwidth while routine network maintenance activities have maintained reliability, but copper has effectively reached its limit.

To go faster needs fiber. Next-gen FTTP networks are based on GPON (Gigabit Passive Optical Network) technology. A typical deployment for a residential property today supports a single connection with up to 2.4Gbps downstream. As the current deployable architecture for GPON can split a signal up to 32 ways this delivers a theoretical limit of 80Mbps per home, enough to support at least 10 simultaneous HD video streams.

The 2.4Gbps speed is only the starting point of GPON technologies that will be rolled out over the course of the 21st century. There are already field-proven deployments of 10Gbps fiber technologies called XG-PON, and 100Gbps GPON is now at the experimental phase.

These speed enhancements will be achieved by advances in the electronics attached to the fiber – the ONTs (optical network units) and OLTs (optical line terminals) – to utilize more of the fiber-optical network capacity over time. These electronic upgrades are expected to enable fiber networks to significantly increase bandwidth for many decades to come.

The Need For Speed?

An HD video typically streams to an IP-connected device at a maximum bitrate of 8Mbps. A UHD stream is typically up to 14Mbps. But what applications will utilize all the bandwidth being made available by greater than 1Gbps (i.e. 1000 Mbps) bandwidth connections?

The use of live services such as video streaming, video conferencing and gaming is expected to expand dramatically over time. In an average household with multiple connected devices being used for work, school, gaming, entertainment and socializing it's easy to imagine using over 100Mbps.

Non-live services are where the bandwidth is heavily consumed. Downloading files, such as video, photographs and documents will use all available bandwidth. Generally, a file download will squeeze a live stream and could potentially disrupt the live stream quality. This is one reason why OTT video operators are increasingly looking for CDN solutions that

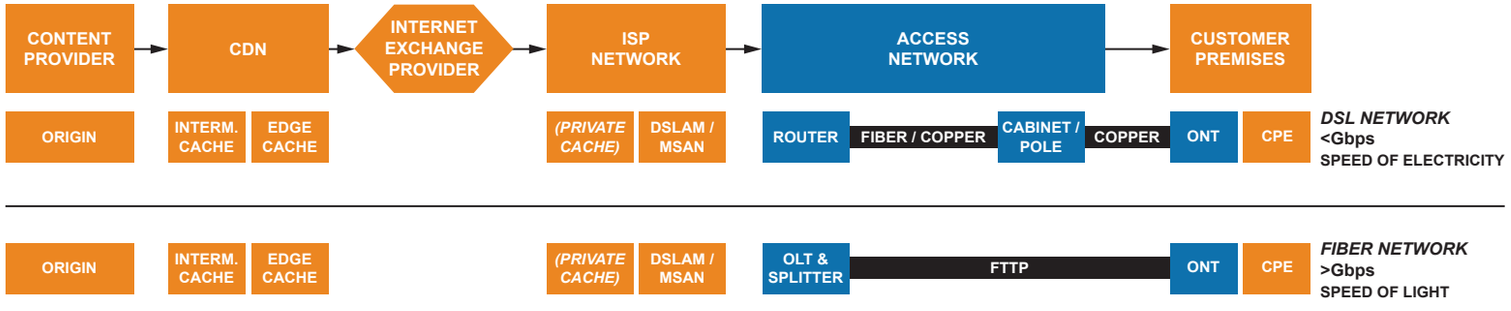


Figure 1 – OTT Video Delivery and two types of access network topology.

prioritize live video streaming over VOD downloads.

Looking further to the future, higher bandwidth will be needed for virtual reality and augmented reality experiences. How far these types of services will penetrate in the near future is unclear, but technology advances will create the option for these types of applications to become commonly used.

Combining these various use cases, and accounting for the growth in video file sizes (e.g. UHD formats are 2-4 times bigger than HD formats depending on compression) it is clear that the total quantity of content that will be downloaded and streamed to the home will increase over time, even if the number of users remains constant. However, with general population growth and increasing numbers of IP-connected devices, not only will content-per-person increase but so will the number of people using the internet. Cisco's Annual Internet Report 2018-2023 forecasts that global internet users will increase from 3.9 billion in 2018 to 5.3 billion in 2023. And while more saturated regions like Western Europe are not growing as fast, 87% of the population is expected to be internet-connected by 2023, up from 82% in 2018, while the number of IP-connected devices per capita will grow from 5.6 to 9.4. If we achieve all this by the end of 2023, how much more advanced will the situation be in 2030?

