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# The Big Guide To OTT: Part 7 - Content Delivery Networks

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# Introduction

By Paul Martin. The Broadcast Bridge.

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

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

Streamers 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 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 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**
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- CX - Customer Experience**
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- Assuring Viewer QoE**
- Internet Infrastructure**
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- Broadcast Grade Streaming**
- Streaming Sustainability**
- Quality Of Experience**
- Monetization & ROI**

# CDN For Live And VOD

By Paul Martin. *The Broadcast Bridge.*

**CDNs are much more than just high-speed links between Origins and ISP (Internet Service Provider) networks. Instead, they form a complete ecosystem of storage and processing, and they create new possibilities for highly efficient streaming at scale that will likely replace broadcasting technologies. In this article we look at the different workloads for Live and VOD to understand better how they operate.**

A typical mix of content delivery for an OTT service from a large public or commercial Broadcaster that delivers both Live and VOD is about 80-90% VOD and 10-20% Live. The CDN workloads in each scenario are different with important ramifications for the technology.

For Live content, large audiences are watching the same content at the same time. Inside the CDN, this workload places pressure on server memory, CPU, and network ports to sustain the stream and the bit-rate. As a CDN Edge Cache operates as a proliferation mechanism for the same live-streams – e.g., one 5 Mbps HLS stream in, with 1000 x 5 Mbps HLS streams out – the job is to sustain egress with low latency to every single viewer.

On the other hand, the VOD workload is driven by individual consumers watching varied content that is being streamed at different times. Pressure is placed on Storage, CPU, and streaming algorithms at both Origin and CDN levels. Not only does the stream of a single VOD file need to be sustained, but this has to be achieved on potentially hundreds

or thousands of discrete files to unique viewers.

## Edge Computing

Edge computing has been a hot topic over the last few years as OTT video and general use of public cloud services have expanded. For OTT, edge computing can be defined as processing video into its final delivery format at the CDN Edge. Specifically, this involves delivering from the Origin to the Edge in a mezzanine format, like CMAF, and then processing at the Edge to the client device in the required package, like HLS, DASH or MSS. But where is the Edge?

In theory, the Edge should be as close to the consumer as possible. In a perfect world it would be possible for every consumer device to function as an Edge device. While peer-to-peer networking offers some potential here, at least for Live use cases, there isn't a viable consumer device level solution for peer-to-peer networking for VOD content.

One step further away from the consumer is the telco's access network where there are street cabinets, mobile masts, and the original telephone exchanges. While

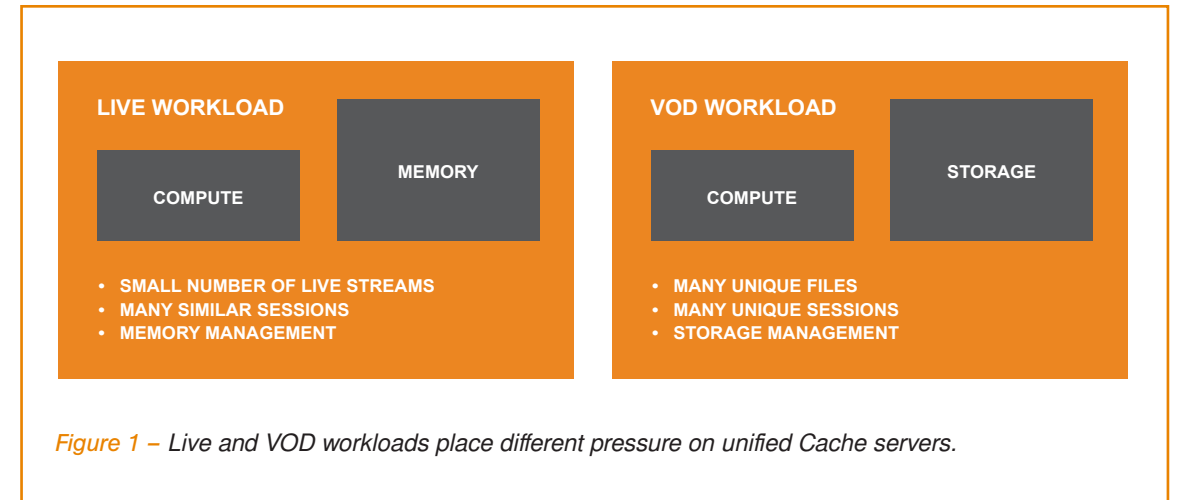


Figure 1 – Live and VOD workloads place different pressure on unified Cache servers.

these may become edge locations in future, today the volume of locations and the volume of video does not justify the expense. In addition, access networks are generally aiming to be data-agnostic, with video as just one form of data. Over time this may change as we move to more advanced forms of video delivery like immersive viewing formats through virtual reality and holographics.

The next step moving away from the consumer towards the origin is the ISP's core network. This is the first opportunity for a CDN to become ISP-specific, and because the centralized core network is serving all data delivery needs, offloading video traffic where possible makes sense for the ISP to save core network bandwidth. This is the current focus for Edge Cache placement for the largest OTT service providers. However, too many caches in the core network can create unwanted technical and operational complexity for the ISP. But given the disproportionate amount of total traffic due to video, the trend towards ISP-based edge caching is strong.

This is why the Edge, for the most part, is currently deployed in Internet Exchange

locations – the “meet me room” for the ISPs and the OTT service providers (via the CDN service providers). Even so, processing at the Edge is not the norm. But it's coming, because it's based on the solid principle of pull-system efficiency. Edge computing will help reduce bandwidth requirements between the Origin and the Edge, but it will put more pressure on the Edge as it will add an 8th function (see prior article for the first 7 functions of the Edge) of managing just-in-time packaging and encryption. The business trade-off for edge computing is between network cost, CDN cost and server cost. In the end, each OTT network topology will be evaluated on a case-by-case basis to find the optimal approach.

## The Appearance Of The iCDN

CDNs are transitioning from being a series of interconnected computers to a series of interconnections. The difference may sound subtle, but it is fundamental. It means that instead of using centralized brains with “dumb” pipes, we will use distributed brains with “actively engaged” pipes. Greater interconnectedness will create greater intelligence, and see the rise of the iCDN.

