Managing the growth of video over IP

The media-content equation contains three parameters: content consumers, content providers and content delivery. All three elements affect the way technology will develop to create a universal cost-beneficial media system and each one is driven by diverse motivational factors.

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Background

TV and video consumer behavior is changing. While broadcast TV is still popular for news and live events, consumers are using a wider variety of platforms and different ways to view content. There is a very obvious shift towards media services that focus on the individual, are simple to use, and deliver on-demand content in a way that meets user expectations for quality. There is an increase in on-demand spending among consumers that is driven by the quality of the user experience, ease of access and good content. In short, users are willing to pay if the content, experience and price are right.

The change in the way people consume content – 50 percent of consumers now use internet TV on a weekly basis – has led to an increase in network data traffic. Mobile data traffic doubled in 2010 and is set to double every year for the next three years. The growth in connected devices and increased access to video indicate that both the behavior shift and data traffic growth will continue.

Content providers want to sell their products at competitive prices, continue to create revenue from advertising and deliver a personalized experience catering for each consumer. They want to do this while maintaining brand value by ensuring that content is delivered according to user expectations and users get what they pay for.

Operators will incur increased costs to deliver increasingly large amounts of data efficiently while keeping customers satisfied. There are various business models that operators can adopt to manage the traffic growth and create new revenue streams by developing services.

Ericsson introduced its Media Delivery Network (MDN) to help operators cope with the growth in managed and unmanaged content. MDN includes three core functions: content delivery network (CDN), transparent internet caching (TIC), and service and performance enhancers (S&PEs). These functions enable fixed and mobile operators to:

- create new revenue streams via wholesale content distribution and delivery;
- differentiate through S&PE; and
- reduce operational costs and capital expenditure.

Handling the massive amount of OTT or unmanaged traffic is a major business challenge for network operators. Better compression techniques and improved connections have created a new business model in which countless video-based applications are generating substantial amounts of unmanaged traffic. Examples include YouTube, Apple TV, Netflix and applications from national broadcasters, such as BBC iPlayer, SVT Play, CBS Video and many others. Typically, these types of premium OTT services employ the capabilities of a CDN service provider. The CDN service provider distributes OTT content based on the agreement with the content owner across the internet as far as an exchange point, or in some cases further into an operator’s network when a cooperative agreement has been reached.

OTT applications can present network operators with several challenges:

- rising backhaul transit costs;
- mounting last-mile bandwidth demands coupled with decreasing subscription revenues; and
- deeper penetration of CDN service providers’ caches in operator networks.

With internet traffic set to double every year over the next few years and the total market for CDN services estimated to exceed USD 5 billion by 2015,
fixed and mobile network operators are investing in CDN solutions to efficiently manage the predicted traffic growth, and to explore new revenue opportunities by positioning themselves inside the digital-content value chain. Ericsson’s MDN is designed to assist network operators to overcome these challenges.

**High-level MDN use cases**
There are four high-level use cases for Ericsson’s MDN. The first three are illustrated in Figure 1, while the fourth – CDN federation – is shown in Figure 3.

**Operator-managed**
In the first use case for MDN, operators efficiently deliver their own content to their subscribers. Here, the operator acquires content at a negotiated cost directly from content owners or aggregators, which can be viewed on a TV platform (IPTV for example), or on a variety of connected devices such as PCs, tablets, game consoles and mobile phones. Subscribers pay the operator for access to the content. MDN provides the operator with a unified delivery infrastructure capable of distributing content across its network with minimum impact on the core, as well as providing the means to deliver that content to a wide variety of user devices. MDN replaces the traditional vertical silos that are usually deployed to provide these types of services, resulting in a simplified architecture and lower operating costs.

**Wholesale CDN**
External content providers buy content-delivery capacity from the operator. MDN helps to minimize the traffic impact on the operator’s network, as well as providing a better quality of service (QoS) to end users, whose content will be delivered from edge nodes located close to their network access points. Content providers benefit from improved delivery of their content by using the operator’s optimized MDN-delivery capacity – saving them from having to purchase delivery capacity of their own – and from increased end-user retention due to the improved QoS.

MDN provides external content providers with a comprehensive user interface through which they can manage and monitor content and access full usage reporting. Through wholesale distribution and delivery capabilities, MDN supports the operator to provide CDN services to multiple content owners in parallel with long-term agreements or on an event-by-event basis.

In addition to pure content distribution and delivery, MDN allows the operator to offer content management and adaptation services, such as ad insertion and rights management. These value-added services provide further benefit to the content providers and additional revenue opportunities for the operator.

