ADTRAN

Configuration Guide

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IP Multicast Stub Routing in AOS

Overview and Examples for IP Multicast Technology

IP multicast provides an efficient method for delivering common information from a single source to multiple recipients without unnecessary duplication and network resource waste. It is most often associated with the delivery of media content such as video and audio, but may also be used to deliver data such as news, stock tickers, and other one-to-many messages.

This document provides a high-level description of IP multicast and describes the multicast features introduced in the ADTRAN Operating System (AOS) Release 7.1. For more detailed information regarding specific command syntax, refer to the *AOS Command Reference Guide on your ADTRAN OS Documentation CD.*

This guide consists of the following sections:

IP Multicast Overview

IP multicast has many applications, ranging from video and/or audio program delivery, music-on-hold for an IP PBX, conferencing applications, and delivery of software updates, data, or other information to multiple sites and/or devices. This document uses simple example applications to illustrate the various components of IP multicast.

Satellite Classroom Example

The following example describes a one-to-many application and compares operation in a non-multicast network to operation in a multicast network. This example is illustrated in Figure 1 on page 3.

A university has opened satellite classrooms in several towns across a large rural portion of the country, providing local residents access to live classes. Satellite offices connect to the university backbone and include a small LAN at each location. Students participate in classes using computers connected to the satellite classroom LAN. Headsets are used since each student may be attending a different class. Classes are conducted at scheduled times from the central university campus, and the live audio and video streams are made available via the media server. To join a class, the student logs into a computer at the satellite classroom and selects a URL, opening a media player and pointing it to the appropriate content on the media server. The media server configures the media player for the content's stream format (CODECs, etc.), preparing it to receive and play the selected content.

Satellite Classroom Application on a Non-Multicast Network

Referring to Figure 1 on page 3, **PC1**, **PC2**, **PC4**, and **PC6** have subscribed to the same classroom broadcast. Since the network is not multicast-enabled, the **Media Server** must send a separate copy of the content to the IP address of each PC. In this case, there are four copies of the content traversing the network in four streams. The link from the **Media Server** to the **University Backbone** is a potential bottleneck. In this backbone layout, the backbone path serving satellite sites 1 and 2 (**Satellite Router 1**/**Satellite Router 2**) is another potential bottleneck. Notice that **PC1** and **PC2** are on the same broadcast domain. Even though they are subscribed to the exact same content, that stream is transmitted twice and consumes twice the bandwidth on that segment. This solution does not scale.

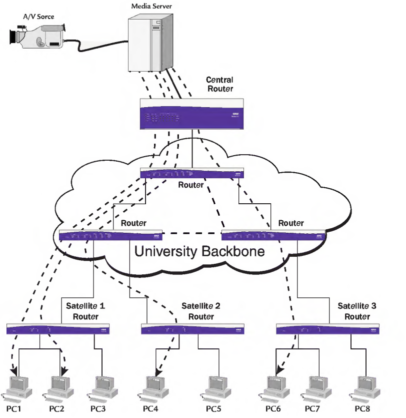

Figure 1. Non-Multicast Network

PCs 1, 2, 4, and 6 have subscribed to a specific media server content which is delivered with a separate unicast stream for each subscribing client PC.

Satellite Classroom Application on a Multicast-Enabled Network

In a multicast-enabled network, the media server sends specific content in a single stream to a specific multicast IP address, much like a local broadcast TV station sends its content on a specific broadcast frequency. The network has multicast intelligence and is able to make copies of the stream as necessary to reach all active receivers.

This provides two significant efficiencies:

1. At any given point in the network there is never more than one instance of a particular content stream.
2. The network will only copy and forward a stream to locations that have active receivers.

Referring to Figure 2 on page 5, **PC1**, **PC2**, **PC4**, and **PC6** have subscribed to the same classroom broadcast. Using IGMP, these PCs have signaled to their local router that they wish to receive this multicast address. In multicast-speak, these PCs have joined the multicast group identified by that multicast address. The satellite routers use a multicast routing protocol (most likely PIM) to signal other routers in the backbone and the **Central Router** that they have receivers for that multicast group. Each router in the network then understands if it is in the path toward receivers for that group (this description is greatly simplified).