Today CDNs can be described as the HOV (High Occupancy Vehicle) lanes of the multi-lane internet – they give a faster, less congested, more managed route for data delivery than the unmanaged public internet. As OTT traffic grows, we generally think about building more and bigger HOV lanes, with “exit ramps” closer and closer to the consumer. This is the natural progression of the pull-system – to place the final content delivery location closer to the point of consumption.

These HOV lanes are being supported by multiple access network expansions, including telco fibre-to-the-home roll-outs, CableLabs’ 10G programme in the cable industry, and 5G in the mobile industry. These major infrastructure changes will improve the customer experience of OTT video, but also pave the way for enhanced video experiences, like immersive viewing, that place new pressures on the network in a continuous cycle of consumers making use of the capacity that we have available to us.

In this context, OTT service providers need to think differently, as their traffic demands outstrip network supply. Deploying Edge Caches closer to the consumer is important, but as noted there are challenges. Leading CDN businesses have recognized this issue and are focused on making more intelligent use of network resources to reduce dependency on network supply. So, what is being done by these leading CDN businesses to create the iCDNs?

First, leading CDNs are interconnecting all their Edge servers, and then distributing content caching and processing across them. This reduces the traditional dependence on a single Edge Cluster or POP, while utilizing performance intelligence gathered from all parts

of the CDN infrastructure. This more sophisticated approach is superseding the traditional CDN “acquirer server” method that is oriented around vertical and hierarchical content caching and distribution.

Second, leading CDNs are using performance data from all 5 service domains – the 4 QoS domains of hardware, software, network and stream, and the QoE domain of the client – in order to create a complete customer-centric view. This view becomes even more important as CDNs expand their workload for bigger audiences. All CDNs monitor software, hardware and streams, focusing on the metrics that are directly under their control. Some CDNs go beyond this to add 3rd party network data into a unified QoS view. But only the most advanced CDNs combine QoE and QoS for a complete view of performance.

Third, the iCDN takes data from the 5 domains and applies intelligent algorithms in real-time in order to predict quality issues and take proactive actions to avert them. This proactive approach based on all available information – which must be filtered to avoid data overload and slow decision-making – is the hallmark of the intelligent CDNs and will be how OTT service providers assure QoE as their audiences grow. In summary, the iCDN is the next-generation of CDN platform.

The roadmap for CDNs is not just about supporting the pull-system principles with more powerful edge caches that are simply placed closer to the consumer, although this remains fundamentally important because this addresses the traffic volume challenge. The roadmap is also about making the Edge more interconnected and more intelligent in order to be more proactive, thereby also

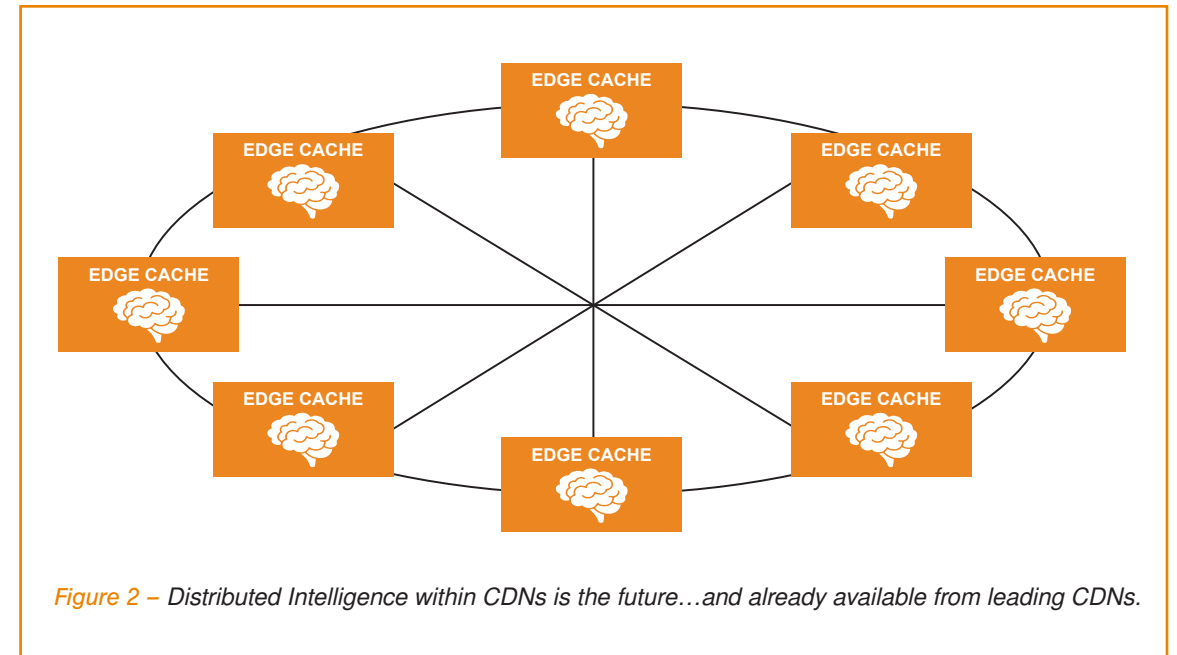


Figure 2 – Distributed Intelligence within CDNs is the future...and already available from leading CDNs.

addressing the need to achieve optimal streaming efficiency.

OTT service providers should therefore look at their CDN strategy in terms of the combination of placing Edge caches in the optimal locations (i.e. peering points or inside ISP networks) with the optimal business model (i.e. public, private or hybrid CDN) and ensuring that the CDNs make maximum use of relevant data for intelligent, real-time stream routing. This strategic approach to scaling out content delivery capacity as streaming grows and grows will make a significant difference to both customer satisfaction and business profitability.

# Evolving CDNs To Improve QoE

By Paul Martin. *The Broadcast Bridge.*

**To attract and retain an audience, OTT services must provide excellent customer experience by delivering content at the highest possible quality. Service must be smooth, uninterrupted and in the resolution required by the customer. This is one of the key ways OTT will continue to attract more viewers and fulfil its potential of being the main-stream method of media consumption.**

CDNs – Content Delivery Networks – are at the heart of this drive for excellent quality. CDNs were born as the internet grew up, originally designed to manage the movement of files between connected servers. A CDN created a managed pathway for the most efficient delivery of content over the internet. In essence the CDN was the “high occupancy vehicle lane” of the internet – allowing traffic to travel a faster route because it was managed to allow it.

