

VELOCIX UNIFIED CACHING

DELIVER ANY CONTENT
FROM ANY SOURCE

STRATEGIC WHITE PAPER

The content industry is being reshaped by exponential video traffic growth, rapid proliferation of connected devices and delivery formats, and surging consumer demand for video from many different online sources. To stay competitive, service providers need solutions that can cost effectively deliver pay TV content and Internet traffic with the superior quality of experience (QoE) consumers expect.

Increasingly, service providers are addressing these challenges with on-net CDN and transparent caching solutions. On-net CDNs reduce costs and assure QoE by bringing content closer to consumers. Transparent caches make it easier and cheaper to access, cache and deliver content from over-the-top (OTT) content providers. The challenge for service providers is to find an effective way to combine all of these capabilities.

This paper presents Alcatel-Lucent's vision for an evolution that will enable unified caching to become a vital element of every on-net CDN. Embodied by Velocix unified caching, this evolution will allow service providers to support enhanced CDN and transparent caching capabilities using a single, flexible on-net CDN deployment. This unified approach will help service providers streamline their processes and deliver any content from any source with a consistent QoE.

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INTRODUCTION

The behavior of video consumers is evolving, and so are the fundamental challenges facing network service providers. Today's service providers have to contend with exponential growth of video traffic, rapid proliferation of connected devices and delivery formats, and surging consumer demand for video from many different online sources. At the same time, providers have to keep up with consumer expectations relative to video quality — expectations that are increasing as more content becomes available in higher-quality formats such as full-resolution standard definition (SD), high definition (HD), ultra HD and 3D. Service providers continue to search for new solutions and strategies that can help them cost effectively deliver pay TV content and Internet traffic with the superior quality of experience (QoE) consumers expect.

To address these challenges, service providers are entering business relationships with content providers and deploying their own on-net content delivery networks (CDNs). On-net CDNs deliver content from the edges of fixed and mobile networks, closer to consumers. This proximity to consumers reduces transport and peering costs, and provides a consistently high QoE. Increasingly, service providers are using on-net CDNs as the basis for exploring value-added services that can enhance the user experience and maximize content value chain revenue. These services include advanced capabilities such as content personalization, tiered service levels and personalized advertising.

In deploying on-net CDNs, service providers are aiming to serve a growing consumer population that watches premium content from many different online sources. But service providers don't typically have business relations with all online content providers. In addition, most have a need to reduce transport costs, improve QoE and manage traffic surges for online content.

New transparent caching solutions are emerging to address these challenges. These solutions enable service providers to cache and deliver over-the-top (OTT) content from inside their networks. Transparent caching allows them to store content that originates from content providers with which they have no business relations. It uses caching islands such as centralized or geographically distributed caching clusters and standalone caches to transparently intercept and deliver online content to consumers. The term 'transparent caching' refers to the fact that the content is cached and delivered without the involvement — and often without the knowledge — of the content owners.

With the introduction of Velocix unified caching, Alcatel-Lucent enables service providers to deliver any content from any source in a cost-efficient manner. Velocix unified caching allows service providers to support traditional CDN delivery and transparent caching capabilities using the same CDN deployment. This unified approach helps service providers simplify their management, operations and reporting processes and deliver a consistent QoE across many different content sources.

This paper presents Alcatel-Lucent's vision for an evolution through which unified caching will become a key part of every on-net CDN. Alcatel-Lucent believes that this evolution will enable service providers to deliver over 50% of all traffic from inside their own networks.

DELIVERING CONTENT FROM ANY SOURCE

On-net CDNs and transparent caches are becoming essential tools for service providers seeking to address growing consumer demand for content from any source.

On-net CDNs

On-net CDNs can help service providers address exponential growth of video and online traffic. They can also help service providers deliver online content to a broad range of consumer devices with a superior QoE. An on-net CDN delivers content from edge nodes deep inside fixed and mobile networks. This reduces transport and peering costs and gives service providers complete control over content delivery flows within their own domain. Unlike third-party CDNs, on-net CDNs natively support premium pay TV services for on-demand, live and time-shifted video.

