

## **SERVICE PROVIDER**

# **Technical Brief: High Scalability, Future-Proof IPTV Delivery in Telco Networks**

Recently, there has been an increasing interest in deploying IPTV services among telecom operators who provide broadband access services to residential subscribers. This paper details the Brocade solution for delivering IPTV service in telco networks.

**BROCADE**

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## WHY THE INTEREST IN IPTV?

There are many reasons behind the recent interest in IPTV.

Increasing competition from cable operators has made telecom operators look for new sources of revenue. Broadband penetration rates have reached critical mass, with about 283 million broadband subscribers worldwide and a penetration rate that ranges from 10 to 35 percent in many countries according to OECD broadband statistics (<http://www.oecd.org/home/>), June 2009. Among broadband subscribers, DSL subscribers outnumber cable subscribers 2:1. Telecom operators therefore have an unprecedented opportunity to tap into this large and growing customer base of broadband subscribers by offering new services to them.

Well over 90 percent of voice customers are still owned by telecom operators, and preventing customer churn is a top priority. Consequently, offering additional services on the same infrastructure helps not only to drive up the Average Revenue per User (ARPU) but also improve subscriber retention. For instance, several studies have shown that the churn rate among customers who have both phone and DSL service is lower than the churn rate among customers who have just phone service.

Telecom customers have the convenience of a single bill when multiple services are offered.

In the wake of the post-Internet-bubble era, conservative Operating Expenses (OpEx) and Capital Expenses (CapEx) budgets mandate that the next-generation, converged networks deployed today yield the maximum benefit by offering additional services.

**NOTE:** Although DSL is the dominant form of broadband access deployed today by telecom operators, this paper is agnostic to the actual form of broadband access deployed. Recent advances in VDSL, ADSL2+, PON and Ethernet in the First Mile (EFM) allow a variety of options to be used in the “last mile” of the access network.

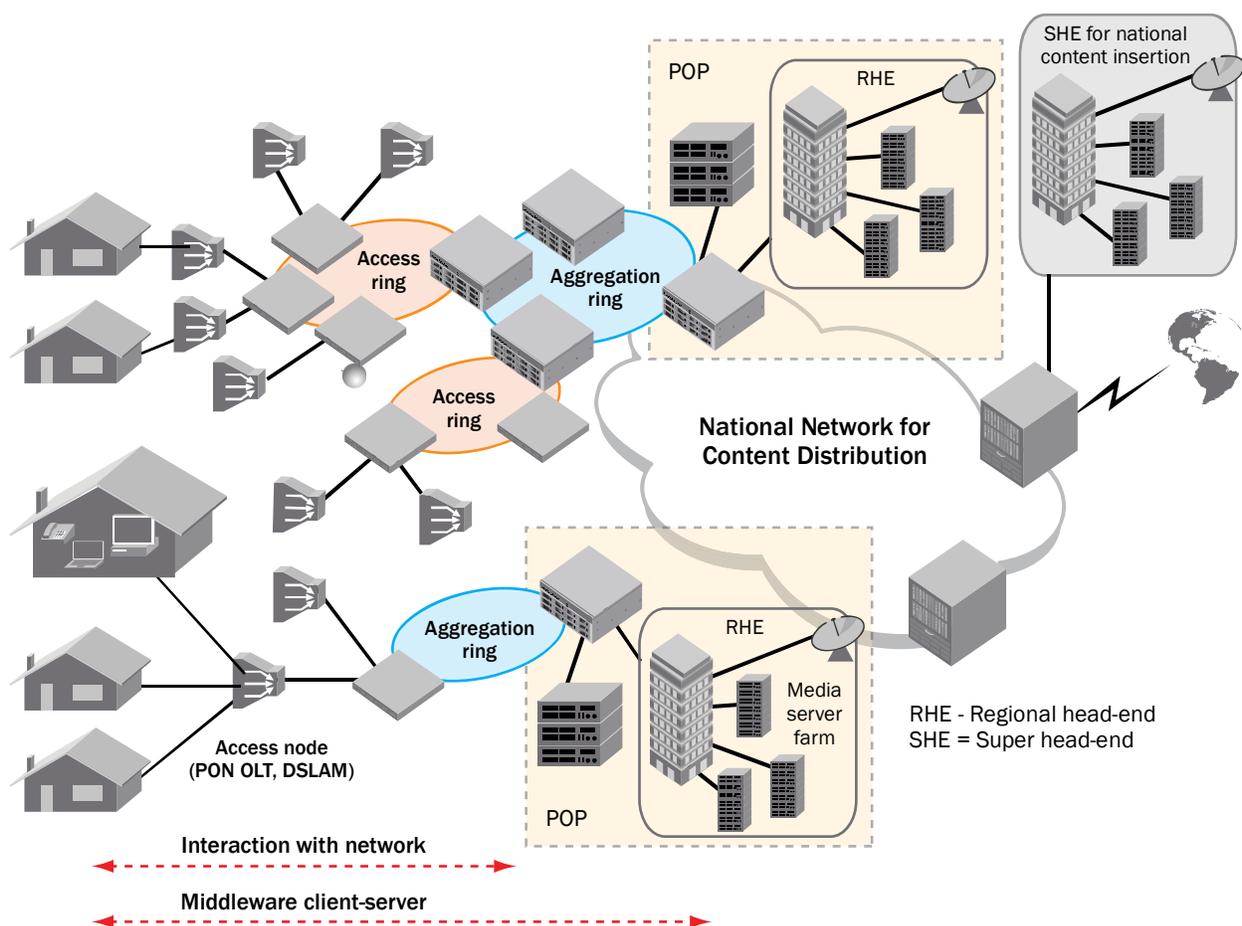
## REFERENCE ARCHITECTURE FOR DELIVERING IPTV