As video streaming emerged, the HTTP technology that was built for fast file exchange was adapted to accommodate streaming video. For VOD, this was fairly straightforward as it built on similar “file transfer” concepts. For Live video, the challenges have been more fundamental as HTTP was not originally conceived for frequently updated, low latency video delivery.

That said, latency and performance have reached very acceptable standards, largely matching the benchmarks set by satellite, cable and IPTV delivery methods. But that is only a small part of what the CDN is doing to assure an excellent OTT customer experience.

This article looks at the CDN’s complete responsibility, and how they are evolving.

### CDN Functions

The functions performed by the CDN are varied.

The first function is to manage ingress and egress of the video content, moving it from the Origin to the final ISP Network that transports it onwards to the IP-connected device. The CDN will contain at least one layer of Cache server – the Edge Cache – to perform this function. Often the CDN will contain multiple layers of Intermediate Cache servers that “buffer” content between the Origin and the Edge Caches.

Related to this, the second function is to initiate and manage streaming sessions. Whether live or VOD, each unicast stream must be monitored and managed. Every stream can be characterized by dozens of stream parameters such as IP address, device type and bitrate.

The third function is to store content. Storage varies from long-term storage of a VOD asset, like a film, to shorter-term storage of a catch-up TV asset, like

yesterday’s soap opera episode. Storage also includes the short-term storage of live content that can be rewind, which is often held in memory rather than in storage. This multi-faceted storage function is why Cache storage is high-performance and (relatively) low capacity.

stream 100 Gbps, then ideally they would each be 50% loaded. Naturally this rarely happens perfectly due to stream request location and network topology, but the Caches are continuously working to balance as evenly as possible. At a more granular level, a Cache server can also load-balance internally, typically across

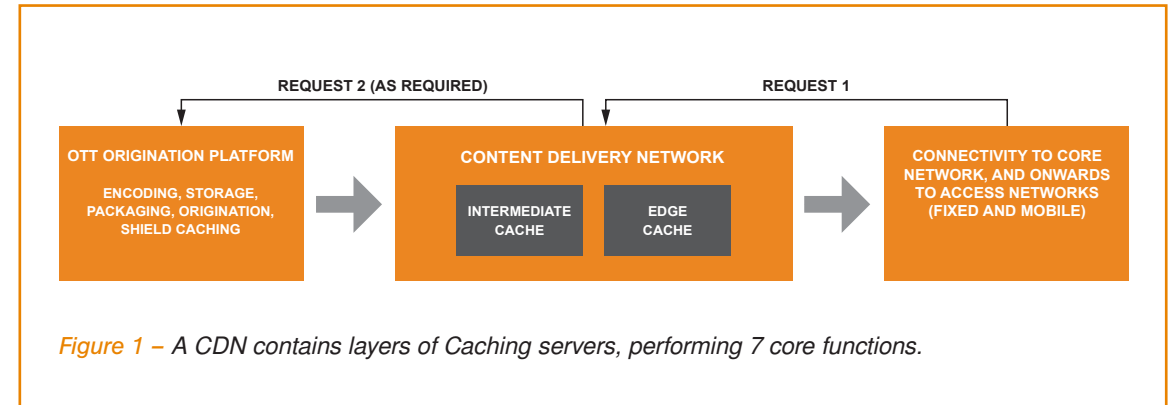


Figure 1 – A CDN contains layers of Caching servers, performing 7 core functions.

Related to storage, the fourth function is content management. Managing what stays on storage and what is deleted is a continuous process. Generally, Caches use a simple First In First Out model with oldest content being deleted first. However, as a pull system, if any item on the list is re-requested it will be delivered and then immediately moved to the top of the list. The management of content to be storage-efficient but to also be bandwidth-efficient (i.e., minimize requests to the Origin) is a continuous process.

Load balancing is the fifth function. Normally this is performed across all the servers responsible for delivering the specific content. If, for example, ten Edge Caches are collectively delivering a live event to 100,000 people at an average bitrate of 5 mbps, the 500 Gbps of Cache egress should be balanced across servers. If each Edge Cache can

multiple CPUs. The Cache software should routinely balance CPU and Server for optimal performance.

The sixth function is platform monitoring. All hardware, software and network should be monitored to detect outages and degradation and then redirect stream requests appropriately. CDNs can be configured for servers to either seamlessly failover the streams they are carrying (by having matching IP addresses) or with a stream restart (by having unique IP addresses per server).

And finally, the seventh function is scale-out management. Expanding streaming and storage capacity involves the integration of new capacity to the CDN, typically while the CDN is in-service. Bringing new Caches online by adding them to the cluster or the overall CDN needs to be a seamless process

to the overall OTT service that is being delivered.

### CDN Architectures

There are two basic CDN models – public and private. A public CDN is generally multi-tenanted, where server and network capacity are shared. A private CDN is generally dedicated to one OTT service provider, where server capacity and network port capacity are not shared.

Over the last ten years OTT service providers have largely used public CDNs. In this mode, many of the largest service providers have adopted the multi-CDN model where total traffic is balanced over multiple CDN service providers. This provides network resilience, pricing competition and often delivery reach to specific markets where one CDN may have better presence than another.

The largest OTT service providers, most of which are VOD-centric, have largely adopted the private CDN model. Today, the next wave of large OTT service providers, offering a combination of Live and VOD content, are embracing the private CDN model to improve their service latency and control.

But private CDNs are selected not only for improved performance and service control, but also to manage costs more effectively. Public CDNs are generally priced on a “Per GB of Output” basis, which is variable and increases in line with audience size, video bit-rate and consumption time. Private CDNs, on the other hand, are generally priced on a “Per Gbps of Throughput” basis, which provides cost certainty. To illustrate, if an OTT service provider delivers to 10,000 people at 5 Mbps average bitrate then they will egress at 50 Gbps from the CDN. If they do this for 1 hour, they will stream 36,000 GBs. If they do this for 2

hours, they will stream 72,000 GBs. The output is doubled, while the throughput is constant. When an OTT service provider has regular consumption or increasing consumption, the private CDN can offer big cost benefits versus the public CDN.

### CDN Performance

One of the challenges for OTT service providers is that CDNs typically only offer service availability performance commitments, when OTT service providers want QoS (Quality of Service) and QoE (Quality of Experience) commitments. Given CDNs are normally multi-tenant environments, are only part of the OTT Ecosystem, and they undergo enormous pressure to perform in the video use case, it is only natural that CDN service providers take this simple SLA position. So how do CDNs look at performance?