The **Media Server** is able to send a single copy of the stream to the multicast IP address (group address). The **Central Router** receives this stream and sends a copy out all interfaces that have receivers for that group. This is repeated at each router until the stream arrives at each segment that has receivers. Since there is never more than one copy of the stream on any given link, the possibility of a bottleneck is greatly reduced. Notice that **PC1** and **PC2** are on the same broadcast domain. **Satellite Router 1** makes a single copy of the stream and transmits it into that broadcast domain, where it is received by both PCs. This solution is much more scalable.

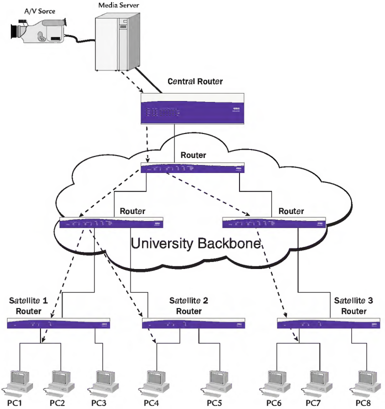

Figure 2. Multicast-Enabled Network

PCs 1, 2, 4, and 6 have subscribed to a specific media server content which is delivered on a single multicast stream and copied once to each segment containing subscribing client PCs.

NOTE	*When using subinterfaces (frame relay PVCs, VLAN subinterfaces, etc.), each subinterface is a separate logical IP interface. It is possible that a multicast stream may be forwarded to each subinterface, resulting in the stream being sent multiple times over the same physical interface.*

IP Multicast Addressing and Protocols

Multicast Addressing

The IPV4 address scheme (layer 3) sets aside Class D addresses for use in IP multicast. RFC1112 discusses multicast addressing in detail. The Class D range is from 224.0.0.0 through 239.255.255.255. The range from 224.0.0.0 through 224.0.0.255 is reserved for local administrative or maintenance use and is usually limited to the scope of a single subnet. In other words, processes on devices connected to the same segment use these addresses to communicate with each other.

Examples in this range include:

- The all-hosts address (224.0.0.1)
- The all-routers address (224.0.0.2)
- Routing protocols such as RIP V2 (224.0.0.9) and OSPF (224.0.0.5 and 6)
- Multicast IP routing protocols such as DVMRP (224.0.0.4) and PIM (224.0.0.13)

The range from 224.0.1.0 through 239.255.255.255 is used for IP multicast where a source sends content to multiple receivers via a multicast-enabled network, as this document describes.

For layer 2, a specific range of ethernet addresses for IP multicast use has been set aside (01-00-5E-xx-xx-xx). RFC1112 discusses the technique used to map IP layer 3 multicast addresses into Ethernet layer 2 multicast addresses. Use of layer 2 multicast addresses is critical to network performance since it allows a device's network interface to listen for a specific set of addresses in hardware instead of having to listen to all addresses and sort through them in software.

The benefit of using a multicast address instead of a broadcast address is that only devices running a process that uses a given multicast address need listen for the address. Other devices are not interrupted when a multicast address is transmitted. With broadcast addressing, all attached devices are interrupted to listen to a broadcast packet, whether they need it or not.

All devices that wish to receive the same IP multicast content are referred to as a group. The multicast IP address that a specific content is being sent to is referred to as the group address.

IGMP – Internet Group Management Protocol

The IGMP protocol allows a device to notify a directly-connected multicast router that it wishes to join a specific group and therefore receive packets sent to that group address. It also allows a router to query attached segments (subnets) to determine whether any group members remain. If no remaining group members are detected, streams to that group are no longer forwarded to that segment. In IGMP V1, when a device wishes to leave a group, it ceases to respond to the router's query. When no devices respond on a given segment, the router stops forwarding that group to that segment. This causes some lag time between when the last device stops needing a stream and when the router stops sending the stream. To reduce this lag time and make better use of network resources, IGMP V2 introduced a specific *leave* message and process that expedites termination of a stream to an interface when the last member leaves.

