CISCO SYSTEMS

CISCO 7600 ROUTER: RESILIENCE AND AVAILABILITY FOR VIDEO DEPLOYMENTS

Service providers are continually looking to expand their markets and increase market share while delivering services profitably to subscribers. Those that have a "Triple Play" delivery strategy that includes IPTV/video appear destined to thrive in the marketplace through differentiation of offerings, increased customer satisfaction, and reduced turnover. Cisco Systems® has made strategic product additions and enhancements to its Cisco® 7600 Series routing portfolio, underscoring its leadership in helping service providers build out flexible IP Next-Generation Networks (IP NGNs) that deliver scalable, profitable, and differentiated IPTV/video, voice, and data—Triple Play—services to their customers.

CISCO 7600 SERIES ROUTER DELIVERS AVAILABILITY, SCALABILITY, SECURITY, AND FLEXIBILITY FOR VIDEO DEPLOYMENTS

In a world of shrinking profit margins, steady commoditization of traditional services, and intense competition, service providers are seeking new opportunities to expand service offerings to reduce turnover, increase average revenue per user (ARPU), and boost profitability. Many service providers are turning to Triple Play (voice, data, and video) services to meet these goals. IPTV/video is a critical component that will direct the growth of Triple Play services over the next few years because of its ability to generate new revenue and meet subscriber demand for enhanced services. Cable service providers have already taken the lead delivering video-on-demand (VoD) services. It will be critical for existing local exchange carriers (LECs) and regional Bell operating companies (RBOCs) to do the same to grow revenue over the next few years.

Triple Play video, however, places increased demands on service provider networks. Concerns to be addressed include the need for high bandwidth, low latency, availability (routing around failures), scalability to grow, security to protect the network, and flexibility to meet changing requirements.

As more and more subscribers sign up for HDTV services, the network will need to support throughput several orders of magnitude larger than today's standard services. Combine this with the need to simulcast the same channels in standard definition, increasingly popular niche/specific-interest channels, and a successful on-demand service that typically consumes four to six times the bandwidth of broadcast alone, and the need to efficiently utilize network bandwidth for video becomes a must.

For example, a video broadcast service that uses an advanced video codec and offers 150 channels of standard-definition content requires approximately 300 Mbps, assuming 2 Mbps or less for each channel. Add another 50 HDTV channels, each consuming 8-10 Mbps, and the total network bandwidth required for the broadcast service approaches 1 Gbps, with more bandwidth needs for the broadcast service likely to accelerate.

Because IP Multicast is the most efficient means of supporting video transmission, and because it builds on IP, the accepted standard for data traffic, IP Multicast has become the preferred solution of service providers for IPTV/video delivery going forward.

IP Multicast is a bandwidth-conserving routing technique that reduces traffic over the network by simultaneously delivering a single stream of information to potentially tens of thousands of homes or corporate locations. It allows IP traffic to be sent from one source or multiple sources and delivered to multiple destinations.

Instead of sending individual packets to each destination, a single packet is sent to a group of destinations known as a multicast group, which is identified by a single IP destination group address. High-bandwidth applications, such as MPEG video, may require a large portion of the available network bandwidth for a single stream. In these applications, IP Multicast is the only way to send to more than one receiver simultaneously.

Applications that take advantage of IP Multicast include VoD, IPTV, videoconferencing, corporate communications, distance learning, and distribution of software, stock quotes, and news.