First, capacity. Storage capacity is relatively simple and is typically measured in Terabytes (TB) of usable storage deployed across the relevant Cache servers. Streaming capacity is measured in Gbps (Gigabits per Second). The largest OTT service providers regularly stream in Tbps to their peak audiences. We should refer to this capacity as “throughput”. It is normal today for OTT service providers to talk about Petabytes of content delivered. A typical statement for an OTT service provider is to refer to Petabytes delivered in a day, week, month or year. Of course, this indicates consumption level which is clearly what the OTT service provider cares about. But the CDN looks at its performance in terms of throughput because this is the measure of streaming capacity, and when 1 million concurrent viewers are streaming for 1 hour, this is a very different technical and operational situation to 200,000 people streaming for 5 hours, even though the consumption is identical.

Second, quality. QoS typically refers to metrics like average bitrate and cache failover, while QoE includes metrics like rebuffering ratio, start-up time and viewing time at peak bitrate. As a rule, OTT service providers focus on QoE metrics because they reflect the viewer’s actual experience. The OTT service provider deploys software in almost every client to capture QoE metrics and uses this information to switch traffic between CDNs (if a multi-CDN is in place). Typically, the CDN is focused on QoS metrics, but leading CDNs are moving to QoE to meet their customers’ expectations (see the next part of this series). This is changing the balance from reactive client-side performance management to proactive CDN-side performance management.



# How Open Caching Aims To Support Broadcast Grade Streaming

By Paul Martin. *The Broadcast Bridge*.

**Open Caching, a specification created by the Streaming Video Technology Alliance (SVTA), promises Content Providers a standardized CDN (Content Delivery Network) model that delivers a better end-customer QoE (Quality of Experience), and a possible way for ISPs (Internet Service Providers) to gain new operational efficiencies and earn new revenues from the delivery of OTT services.**

These promises are some of the most important issues to resolve for D2C streaming video services to reach full “broadcast-scale”, according to some industry observers and participants. So how does Open Caching help to resolve them?

The grand vision for Open Caching is of an open and global CDN marketplace with CDN capacity provided directly inside ISP networks. Saying this another way, it is a way for ISPs and their CDN partners to serve Content Providers to achieve the same benefits from Edge Cache proximity to customers that Netflix, DAZN and other major streamers have already achieved for their own D2C streaming services through their own private CDNs.

The hype around Open Caching has grown as demand increases for broadcast-grade and broadcast-scale streaming. So, what is all the hype about? This article inspects the latest information about Open Caching and, with inputs from various industry leaders, looks at

how it is expected to become a more important part of the Content Provider CDN ecosystem in future.

## The Drivers Of Open Caching

The Open Caching initiative is founded on achieving three key objectives for video streaming:

1. **Multi-CDN And Interoperability.** Content Providers have audiences that transcend individual CDNs and ISPs. Therefore, Content Providers naturally consider how to achieve the required combination of audience reach, service price, and service performance from their CDN suppliers. To achieve this, they have progressively migrated to a multi-CDN model. While multi-CDN brings certain benefits, like targeted reach for specific locations, price-competition between providers, and opportunities to improve service resiliency, it also brings extra complexity to a Content Provider because it involves managing multiple suppliers across a non-standardized set of interfaces. As streaming grows, the importance of standardization between

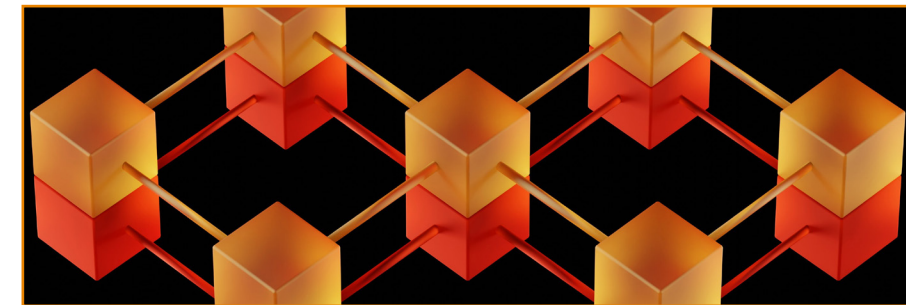
CDNs also grows. Standardization can simplify operations for the Content Provider, in terms of supplier management and daily operational activities such as managing content across multiple caching environments.

2. **Closeness To Consumers.** Streaming video generally benefits from being delivered closer to the consumer. A CDN platform deployed inside an ISP network creates the closest possible content delivery point to a consumer— imagine a location in a major city in any country. For people in or near that city this is typically the best place for a CDN Edge to serve a stream. In the future, as streaming quantities and peak throughputs grow, this location may need to be even more distributed – such as in smaller cities, where telephone exchanges host important broadband access network systems. This “deeper point” inside the ISP network is generally not where any CDN infrastructure is deployed today – we simply have not needed to do it yet, but things are set to change as D2C services grow.

For Content Providers, this closer-to-the-consumer positioning typically results in best possible quality and latency (i.e., best Quality of Experience or QoE), which are critical factors for the success of their services, particularly given the growing amount of live and linear content that is being streamed. For ISPs, a more deeply distributed Edge layer yields important benefits – it decongests their core network by shifting often many Tbps of throughput to deeper network locations, which means they can deliver higher quantities of streaming video while avoiding the expense of

dramatically expanding their core network to handle it. This, in turn, leaves the core network capacity more available for all the other digital services that are growing at the same time as video streaming, such as IoT (Internet of Things), video conferencing, and security services.

It is important to note that “closeness” does not necessarily equal “better throughput”. Better throughput is really a function of “available capacity”. If capacity was unlimited, a stream could traverse an IP network to reach a consumer at its target bitrate without any problems. Capacity bottlenecks are what cause streaming performance issues. However, with that said, being closer to the consumer avoids the all-important network capacity bottleneck which is the ingress point into the ISP (i.e., the peering, transit, or interconnect points where today’s traditional CDN Edge interfaces to an ISP network), which is



representative of the internal capacity available on the ISP’s core network.