Before examining the components in an IPTV solution, it is useful to consider the reference architecture for deploying IPTV service, as shown in Figure 1. In practice, such a converged network is also used to provide Voice over IP (VoIP) services, however, the components required to offer VoIP service are not shown.

Several components are required to deploy an IPTV solution. Note that IPTV refers to IP-based delivery of *any video signal* and is not limited to broadcast television programming. Other forms of video can also be transported in an IPTV service, such as the delivery of value-added services:

- Video on Demand (VoD)
- Premium channel transmission
- Pay-per-view event programming
- Network Personal Video Recording (Network PVR)

Hence, the network infrastructure should optimally handle multicast traffic (required for broadcast channel or premium channel transport) and unicast traffic efficiently (required in Video on Demand or Network PVR services).



**Figure 1.** Reference architecture for a network providing IPTV services on a carrier network

### Components in an IPTV Network

For an IPTV deployment, several critical pieces of the infrastructure need to interoperate seamlessly in order to ensure a superior user experience. Understanding these components helps to recognize the unique requirements of the network infrastructure for deploying IPTV services:

- A **residential gateway** located at the customer premise, which provides a broadband access connection to the service provider’s network and acts as the gateway to the home network.
- A **set-top box**, part of the home network, which has an IPTV receiver to decode the video signal along with the embedded middleware client. In Figure 1, the set-top box and residential gateway are shown in only one of the homes, although they would be present in all homes.
- A **broadband access node**, owned by the service provider offering IPTV service. The access node is typically a next-generation DSLAM (DSL Access Multiplexer) or an OLT (Optical Line Terminal) with PON (Passive Optical Network) interfaces. The network from the access node to the subscriber is referenced in this paper as the “access network.”

- The **aggregation network** is responsible for efficient distribution of the video content to the access network. Based on the size of the network, the aggregation network might be split into two tiers—a smaller “access ring” that interfaces with the access node and a larger aggregation ring. In addition, the aggregation network also plays an important role in assisting the migration of users from legacy access nodes that may not have all the advanced capabilities required for ensuring security of the infrastructure. The aggregation network consists of aggregation switches and routers as well as a broadband network gateway.
- The **middleware** is the management software that consists of both the head-end software and client software (running on a set-top box). The middleware provides the necessary back office tools to provision subscribers, deliver the appropriate programming to the subscribers, insert targeted ads, manage billing and subscriber packages, and so on.
- **Digital Rights Management (DRM) software** allows the subscriber content to be encrypted when transported from the head-end to the subscriber, to protect against piracy.
- Closely associated with the middleware and DRM are **high capacity, secure media servers** used for storing the content required for services such as VOD and Network PVR.
- **Acquisition systems and encoders** at the head-end acquire the content from satellite feeds encode and compress the signals into a format suitable for transport over an IP network. Typically, the acquisition systems and encoders are distributed between a regional head-end and a “super head end”. The regional head-end is also referred to as a Video Head Office (VHO).
- **Policy management software** determines the network policies required for ensuring the right quality of service and service levels to individual subscriber sessions.