Service providers deploy on-net CDNs and establish business relations with content providers so that they can publish initial copies of content or make content available for acquisition and distribution inside their CDNs. To support these capabilities, an on-net CDN requires interfaces that enable it to publish or acquire content prior to delivery. If content providers choose to publish their own content, an on-net CDN can use these interfaces to notify them that publishing is complete and that the content can be delivered or added to content portals. Alternatively, an on-net CDN can use these interfaces to acquire content on demand from live sources or an off-net Origin when the content is first requested by the consumer.

The Velocix CDN is an innovative, industry-proven on-net CDN that supports the secure delivery of premium TV and multiscreen content. It offers extensive content publication and acquisition interfaces, and can scale up pay TV services to reach many different connected devices. The Velocix CDN supports a broad range of industry-leading delivery mechanisms, including Apple HLS, Microsoft Smooth Streaming, Adobe Dynamic Streaming, MPEG DASH, progressive download and Adobe Flash.

The design principles for an on-net CDN often differ from those used for online web caching systems. Third-party web caches are not typically designed to support the sustained high throughput and low latency required to deliver HD video with a high QoE, or to replicate content based on dynamic demand and content popularity. Conversely, a carrier-grade on-net CDN must be designed to provide enhanced availability, operational efficiency, performance, resilience and security. The Velocix CDN builds these enhancements into key content delivery functions across the service, storage and delivery tiers.¹

In the **service tier**, the Velocix CDN provides enhancements in several important functional areas, including:

- **Logging and log aggregation:** Support for scalable recording of key events and associated information about content delivery and CDN operations.
- **Management and reporting:** Support for an interface and toolset that simplify CDN configuration, monitoring, and operation and content management tasks. The interface and tools are complemented by key reports for content owners and CDN operators.
- **Session management:** Support for per-device and per-user experience adaptation — for example, through content personalization or the application of QoE policies.

In the **storage tier**, the Velocix CDN provides enhancements to the following functional areas:

- Publishing: Support for the pre-provisioning of live and on-demand non-HTTP adaptive streaming content. This support eases distribution inside the CDN and streamlines delivery to consumers.
- Storage: Support for secure storage and replication of non-HTTP adaptive streaming content copies.
- Origin: Support for functions that can pre-position, prepare, repackage, store and ingest HTTP adaptive streaming content copies into the CDN.
- Acquisition: Support for a mechanism that can dynamically acquire content from the content provider Origin on demand (for example, using a reverse proxy).

In the **delivery tier**, the Velocix CDN offers enhancements to the following functional areas:

- Caching: Support for the secure replication of content inside CDNs.
- Delivery authorization: Support for per-user authorization capabilities that can watch content using tokens and apply content policies relating to availability windows or geo-blocking.
- Cache selection and request routing: Support for functions that use configurable business rules to select and direct clients to the optimal delivery nodes.
- Secure delivery: Support for the streaming of content to consumers using standard delivery protocols and optional per-session encryption.

Transparent caching

The number and variety of online content sources continue to expand. More and more consumers are choosing to watch content from many different online content providers. It is unlikely that service providers will have business relations with all of these content providers. With transparent caching, service providers can reduce peering and transit costs, provide a consistent QoE and manage traffic surges by caching and delivering online content from their own networks.

Service providers can also use transparent caches to cache content owned by their content provider partners. By using transparent caches in this way, service providers can take an easy step toward using on-net CDNs. Transparent caching does not require any involvement from the service provider. Content providers do not need to change existing processes to accommodate transparent caching.

The design principles for transparent caches differ from those used for online web caching systems. As with on-net CDNs, the core design principles for transparent caches are performance, resilience and efficiency. However, the key content caching functions are different. A transparent cache needs the ability to handle online content in cases where the initial content copy is not available to the CDN — for example, where content owners or online service providers use cache avoidance techniques such as semi-dynamic or fully dynamic URLs. In semi-dynamic URLs, content is identified by unique dynamic query string parameters attached to the content request. These parameters make it more difficult to uniquely index and cache associated content. In fully dynamic URLs, the content name can be obfuscated completely.

