IP Multicast on Cisco ASR 1000 Series Aggregation Services Routers

The Cisco® 1000 series aggregation services routers makes it cost-effective for enterprises and service providers to deploy a high-performance IP multicast network that is easy to install, manage, secure, control and scale. This paper provides an overview of multicast capabilities and benefits on the Cisco ASR 1000 series router. It assumes the reader is aware of basic Cisco multicast concepts and Cisco ASR 1000 series router architecture.

The Challenge:

Enterprises and service providers alike have used the bandwidth-conserving technology of IP Multicast for years to enable services. As new applications start to use multicast to deploy high-bandwidth and mission critical services, it raises a new set of challenges for deploying IP Multicast in the network. Before addressing these new challenges it is also important to understand the possible deployment scenarios of IP Multicast in enterprise and service provider networks.

IP Multicast in an Enterprise Network:

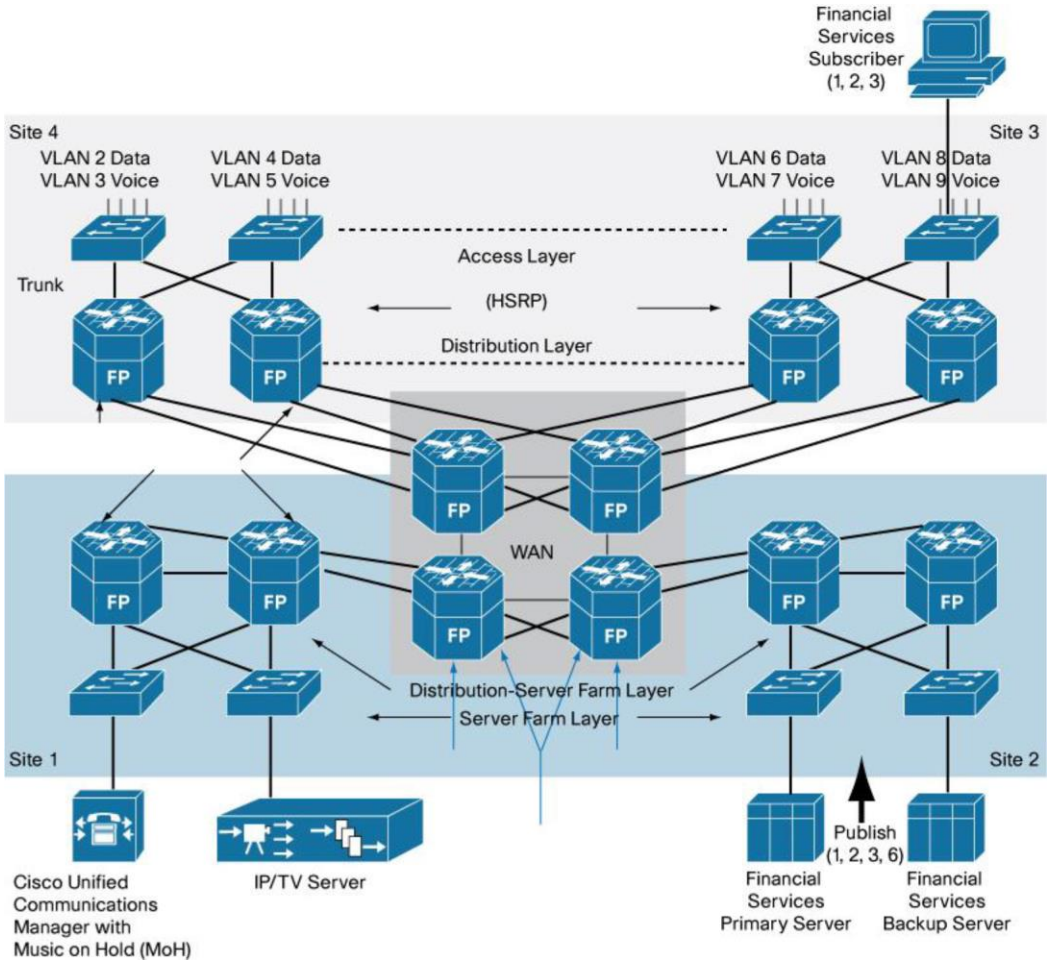
IP Multicast applications are becoming increasingly popular among enterprises as an essential communications protocol to effectively manage bandwidth and offload application server load by replicating the traffic on the network when the need arises.