The reference architecture in Figure 1 depicts some of the above components, but is generic enough to allow variations such as the insertion of content acquired from a national source or the interaction with legacy BRAS (Broadband Remote Access Server) systems for subscriber management in situations where such interaction is required. As can be seen, there is extensive interaction between the subscriber and the head-end, and the intervening infrastructure plays a critical role in ensuring superior user experience.

## DESIGNING THE RIGHT NETWORK INFRASTRUCTURE FOR IPTV DELIVERY

IPTV service has several unique characteristics, discussed in this section, which you should consider while designing the network.

### Enormous Amounts of Bandwidth Consumed

Video signals require encoding before they can be transmitted on an IP network. The most popular encoding method used today is MPEG-2. While MPEG-2 encoders and decoders have the advantage of having large volumes and therefore affordable mass-market prices, they consume a disproportionately large amount of bandwidth. For example, standard definition video in MPEG-2 consumes 4 Megabits per second (Mbps) whereas High Definition Television (HDTV) video consumes between 14 and 18 Mbps. Recent advances in encoding available in formats such as MPEG-4 or Windows Media allow much greater compression. However, even these formats still require 1.5 to 2 Mbps for standard definition video quality and up to 8 Mbps for HDTV quality. The consumer appetite for high-definition services means that service providers need to scale their networks to accommodate bandwidth-hungry services.

In addition to high per-channel capacity, there are two other significant factors affecting the bandwidth in the network—the number of channels to be delivered per subscriber and the presence of multiple television sets in a home—each of which could be receiving different channels from the network. The number of channels offered in IPTV networks often approaches or exceeds 250, when premium channels and pay-per-view channels are included.

Delivering such massive amounts of bandwidth per subscriber requires enormous capacity to be built into the video delivery network. Note also that efficient multicast alone will not solve the issue of capacity. Several studies have shown that unicast-oriented video services, such as VOD and Network PVR, have been seeing spectacular growth rates when offered to subscribers. Putting up with legacy network infrastructure that cannot guarantee wire-speed performance is therefore unacceptable in an IPTV application.

## Latency

A significant factor that affects IPTV user experience is latency in response to subscriber requests, particularly noticeable users are changing channels (“channel surfing”). Although decoder delays and buffer-fill times in a set-top box are typically the largest contributors to latency during channel change operations, the latency added by the network infrastructure is an equally critical component of this operation. These latencies can be one of two kinds:

- **Latency during IGMP join/IGMP leave operations.** Channel change requests by a viewer are converted into IGMP join/leave requests to the network after the necessary authentication performed by digital rights management software. IGMP join latency refers to the time taken by a router or switch to commence delivery of multicast (video) to the client after receiving an IGMP join request for a certain multicast group.
- **Latency during video delivery.** The latency during the delivery of content needs to be low in order to ensure a superior subscriber experience.

## Quality of Service (QoS)

It is common for the IPTV service to coexist with other services in the network such as VoIP, high-speed data, and interactive gaming. With the wide popularity of commercial VoIP, P2P, and other ASP services, subscribers expect the network to provide service guarantees even if the service is only delivered through the broadband provider’s network and not purchased directly from the provider.

Encoded traffic used for IPTV exploits the temporal and spatial similarity between adjacent frames in motion video to achieve very high compression rates. This implies that motion video with few changes between successive frames (for example, a newscast) generates much lower traffic on the network compared to fast-action video, which has a large number of changes between images in successive frames. As a result, IPTV traffic has the characteristics of real-time variable-bit-rate traffic. The bursty nature of traffic necessitates innovative ways of addressing QoS in the network. Some middleware used in IPTV requires higher tolerance to bursts in order to offer subscribers a good channel change experience. The network should therefore have the intelligence to discriminate between different traffic classes in the network.

## Network Reliability

For telco service providers to convince consumers to subscribe to an IPTV service, a network infrastructure with very high reliability is paramount. Consumers have come to expect as high a level of service guarantee from their television service provider as they expect from their phone service provider. To avoid customer churn, IPTV should maintain or exceed these expectations.

## High Density

With capital budgets squeezed, moderately dense yet scalable access nodes located close to residential neighborhoods provide a balanced approach for telcos' IPTV services. For this strategy to succeed, high-density aggregation devices are required to effectively backhaul the traffic from access devices to a POP.