Transparent caching needs to support flexible caching policies and be capable of caching any type of online content. This includes video, software updates, web objects and files. Video is the fastest growing type of online traffic, but gains of up to 90% in terms of cache hit rate can be achieved by caching other content types such as software updates or file downloads. This represents a major step toward the goal of enabling service providers to deliver over 50% of all traffic from inside their own networks.

For transparent caching, the key functional areas are caching, delivery, management and control. These functions should be implemented across the service and delivery tiers to ensure comprehensive transparent caching support. The Velocix CDN implements all of these functions with carrier-grade reliability and resilience.

In the **service tier**, the Velocix CDN provides carrier-grade enhancements to several key transparent caching functions, including:

- Logging and log aggregation: Support for scalable recording of key events and associated data.
- Management and reporting: Support for configuration, monitoring and operation functions. Reporting functions generate reports tailored to transparent caching. For example, these reports can cover network and HTTP throughput, bandwidth savings, top sites and clients in terms of requests, traffic and disk usage.

The Velocix CDN offers additional enhancements to key transparent caching functions in the **delivery tier**. These enhancements cover:

- Caching policies: Support for configurable rules that can uniquely identify cacheable objects. Different policies can be defined for each content site. Cache avoidance can be managed using indexes that match specific items in content URLs. Service providers can configure their own indexes or use predefined custom indexes that cover popular sites.
- Video caching: Support for transparent caching capabilities that can store video content from external sources and make it available for future delivery. Video seek requests and byte-range requests ensure that each object is cached only once. Video seek requests recognize and cache different ways to apply offsets to video files, while byte-range requests recognize and cache byte-range HTTP requests.
- Filtering: Support for the inspection of content URLs in real time and the blocking of access to undesirable sites.
 - Static filtering keeps users from accessing a custom-defined 'black list' of URLs. This list can be complemented by a 'white list' that disables filtering for trusted sites.
 - Dynamic filtering keeps users from accessing URLs that are dynamically received from an online URL classification database.
- Traffic surge protection: Support for a mechanism that can cope with unexpected surges in online traffic.
- Scaling: Support for a cost-efficient means to handle Internet-scale volumes of data while operating in a carrier grade environment. Inter Cache Communication (ICC) is an intelligent clustering technology that optimizes cluster resource utilization and eliminates "double caching" of the same object on different cluster nodes.

UNIFIED CACHING: A NEW VISION FOR CONTENT CACHING

The Velocix CDN offers unified caching capabilities that enable service providers to cache any content from any source with or without business relations with the content owner, and regardless of whether the initial content copy is available for acquisition or publication. Alcatel-Lucent has implemented unified caching by adding transparent caching functions to the Velocix CDN. These added functions will enable service providers to deliver a majority of all traffic from inside their own networks.

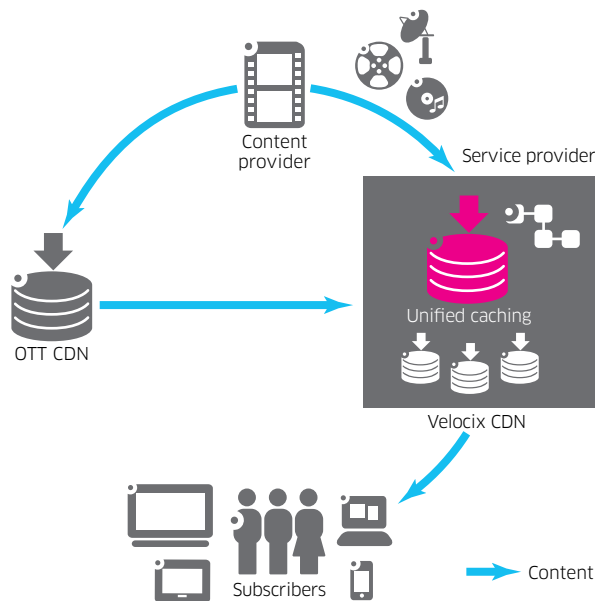
The true value of Velocix unified caching extends far beyond overlaying a CDN with transparent caching appliances. Velocix unified caching helps service providers avoid the pitfalls involved in underestimating the complete cost and complexity of a do-it-yourself overlay approach. These pitfalls include:

- Overlaying an on-net CDN with a functionally disconnected transparent caching solution that is managed separately and deployed on different hardware. This approach escalates deployment and operating costs.
- Having two overlay networks. This approach creates more complex deployment scenarios and increases the risk of human error.