IPTV: More and more enterprises are using IPTV broadcast to send training videos and broadcast corporate announcement messages to employees, customers and partners spread across diverse geographical regions. IP Multicast is also being used to facilitate effective communication between branch offices using high bandwidth and delay sensitive technologies such as Cisco TelePresence.

Financial Applications: Financial enterprises are using multicast to efficiently distribute financial data including stock ticker services over the trading floors to customers.

With IP Multicast your enterprise can efficiently distribute content and media within your network (Figure1).

Figure 1. IP Multicast Deployment with Cisco ASR 1000 Series Routers in an Enterprise Network.



IP Multicast in a Service Provider Network:

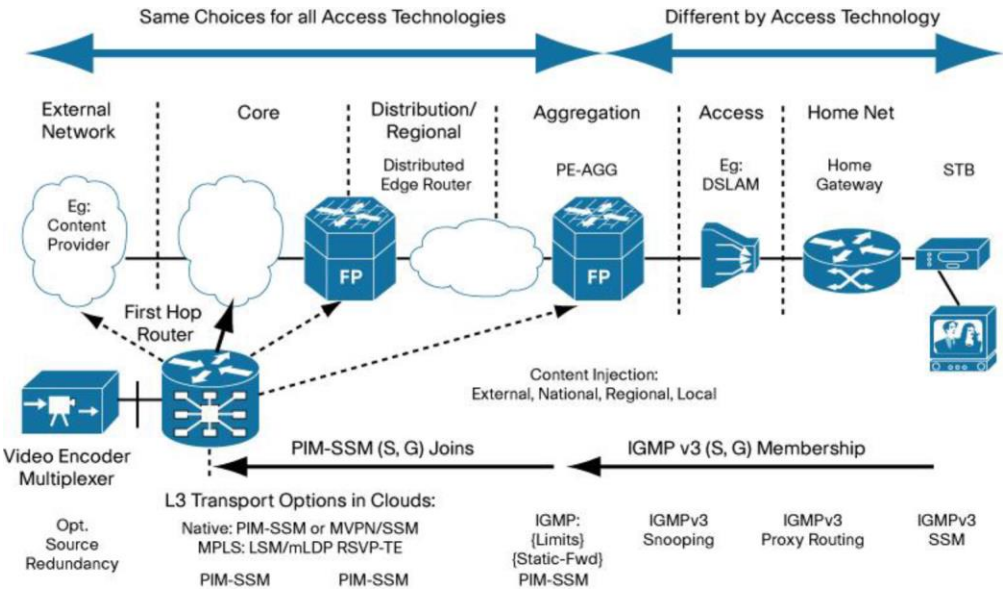
Service providers are seeking new revenue generating opportunities and IP Multicast can help them offer these revenue generating value added services.

Multicast Virtual Private Network (MVPN): Services Providers have migrated from traditional VPN services to MPLS VPN services. Because MPLS has no native support for Multicast, a separate function is required to enable IP Multicast over a Multiprotocol Label Switching VPN (MPLS VPN) network.

IP/TV: Service providers offer primarily two types of IP/TV services that use the IP Multicast protocol for efficient distribution:

- **Broadcast video:** Service providers have started to offer TV channels over the existing broadband networks as a value-added service.
- **near-Video on demand (n-VOD):** n-VOD is a service that plays a movie or a clip at 10 to 15 minute intervals spread over a range of channels so you do not have to wait more than the minimum interval minutes to watch a movie.

Figure 2. IP/TV Deployment with Cisco ASR 1000 Series Routers in a Service Provider Network.