3. **ISP Revenue Generation From OTT.** Some ISPs offer pay-TV services, aggregating many content providers into a set of media packages for consumers. But many ISPs do not offer pay-TV services. Existing pay-TV services are under pressure from D2C streaming services that encourage “pay-TV cord-cutting”. At the same time, the level

of video traffic delivered over ISP networks is increasing because of D2C video streaming, but the ISPs are not participating in the revenue generated from those services. In fact, in some countries, regulators are currently focused on creating a new industry balance by taxing the largest bandwidth users, like Netflix, to return some revenues from their above-average usage (i.e., the “fair share” argument). But simply put, as “closer to the consumer” becomes more important for QoE and network decongestion reasons, demand for and support for CDN capacity inside ISP networks grows.

ISPs are therefore very well-positioned to support the Media industry to provide high-bandwidth, high-quality, low-latency video services to consumers. It’s a win-win-win for the consumer, ISP and D2C Streamer. And as well as enabling this best possible QoE, ISPs can potentially replace their pay-TV profits with D2C streaming profits. For ISPs who do not have pay-TV services today, the D2C streaming trend offers them an opportunity to generate new revenues from their network infrastructure.

**The Technical Specification Headlines**

Open Caching is a technical specification – not a standard – that enables CDNs to interoperate with other CDNs within an Open Caching network. This provides the necessary building block for Content Providers to have simpler and more efficient standardized interfaces across multiple CDNs, and for ISPs to build out capacity that can be uniformly and easily used by the Content Providers. For Content Providers, Open Caching should be thought of as an overlay across multiple CDN domains (private CDN, public CDN, ISP-CDN). It could provide Content Providers with a way to manage their content delivery and their content in a consistent way, regardless of which

CDN infrastructure is physically being used.

While Open Caching is positioned as a performance and operational benefit to Content Providers, the main financial beneficiaries are anticipated to be ISPs and their CDN partners who would carry the bulk of the content delivery responsibility. The commercial aspects of Open Caching are still in the early phases of being market tested, and will form the basis of a future article.

Some major industry players are behind the Open Caching initiative, including ISPs (e.g., BT, Orange, Telefonica, Verizon, Viasat), CDNs (e.g., Edgio, Fastly, Qwilt, Stackpath), technology vendors (e.g., ATEME, Broadpeak, Vecima, Velocix), and championed by what is currently a small set of content providers including Disney, Globo, Hulu, and Paramount. Notably, some major industry players not involved in the Open Caching initiative include Akamai and Microsoft.

The Open Caching (OC) technical specification covers three principal components:

1. Open Caching Node (OCN) – this is a server and its software that are deployed at the CDN Edge, whether that is inside the ISP network or peering with an ISP. OC specs can be used either to build an entire OC system, or to implement OC-compliant software on an existing CDN platform. The full vision for the OC specification that has ISP-owned Caches deployed inside ISP networks (i.e., the ISP’s OC-CDN) considers the OCN to be the final Cache in a multi-layered CDN architecture.
2. Open Caching Controller (OCC) – this software component allows content providers, CDNs, and ISPs to

interact with the OC platform. It is the management component for delegations, configurations, content purging and pre-positioning, logging, and security. It must be deployed on a Cache prior to the OCN, not at the Origin, per Figure 1 below.

3. Request Router (RR) – this is the routing logic that directs viewers towards the appropriate OCN to deliver the content. There are three methods

available in the OC specification – DNS, HTTP and Manifest. The RR logic exists at multiple layers of the CDN architecture, from the CDN Selector to the ISP’s OC-CDN.

With these 3 components, an API-based Open Caching solution can be constructed for a Content Provider, to which they can connect their Origin and CDN Selector systems. At that point, an Open Caching CDN will form part of a