Similarly at the head-end, large server farms are required for services such as VOD and network PVR. The popularity of such services among subscribers necessitates the use of high-density switches and routers at the head-end infrastructure with ample room for growth.

## Future-Proof Infrastructure

The bandwidth needs of an IPTV infrastructure were highlighted in an earlier section. Yet this may be only the tip of the iceberg in terms of the types of services the network is expected to deliver. Future-proofing the network infrastructure with bandwidth capacities well above what is needed today is a requirement. And it is necessary to ensure that the infrastructure is capable of supporting emerging technologies such as IPv6 to protect a service provider's investment.

## Flexibility in Service Delivery Models

The jury is still out on the best way to offer next-generation services such as IPTV, while providing a smooth migration from the present mode of operation. Every service provider network has unique characteristics—examples are geographical distribution of subscribers, density of subscribers, amount of fiber in the network, location and capabilities of the access nodes, local regulations, and present mode of operation.

A large number of broadband providers today offer data-only broadband services using PPP over Ethernet (PPPoE). Unfortunately, PPPoE is highly unsuitable for the delivery of multicast services. More importantly, the prevailing mode of operation for data-only broadband service backhauls traffic to a Broadband Remote Access Server (BRAS). Continuing this model is one choice for a service provider. In this model, the aggregation network acts primarily as an Ethernet-based Layer 2 network.

An alternate method is to use a more distributed form of video delivery where the aggregation network plays an active role in the service delivery to each subscriber. In this model, the aggregation network performs the functionality required for guaranteeing service levels to each subscriber and interacts with a policy management system to dynamically enforce per-subscriber guarantees.

Since both modes have their respective strengths and weaknesses, the infrastructure for the aggregation network should be fine tuned for price, performance, and functionality to adapt to both scenarios. When deciding on this vital service offering service providers must have options, because *one size simply does not fit all*.

## Network Infrastructure Security

Because of the amount of bandwidth consumed per multicast stream in a network and the expected availability of IPTV-based services, there are special security considerations to ensure network infrastructure security. For instance, the network infrastructure should prevent a subscriber from sourcing specific multicast groups into the network. IGMPv3 is commonly employed to prevent such spoofing of multicast sources. In addition, advanced security policies need to be implemented at the edge of the network to protect the infrastructure from becoming compromised.

## BROCADE SOLUTIONS FOR IPTV

Brocade® has a broad range of network infrastructure offerings to enable IPTV service deployment by service providers. Brocade's breadth of products provides the flexibility and scale needed for supporting different types of IPTV infrastructure. Whether the aggregation layer is made up of small access rings aggregated by a larger aggregation ring or large aggregation rings, or a hub-and-spoke architecture, Brocade offers the right set of capabilities with optimal density and a future-proof architecture that allows the network to scale to the needs of the future, while meeting today's needs.

These products include:

- The **Brocade NetIron® CES 2000 Series** of compact switches offer 24 – 48 ports of 1 Gigabit Ethernet (GbE) and optionally 2 x 10 GbE ports. The compact form factor of NetIron CES 2000 switches occupies just 1U in space. Availability of both copper and fiber interface options for the 1 GbE ports makes it an appealing choice for aggregating traffic from several access nodes that are either co-located or geographically distributed. The NetIron CES 2000 Series also supports advanced Layer 2 functions such as Provider Backbone Bridging (PBB) and Provider Bridging (PB) including advanced tag manipulation. The NetIron CES 2000 is ideal for extending VPLS and VLL to the edge and when smaller route tables need to be supported (less than 32,000 IPv4 routes.)
- The **Brocade NetIron CER 2000 Series** of compact IP/MPLS routers offers 24 – 48 ports of 1 GbE and optionally 2 x 10 GbE uplink ports. With up to 136 Gbps of non-blocking wire-speed performance, this scalable series of routers is available in copper and hybrid fiber configurations. The NetIron CER 2000 has the complete suite of IPv4/IPv6 unicast and multicast routing with fast convergence times and supports large route tables (including full Internet routes.) The NetIron CER Series also supports edge router applications including advanced QoS to enforce strict SLAs at the provider edge. Other key applications for the NetIron CER Series include large VRFs, Layer 3 VPNs, and route reflector applications.
- The **Brocade MLX Series** of routers, with full Layer 2, Layer 3 and advanced MPLS capabilities is available in four form factors. The Brocade MLX Series is a MPLS-enabled metro router that offers wire-speed performance on all ports, full IPv6 unicast and multicast routing today, and 480 Gbps of full-duplex capacity per full slot. The NetIron MLX Series offers unparalleled flexibility to providers in choosing the right mode of service delivery and is specifically intended for advanced aggregation functions required for IPTV/multi-service delivery.