Multicast Routing Protocols

Multicast routing is a complex topic, and its details are beyond the scope of this document. To summarize, whereas IGMP is typically used by an end device to signal a directly-connected router that it wishes to join a specific multicast group, a multicast routing protocol allows a router to pass this information on to other routers (ultimately reaching the router connected to the source of the multicast stream). This allows a distribution tree to be built from the source to all receivers, thus ensuring the following:

- There is a path to all receivers.
- No stream is sent where there are no receivers.
- There are no loops in the distribution tree.
- The proper path is used between a source and a receiver.

These are critical factors in building a distribution tree.

When a router receives a multicast packet, the source IP address in the packet is examined and tested to make sure the packet was received on the proper interface for the routing protocol in use. If not, the packet is dropped. This is referred to as reverse path forwarding (RPF).

If the packet is not dropped, the router will forward multicast packets through an interface only if one of the following is true:

- The router has detected that members of the specific multicast group are present on the segment attached to that interface (learned through IGMP or statically configured).
- The router has detected another multicast router using a multicast routing protocol, and that router is on the correct path to current group members.

Of the various multicast routing protocols, PIM (Protocol Independent Multicast) is the most common.

The following sections contain short descriptions of several multicast routing protocols. Some important concepts for multicast routing protocols include:

- Source-based or shared trees
- Dense or sparse mode
- Reverse path flooding
- Pruning

The methods used by each protocol are listed below, but a detailed definition is beyond the scope of this document.

Distance Vector Multicast Routing Protocol (DVMRP)

DVMRP (RFC1075) is a dense mode, source-based tree protocol. It provides it own unicast routing protocol that is very similar to RIP. It is possible that DVMRP will resolve a different path than the network's own unicast protocol. DVMRP is used in the Internet Multicast Backbone (MBONE), an experimental multicast network.

Multicast Open Shortest Path First (MOSPF)

MOSPF (RFC1584) is a dense mode, source-based tree protocol. As with OSPF, MOSPF is for use within one administrative or routing domain. MOSPF uses OSPF as the unicast routing protocol and works by adding multicast information to OSPF link state advertisements. This protocol is limited when there are many sources and when links are not stable. It is not widely used today.

Protocol Independent Multicast (PIM)

PIM has a sparse mode (shared tree) and dense mode (source-based tree) variation. PIM relies on information in the router's unicast routing table without concern over how the routes are installed in the table (thus the name *protocol independent*). PIM is the most widely-used protocol.

IP Multicast in Stub Topologies

A stub network is a portion of a network with a single connection to the remainder of the network. The spokes in a hub-and-spoke network are a common form of stub network, although there are other forms. In the stub portion of a network, a multicast routing protocol is not necessary for IP multicast operation. Since there is a single link, there is a single best path and no potential for a loop. All that is needed is a way to signal to the multicast network when there are active group members within the stub, allowing multicast streams to be sent to the stub network only when needed.

Referring back to Figure 2 on page 5, the satellite classrooms have a single connection to the multicast-enabled backbone, making them a stub network. When a student logs into **PC1** and selects a class from the **Media Server** web interface, the following actions occur:

1. **PC1** sends an IGMP message on its LAN indicating that it wants to join the multicast group for that class (let's say address 224.1.1.1).
2. **Satellite Router 1** (the stub router) registers the group membership on that interface.
3. Using its multicast routing protocol, **Satellite Router 1** signals to the backbone router that it needs to receive packets to that group.
4. This signaling propagates to other routers (depending on the exact multicast routing protocol in use) and eventually to the **Central Router**.
5. IP packets from the **Media Server** to the group address 224.1.1.1 then flow through the backbone and ultimately to **PC1**.

While the multicast routing protocol does not consume significantly more bandwidth relative to other solutions, it does consume CPU and memory resources on the stub router even though it is performing only a portion of its total job, due to being a stub link.

An alternative would be to configure the satellite routers to proxy the IGMP messages from the classroom PCs to the multicast network. This alternative setup is described in the next section.

IGMP-Based Multicast Forwarding (IGMP Proxying)

Internet Draft **draft-ietf-magma-igmp-proxy-06.txt** specifies a technique for performing just such a proxy function.