With a deep network appliance that transparently caches online content and acts as a CDN proxy cache, service providers can eliminate the inefficiencies inherent in approaches that rely on functionally disconnected transparent caching and CDN delivery appliances.

Velocix unified caching, shown in Figure 1, addresses these challenges through a natural evolution of on-net CDN capabilities. This evolution unifies the management and control of on-net CDNs and transparent caches, enabling them to work together to cache and deliver any content. It promotes coherent collaboration between different caching nodes to ensure that video and content caching intelligence is distributed into the most appropriate network locations. For example, it enables service providers to place transparent caches close to the network edge to support scalable content personalization capabilities. Over time, Velocix transparent caching will evolve to become a trusted and authorized CDN proxy cache that takes responsibility for specific CDN functions, including per-session encryption, content management and content personalization.

Figure 1. Velocix unified caching



With unified caching, the Velocix CDN brings together all of the key on-net CDN and transparent caching functions described in the “Delivering Content from any Source” section, above. This unification is built on three main pillars:

- **Unified management:** The Velocix CDN allows service providers to manage and operate CDN and transparent caching functions using a unified single sign-on interface. Service providers can use this interface to configure and provision any CDN appliance. The interface supports common monitoring, alert notifications and troubleshooting across all CDN nodes. It also extends consistent reporting and analytics across all types of caching appliances. This unified approach to CDN and transparent cache management provides efficiency and ease of use that are not available with do-it-yourself overlay solutions that require multiple interfaces and sign-ins.
- **Common hardware platform:** The Velocix CDN supports a transparent caching appliance that can be deployed on the same type of hardware as that used for CDN appliances. This hardware can be scaled to support total cache sizes that range from 1.1 TB to 1 PB. The use of common hardware platforms for CDN and transparent caching appliances simplifies procurement and operations by reducing the number of different platforms in the network. When the same hardware platforms are used for CDN and transparent caching appliances, all transparent caching features are supported regardless of the total cache size.
- **Converged appliance:** The Velocix CDN offers a transparent caching appliance that can selectively deliver CDN and online content with enhanced CDN features such as per-session encryption and rule-based transformation. A trusted and authorized transparent cache can act as a deep CDN cache and, if required, cache the CDN’s own content.²

Building on these pillars, Velocix unified caching adds several unique features to the Velocix CDN, including:

- The first evolution of market-proven CDN technology to incorporate CDN and transparent caching capabilities that can be deployed on the same type of hardware and managed using a single unified interface.
- A long-term vision toward coherent collaboration between different caching nodes. This collaboration will enable the Velocix CDN to distribute video and content caching intelligence into the most appropriate network locations.
- Flexible deployment options that can position transparent caches as deep Velocix CDN edges on pseudo inline or traffic mirror topologies. This flexibility will enable the CDN to reach any client with or without support for redirects.
- Market-leading performance supported by nearline rate cache output with intelligent clustering technologies that use ICC to maximize cluster resource utilization, protect against traffic surges and provide carrier-grade reliability.

Service providers can use Velocix unified caching as a means to explore and pursue new business opportunities. For example, a service provider can start a trial by transparently caching online content to reduce peering and transit costs. Later, it can expand its footprint in the content delivery chain by using a simple software change to migrate to a full CDN appliance.