## Advanced Capabilities for IPTV Services in Brocade Solutions

Brocade's products described in the previous section offer advanced capabilities that are essential for successful IPTV service delivery. The ability of these products to offer both advanced Layer 2 and full Layer 3 capabilities gives unparalleled flexibility to a service provider in deploying IPTV service models that are best suited for their network. For the specific equipment models and software release required for these functions, consult the product documentation and/or Release Notes. Brocade's products support the necessary capabilities mandated for an aggregation node in the TR-101 specification by the DSL Forum.

Brocade aggregation products provide several advanced Layer 2 and Layer 3 capabilities such as:

- Flexible VLAN tag manipulation
- Aggregation of 1 GbE links using IEEE 802.3ad, including cross-slot trunks on chassis-based models for higher availability
- Rapid spanning tree protocol support as per IEEE 802.1D
- Port MAC security to limit the number of MAC addresses that are learnt per interface

- Maintaining 8 distinct queues, one per class of service. In addition, the Brocade MLX Series use a unique Virtual Output Queuing (VOQ) architecture that is described below.
- Support for IGMP snooping
- Support for IGMP v2 and IGMP v3 modes, including IGMP member tracking required for “fast leave” operations
- IGMP mode selection to allow interoperability with network nodes that support only IGMPv2
- Flexibility in deploying access control lists that can be formed based on Layer 3 and Layer 4 header information
- Support for private VLANs to allow isolation of subscribers
- Large MAC address tables to facilitate the deployment of scalable Layer 2 aggregation networks
- DHCP option 82 processing and DHCP relay functionality, which is useful in deployment models where legacy access nodes in the network do not have the ability to perform such processing. It is also useful in deployment models where IPTV is directly offered over Ethernet fiber to the neighborhood.
- Support for very large number of multicast groups. The Brocade MLX Series, Brocade NetIron CER 2000, and Brocade NetIron CES 2000 support up to 8,000 multicast groups.
- PIM-SM, PIM-SSM and MSDP support
- Anycast RP support to allow redundancy and load sharing in the network
- Parallel processing of IGMP Join/Leave requests to ensure very low IGMP Join and IGMP Leave latencies
- Large number of policy-based rate limiters to dynamically enforce per-subscriber flow guarantees.
- Support for spatial multicast to ensure efficient transport of multicast packets within the system from the multicast source port to destination port.
- Static IGMP joins, a capability that is useful when downstream access nodes are incapable of generating the IGMP requests or when channels are desired to be always present at certain nodes to improve the channel change time
- Passive Multicast Route Insertion
- Hardware-based IPv6 unicast and multicast support, including support for MLD, and PIM-SSM (on Brocade MLX Series)
- Metro Ring Protocol (MRP) support for rapid convergence in the event of aggregation ring failures
- Availability of 100-FX and 100-BX (for single-strand optics) interfaces on all the Brocade platforms mentioned above. This makes the Brocade platforms such as the NetIron CES 2000 suitable as a compact access device for offering video services.
- Extensive range of options for optical layer connectivity including BX optics (single-strand fiber optics), CWDM and DWDM optics, and 10 GbE WAN-PHY support for maximum flexibility
- Rich support for multicast statistics for data analysis and network troubleshooting

Table 1 lists the requirements of IPTV and how a Brocade solution can be applied to address the requirement.