> **CAUTION**
>
> *Terminology is tricky in this area. Other vendors support this technique, but some refer to it as **Stub Multicast Routing** where the stub router is configured as an **IGMP Proxy Agent**. Some vendors have another feature called **IGMP Proxy** which is an entirely different capability and not directly related to this application.*

The following key concepts and terminology need to be understood regarding IGMP Forwarding.

- The stub router is typically the router at the stub location that connects to the remainder of the network. In Figure 2 on page 5, the satellite routers are the stub routers.
- When discussing multicast, it is common for the words *upstream* and *downstream* to be used relative to the distribution tree and the flow of a particular multicast stream. Regarding IGMP forwarding, it is important to note that these words are used relative to the stub router's connection

to the multicast-enabled network (the backbone in Figure 2). The connection to the backbone is the stub router's upstream connection. The connection to the classroom LAN is the stub router's downstream connection.

- A downstream connection faces multicast clients (PCs in Figure 2) and performs the IGMP router function as would a typical multicast router. The upstream connection faces the multicast network and would normally run a multicast routing protocol. With IGMP Forwarding, the stub router instead runs an IGMP client process on the upstream interface, appearing to the multicast network as a single multicast client. Even though the link to the backbone router is typically a WAN interface, the backbone router still performs the IGMP router process on that interface and will use IGMP for communicating group membership activity with the stub router.
- IGMP forwarding is best used when there is a single active link to the multicast network. This includes redundancy solutions such as dial backup where either the primary link or the backup link is active at any given time. In situations where there is more than one simultaneously active link to the multicast network (used for redundancy, load sharing, meshing, etc.), it may be possible through extremely careful network design to use IGMP forwarding. However, a multicast routing protocol is strongly recommended to protect against loops and to ensure that multicast packets are transmitted and received on the proper path.

Using IGMP forwarding, when a student logs into **PC1** and selects a class from the **Media Server** web interface, the following actions occur:

1. **PC1** sends an IGMP message on its LAN indicating that it wants to join the multicast group for that class (again, let's say address 224.1.1.1).
2. **Satellite Router 1** (stub router) registers the group membership on that interface.
3. Using its IGMP client on its upstream interface, the **Satellite Router 1** sends an IGMP message to the backbone router indicating that it wants to join the multicast group.
4. The backbone router registers the group membership on that interface and then uses its multicast routing protocol to signal the backbone in the usual manner.
5. IP packets from the media server to the group address 224.1.1.1 then flow through the backbone and ultimately to **PC1**.

IP Multicast Stub Routing in the AOS

In Release 7.1, AOS introduced IP multicast support in the form of IP Multicast Stub Routing using IGMP Forwarding. Note the following key points for this release:

- AOS command syntax differs from some other vendors when configuring this feature. In other vendor implementations, multicast forwarding, PIM, and IGMP functions are intertwined. By enabling PIM on an interface, you also enable IGMP and multicast forwarding. Even when configuring multicast stub operation, PIM commands are used and the PIM process is running on the stub router. In contrast, AOS performs a pure IGMP forwarding operation with no multicast routing protocol process. A unique command set was developed for AOS to clearly indicate these differences in architecture.
- IGMP forwarding is based on the Internet Draft **draft-ietf-magma-igmp-proxy-06.txt,** but some differences exist. Most notably, if there is a multicast source on a stub router's downstream interface, it may be received by group members on other downstream interfaces of the same router, but it will not be forwarded to the upstream interface. Therefore, applications requiring a multicast source located on an AOS stub network with receivers outside of that stub network are not supported. For instance, in Figure 2 on page 5, if **PC3** were acting as a media server or some other form of multicast source, **PC1** and **PC2** could join the group and receive the stream. That stream will never be sent to the backbone, so no other part of the multicast network can receive the stream.
- While multiple upstream interfaces may be configured, only one will be selected to serve as the current upstream interface for IGMP Forwarding. This works well in situations such as dial backup when either the primary or the backup interface is operational at any one time. Topologies with multiple operational upstream interfaces (such as dual PVCs or PPP links) to the multicast network require special care since there is no automatic protection from multicast loops and no dynamic best-path selection. Dual active links can be used, but careful network design is required.