At the same time, specifically for video streaming, we can also see that encoding technology is focused on delivering equal quality at lower bitrates. For example, HEVC encodes and streams at 66% of the bitrate of the older H.264 codec. This sort of change could reduce some of the bandwidth consumption but is likely to be offset by customers choosing to stream at higher bitrates because they can, and because they want to benefit from their 4K Smart TVs which are rapidly growing in volume deployed each year.

Access network operators see this large and general demand for increased bandwidth. In advanced markets, copper networks have reached their limits. FTTP is the choice for the future and today's large-scale network upgrade investments will provide many decades of support for bandwidth-hungry applications to grow.

Revamping Reliability

For video streaming services, reliability is as important as speed. After decades of reliable terrestrial and satellite video services, and with ever-growing pressure on internet capacity, we can be easily frustrated by poor quality OTT video (and videoconferencing). And the more serious network service outages, while relatively rare, can be very disruptive. FTTP has various features that provide higher levels of performance and reliability than legacy networks.

Most broadband networks today have sections of copper networks which were originally deployed for conducting voice signals. With FTTC, VDSL and ADSL, copper wires connect the street cabinet to the premises. Copper wires are susceptible to rain as they can erode and rust, affecting the quality of the electrical signal being carried over them. FTTP is much less weather-sensitive which is important if we are to rely on it consistently delivering 100s of Mbps of latency-sensitive content and data to our homes.

Put simply, FTTP has an "on/off" performance status because it is based on transporting light, instead of electricity. This avoids the very challenging service degradation problems that affect the electricity-based delivery format of legacy networks and cause the various performance and intermittent fault problems each of us has experienced at some point.

In addition, while FTTP networks have fiber joints and splices like copper networks, the network architecture removes points of connectivity which are potential points of failure. For example, FTTP architectures do not include street cabinets, which will gradually become extinct. Instead, the fiber network runs underground from major exchange buildings to termination points near or at the premises. This network simplification directly improves reliability.

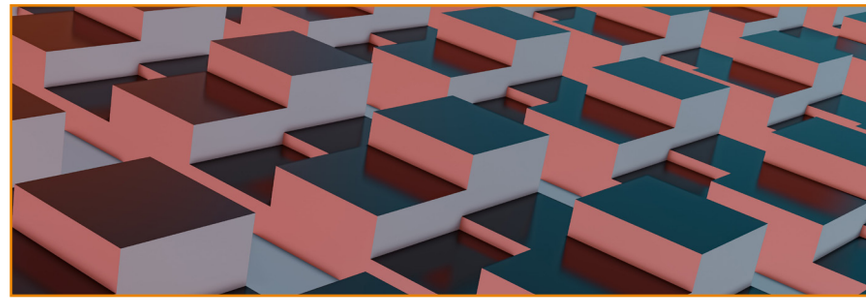
FTTP also removes points of intervention when compared to legacy networks. If a household changes broadband provider in a legacy network, a technical intervention is required at the street cabinet. This creates a risk of interrupting an existing service to another premise connected through the same cabinet. With FTTP, broadband provider changes will be controlled through the central exchange locations where ISP services meet the access network, dramatically reducing the level of intervention-caused network faults.

Overall, the FTTP architecture is more centralized than legacy networks. For example, BT Openreach's FTTP deployment will require 1000 telephone exchanges, while the legacy network requires 5500. While FTTP is less-distributed, it is efficiently-distributed and more quality-controllable.

Moving The Bottleneck

Historically, access networks have been a well-publicized bottleneck to performance because of contention and service degradation on last-mile networks. But with FTTP, the dynamics will shift.

It is worth noting that FTTP capacity is still "oversold" based on estimates of normal and peak-time usage, much like airplane seats. The 2.4Gbps connection serving up to 32 homes will allow each home to have up to 80Mbps uncontested, but it is often sold at speeds of "up to" 1 Gbps. There could be peak moments when a home wants to have 1Gbps and cannot have it, but the expectation is that 80Mbps will work well in most situations for now.