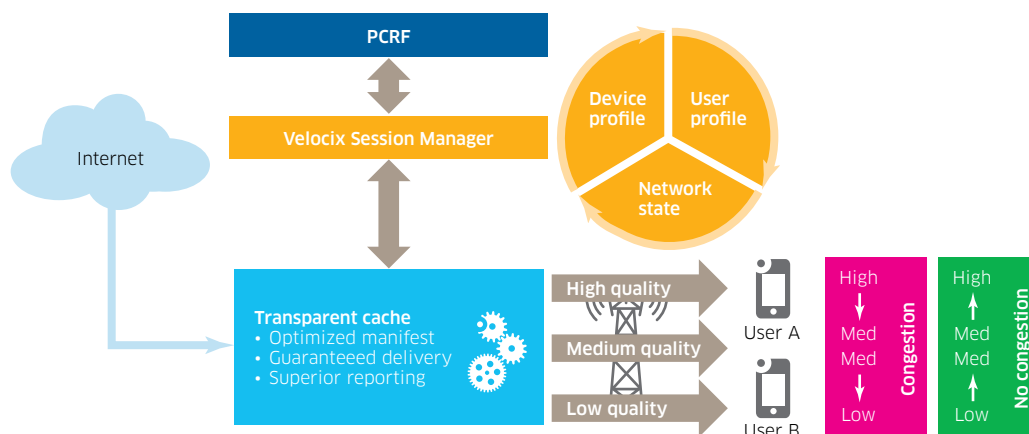
THE EVOLUTION OF CONTENT CACHING INTELLIGENCE

Alcatel-Lucent is evolving content caching technologies to enable and promote coherent collaboration between CDNs and transparent caching nodes. With the Velocix CDN, this collaboration will occur in harmony with the underlying network to ensure that video and content caching intelligence can be distributed into the most appropriate network locations.

Velocix unified caching goes beyond simple unification of common management and control functions. It supports distributed cooperative caching to allow transparent caches in locations close to consumers to act as deep, authorized proxy caches and implement functionality on behalf of the CDN. This functionality can include per-session encryption, HTTPS termination, content personalization, manifest manipulation, content management (for example, purging) and geo-blocking.

Within the Velocix CDN, authorized transparent caches (Figure 2) can be extended with interfaces to session and policy control functions such as policy charging rules function (PCRF) or PacketCable™ Multimedia (PCMM) policy control servers. For example, a transparent cache can personalize a content manifest, insert ad URLs or enable tiered service levels by marking QoS per user content delivery session based on session-specific information retrieved from the Velocix Session Manager.

Figure 2. Authorized transparent cache



By acting as authorized proxy caches, transparent caching appliances can provide better reporting to content owners about delivery statistics. What's more, they can expose value-added functionality that is not traditionally available from transparent caches that are deployed without the content owner's knowledge. This exposure can enable CDN operators to expand their footprint in the content delivery chain by offering transparent caching capabilities to participating content owners. In return for making their content easier to cache, content owners receive accurate delivery reports and benefit from comprehensive content management functionality exposed by the CDN — for example, the ability to purge content from the transparent caches.

Transparent caching appliances that are fully integrated into the Velocix CDN can benefit from standards-based CDN interconnection (CDNI) interfaces championed by Alcatel-Lucent in international standards bodies such as the Internet Engineering Task Force (IETF),³ the European Telecommunications Standards Institute (ETSI) and the Alliance for Telecommunications Industry Solutions IPTV Interoperability Forum (ATIS IIF). These appliances can request content from CDNs owned by partners instead of requesting it from the Origin. They can also offload CDN streaming to partners' CDNs using standards-compliant HTTP redirects.

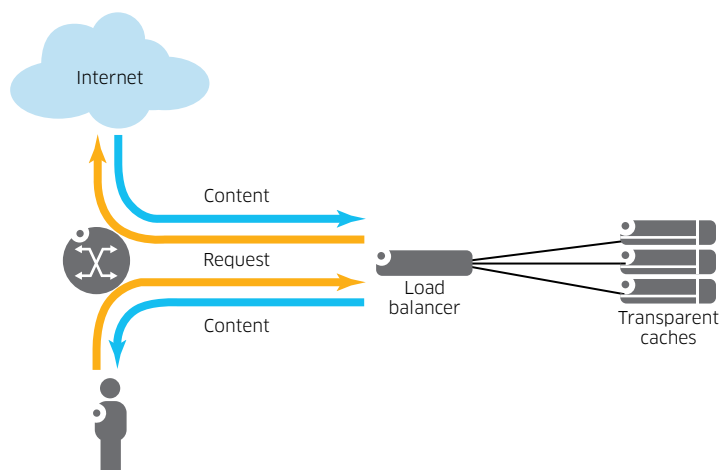
FLEXIBLE DEPLOYMENT SCENARIOS

Alcatel-Lucent is implementing its unified caching vision by building a transparent caching appliance into the Velocix CDN. Service providers have the flexibility to deploy the caching appliance at deep edges of the Velocix CDN in a variety of network locations. Some service providers may choose centralized deployments of transparent caching clusters in large points of presence (PoPs). Others may opt for distributed scenarios in which a single appliance is sufficient for caching local traffic. Velocix unified caching offers deployment models that can support both of these deployment scenarios.