The decision to deploy Triple Play and video services is a significant one. Service providers want to know the impact on their network, their budget, and their bottom line. Revenue from broadband Internet access has been steadily declining as the service becomes a commodity. VoD or IPTV offer service providers an opportunity to reverse that trend. Experience suggests that ARPU increases when service providers begin delivering VoD and IPTV as part of their service offerings. But will the IP Multicast network be reliable and secure enough to ensure customer satisfaction; that is, will it attract new subscribers and retain existing customers? Can the network scale to meet initial and long-term needs as new users are added? And will the network offer the flexibility to meet changing business conditions? Service providers that chose the Cisco 7600 Series router solution for IP Multicast IPTV/video can rest assured.
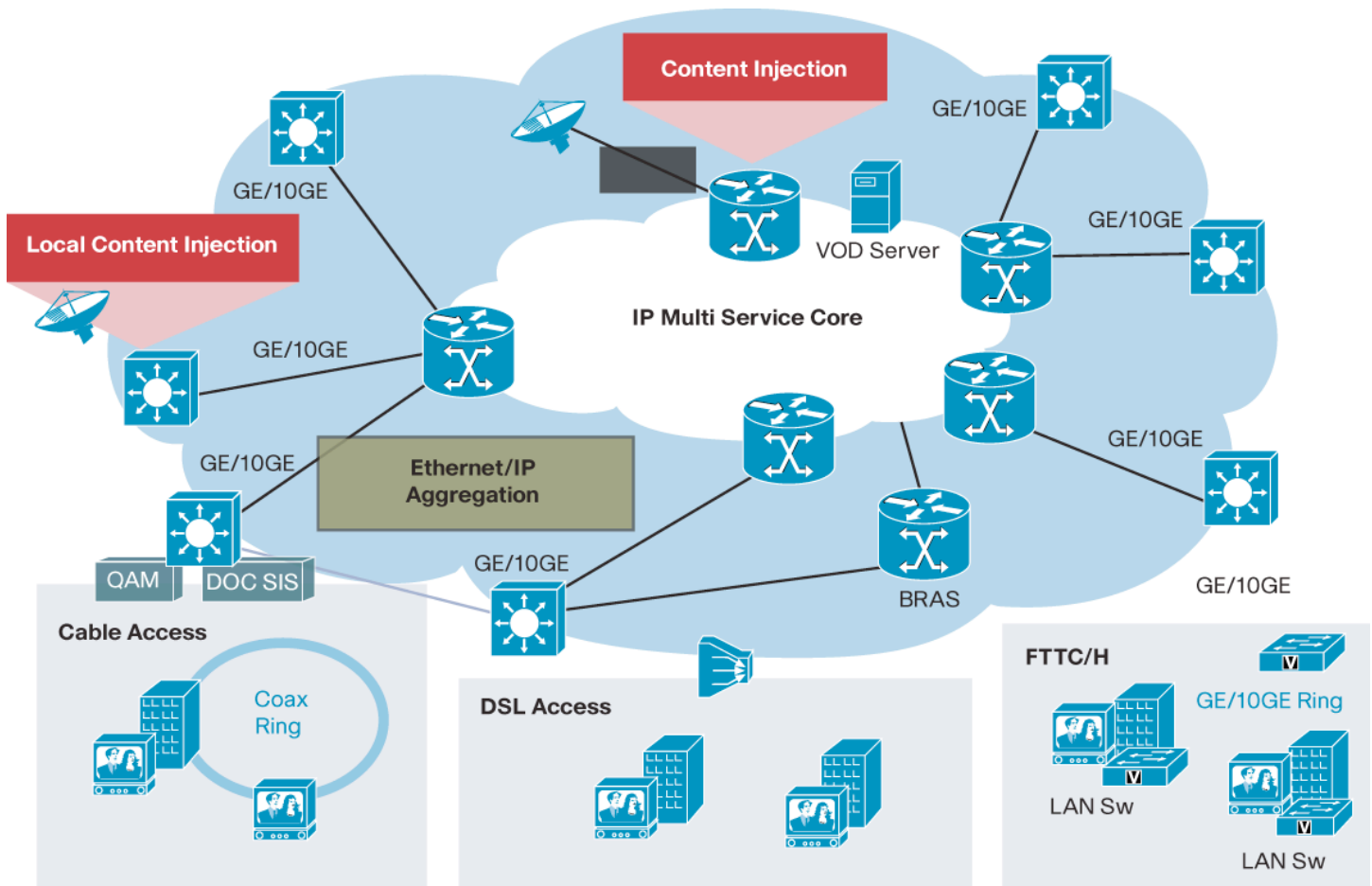
THE CISCO 7600 SERIES ROUTER SOLUTION FOR IP MULTICAST VIDEO

Cisco has delivered strategic product additions and enhancements to its Cisco 7600 Series routing portfolio, underscoring its leadership in helping service providers build out flexible IP NGNs that deliver scalable, profitable, and differentiated video, voice, and data—Triple Play—services to their customers.