But even if a house can receive 80Mbps uncontested, can this be sustained to the receiving devices? One new dynamic with FTTP is that it pushes today's intermittent and performance-sensitive issues from the legacy access network to the home network, which is often not designed for high-performance broadband delivery, and to the on-premises equipment

It is well understood that WiFi speed reduces as you move further away from the home router. It is also true that most homes are not fitted with CAT5 or CAT6 ethernet networks, and in new homes builders will often install

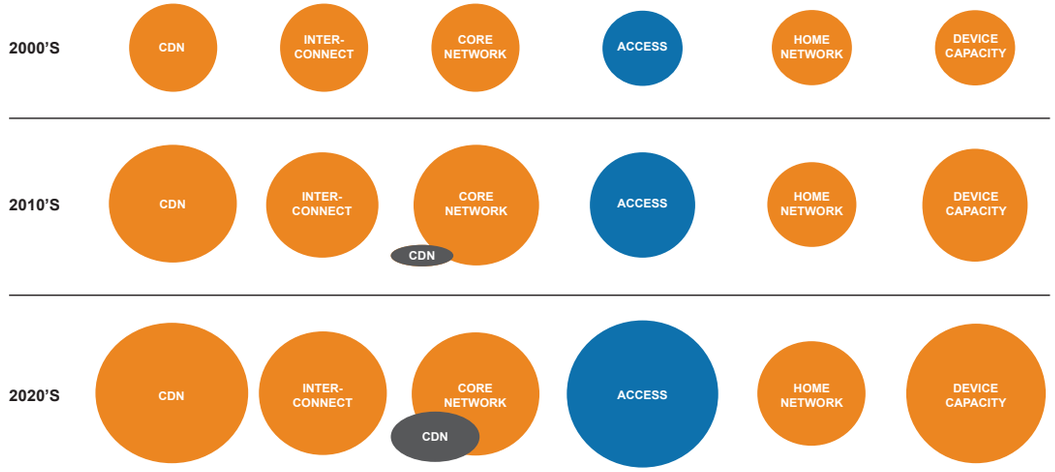


Figure 2 – Relative capacities of E2E network elements over time. Note that in some countries, Access and Core Network relative capacities are reversed.

the FTTP termination equipment in a location that is out of sight, which is aesthetically pleasing but sub-optimal for wireless network performance. We then find ourselves trying to strengthen performance through in-home network extensions. So, while access network speeds expand dramatically with FTTP, can the home network can keep up? Because the answer is "probably not", it is conceivable that professional AV deployments will become more commonplace in homes of the future to assure performance to the end devices.

Caching Deeper In The Network

Low latency OTT video delivery for Live and VOD relies on caching content close to the consumer. Generally, this means the place where the network speed will ensure low latency. Today, caches for OTT video are deployed in a small number of POPs in the ISP Core Networks. Network operators themselves deploy caches throughout their core networks to serve large populations over the last-mile access network without consuming unnecessary core network capacity.

ISPs deploy their own Edge sites in Exchange buildings. This is where an ISP network termination point (like the DSLAM and MSAN) will connect to the access network operator's infrastructure. Not all countries have the same corporate and/or State ownership of core and access network operators, but network architecture designs are generally consistent.

In the Openreach example, it is conceivable in the future that the UK's 1000 Exchange buildings will be the target for Edge Cache deployment, including the potential for deploying private caches for the largest content providers. ISPs will most likely decide these deployment plans based on business cases related to content provider bandwidth requirements and core network capacity expansion costs.

Prime-time OTT

Openreach, like other access network operators, sees high-quality live OTT content delivery for the largest prime-time audiences as a major challenge for content providers in future.

Every country has a different situation to manage based on population and geography, but if we calculate that a large live OTT event today can attract 1 million viewers in a single country, and we calculate that by the end of the 2020s most households will watch their evening and prime-time TV on an OTT service, then the access network in the UK must be ready for 25x-30x the volume of traffic, at least based on today's average bit-rates.