AOS Multicast Stub Routing Feature Details and Operation

Figure 3 on page 12 shows a stub network connected to a larger multicast-enabled network via an AOS-based stub router.

- Referring to Figure 3 on page 12, interfaces **eth 0/1** and **eth 0/2** on the **Stub Router** are configured as multicast stub downstream interfaces (using the **ip mcast-stub downstream** command). These interfaces run IGMP in router mode and can support IGMP V1 or V2. Most applications will use V2. Both interfaces are configured with IGMP helper enabled (using the **ip mcast-stub helper-enable** command).
- Interface **fr 1.1** is the primary WAN link to the multicast network. Interface **ppp 1** is the dial backup for the primary link. Both are configured as multicast stub upstream interfaces.
- An IGMP helper address is defined as a global parameter for the router (using the **ip mcast-stub helper-address** *a.b.c.d* command). The router will use the unicast routing table to select the best interface to reach the specified address. If the selected interface is an IP multicast upstream interface, that interface will become the IGMP forwarding interface and will run the IGMP client process. This interface will perform IGMP forwarding (proxying) for any downstream interface that has IGMP forwarding enabled (using the **ip mcast-stub helper-enable** command). In this example, the helper address is the address of the media server.

Helper Address Technical Note

The helper address can be any address on the path from the desired upstream interface to the multicast-source device. The choice depends on several network design parameters such as:

- Where the upstream interface(s) connect in the multicast network.
- The number and location of sources in the multicast network.
- The granularity of network routes in the stub router's unicast routing table.

If using default routes, the helper address can be a dummy address since it will resolve to the current default route interface. If using highly granular routes (and if more than one upstream interface can be simultaneously operational), it should be a point in the multicast network that is common to the paths used by all upstream interfaces to reach all sources.

In the example of Figure 3 on page 12, the primary and backup interfaces connect to different locations in the multicast network. Since there is only one **Multicast Source**, an address common to the primary and backup interfaces in reaching the source would be the best choice. This setup would eliminate concern of route granularity and of whether one or more upstream interfaces is ever up simultaneously (assuming routing is properly weighted and symmetrical). In this case the address of the **Central Router**, **Router 3**, or even the address of the source itself would be ideal. In a scenario with a single interface to the multicast network, the helper address could simply be that of the next hop toward the source.

Feature Operation

- The helper address is set to the address of the media server, and the primary and dial backup interfaces are both configured as upstream interfaces. Therefore, when the primary interface is up, the backup interface is down and the primary is selected as the IGMP forwarding interface and performs the IGMP host function.
- When **PC1** wishes to receive the media server stream being transmitted on group address 224.1.1.1, it sends an IGMP message on its segment indicating it wishes to join that group. The AOS router registers that group address on interface **eth 0/1**.
- Since **eth 0/1** is set with IGMP helper enabled (using the **ip mcast-stub helper-enable** command), interface **fr1.1** (acting as an IGMP host) sends an IGMP message toward the multicast network indicating that it wishes to join group address 224.1.1.1. The peer multicast router registers that group address on its interface toward the stub. Using its multicast routing protocol, the multicast router signals towards the media server, and the stream begins to flow to **PC1**.
- If the primary link has a failure, the dial backup interface is activated and connects. The unicast route table establishes a new best path toward the specified helper address, and the **ppp 1** interface becomes the IGMP forwarding interface, taking over the IGMP host function. Since **eth 0/1** is still a member of group 224.1.1.1, interface **ppp 1** (acting as an IGMP host) sends an IGMP message toward the multicast network indicating that it wishes to join group address 224.1.1.1. The peer multicast router registers that group address on its interface toward the stub. Using its multicast routing protocol, the multicast router resolves the path, and the stream again begins to flow to **PC1** via the dial backup interface.
- When the primary link is restored, the process reverses and the primary interface is used once again.
- When **PC1** signals it is leaving group 224.1.1.1, interface **eth 0/1** is unregistered as a group member. The IGMP forwarding interface signals upstream that it is leaving the group, and the stream is no longer forwarded to the stub.
- Should **PC4** become a multicast source, **PC1** can join the group and the router will forward the stream toward **PC1**, but not toward the multicast network.