In April 2005, as part of its IP Next-Generation Networks announcement, Cisco introduced new functions on the Cisco 7600 Series. This included video-optimized asymmetric networking, which reduces total cost of ownership by helping providers configure only the bandwidth needed across the core and distribution networks for downstream and upstream pay-per-view (PPV) and VoD communications. Also introduced was *enhanced dynamic IP Multicast and broadband source redundancy of live TV, PPV, and VoD*, which minimizes the bandwidth needed to serve customers and supports source redundancy, thus helping ensure a quality experience. In addition, Cisco introduced Source Specific Multicast (SSM), which helps enable Layer 2 customer equipment to interwork with Layer 3 signaling and prevents distributed denial-of-service (DDoS) attacks.

The Cisco 7600 Series Router provides aggregation of traffic at the network edge, as shown in Figure 1. It is the industry's first high-performance Ethernet aggregation platform with a 256-gigabit backplane and 30 million packets-per-second routing performance. The Cisco 7600 Series takes full advantage of a 40-Gbps-per-slot infrastructure to offer unsurpassed Ethernet densities of 32-Gbps ports per slot with 10-Gbps port uplinks.

Figure 1. Cisco 7600 Series Router Supports Triple Play Converged Ethernet and IP Aggregation

The Cisco Ethernet-based transport network using Cisco 7600 Series routers can deliver not only IPTV/video services, but other services as well. The same infrastructure can be used at the aggregation level for cable; DSL; Ethernet to the home, building, or campus (ETTx); and mobile wireless.

Cisco 7600 Series routers have industry-leading-edge availability, scalability, security, and flexibility features that service providers should look for in Triple Play equipment solution vendors.

High Availability

Any network downtime for service providers can be costly. Delivering revenue-critical services demands a high level of uptime—typically five 9s (99.999-percent) availability. From its initial introduction, the Cisco 7600 Series Router has delivered hardware-based high-availability capabilities. The router has been subsequently enhanced to provide software support of nonstop forwarding (NSF) with stateful switchover (SSO), which initially included features for Layer 3 VPN and Enhanced Interior Gateway Routing Protocol (EIGRP) protocols. The capabilities of the Cisco 7600 Series Router have now been extended to support NSF with SSO for multicast, ensuring high availability of IPTV/video services.

SSO keeps voice-over-IP (VoIP) services up during supervisor switchover in a Layer 2 network. NSF with SSO also offers transparent supervisor switchover in a Layer 3 network. Both active and standby supervisors are synchronized at all times with NSF and SSO. In multicast applications, NSF with SSO synchronizes the multicast forwarding state between active and backup supervisors, resulting in minimal disruption of traffic during

switchover. NSF and SSO on Cisco 7600 Series routers dramatically increases operational efficiency by eliminating service disruptions, minimizing network downtime, and reducing troubleshooting costs.

The Cisco 7600 Series router also provides *Broadcast Source Redundancy*. Dynamic IP Multicast allows the service provider can take advantage of 'anycast' support in the Cisco IP Multicast solution to load balance video encoders and enable fast failover of video broadcast sources, such as encoders. Cisco IOS® Software creates different multicast trees to serve a subset of the subscriber set-top boxes for each of the different broadcast sources located in separate video headends, which are all transmitting the same sets of channels using the same host address. If a broadcast source fails, IOS Software in the Cisco 7600 Series router detects the loss of that source, automatically switches that source's multicast trunk and its branches, and merges it over to a remaining multicast tree. Only a subset of the subscribers might experience an almost imperceptible interruption of service, nearly instantaneously receiving a healthy broadcast stream from the remaining source. The broadcast sources and their respective IP multicast trees can be separated by considerable geographic distances, allowing national sources to be the back-up for local source (content, ads) insertion points.

The Cisco 7600 Series Router also supports redundant forwarding engines, switch fabric, power supplies, and tray fans.

Scalability

Service provider networks can be very extensive. Multicast deployments must have the capability to scale to hundreds of thousands or millions of subscribers without impacting performance or reliability. Cisco's own tests have shown that the Cisco 7600 Series router can receive over 15,000 simultaneous IGMP requests (without options) from subscriber set-top boxes without dropping a single packet, exceeding the largest theoretical demand any one video serving office will experience. Cisco 7600 Series routers have been successfully deployed in a leading cable service provider network to deliver VoD for 10 over million subscribers.