**OTT service caching**
OTT services are characterized by the lack of a business relationship between the content provider and the operator. In this use case, MDN’s...
TIC capabilities allow the operator to minimize the cost of delivering OTT services. TIC is transparent to both the content provider and the consumer of the service. TIC helps the operator to significantly reduce peering and transit costs, as well as reducing the need to invest in internal network upgrades to support growing volumes of OTT traffic.

Some content providers are concerned that TIC adversely impacts their business by obscuring service usage and reducing advertising revenue. Although these fears can be allayed by modern TIC solutions that preserve application logic, some content service-providers intentionally undermine transparent caching by signaling content as un-cacheable or by using hashed URLs.

TIC provides a good short-term solution to minimize the impact of OTT traffic. The long-term strategy for most operators would be to create wholesale CDN agreements with the most prolific OTT content traffic generators.

**CDN federation**

CDN federation – or CDN peering – allows independent CDNs to cooperate and deliver services across CDN boundaries. One CDN might, for example, acquire content that is accessed by a subscriber located nearer to another CDN. CDN federation allows the CDN closest to the user to deliver the desired content and for the two CDNs to reconcile carriage payments and usage reporting. CDN federation has a number of important applications:

- **off-net distribution** – operators can make content on their CDN available to subscribers outside their footprint. CDN federation supports global content delivery by enabling operators to buy capacity in peered CDNs;
- **operator-to-operator peering** – a collection or federation of CDNs appear as a single CDN. Internally, the CDNs aggregate usage information and cross-charge for carriage in much the same way as mobile operators do today with roaming. The federation model enables operator-based CDNs to compete for global content customers, who are likely to favor a single contract with one CDN with global reach over separate negotiations with each individual operator; and
global CDN-to-operator peering — global CDNs provide improved QoS to the edge of operators’ networks. Global CDNs federate with operator CDNs, purchasing capacity to deliver content deeper into the network, increasing QoS. Although not a new concept, there are still no established standards for CDN federation. A significant amount of activity is ongoing to define a common standard within the international standards organizations, including IETF, ETSI and ATIS. In the meantime, however, bespoke and ad-hoc CDN federations are forming. The emergence of a global standard will drive content providers to accept CDN federation and may fundamentally change the global CDN market.

**MDN functional architecture**

As illustrated in Figure 4, MDN includes three core functions: Content delivery network; Service and performance enhancers; and Transparent internet caching. These functions enable fixed and mobile operators to reduce opex and capex by caching unmanaged OTT content, generating new revenue streams through wholesale content distribution and delivery capabilities, and to differentiate themselves through enhanced service and performance.

**Managed content**

**content delivery network**

The functional network architecture for a CDN integrated in an operator’s network is illustrated in Figure 5. Today, the control interfaces are not standardized and the main functional groups are as follows:

- **ingest function** — receives new content and updates to existing content from the content owner. It contains procedures to store content in the CDN master storage and gets instructions from the ingest control function on how to handle updates and add new content;
- **ingest control functions** — authenticate content and content owners and respect business agreements with content owners. Ingest control can create, modify and delete metadata, check the consistency of metadata, deliver content to master storage and report usage statistics back to content providers;
- **content metadata storage node** — is a database that contains metadata relating to content, such as: ownership, SLAs, ad insertion rules, distribution area rules, and locality and charging principles relative to the consumer;
- **master storage** — is where the master copy of content is stored. Content is then typically replicated to a set of distributed content storage areas;
- **content delivery control (CDC)** — receives or intercepts content requests from a client device. Its decision logic determines what content to deliver and from which storage. The CDC controls the format and packaging, including personalization and ad insertion;
- **content distribution logic (CDL)** — is the brain of the system, determining where in the network each piece of content should be stored. CDL functions control where copies of content are stored, maintain consistency between master content and copies, initiate replication from one storage area to another and delete content from a storage area;
- **content storage area** — contains copies of content either from the master data storage node, a peer content storage node or content fetched on-the-fly;
- **content delivery function (CDF)** — packages content in response to a client or CDC request, acting on the decisions made by the CDC. CDF first fetches requested content and then delivers it to the requesting client, including protocol functions for HTTP, HTTP streaming and Flash;
- **broadband network functions** — performs L1/L4 network commands in an operator’s network and includes functions for transport, access, edge, authentication and security;
- **subscriber and network data database** — contains subscriber and operator network information, such as HLR, charging and user location, as well as network topology and fault status data;
- **broadband client and access termination** — handles access and connection to the operator’s broadband network; and
- **client function** — the application used by, for example, standard web clients or IPTV clients.