Pseudo inline deployment model

The pseudo inline deployment model, shown in Figure 3, is rooted in policy-based routing (PBR) techniques. In this model, the service router intercepts HTTP requests and redirects them through a load balancer (optional) to a transparent cache. The cache inspects each request and either passes it to the Internet or delivers the requested content. A transparent cache can work in transparent or semi-transparent mode. In transparent mode, the cache spoofs the client's IP address when it passes content to the Internet. In semi-transparent mode, the cache uses its own IP address.

Figure 3. Policy-based routing – Pseudo inline deployment model



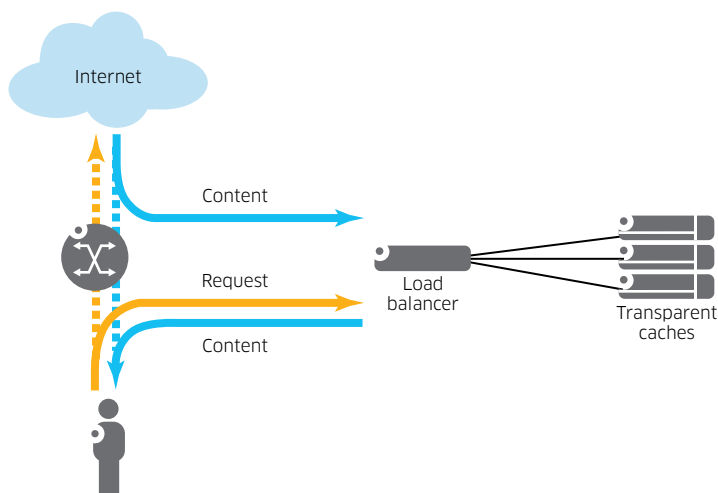
Policy-based routing is the most commonly used approach for deploying transparent caches. In PBR-based deployment models, caches are inline of Internet traffic. To meet high availability criteria, redundant caches are often used behind a load balancer. The use of inline locations and reliance on load balancing make PBR-based models best suited for large PoP deployments, where the cost of load balancers and redundant caches can be more easily absorbed.

Service providers often have business requirements that compel them to deploy transparent caches close to IP network edges. For example, they may deploy transparent caches as deep, authorized CDN proxy caches in metro exchanges or smaller PoPs where a single cache may be sufficient to serve all PoP customers. The PBR model is not well suited for these scenarios. The cost and overhead associated with load balancers and redundant caches deployed in distributed locations make the solution prohibitively expensive.

Mirror- or tap-based deployment model

Alcatel-Lucent has developed an innovative way of deploying transparent caches, called mirror- or tap-based out-of-path deployment (Figure 4). In this model, an IP router mirrors traffic from a physical Internet port to the cache. Service providers can optimize cache performance by using an advanced service router (for example, the Alcatel-Lucent 7750 Service Router) to mirror only HTTP requests with destination port 80 to the cache. As an alternative, service providers can use network taps to create mirrored flows of all traffic to the cache.