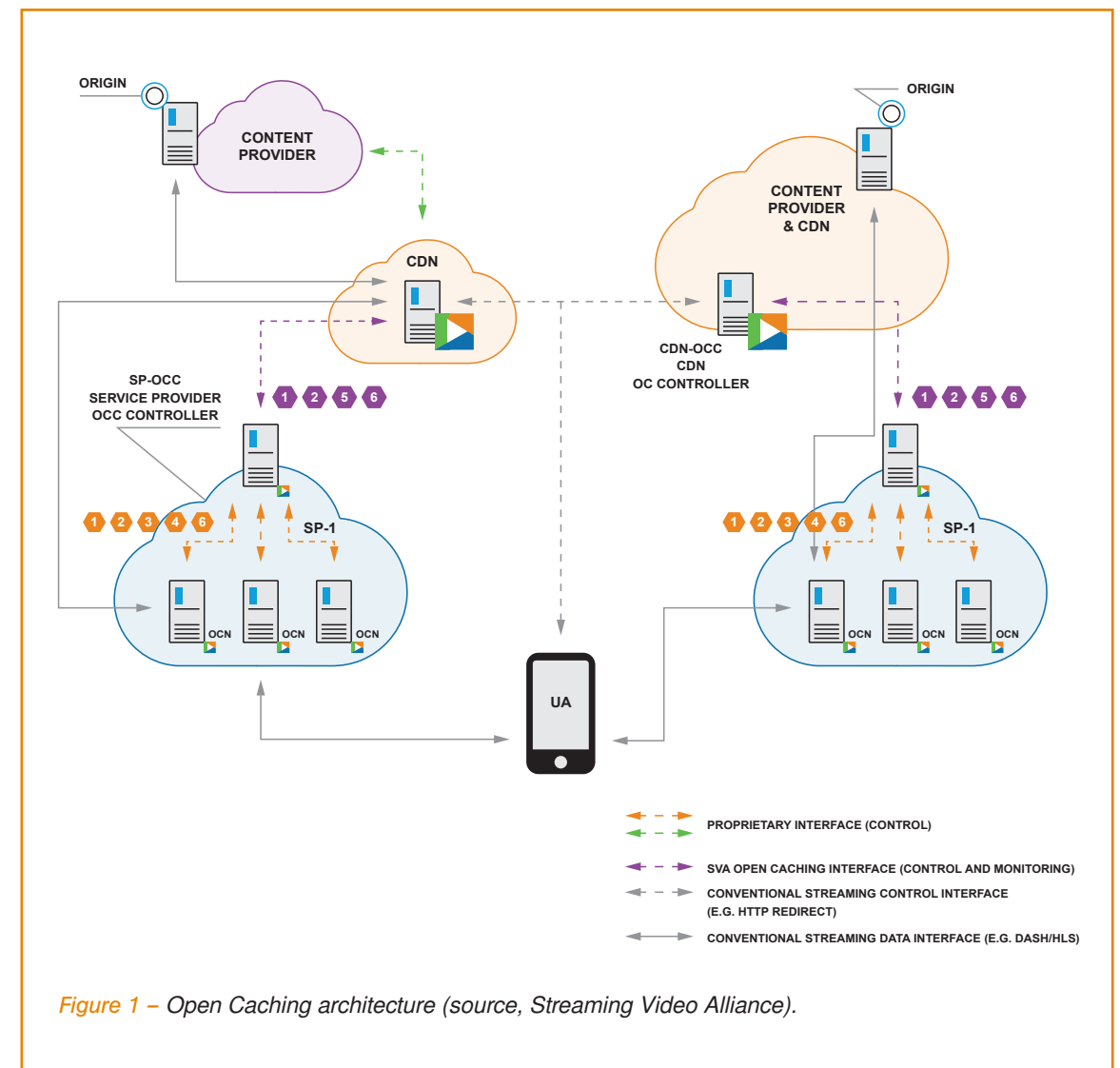


Figure 1 – Open Caching architecture (source, Streaming Video Alliance).



multi-CDN ecosystem. But in contrast to a public CDN service, albeit similarly to a private CDN or a proprietary ISP CDN, the ISP's OC-CDN introduces "on-net" capacity and its associated QoE benefits.

But a point of clarification – being on-net (i.e., closer to the consumer) does not automatically mean perfect performance. There are still technical elements to consider in how a CDN service is architected (e.g., private dedicated capacity or multi-tenanted) and in how a CDN performs based on its software design (e.g., start-up times, session management, origin connectivity methodology). As an initiative, Open Caching is focused on these points, but so are other CDN suppliers that deploy CDN capacity inside ISP networks using their proprietary platforms.

### Open Caching History & Vision

Open Caching began in 2014 and was the foundation stone of the Streaming Video Technology Alliance. This initiative has a clear ambition to improve the world of video streaming, and it has come a long way in the last few years. As broadcast-grade and broadcast-scale become hotter buttons for D2C streaming services, Open Caching could play a major part in delivering those requirements.

As Jason Thibeault, Executive Director of the SVTA states: "The primary strengths of Open Caching are its openness and the fact it is API-based. This allows network operators, CDNs, and Content Providers to easily implement it through software upgrades to existing CDN infrastructure, rather than hardware changes. In addition, Content Providers can benefit from the single control-plane that allows for management of all caches across different delivery networks, while network operators can benefit from delivering popular content from an Edge deployed

in their network that reduces backhaul network utilization."

In the long-run the vision for Open Caching is that all CDN platforms will be OC-compliant and therefore enable a Content Provider to connect to all CDNs in a standardized way, to manage their unified CDN and their content through a single control plane.

But almost a decade has passed since Open Caching was launched as a working group of the Streaming Video Technology Alliance, and deployment is still relatively sparse and interest within the industry appears relatively low. So, now that D2C streaming is firmly fixed in the latest strategies, plans and activities of Broadcasters all over the world, are we at the coming-of-age moment for Open Caching?

### Open Caching Deployment

Open Caching has 3 primary components – Open Caching Node, Open Caching Controller, and Request Routing. These components have been defined and are partially specified by the SVTA Open Caching Working Group. To deploy an Open Caching (OC) solution in its fully envisaged form requires the deployment of these OC-compliant software components in all layers of the CDN architecture. For many Content Providers that are using public CDNs today, this means that those CDNs must first implement OC-compliant software (or the Content Provider must build/buy a new OC-compliant CDN). Then the ISP CDNs that are OC-compliant (we refer to them as "ISP OC-CDNs" in this article) can be delegated to, enabling the onward delivery – and critically, the management – of the video streams.

This multi-CDN delegation approach is being worked out at a technical level.

How it works commercially is another matter. Some of the major public CDN providers are not part of the SVTA Open Caching Working Group – most notably Akamai and Microsoft. This is understandable given that once a stream is delegated to an OC-CDN, then all consumer-level egress from that point onwards is managed by the ISP's OC-CDN. The business model of "Pay per GB" or even "Pay per Gbps" – with a cache hit rate of 95%+ - could mean somewhere between 90-95% revenue reduction for the Public CDN if they hand off to an OC-CDN provided by an ISP and their CDN provider. This is a significant commercial problem to overcome and there is not yet an obvious solution.

Jason Thibeault comments: "Adoption will not be driven by a single event. As network operators continue to implement open caching deployments, more companies will adopt it. But, ultimately, the pressure to adopt will come from the Content Providers or their platform operators that are looking for a better way to holistically manage all their caches across all of their delivery networks. This will probably play a key role in moving CDNs towards being Open Caching compliant."

Without the solid commercial footing, Open Caching specs, as defined, are not able to be validated in full production mode because there isn't yet a full multi-layered CDN ecosystem in which to validate them (however, to support development-stage interoperability testing, the SVTA provides an API testbed to its member companies). Instead,

pioneering solutions are being built today by leading OC proponents, such as Verizon, Qwilt and Velocix, for specific Content Providers with their own private OC-compliant CDNs, like Disney. Recent headlines from large ISPs including J:COM, British Telecom and Telecom Argentina highlight the deployment of the Qwilt solution that is based on Open Caching specifications. Other sources explain that recently deployed ISP OC-CDNs are now being promoted more widely by those ISPs to the Content Provider market.

But these ISP OC-CDN deployments are just a start. Now the upstream CDNs –



either owned by the Content Provider or available on commercial CDN services – need to implement the OC Controller component to complete the Open Caching ecosystem.

### Performance Testing

Early field tests for an Open Caching platform, reported by Verizon at NAB 2022, showed that QoE performance KPIs all improved over the base case – including start-up time, sustained bitrate, and peak bitrate.

These results align well with reports from leading D2C Streamers that are using Private CDNs deployed inside ISP networks. The improved results stem

mostly from the placement of Edge Caches inside the ISP's network, which improves performance by avoiding congestion with other internet traffic at peering points and inside ISP core networks.

But other factors can also drive performance improvements, such as the degree to which the Edge platform is managed to assure there is sufficient capacity to support 100% of the demand. For example, if capacity is allocated to a single Content Provider and the total platform is planned to provide sufficient excess capacity, then performance will be higher than on a multi-tenant platform without any excess capacity. Running "hot" against available capacity is always a risky strategy for high-performance, latency sensitive applications like live video streaming. Open Caching specifications provide ways for capacity to be understood before allocating traffic to an Open Caching Node (OCN), but if demand exceeds capacity overall, then QoE problems will persist.