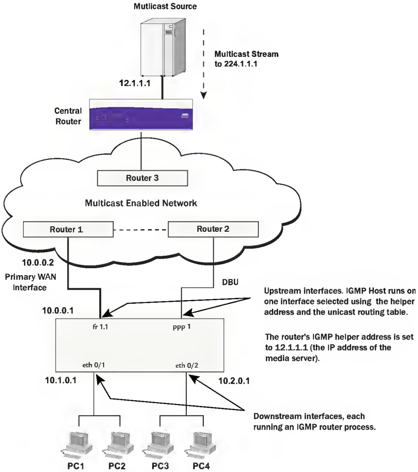

Figure 3. AOS Multicast Stub and IGMP Forwarding Support

Example Configuration

In the following example, **Router 1** is assumed to be a non-AOS product configured with an operating system common to other vendors, and the **Stub Router** is an AOS product. Though not shown in Figure 3 on page 12, the **Stub Router** receives a default route from the peer router through whichever interface is currently connected (primary or secondary).

Other vendor as Router 1:

```
ip multicast-routing
int s0.1 (PVC to the stub router, other configuration details omitted)
 ip address 10.0.0.2 255.255.255.0
 ip pim sparse-dense-mode
```

AOS as Stub Router:

```
ip multicast-routing
ip mcast-stub helper-address 12.1.1.1 (ip address of the media server)

int eth 0/1
  ip address 10.1.0.1 255.255.255.0
  ip mcast-stub downstream
  ip mcast-stub helper-enabled

int eth 0/2
  ip address 10.2.0.1 255.255.255.0
  ip mcast-stub downstream
  ip mcast-stub helper-enabled

int fr1.1 (PVC to the network router, other configuration details omitted)
  ip address 10.0.0.1 255.255.255.0
  ip mcast-stub upstream
  dial-backup number 5551212 ppp 1

int ppp 1 (dbu to network, other configuration details omitted)
  ip address negotiated
  ip mcast-stub upstream
```


Key Differences in Multicast Stub Routing

The key differences between AOS multicast stub routing and that of some other common product operating systems are as follows:

- In AOS, the multicast helper address is a single global setting. Each downstream interface can be configured to use or not use IGMP forwarding. In some other products, each interface may have a separate helper address specified.
- With other products that use multicast stub functionality, PIM must still be turned on to enable multicast forwarding on all involved interfaces and to enable IGMP on downstream interfaces. In AOS, multicast stub operation has unique commands that enable only the functions necessary for multicast stub operation (wasting no CPU, memory, or bandwidth resources on a routing protocol that is hardly used).
- In some other products, the upstream peer router must also have PIM enabled and in certain modes must be configured to filter PIM from the stub routers (preventing it from forming a PIM relationship with the stub router). Again, AOS only invokes the processes needed for multicast stub operation.

Frequently Asked Questions (FAQs)

Q1: What multicast applications does AOS support?

A1: AOS 7.x (and later) supports local IP multicast (source and receivers attached to local router interfaces) and IP multicast in stub networks using IGMP forwarding.

Q2: What is a stub network and why is it important in this application?

A2: A stub network is one that has a single connection to the remainder of the network. A router with two PVCs is not a stub network. Since AOS 7.x does not support a multicast routing protocol, it cannot prevent multicast loops; nor can it converse with other multicast routers to resolve proper paths. While IGMP forwarding can be used in non-stub networks, it requires very precise design and provides no dynamic safeguards.

Q3: My network has two PVCs connecting to the WAN backbone. Does AOS support multicast in this application?

A3: See answer A2.

Q4: Will AOS 7.x support multicast in a dial backup scenario?

A4: Using IGMP forwarding (ip mcast-stub helper-address), AOS 7.2 can forward IGMP over a primary link, then re-resolve the forwarding via the unicast route table over a dial backup link when the primary fails.