As these services are deployed, the need for IP Multicast for high bandwidth and revenue-generating mission-critical services has raised some of the following challenges:

- Efficient replication of IP Multicast traffic without a significant effect on performance.
- Efficient control of IP/TV video traffic in the enterprise and service provider network.
- Capability of achieving sub-second convergence after failure of a network node or link.
- Support for efficient mechanisms to provide encryption and quality of service (QOS) for IP Multicast.
- Ability to offer key admission-control mechanisms per node/interface/subscriber.
- Provisioning an effective security and filtering mechanism.
- Ability to easily deploy and manage the network.
- Faster rollout of standardized features to the field.
- Addressing concerns of a depleting IPv4 address space.

The Solution:

The Cisco ASR 1000 Series Aggregation Services Router uses Cisco's existing strength in breadth and scale of IP Multicast functions to full advantage to meet the current and future networking requirements.

Multicast Features on the Cisco ASR 1000 Series Routers.

The Cisco ASR 1000 Series Routers run Cisco IOS® XE Software that inherits IP Multicast features from Cisco IOS Software. Some highlights of Cisco IOS Multicast features inherited by Cisco IOS XE Software are as follows:

Protocol Independent Multicast (PIM): IP PIM is the accepted industry standard for building multicast distribution trees. In most cases, the system uses the information learned from PIM to install and dynamically maintain hierarchical multicast routing tables (routing trees).

The following are the main versions of the PIM protocol supported by Cisco IOS Software, all of

which are control plane protocols:

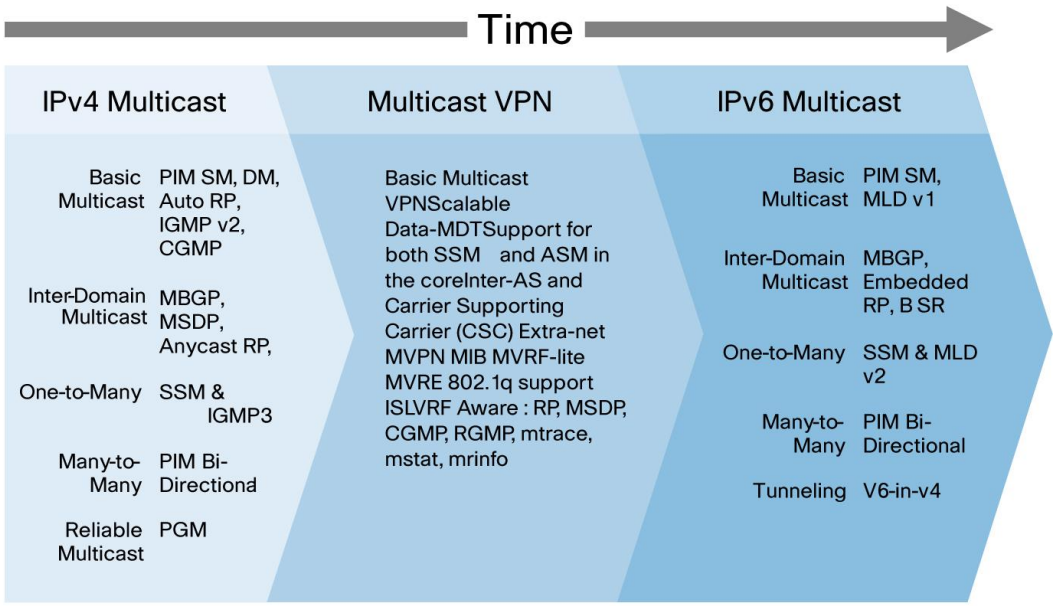
- PIM Dense Mode
- PIM Sparse Mode
- PIM Source Specific Multicast (SSM)
- Bidirectional PIM

IP Multicast Call Admission Control (CAC): To control oversubscription of resources, Cisco IOS XE Software implements some of the following different options to configure IP Multicast CAC in Cisco IOS Software:

- **Internet Group Management Protocol(IGMP) limit:** Customers can enforce a maximum broadcast bandwidth limit by limiting the number of IGMP joins on the ranges of IP Multicast addresses associated with broadcast video to a configured maximum on the aggregation links that the router controls.
- **IP Per Interface Mroute State limit:** This feature limits the number of Mroute states on an interface for different access control list (ACL)-classified sets of IP Multicast traffic. You can use this feature to prevent Denial of Service (DoS) attacks, or to provide an IP Multicast CAC mechanism when all the multicast flows use roughly the same amount of bandwidth.