Open Caching envisages global, democratized, unified CDN capacity. This is a grand vision of easily accessible streaming capacity for the world's streaming video businesses that are looking towards a future where most content will be consumed via IP over fixed and mobile broadband networks, and at higher resolutions / bandwidths than today. In this vision the capacity usage interfaces and operations would be standardised by OC specifications. Also, capacity availability would be made visible through the same standard interfaces, allowing Content Providers to understand and buy capacity from any OC CDN supplier to meet their needs. In short, a dynamic map of global OC-CDN capacity could become visible by OC-CDNs being widely deployed. This idea would democratize access to CDN capacity and would simplify the technical operation of a multi-CDN platform that spans multiple ISPs to achieve audience reach.

This model could potentially be the key differentiator for Open Caching as Content Providers consider their CDN strategies. Today, larger Content Providers access CDN capacity through a range of relationships, often with multiple CDN providers, mostly direct with public CDN providers or via a CDN aggregator. Increasingly, private

CDNs are being deployed or considered in RFIs and RFPs by larger Content Providers, like national broadcasters. Smaller Content Providers typically rely on an OVP (Online Video Platform) provider, that bundles CDN services into their content management and content origination services. Open Caching would

introduce CDN services from the ISPs instead, although they would still need support from a range of established CDN service providers or CDN technology providers. If ISPs in a single country broadly deploy Open Caching platforms, then Content Providers with large national audiences would be able to consider those platforms for large percentages of their audiences.

So, can this work? Technically, yes, the specifications are emerging now. And as Jason Thibeault, explains, "Open Caching is an overlay on existing CDN infrastructure, so it can exist as an option alongside other CDN services and technologies. The big difference is that in Open Caching, the Content Provider or their CDN operator can directly manage the Open Caching Nodes, which they are typically unable to do in a proprietary CDN environment."

So, two large questions remain: 1) will ISPs implement Open Caching platforms and offer CDN services? and 2) does Open Caching result in a better set of commercial relationships for Content Providers with CDN suppliers? These questions will be explored in a separate article about the commercial aspects of Open Caching, and what this means for broad industry adoption.

#### CDN Selection

Larger Content Providers with regional, national and international audiences need to think about multi-CDN strategies, generally because no single supplier will have the right capacity to support all the demand. Therefore, the CDN selection capability is important to choose the best CDN to utilise based on a mix of price and performance parameters. In a multi-CDN environment that has an OC-CDN within it, the Request Router (RR) component will first select the CDN to

deliver the content. Once the stream has moved inside that OC-CDN, the local RR component will select the Edge Cache for stream delivery to the client.

If there are two layers of CDN (e.g., a public CDN interfacing with an ISP OC-CDN), then the RR component of the first CDN layer (i.e., the public CDN) will select the ISP OC-CDN after understanding that it has available capacity and appropriate performance. Once selected, the ISP OC-CDN platform will own the stream and its future session management control. Within the ISP OC-CDN, the RR component will choose which specific OCN to serve the stream from. At that point, all communication between the Client and the CDN is between the Client and the OCN.

CDN selector tools, including those integrated with client-side analytics, would remain the overall controller of which CDNs serve which end customers. The Open Caching Request Router sits underneath a CDN selector in the decision-making hierarchy. It is therefore possible that an OC-CDN could be blacklisted for poor performance, like any other CDN. To be re-activated by the CDN selector, the OC-CDN would republish information about its available capacity and performance levels via the Footprint and Capabilities API, to demonstrate it is ready to receive new traffic.

#### Interoperability

Open Caching at its core is about interoperability for metadata, capacity management, location management, and logging, which today are managed by CDN's proprietary algorithms. The rest of Open Caching is about HTTP routing, which all CDNs apply using approaches that include eDNS0, DNS resolver, Anycast, and HTTP redirect.



#### Open Capacity Management

Performance is critical for video streaming. And as noted, performance is tied mostly to capacity availability. The Open Caching specification for Open Capacity Management is potentially its killer app.

Open Caching adds a fifth interoperability category of transparent stream management between multiple OC-CDNs. But as with any specification or standard, this does not mean a seamless integration between CDNs because specification implementations can vary. Real-world technical testing and ongoing alignment of specification implementation will be necessary across all suppliers of OC-CDNs for full interoperability.

CDNs deployed inside ISPs today that are already capable of operating with multiple types of Origins generally have the preliminary building blocks for implementing Open Caching. There are various ways to upgrade these CDNs to implement the Open Caching compliant software. Jaya Devabhaktuni, Architect at Velocix and a contributor to Open Caching specifications, states, "The approach to an upgrade depends on how each CDN vendor chooses to implement the OCC and OCN functions – they could be standalone software modules, plugins, or enhancements to existing control and data planes. The main points are that the control plane must support the OCC capabilities, and the data plane must implement the OCN capabilities. These OC capabilities could be deployed as an overlay on top of an existing Edge Cache, or they could be deployed on new standalone OC nodes within the network operator."

**Summary**

Today, there are a range of CDN models that Content Providers can consider today, as shown in Figure 2.

The Public CDN connected directly to an ISP without any on-net CDN capacity has been the normal model for over a decade and continues to be the dominant model today for broadcasters' D2C services. This appears likely to diverge

to include one or more of the following 3 models based on the scaling up of the broadcasters' streaming volumes.

The leading global streamers have driven the deployment of the CP Private CDN model, deployed at Internet Exchanges and often deep inside ISP networks.

And as Content Provider apps are integrated into existing pay-TV services which already use an on-net CDN, some of the Content Provider traffic traverses the ISPs' existing proprietary CDNs.

After 9 years, Open Caching is bringing a new model into the mix, which we see today primarily in the form of point-to-point solutions between Content Providers supporting Open Caching and some ISPs that are deploying OC-CDNs. The full vision of all public/private CDNs and all ISPs deploying OC-compliant CDNs is still a long-term vision for now, and indeed the path to achieve the full vision is not yet clear given the various stakeholders with different commercial interests.