Access network upgrades to next-gen architectures are therefore a critical enabler for large audiences of the future that will expect reliable OTT video delivery, whatever the weather.

ISPs And The Growth Of OTT Video

By Paul Martin. *The Broadcast Bridge.*

Internet Service Providers (ISPs) are experiencing significant growth in bandwidth consumption largely due to the uptake of OTT video services and the growth in numbers of connected devices per household. ISPs are therefore navigating the path of making investments in their networks that support their own financial requirements and their customers' expectations.

An overarching objective for ISPs is to provide sufficient bandwidth to supply their customers' data demands. As demand grows new bandwidth bottlenecks appear, which in turn create new areas of performance degradation. ISPs therefore manage a continuous cycle of network expansion, upgrade and maintenance. Video traffic in particular is placing the heaviest of demands on ISP networks, quickly revealing new bottlenecks and new performance issues. As providers of competitive broadband services, ISPs have a firmly vested interest in ensuring that their networks are delivering what their customers expect.

From a network performance perspective, ISPs focus mostly on bandwidth and data packet loss. Bandwidth looks at how big the capacity is, packet loss states how well the network transports the data. Net neutrality rules that prevent ISPs from prioritizing some types of data delivery over other types mean that a focus on data packet loss is the best an ISP can do. But video, particularly live streaming video, is most sensitive to network conditions, and because the customer experience of OTT streaming video is of growing importance to the whole media industry, ISPs are acutely aware of how important it is to know that video is traversing their network successfully. This ISP-consumer dynamic is leading ISPs to deploy new technologies that support video quality management while creating new and deeper partnerships with OTT operators.

ISP Network Capacity

Managing network capacity is an everchanging balancing act. The network is the supply and the data it transports is the demand. Push too much demand at the supply, and the first point at which a lack of supply is encountered will result in performance degradation. Unlike a riverway that can burst its banks if too much water flows through, a fiber-optic cable or copper wire will simply drop data that it cannot transport. Video consumers then see spinning wheels or sub-standard images – this is the Quality of Experience (QoE) issue that must be avoided, particularly for live video. Unlike water loss from rivers, packet loss from video streams immediately creates pressure on upstream capacity as packets are re-requested.

In managing network supply, ISPs have various bandwidth challenges to overcome. Many ISP networks buy "last mile" services from a national or regional access network provider. Some ISPs build their own end to end network and have full autonomy. But the level of investment over time in different network elements, and the relative speed of consumer uptake of bandwidth-hungry services, creates different bottleneck dynamics to resolve for each ISP.

Italy's Fastweb, for example, is expanding its aggregation layer capacity between core and access network domains that will better utilize the available 1Gbps of access network capacity per home. As part of this process Fastweb is distributing network capacity closer to consumers and now has 100 data-centers throughout Italy that pass over 22 million households and businesses. In 2020, they experienced a 30% increase in day-time bandwidth consumption as lockdown kept people at home. Like many other ISPs, they have had to review their network capacity planning rules – such as traffic thresholds for network link upgrades – due to the critical nature of working and studying from home.

In comparison, the UK's BT Openreach is embarking on a large FTTP program to expand bandwidth in their access network. The British Telecom core network was upgraded in the 2000s in BT's "21CN" Programme, and now the access network is the capacity bottleneck. But by 2030 BT Openreach estimates the bottleneck will have shifted to the home network.

The OTT Operator Relationship

ISPs note how OTT operators are adopting different video delivery strategies and models. While some are investing in public CDN partnerships, others are investing in their own video edge delivery infrastructure. The OTT operators with distributed audiences (i.e. multi-national audiences) or relatively infrequent streaming patterns continue to focus on their public CDN partnerships, while OTT operators with densely located (i.e. national) audiences and frequent streaming patterns are creating private video network capacity by working directly with a relatively small set of ISPs.