IPv6 Multicast: With the depleting IPv4 address space, Cisco IOS XE Software has added support for PIMv2 for IPv6 and Multicast Listener Discovery (MLD) version 1 and MLDv2.

Figure 3. IP Multicast Evolution on Cisco IOS Software Inherited by Cisco IOS XE Software.



Multicast High Availability (HA) Architecture on the Cisco ASR 1000 Series Routers

To achieve High Availability (HA), the Cisco ASR 1000 Series Routers are designed to provide both redundant hardware and software components. These components also provide modularity which helps to contain faults so that during failover or restart events, other parts of the system continue to function normally.

A fully redundant configuration of the Cisco ASR 1000 Series Routers has a physical separation of the control plane from the forwarding plane. To Understand High Availability on the ASR 1000

Series Routers, the key components of the Cisco ASR 1000 Series Router need to be understood. Following are the essential components in a Cisco ASR 1000 Series Router system:

- **Cisco ASR 1000 Series Route Processor (RP1):** IP PIM, IGMP/MLD packets are processed here and it also computes the Multicast Forwarding Information Base (MFIB).
- **Cisco ASR 1000 Series Embedded Services Processor (ESP):** On this data plane, IP Multicast forwarding is handled using MFIB, which is platform and routing protocol independent. Hence, when using MFIB to forward multicast packets the ESP platform needs only a minimal knowledge of the multicast routing protocols.
- **Cisco ASR 1000 Series SPA Interface Processor (SIP):** The SIP is the housing for the shared port adapters (SPA), each SIP can take up to 4 Half-Height SPAs. The SPAs on their own do not play an active part in providing High Availability functionality for multicast services because they provide only the physical network connection and buffering.

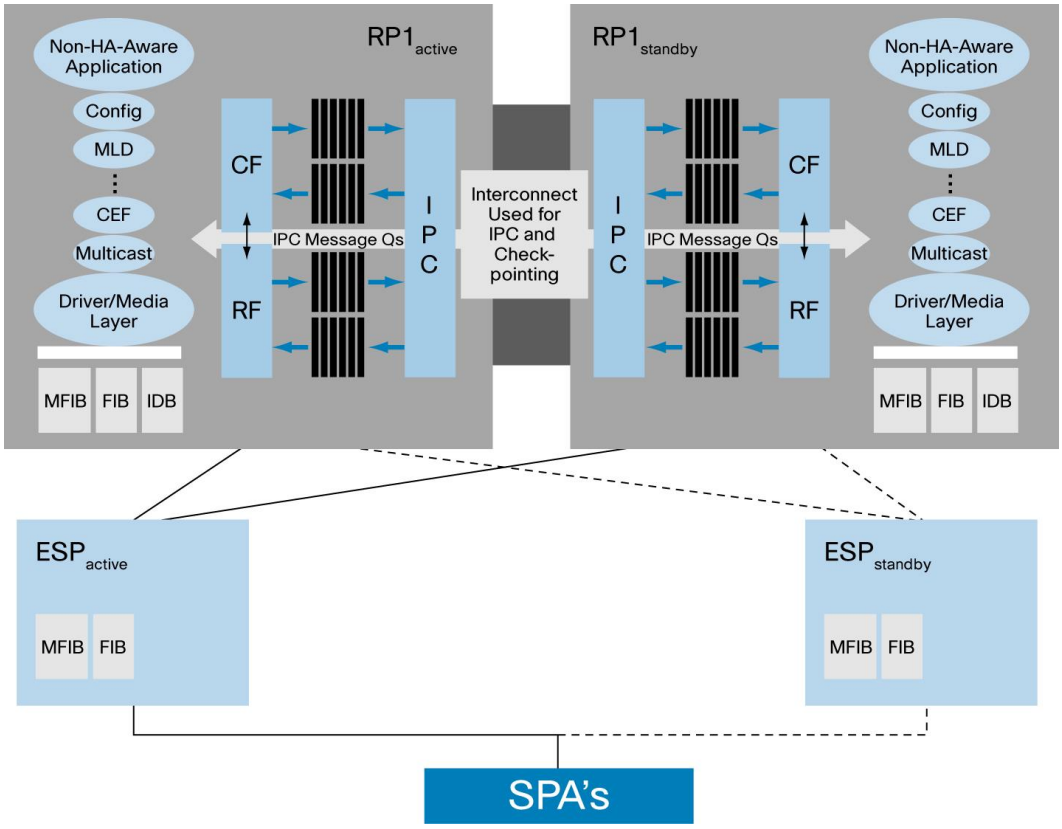
The hardware architecture uses unique Cisco IOS XE Software and inherited Cisco IOS Software features such as Non Stop Forwarding (NSF), Stateful Switch Over (SSO) and In Service Software Upgrade (ISSU) to provide High Availability. IP Multicast High Availability operates in a manner similar to other protocols on the Cisco ASR 1000 Series Routers and a reliable Inter-Process Communication (IPC) transport is used for synchronization.