A performance test conducted by EANTC demonstrated the ability of the Cisco 7600 Series Router with the Cisco Catalyst® 6500/7600 Series Supervisor Engine 720 to support 25,000 S,G mroutes and 375,000 outgoing-interface-list (OIL) entries over Protocol Independent Multicast sparse mode (PIM-SM) at a forwarding rate of 195.83 Mpps with zero loss. Another test showed the platform could support 200,000 S,G mroutes over bidirectional PIM (PIM-Bidir) at 195.83 Mpps with zero loss. The platform further demonstrated up to 407 million packets per second IPv4 aggregate performance, and up to 230 Mpps IPv6 aggregate performance. No performance degradation occurred with 10,000-line access control lists.

Security

Like any network, an IP Multicast network is subject to threats by hackers and malicious subscribers that, if not checked, can bring down the network. Cisco 7600 Series routers protect and secure the network on multiple levels. At the device level, the router is protected from control plane attacks, unauthorized user access, and spoofed addresses. At the service level, end-user consumers' service is protected through VPN routing and forwarding (VRF)-aware IP Security (IPSec) VPN, virtualized firewalls, virtualized intrusion detection, and virtualized Secure Socket Layer (SSL) VPN.

At the network level, both the network and the applications are protected against "day zero" attacks through DDoS prevention and "clean pipes" service. Averting DoS attacks is an important strategy in preventing service disruption. Cisco has added enhancements to multicast routing such that only network-specified sources can send multicast streams. In addition, Cisco has implemented rate limits in aggregation routers that thwart malicious subscriber behavior.

Flexibility

Service providers are interested in maximizing their investments and providing the flexibility to support a range of services with existing network infrastructure. Cisco 7600 Series routers provide a portfolio of services that include support for Layer 3 and Layer 2 VPN services, Internet peering, cable headend aggregation, and data center.

MULTICAST FEATURES ENABLED IN THE CISCO 7600 SERIES ROUTER

The Cisco 7600 Series of routers introduces numerous important multicast features and capabilities to enhance availability, scalability, security, and flexibility. These include PIM Source-Specific Multicast (SSM), PIM Bidir, SSM mapping, IP Multicast VPN (MVPN), hardware replication, and multicast rate limiters.

PIM SSM

PIM is a multicast routing architecture that allows service providers to deploy IP Multicast on their existing IP network. PIM is unicast routing protocol-independent and is typically operated in sparse mode, which is much more efficient for building multicast distribution trees.

SSM is a datagram delivery model that best supports one-to-many broadcast applications. It is the core networking technology for the Cisco implementation of the IP Multicast suite of solutions targeted for audio and video broadcast application environments.

Bidir PIM

Bidir PIM is an extension to the PIM suite of protocols that implements shared sparse trees with bidirectional flow of data; that is, data flows both up and down the same distribution tree, as opposed to other multicast protocols that have trees rooted at either the source or at a route processor. Recommended for many-to-many applications, Bidir PIM is an important protocol that is used extensively for financial trading applications where there is a need for bidirectional multicast capabilities.

SSM Mapping

IP Multicast with SSM offers bandwidth-efficient delivery of the broadcast service while providing greater simplicity and inherent security than previous versions of multicast routing. Although Internet Group Management Protocol Version 3 (IGMPv3) on the subscriber edge is the most appropriate signaling mechanism, SSM mapping in Cisco 7600 Series aggregation routers allows the installed based of DSL access multiplexers (DSLAMs) and set-top boxes (STBs) that support only IGMPv2 to be used without compromising the advantages of multicast routing with SSM (PIM SSM).

Anycast

An Anycast implementation strategy provides load sharing and redundancy in PIM networks. Anycast allows two or more multicast trees to share the load of the multicast subscribers and enables the multicast source (broadcast service sources such as an encoder) to act as a hot backup for each other.