Q5: What versions of IGMP does AOS 7.x support?

A5: AOS 7.x supports IGMP Versions 1 and 2.

Q6: Can a multicast source be connected to an AOS 7.x router?

A6: In AOS 7.x, a locally connected multicast source can be connected, but only locally connected receivers can join the group. AOS will not forward local sources upstream toward the multicast-enabled network. In other words, a source connected to a downstream interface may be received by devices connected to other downstream interfaces on the same router, but the stream will not be sent to the upstream interface.

Q7: Does AOS 7.x multicast interoperate with other router vendors located in the multicast network?

A7: Any router that runs IGMP in router mode on its adjacent interface will work with AOS 7.x.

Q8: I'm familiar with multicast using other vendors' products, but I don't recognize the AOS multicast commands. Why the differences?

A8: Since the multicast stub architecture is significantly different in AOS, a new set of commands is used to illustrate the differences and better align the command with the capability. In some other operating systems, PIM, IGMP, and multicast forwarding are tightly intertwined. Even in a multicast stub application using IGMP forwarding, PIM commands are used to enable the feature. Since AOS performs the function without enabling PIM, a unique set of commands was implemented.

Glossary

Broadcast: A transmission addressed to all receivers, usually contained within the given broadcast domain.

Broadcast Domain: A layer 2 domain, separated by layer 3 devices (routers). A VLAN or LAN segments connected layer 2 switches and/or bridges typically form a broadcast domain. An IP subnet is typically contained within a broadcast domain.

Content: The information being conveyed by a source via transmission of a multicast stream.

Downstream: With regard to IP multicast stub routing (IGMP forwarding), the router interface that connects to multicast client devices.

DVMRP: Distance Vector Multicast Routing Protocol. A multicast routing protocol similar in operation to RIP. DVMRP creates its own unicast route table.

Group: A set of devices that request to receive a particular content being transmitted in a stream addressed to that specific group address. A host uses IGMP to communicate with the local multicast router and join a specific group, becoming a group member. The group member then listens for IP multicast packets addressed to that specific group address.

Group Address: The IP multicast address to which a specific multicast stream is transmitted. Somewhat analogous to the frequency on which a particular TV or radio channel is transmitted. End devices use IGMP to join (subscribe) a specific group to receive packets transmitted to that group address. In doing so, they become group members.

IGMP: Internet Group Management Protocol. Used between end devices and multicast routers allowing the end devices to join and leave a multicast group. The multicast router performs IGMP router mode. The end devices perform IGMP client mode.

IGMP Forwarding: A function that allows a device (multicast stub router) to forward or proxy IGMP activity from a client on one interface to a router on another interface.

IGMP Helper: See *IGMP Forwarding.*

IGMP Proxy: See *IGMP Forwarding.*

Listener: A device that has joined a particular multicast group and is listening for packets addressed to the group address. Also referred to as a receiver or subscriber.

Media Player: An application that receives streams, reads the content, and presents it to the user.

Media Server: An application that manages content streams and transmits them to or toward devices in the network.

MOSPF: Multicast Open Shortest Path First. A multicast routing protocol based on OSPF that uses OSPF for unicast route information.

Multicast: A transmission sent to a specific set of receivers.

Multicast Routing: The ability to determine the proper loop-free paths on which to forward multicast packets such that all subscribing listeners receive the stream without wasting network resources.

PIM: Protocol Independent Multicast. A multicast routing protocol that uses the unicast routing table with no concern of how the routing table is populated.

Receiver: See *Listener.*

Source: A device that originates multicast packets to be received by one or more receivers.

Stream: The flow of information being sent by a multicast source to a specific group of receivers. For certain content types (e.g., audio, video, etc.) the stream may be a constant flow. For other content types (e.g., data, software updates, etc.) the flow may be sporadic.

Stub Network: A network portion that has a single connection to the remainder of the network.

Subscriber: See *Listener.*

Unicast: A transmission sent to a specific receiver.

Upstream: With regard to IP multicast stub routing (IGMP forwarding), the router interface that connects to the multicast-enabled network.