The ASR1000 series routers have a physical separation of routing plane (RP) from the forwarding plane (ESP). In a fully redundant 6RU chassis the RP and ESP operate in an active/standby mode. On failover the High Availability works as following:

- On the active RP Failure, the standby RP takes over and the now newly active RP re-builds the PIM state IGP re-converges to assure uRPF check. The MFIB proceeds to incorporate refreshed PIM state and the active ESP continues to forward multicast traffic based on its version of the MFIB. Forwarding of IP Multicast packets is not disrupted.
- On the active ESP Failure, the standby ESP takes over and forwarding is disrupted by a momentary packet loss. This can be mitigated by prioritizing multicast traffic over other types of traffic, packet / byte statistics will be lost. After restart, ESP receives state information from active RP via reliable IPC communication.

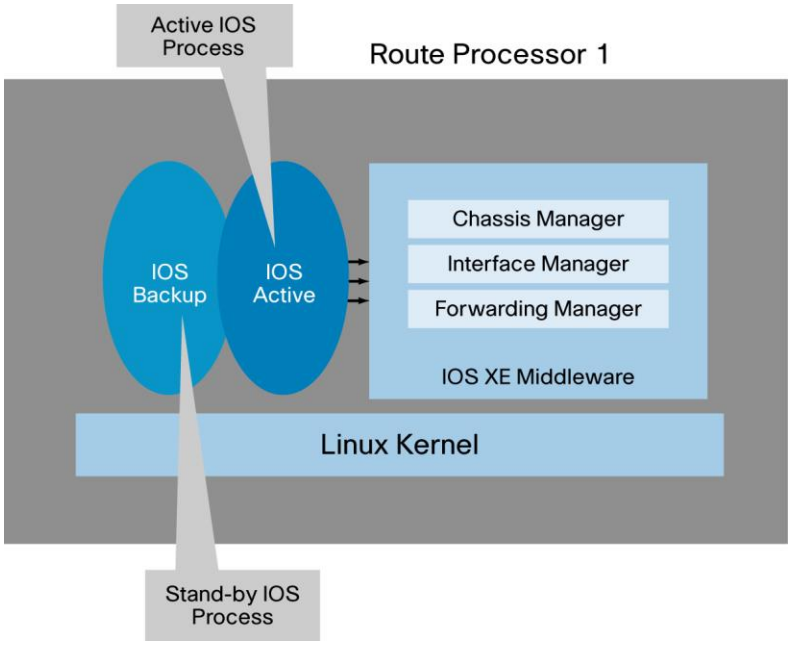
Figure 4 shows an internal overview of a completely redundant configuration of the Cisco ASR1000 Series Routers.