MVPN

In 2002, Cisco provided a practicable solution called Multicast VPN (MVPN) for the rapidly growing service provider market. Simple to set up, it is highly scalable and has minimal administrative overhead. With the latest MVPN technology, providers now can dynamically provide multicast support over Multiprotocol Label Switching (MPLS) networks. An MVPN architecture introduces an additional set of protocols and procedures that help enable a service provider to support multicast traffic in a VPN. It allows for transparent transport of a customer's IP Multicast traffic across a provider's VPN backbone, and it is integrated transparently with the Cisco IOS® Software Unicast MPLS VPN solution. It allows a service provider to offer multicast services to its VPN customers in addition to its current unicast VPN offering.

Hardware Replication

In the process of forwarding IP Multicast traffic, the Cisco 7600 Series routers must bring data into the router on one port and send it out on one or more ports toward its destination. If this data is to be sent out on multiple ports, it must first be duplicated or replicated, and this replication function is most efficiently performed in hardware. Hardware-based multicast replication engines in the Cisco 7600 Series Router (including the central engine on the supervisor and the distributed engines on the switching modules) perform the critical task of replicating IP Multicast traffic to multiple output interfaces.

The Cisco 7600 Series Router provides ingress and egress replication models for efficient replication. In the ingress replication model, traffic is replicated by the line card receiving the packet, whereas egress replication (a more efficient model) allows for one copy of the stream to be sent to the egress line card. This greatly reduces the traffic on the backplane. Egress replication can be configured manually if needed for greater efficiency. The hardware replication techniques used by the Cisco 7600 Series Router provide exceptional throughput and scalability.

Multicast Rate Limiters

Service providers must guard against the threats of hackers and malicious subscribers who seek to bring down the network. Multicast rate limiting is an effective deterrent in preventing DoS attacks. The supervisor engine within the Cisco 7600 provides control plane protection for the route processor and switch processor CPU using numerous hardware rate limiters. These rate limiters allow the forwarding engine to throttle back traffic destined for the CPU, while leaking some traffic through to allow the multicast protocols to continue to function properly. Thus, an attacker attempting to use multicast traffic for a DoS attack can be thwarted, while maintaining normal operation. Examples of rate limiters include:

- **Rate Limiting Traffic for which There Is No Route Table Entry**—The absence of a route table entry for multicast packets being received is an important indication that the source is a hacker and these packets should be blocked.
- **Rate Limiting Traffic for which There Is No Forwarding Information Base (FIB) Entry**—A FIB entry occurs when a hacker hijacks an IP address. The rate limiter blocks these multicast packets.
- **Rate Limiting IGMP Requests**—A hacker is attempting to generate more IGMP requests than the router can handle to bring the router down. These packets are blocked.
- **Rate Limiting Multicast Traffic with IP Options**—Multicast packets with options cannot be processed in hardware; they must be sent to the route processor, which is not as efficient at handling them. As with IGMP requests, hackers attempt to generate more multicast packets with options than the system can handle to bring down the network. These packets are blocked.

Unicast Reverse Path Forwarding Checks

To protect against DoS attacks, it is important to restrict possible attack vectors. This can be done through source-address verification mechanisms validating the traffic originator such that attackers cannot use spoofed source addresses. Cisco 7600 Series routers employ Unicast Reverse Path Forwarding (URPF) to discard packets that lack a consistent source IP address, such as spoofed IP source addresses created by malicious users to intercept valuable data. This feature uses Cisco Express Forwarding tables to verify that the source addresses and the interfaces on which packets were received are consistent with the forwarding tables on the supervisor engine. If the packet is received from reverse path routes, the packet is forwarded. If there is no reverse path route on the interface on which the packet was received, the packet fails the URPF check and is discarded. The Cisco 7600 implements URPF checks in hardware, resulting in no loss of forwarding performance.

CONCLUSION

Triple Play with video is a must-have for service providers to remain competitive and profitable. IP Multicast, an industry standard embraced by service providers worldwide, is the most efficient way to deploy Triple Play. Cisco has delivered strategic product additions and enhancements to its Cisco 7600 Series routing portfolio, helping service providers build out flexible IP NGNs that deliver scalable, profitable, and differentiated video, voice, and data—Triple Play—services to their customers. With support for critical IP Multicast features and capabilities such as PIM SSM, Bidir PIM, SSM mapping, MVPN, hardware replication, and multicast rate limiters, Cisco 7600 Series routers deliver industry-leading enhanced availability, scalability, security, and flexibility.