**Table 1.** Requirements of IPTV and corresponding Brocade solution

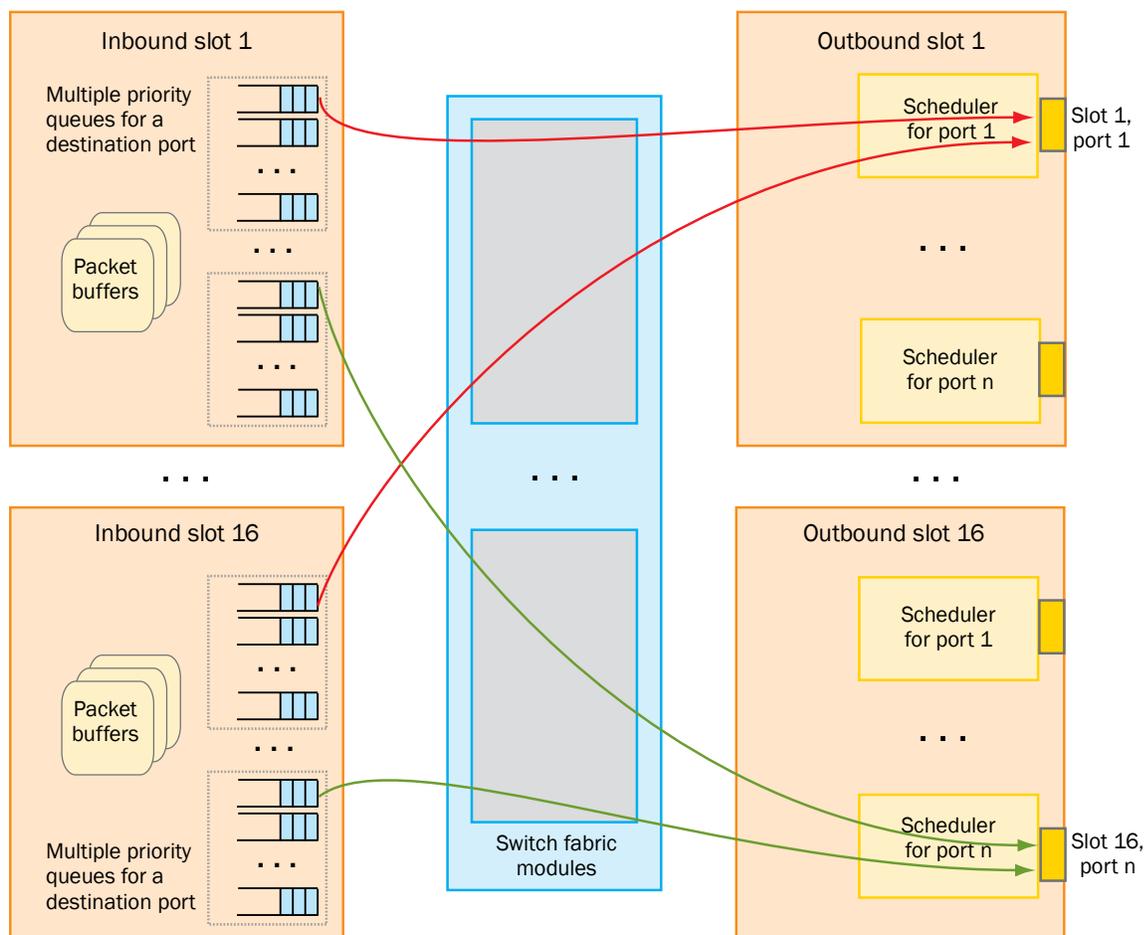
Requirement in IPTV	Brocade Solution
Enormous amounts of bandwidth consumed	Guaranteed wire-speed performance on all ports independent of packet size
Latency	Ultra-low latency in both data path and control path (IGMP Join/Leave latency)
QoS requirements from different services	Superior Virtual Output Queuing (VOQ) architecture on NetIron MLX Series devices allows for distributed buffering in the system
High availability to ensure minimal service downtime	The Brocade MLX Series offers very high reliability and is powered by Multi-Service IronWare®. These products employ an innovative Clos-based architecture that provides intra-SFM redundancy and other advanced capabilities required for non-stop operation of the network such as hitless software upgrade, hitless failover during management module switchover, complete separation of control plane and data plane, graceful restart and graceful degradation under even the most unlikely of component failures.
High density	The Brocade MLX Series offer the industry's highest port density with wire-speed performance among products in their class.
Future-proof infrastructure	Advanced scalability that is well beyond today's needs ensures that infrastructure installed today is future-proof for several years to come. Examples: <ul style="list-style-type: none"> <li>• 10 GbE interface on the Brocade NetIron CES 2000 and CER 2000</li> <li>• 480 Gbps of full-duplex bandwidth per full slot on the and Brocade MLX Series</li> <li>• Support for a very large number of multicast groups, more than 16x what is considered state-of-the-art channel offerings today</li> </ul>
Flexibility in service deployment models	Advanced multicast and unicast security capabilities allow complete flexibility for the service provider in deploying infrastructure consistent with a provider's operational model
Offer large number of channels to the subscriber	Support for up to 8,000 multicast groups on the Brocade MLX, Brocade NetIron CER 2000, and Brocade NetIron CES 2000 allow support for a very large number of broadcast TV and premium channels
Per-subscriber flow guarantees	Policy-controlled rate limiters enforceable per subscriber flow. Per-port controllable scheduling options are available in all products.
Network infrastructure security	Support for IGMPv3, PIM-SSM Very high number of ACLs enforced at the edge of the network.