Figure 4. Multicast High Availability Overview on the Cisco ASR 1000 Series Router



The 4RU and 2RU chassis support a physically separate single RP and ESP. Although the two lack redundant hardware components, they do provide Cisco IOS Software process redundancy. On a failure of the primary Cisco IOS Software the backup image takes over seamlessly. Figure 5 illustrates the Cisco IOS Software process redundancy. The 4RU and the 2RU chassis also support all NSF/SSO features supported by dual-RP (6RU chassis) systems.

Figure 5. Single Route Processor Redundancy on Cisco ASR 1000 Series Router



For more information about High Availability on the Cisco ASR 1000 Series Routers please refer to the High Availability white paper at: http://www.cisco.com/go/asr1000.

Efficient Multicast Replication on the Embedded Services Processor (ESP)

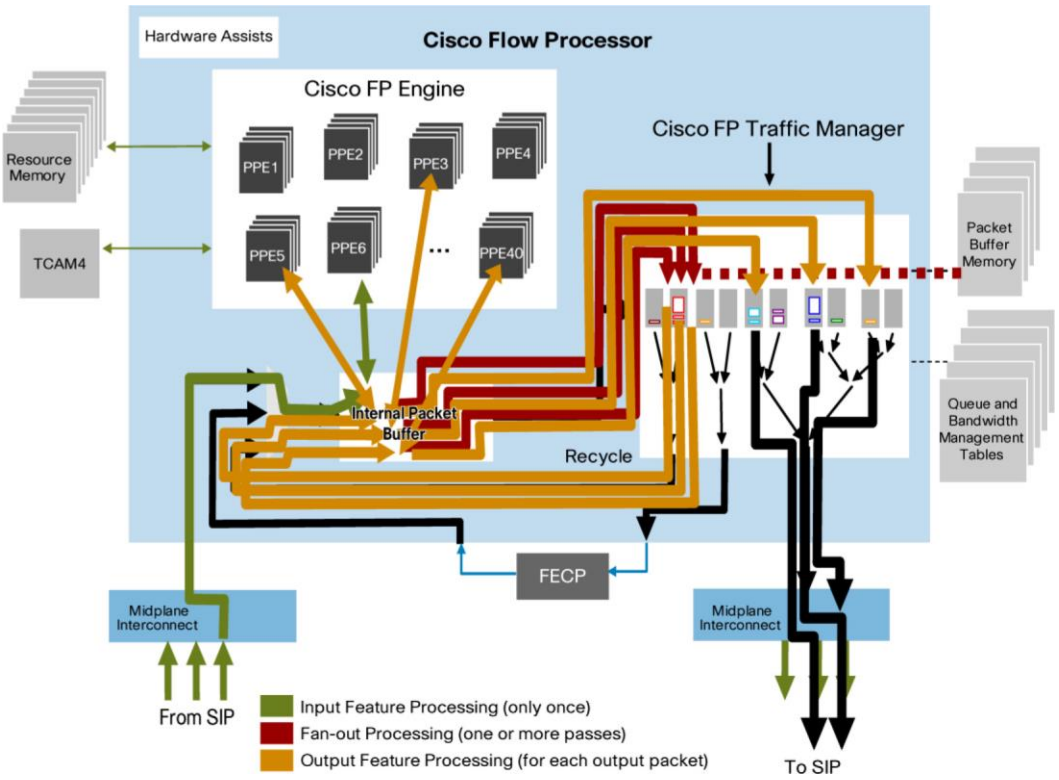
IP Multicast data packets are handled by the Cisco ASR 1000 Series Routers in a similar manner to IP Unicast data packets. They arrive on an ingress interface and are forwarded by the SPA to the ESP for processing. However, the processing within the ESP differs significantly because the multicast packets are replicated in the ESP; the Cisco ASR1000 Series Router uses an efficient replication algorithm to replicate packets.