**Transparent internet caching**

Unlike CDN architecture, TIC has no control-plane interface to the content owner. TIC is transparent — the content owner and the TIC do not interact with it and content owners are unaware of its existence. Due to its transparency,
TIC has a thinner control layer than the CDN architecture, it has no master data storage, no ingest or ingest control functions, and no related BSS functions. The user-plane interface between the TIC system and the content source is managed through broadband network functions. The TIC system captures requests and content by intercepting them in the normal user-data plane. TIC-specific functions are DPI and perform content-management actions to ensure that captured and stored content are synchronized with the original, maintaining accurate maps between URLs and content.

The TIC CDC is a light version of its CDN peer; TIC architecture lacks metadata information and is less complex, as it only uses a subset of information. Consequently, there is less need for control functions in the TIC system, and as most TIC control decisions can be taken locally in the network, all TIC functions can be naturally grouped into a single node type – the TIC node. Physically, this node will scale with storage area, output delivery capacity and DPI capacity to identify content and requests. The TIC node is local by nature and may be physically integrated into another network element.

Service and performance enhancers (S&PEs) are typically part of the TIC and CDN delivery node, such as: fast channel change for IPTV, or compression and optimization functionalities for content adaptation in mobile networks.

CDN research activities

For some time now, Ericsson’s CDN research group has been investigating content distribution technology with the aim of reducing bandwidth costs for operators. Several concepts have been explored: traffic redirection, caching, multi-protocol delivery, content migration and redundancy elimination. These concepts have been applied to both fixed and mobile network architectures.

Traffic redirection addresses the impact of P2P file-sharing traffic on operator network bandwidth. The research group developed a method to reduce bandwidth utilization of P2P traffic in fixed-broadband access networks using forced-forwarding techniques. This method involves local switching of P2P traffic at the DSLAM level instead of at the broadband-access router level. By eliminating the traffic tromboning effect, this method avoids wasting bandwidth.

The commercial deployment of IPTV systems presented a new research challenge: is P2P technology a viable method for redistributing video; in other words, utilizing the storage and computing resources of the end users’ STBs. This research developed the concept of multi-protocol CDN, by using several delivery protocols to bring content from the operator’s video head-end to the end user’s terminal. A time-shift TV prototype was developed based on P2P, unicast and multicast protocols. Multicast was used to populate network-based caches and caches in STBs during linear TV transmission. Once the linear TV distribution phase is complete, queries for previously transmitted TV programs result in a P2P request to the network caches and other STBs. This approach conserves network resources, as peers located closest in the network topology to the requesting STB serve the request.

Deploying caches in a network topology creates a new challenge: how to intelligently replicate content across these caches. A set of algorithms were developed to keep track of request rates for different content assets in a given section of the network and to decide whether to move or migrate content to caches closer to where most of the requests originate. These algorithms consider end-user quality of experience, number of content replicas in system, traffic load across network links and at the network peering point. The algorithms were implemented in a prototype that showed a reduction of overall bandwidth utilization both across the network and at the network peering point.

Terminal mobility and security architecture present additional challenges to content distribution in 3GPP networks. For example, the presence of a GTP tunnel between the GGSN and the RNC limits the placement of caches in the mobile network. Session continuity after mobile handover can...
be problem for video-streaming, where the cache is collocated with the RNC. To address this issue, a method based on redundancy elimination was prototyped. Two new functions – payload remover and payload inserter – together with a cache were introduced both in the core and at the access edge. These functions work as traffic compressors and decompressors, reducing the amount of traffic in the network link. This method enables seamless and stateless handling of mobile handover. The prototype showed that substantial traffic reduction in the mobile backhaul network is possible.

Further studies are ongoing in the area of caching at the RNC. Simulations have shown that cache equalization during off-peak hours enables the cache hit-rate of the system to equal that of a single large cache. Two modes for the RNC cache are being considered: transparent proxy mode enabling traffic reduction; and CDN server mode enabling hosting. Operators have varying needs and preferences and will be able to select the cache mode that is appropriate for them.

Conclusions
Changing user behavior and growing network traffic raise a business need for efficient media distribution and delivery. Ericsson’s Media Delivery Network addresses this need and helps operators reduce costs and increase revenue. The Ericsson solution differs from standard CDNs, as it includes media-specific capabilities as well as optional network awareness. MDN combines capabilities such as wholesale content distribution and delivery, transparent internet caching and service enhance that can be deployed as overlay architecture, embedded in network nodes.

In Ericsson’s view, both fixed and mobile operators will continue to be an important link in the digital-content value chain. Operators are best supported by a solution that enables them to manage both media traffic from the internet and traffic generated by OTT applications, while at the same time reduce transit costs and increase revenue by packaging their media-plane capabilities.

References
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