## Virtual Output Queuing (VOQ) in Brocade MLX Routers

A unique characteristic of the Brocade MLX Series systems is the use of a distributed queuing scheme that maximizes utilization of buffers across the entire system during congestion. This is particularly invaluable in IPTV applications in which the network infrastructure has to cope with large volumes of traffic to subscribers. Figure 2 illustrates the benefits of VOQ used in the Brocade MLX platforms.

This innovative scheme marries the benefits of input-side buffering (Virtual Output Queuing) with those of an output-port driven scheduling mechanism. Input queuing using virtual output queues ensures that bursty traffic from one port does not occupy too many buffers on an output port. An output-port driven scheduling scheme ensures that packets are sent to the output port only when the port is ready to transmit a packet.

Each interface module maintains multiple, distinct priority queues to every output port on the system. Packets are “pulled” by the outbound interface module when the output port is ready to send a packet, ensuring that no information is lost between the input and output stages. The use of “virtual output queues” also, maximizes the buffering capacity of the system by physically storing packets on the input module until the output port is ready to transmit the packet, thereby, leveraging all buffers across the entire system in the event of large bursts from multiple source ports.



**Figure 2.** VOQ on the Brocade MLX—ideal for IPTV applications

## Using the Aggregation Network to Offer VPN Services

Service providers deploying an IPTV network can reuse the aggregation network to offer services to business customers, including E-LINE and ELA- type services, which have been specified by the Metro Ethernet Forum (MEF). Brocade's platforms allow these services to be offered over the same aggregation network used for delivering IPTV services. In addition, the Brocade MLX Series of switching routers provide full support for MPLS VPN services, allowing advanced QoS-aware Layer 2 MPLS VPN and Layer 3 MPLS VPN services to be overlaid on the same aggregation network. Key to such reuse of the network is the flexibility to configure multiple services concurrently— including the same port—of Brocade MLX Series routers.

## BROCADE SOLUTIONS FOR HEAD-END OFFICES

The networking infrastructure at the head-ends plays a very important role in IPTV service delivery. The routers and switches in a head-end need to provide connectivity among:

- Middleware servers
- Servers used for digital rights management
- Media server farm consisting of VoD servers, network PVR storage servers, ad insertion servers, and so on
- Video encoders
- Servers hosting OSS applications such as billing, provisioning, and fault/performance monitoring applications

These devices should also be made available on redundant servers in order to provide high uptime guarantees. The increase in value-added unicast-like services being provided to subscribers means that high density of Ethernet ports in switches and routers is required in such head-end offices with room for growth. In these scenarios, anything less than wire-speed performance is highly detrimental to the overall subscriber experience.

The Brocade MLX Series provides the desired scalability required for a head-end build-out. The low-latency, advanced QoS architecture of these platforms makes them ideal candidates for head-end designs. In addition, the built-in hardware and software resiliency provides simplicity and reliability to the operations.

## BROCADE SOLUTIONS IN DEPLOYED IPTV NETWORKS

Brocade Networks has been powering IPTV networks in North America and Europe since the earliest days of interest in IPTV. These service providers have deployed Brocade switches and routers in both aggregation networks as well as head-end networks. For more details on Brocade's expertise with designing IPTV network infrastructure, contact your local Brocade representative.

## SUMMARY

This paper highlighted the vital role played by the networking infrastructure in the aggregation network as well as the head-ends office networks Brocade's product offerings including the NetIron CES 2000 Series, NetIron CER 2000, and Brocade MLX Series provide a variety of solutions that are fine-tuned to the needs of service providers with different modes of operation while at the same time providing a future-proof infrastructure.

From the head-end to the aggregation network, Brocade routers and switches enable the high-performance networking infrastructure required to power the bandwidth-intensive IPTV service, as well as additional revenue-generating services. The unique and advanced platform architectures powering Brocade platforms are purpose-built for high availability, future-proof scalability, and advanced QoS, thereby ensuring a superior IPTV customer experience and best investment protection for the service provider.

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