In video distribution the "edge" of the video delivery network is a big talking point. This often means the edge of a

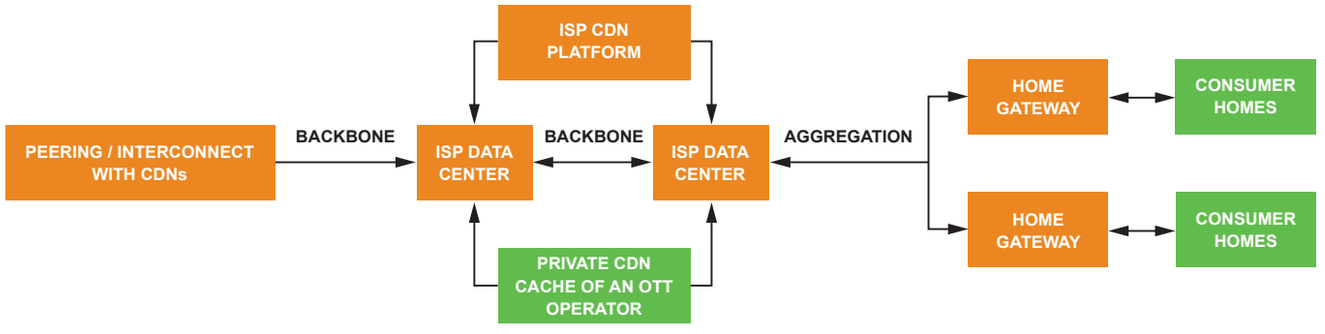
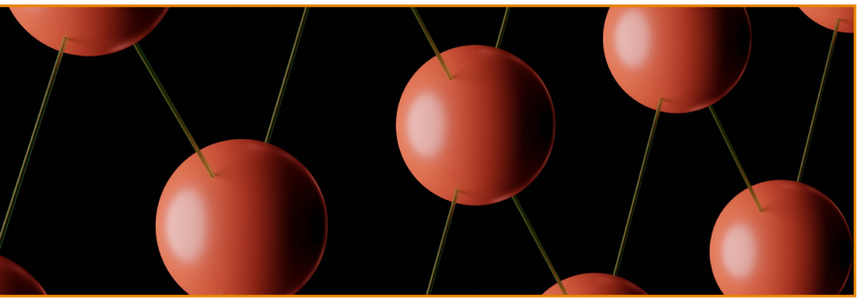


Figure 1 – Capacity expansions for ISPs (orange) and points of focus for improving OTT video quality (green).

CDN which then interfaces with the ISP network, either through peering or direct interconnection. From this point on, ISPs manage a range of widely deployed network infrastructure to transport the video to the consumer. The infrastructure of highest priority to the ISPs includes the interconnection and/or peering points with CDNs, the ISP's own data center infrastructure for data aggregation, the long-haul networks connecting all sites, their own CDN for on-net video distribution (if applicable), and the consumer premises equipment (CPE) including the home gateway.

While the ISP's own infrastructure is complex and distributed, the network paths that video follows can be even more complex, as the total ISP infrastructure in a country involves inter-connection between some, but not all, ISPs. Generally, the larger ISPs have carrier agreements with other large ISPs so data can traverse their



networks to reach an end consumer. In the context of OTT video delivery, and in particular where the OTT operators have QoE concerns, this inter-connected IP transport layer can be a concerning black-box.

OTT operators seeking to address QoE concerns are focusing on private CDN deployments inside ISP networks. This strategy is designed to improve the quality of video delivery and protect the end customer experience. For the ISP, this investment can reduce pressure on peering points, but it can also ensure their broadband customers are more satisfied with their OTT video experience. As live video streaming grows, and major events have larger and larger OTT audiences, the end customer's experience is as important to the ISP as it is to the OTT operator.

The Consumer Relationship

ISPs support all forms of data delivery to their customers, but streaming unmanaged video from OTT operators represents approximately 60% of the total. Live streaming video in particular creates the biggest challenges from a quality-of-service perspective. Not only because live video streaming should be of a consistent quality which is challenging to achieve across dynamic, multi-use IP networks, but also because audience sizes are difficult to predict. Capacity Planning and Video Quality Assurance are inter-connected disciplines within ISPs that together contribute to the final customer experience.

The customer experience is a critical point of market differentiation between ISPs providing a broadband service that is as essential as water, gas, and electricity supply. To provide an excellent customer experience for OTT video is a particular challenge as the ISP cannot see the content of the video stream and cannot independently know what the customer's experience actually is. And yet this is the area in which ISPs are being judged by their customers.