For Multicast, ESP achieves efficiency in the following ways:

- Each IP Multicast packet that arrives is sent to one of the free PPE threads in the Cisco Flow Processor. Instead of just one PPE replicating many packets for all the outgoing interfaces that are joined to that group, the Cisco Flow Processor uses a fan-out technique instead.
- The receiving PPE tells the Cisco FP Traffic Manager to recycle the packet to many PPEs and each one of these performs the same replication until the required number of replications is attained in a few passes (depending on the number of replications required) through the Cisco Flow Processor. Depending on the configuration many thousands of replications could be initiated.
- A dedicated hardware encryption engine and hardware queues for QoS make sure that multicast traffic can be encrypted and prioritized effectively

This efficient replication helps ensure that latency and jitter are kept to a minimum for IP Multicast traffic. The ESP provides an efficient and scalable solution to multicast replication without burdening the overall system capacity. Figure 6 illustrates how multicast data is replicated in the ESP.

Figure 6. Multicast Replication Flow on the Embedded Services Processor



For more information on the Cisco Flow Processor please refer to the Flow Processor white paper at: http://www.cisco.com/go/asr1000.

Benefits of Deploying the Cisco ASR1000 Series Router in an Enterprise and Service Provider Network:

The Cisco ASR1000 Series Routers can help both enterprises and services providers offer services effectively with the following advantages:

- IP Multicast services require efficient and scalable IP Multicast replication. The Cisco ASR 1000 Series Routers were designed to provide carrier-grade High Availability and to scale to thousands of multicast groups.
- In networks running a mix of data, voice and video services, video traffic must contend with voice for priority. Both are critical services with voice being more delay sensitive then video. Directing video traffic in the priority queue with voice over IP (VoIP) can affect the worst case VoIP delay, especially if the video traffic is bursty. Because Cisco understands this problem a dual-priority queue was implemented on the Cisco ASR 1000 Series Routers to provide optimized support for both voice and video traffic.
- Service providers face a constant demand for bandwidth at the edge creating the need to be able to effectively oversubscribe links without affecting end-user quality of experience (QoE). Cisco has successfully implemented a CAC mechanism in voice networks with oversubscription. IP Multicast CAC is treated in a similar manner to voice CAC. Before admitting a new call, the new call-flow repercussions that may affect QoE for existing flows are accounted for by using IP Multicast CAC mechanisms. The Cisco ASR1000 Series Routers takes full advantage of existing Cisco IOS Software capabilities to efficiently control IP Multicast traffic using Multicast CAC.

- Service providers want to securely deploy triple-play services and offer various different service packages to meet individual customer requirements. This kind of service offering also requires allocation of individual IP addresses to each service for each end-user terminal. As IPv4 address space gets exhausted, the need for IPv6 increases. Some carriers are already using IPv6 Multicast for IP/TV deployments. The obvious advantages to service providers is that they do not have to worry about an exhausting IPv4 space and can have the flexibility to assign an IPv6 address to all devices within a end-user home and authenticate each one of these services (data, voice and video) individually. This scenario allows service providers to offer tiered services effectively. The Cisco ASR1000 Series Router is designed for IPv6 Multicast support and even adds High Availability capabilities for IPv6 Multicast.
- To effectively deploy and manage multicast protocols on the Cisco ASR 1000 Series Routers, Cisco Multicast Manager is a network management tool that can be used by enterprises and service providers that use IP Multicast to transport IP Multicast data and video over IP or by service providers that need to manage their Multicast Virtual Private Network (MVPN) environment. Hence, Cisco Multicast Manager makes management of services deployed on the Cisco ASR 1000 Series Routers easier.

In Summary:

The Cisco ASR 1000 Series Routers is an advanced mid-range router that takes full advantage of the Cisco Flow Processor. This innovative platform provides the flexibility to deploy the Cisco ASR 1000 Series in next-generation networks.

Investment protection with the Cisco ASR 1000 Series Routers is offered through field firmware upgrades, software upgrades, and careful attention to future hardware requirements. You can feel confident that with Cisco, your network investments are protected both today and tomorrow.

More information on the Cisco ASR 1000 Series Routers can be found at: http://www.cisco.com/go/asr1000.

To get a detailed overview of Cisco IOS Multicast technologies, please visit: http://www.cisco.com/en/US/products/ps6552/products_ios_technology_home.html.

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