So, for now, the future contains a mix of CDN models. But will the future of D2C streaming in a multi-CDN architecture be simplified because of Open Caching? Technically it should be, but it depends most heavily on the commercial and deployment realities. The technical vision is close to reality after 9 years of specification-writing effort. It is not clear how long it will take to achieve the full operational and commercial vision of an open caching environment, but momentum appears to be building.

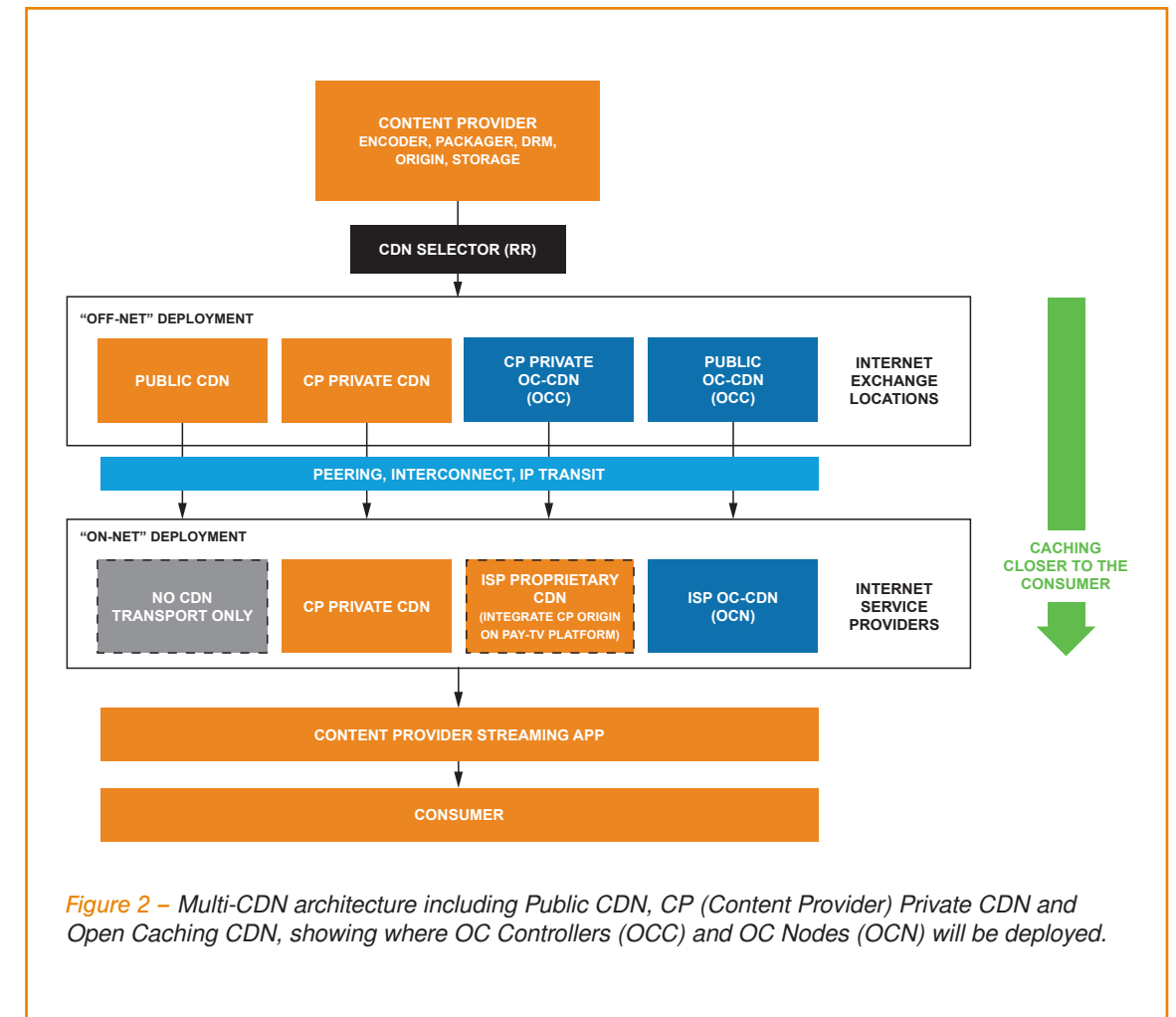
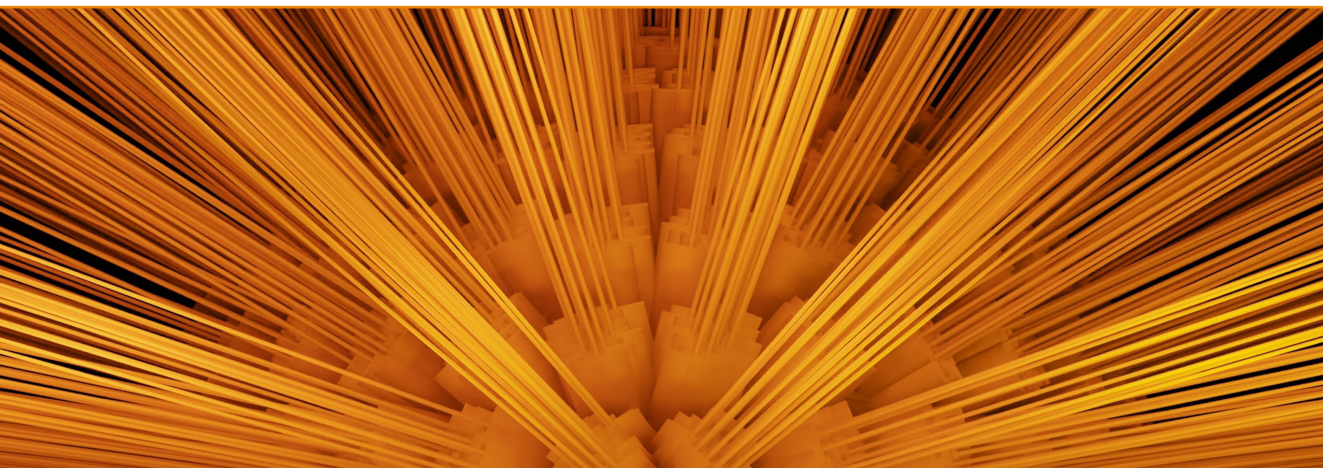


Figure 2 – Multi-CDN architecture including Public CDN, CP (Content Provider) Private CDN and Open Caching CDN, showing where OC Controllers (OCC) and OC Nodes (OCN) will be deployed.



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