Figure 4. Mirror- or tap-based out-of-path deployment model

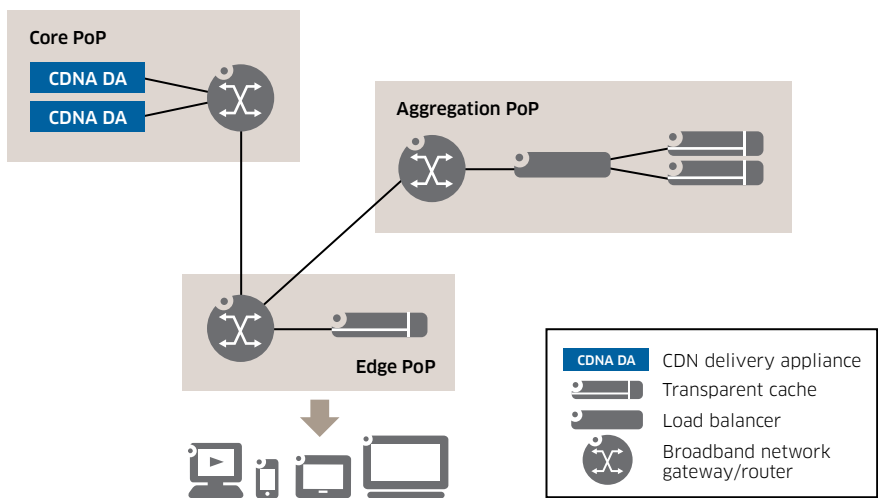


The transparent cache monitors mirrored HTTP requests and responses and fills the cache with the most popular content. Once this content is stored, the cache intercepts subsequent requests and delivers the content from the cache. For example, the cache may divert a client by responding to a content request with an HTTP 302 redirect. This redirect may ask the client to disconnect from the Origin and reconnect to the cache or to a specified transparent cache. If the client does not support redirects, or if the redirect is disallowed by policy configurations, the cache can divert the client’s request by re-writing the manifest to point URLs to the cache or to other transparent caches.

The traffic mirror model lets service providers choose cost efficient and resilient distributed deployments of transparent caches without having to rely on a load balancer. Since caches are not located inline, the solution can tolerate cache failures and allow the Origin or an upper-layer CDN to serve content requests.

Figure 5 illustrates a distributed cooperative caching deployment in which transparent caches located close to consumers can act as deep caching edges for any content.

Figure 5. Distributed unified caching deployment



CONCLUSION

Service providers are searching for the means to deliver any content from any source in a cost-efficient manner. Many of these providers also want to deliver a majority of traffic from inside their own networks and take control of how and when to upgrade their networks to address exponential online traffic growth. On-net CDNs will play a central role in helping service providers achieve these goals. But service providers can't rely solely on on-net CDNs.

Alcatel-Lucent understands the challenges facing service providers. The company addresses these challenges with Velocix unified caching, a unique and innovative extension to the Velocix CDN. Combining an advanced on-net CDN with a transparent caching appliance, Velocix unified caching ensures that video and content intelligence is distributed into the most appropriate appliances and network locations.

Velocix unified caching is based on three unification pillars: unified management, common hardware platforms and a converged appliance. It unites common management and control functions and supports distributed cooperative caching scenarios in which transparent caches located close to consumers act as deep, authorized proxy caches. In this role, transparent caches can implement key CDN functionality such as per-session encryption, content personalization, content management and QoS policy management.

Velocix unified caching helps service providers combine the use of transparent caching and on-net CDN capabilities to explore new service opportunities, reduce peering and transit costs, and extend their influence in the content delivery chain. It supports these capabilities with market-leading performance and flexible deployment models that are suitable for any service provider environment.

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2. "Velocix CDN: A Vision for the Future of Content Delivery." Alcatel-Lucent strategic white paper, September 2012.
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ACRONYMS

ATIS IIF	Alliance for Telecommunications Industry Solutions IPTV Interoperability Forum
CDN	Content delivery network
CDNI	CDN interconnection
DASH	Dynamic Adaptive Streaming over HTTP
ETSI	European Telecommunications Standards Institute
HD	High definition
HTTP	Hypertext transfer protocol
ICC	Inter Cache Communication
IETF	Internet Engineering Task Force
IP	Internet Protocol
IPTV	IP television
MPEG	Moving Picture Experts Group
OTT	Over the top
PB	Petabyte
PBR	Policy-based routing
PCMM	PacketCable™ Multimedia Specification
PCRF	Policy charging and rules function
PoP	Point of presence
QoE	Quality of experience
QoS	Quality of service
SD	Standard definition
TB	Terabyte
URL	Uniform resource locator