There is growing pressure to create clarity of ownership of the OTT video customer experience in the home. For a single stream into a single household, the answer might clearly be "the OTT operator with help from the ISP". But for a single household receiving multiple streams simultaneously from multiple OTT operators, who controls what? Should the answer be "the ISP with help from the OTT Operators"?

If the ISP needs to take a lead role in managing customer experience, they need to know about video delivery and they need a way to act on this for the benefit of their consumers. This idea is strengthening the need for closer direct partnerships between ISPs and the largest OTT Operators. While OTT Operators look to private CDN infrastructure and quality monitoring of their own streams, ISPs are focused on offering stream management tools to their customers to enable device-level prioritization in the home (e.g. prioritizing a SmartTV over a mobile phone), while considering new video monitoring and testing tools that can give them independent verification of video quality over their networks.

The Environmental Relationship

A discussion about expanding network capacity, driven by people's desire to

ENERGY USAGE CATEGORY	2018 EMISSIONS (TONNES OF CO2)	2030 TARGET (TONNES OF CO2)	STRATEGY TO REDUCE
FACILITIES & TRANSPORT	3,410	1,300 (62% REDUCTION)	CONVERT BUILDINGS AND FLEET TRANSPORT TO RENEWABLE ENERGY SOURCES.
THE NETWORK	0	0	CONTINUE TO PURCHASE ALL ELECTRICITY FROM RENEWABLE SOURCES (WHICH AVOIDED 61,000 TONNES OF CO2 EMISSIONS IN 2020).
NETWORK MANAGEMENT	167,200	142,000 (15% REDUCTION)	REFINE PROCUREMENT PRACTICES TO REDUCE CARBON EMISSIONS (PROCUREMENT AND MANAGEMENT IS 64% OF TOTAL EMISSIONS; CUSTOMER EQUIPMENT IS 27% OF TOTAL EMISSIONS).
TOTAL	**170,610**	**143,300**	

YEAR	2018	2019	2020
EFFICIENCY SCORE	47	35	23

consume video, should consider the network's impact on the environment.

In 2015 the United Nations launched Agenda 2030, as part of the drive towards reducing global carbon dioxide levels. The International Science Based Target initiative (SBTi) was established to provide methodology and certification to businesses for their CO2 reduction plans.

Fastweb, part of the Swisscom group, serves 2.7 million residential and business customers on its fixed network in Italy. Fastweb's SBTi-approved plan demonstrates how much energy ISPs consume to provide us with our internet services, and what is being done to minimize emissions.

Fastweb also measures its network's energy efficiency as data traffic increases. The measure is calculated as Total Emissions divided by Total Traffic (TB), with lower numbers reflecting how existing capacity is more heavily utilized.

Finally, the SBTi encourages businesses to measure their indirect emission impacts. Fastweb measured that in 2020 its network helped avoid 245,000 tonnes of CO2 emissions by enabling homeworking and homeschooling making them a net reducer, as opposed to net contributor, of CO2 emissions.

As we consider the impact of ISPs on the environment, and our use of ISP networks for more and more video delivery, it is important to factor in how the overall consolidation of data onto these networks can enable even more energy efficiencies.

Targeting The Win-Win-Win

Video delivery over ISP networks is set to grow continuously for many years to come. Arguably it will grow until we reach maximum digestible screen resolutions, maximum device counts and maximum audience numbers.

OTT Operators and their consumers will push the networks to their limits, and while broadband remains a competitive industry it makes sense that ISPs strive to deliver an industry-leading customer experience to their video-consuming customers.

To assure this all-important customer experience, OTT Operators and ISPs will develop closer partnerships to share information about streaming quality and customer experience, which will then inform ISP investments in their networks. Deploying OTT video tools inside ISP networks to provide this necessary information is a good first step.

Themed Content Collection

EG ESSENTIAL GUIDES

ARTICLES

MEDIA

The Broadcast Bridge publishes hundreds of free articles like this every year. Subscribe online to stay informed via email or our social channels.

www.thebroadcastbridge.com