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Use of Multicast Across Inter-Domain Peering Points
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Abstract

This document examines the use of Source Specific Multicast (SSM) across inter-domain peering points for a specified set of deployment scenarios. The objective is to describe the setup process for multicast-based delivery across administrative domains for these scenarios and document supporting functionality to enable this process.

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1. Introduction

Several types of applications (e.g., live video streaming, software downloads) are well suited for delivery via multicast means. The use of multicast for delivering such applications offers significant savings for utilization of resources in any given administrative domain. End user demand for such applications is growing. Often, this requires transporting such applications across administrative domains via inter-domain peering points.

The objective of this Best Current Practices document is twofold:

- Describe the technical process and establish guidelines for setting up multicast-based delivery of applications across inter-domain peering points via a set of use cases.
- Catalog all required information exchange between the administrative domains to support multicast-based delivery. This enables operators to initiate necessary processes to support inter-domain peering with multicast.

The scope and assumptions for this document are stated as follows:

- For the purpose of this document, the term "peering point" refers to an interface between two networks/administrative domains over which traffic is exchanged between them. A Network-Network Interface (NNI) is an example of a peering point.
- Administrative Domain 1 (AD-1) is enabled with native multicast. A peering point exists between AD-1 and AD-2.

- It is understood that several protocols are available for this purpose including PIM-SM [RFC4609], Protocol Independent Multicast - Source Specific Multicast (PIM-SSM) [RFC7761], Internet Group Management Protocol (IGMP) [RFC3376], and Multicast Listener Discovery (MLD) [RFC3810].

- As described in Section 2, the source IP address of the multicast stream in the originating AD (AD-1) is known. Under this condition, PIM-SSM use is beneficial as it allows the receiver's upstream router to directly send a JOIN message to the source without the need of invoking an intermediate Rendezvous Point (RP). Use of SSM also presents an improved threat mitigation profile against attack, as described in [RFC4609]. Hence, in the case of inter-domain peering, it is recommended to use only SSM protocols; the setup of inter-domain peering for ASM (Any-Source Multicast) is not in scope for this document.
- AD-1 and AD-2 are assumed to adopt compatible protocols. The use of different protocols is beyond the scope of this document.
- An Automatic Multicast Tunnel (AMT) [RFC7450] is setup at the peering point if either the peering point or AD-2 is not multicast enabled. It is assumed that an AMT Relay will be available to a client for multicast delivery. The selection of an optimal AMT relay by a client is out of scope for this document. Note that AMT use is necessary only when native multicast is unavailable in the peering point (Use Case 3.3) or in the downstream administrative domain (Use Cases 3.4, and 3.5).
- The collection of billing data is assumed to be done at the application level and is not considered to be a networking issue. The settlements process for end user billing and/or inter-provider billing is out of scope for this document.
- Inter-domain network connectivity troubleshooting is only considered within the context of a cooperative process between the two domains.

Thus, the primary purpose of this document is to describe a scenario where two ADs interconnect via a direct connection to each other. Security and operational aspects for exchanging traffic on a public Internet Exchange Point (IXP) with a large shared broadcast domain between many operators, is not in scope for this document.

This document also attempts to identify ways by which the peering process can be improved. Development of new methods for improvement is beyond the scope of this document.

2. Overview of Inter-domain Multicast Application Transport

A multicast-based application delivery scenario is as follows:

- Two independent administrative domains are interconnected via a peering point.
- The peering point is either multicast enabled (end-to-end native multicast across the two domains) or it is connected by one of two possible tunnel types:
  - A Generic Routing Encapsulation (GRE) Tunnel [RFC2784] allowing multicast tunneling across the peering point, or
  - An Automatic Multicast Tunnel (AMT) [RFC7450].
- The application stream originates at a source in Domain 1. The source IP address is known.
- An End User associated with Domain 2 requests the application. It is assumed that the application is suitable for delivery via multicast means (e.g., live steaming of major events, software downloads to large numbers of end user devices, etc.)
- The request is communicated to the application source which provides the relevant multicast delivery information to the EU device. This information is in the form of appropriate metadata. At a minimum, this metadata includes the {Source, Group} or (S,G) information relevant to the multicast stream. It may also contain additional information that the application client can use to locate the source and join the stream. The delivery method by which the source transmits this information is determined via arrangements between the source and the two Administrative Domains. The description of the delivery method and the format of the metadata is out of scope for this document.
- The application client in the EU device then joins the multicast stream distributed by the application source in domain 1 utilizing the (S,G) information provided in the manifest file.

Note that domain 2 may be an independent network domain (e.g., Tier 1 network operator domain) or it could also be an Enterprise network operated by a single customer. The peering point architecture and

requirements may have some unique aspects associated with the Enterprise case.

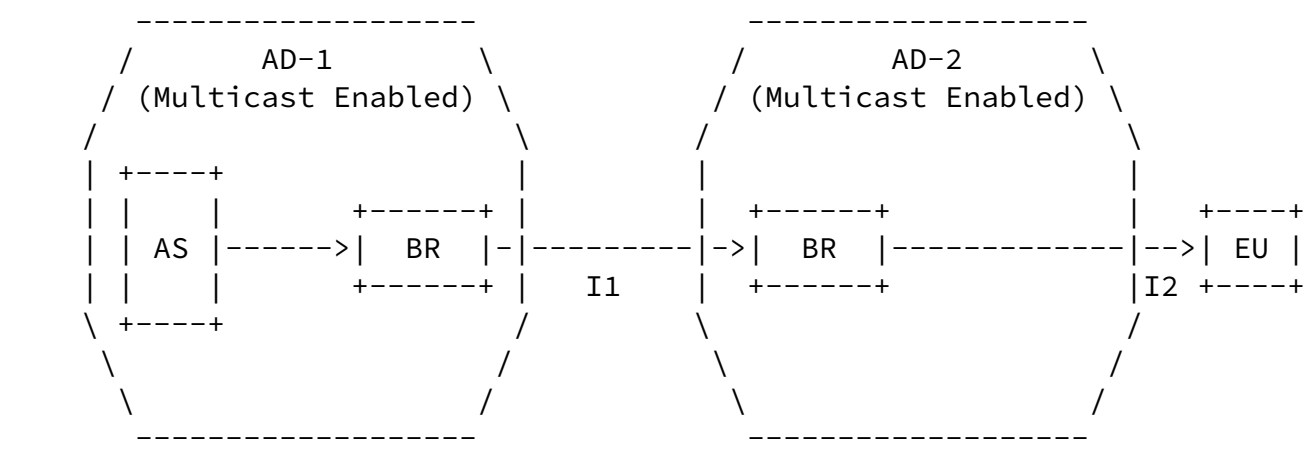
The Use Cases describing various architectural configurations for the multicast distribution along with associated requirements is described in section 3. Unique aspects related to the Enterprise network possibility will be described in this section. A comprehensive list of pertinent information that needs to be exchanged between the two domains to support various functions enabling the application transport is provided in section 4.

3. Inter-domain Peering Point Requirements for Multicast

The transport of applications using multicast requires that the inter-domain peering point is enabled to support such a process. There are five possible Use Cases for consideration.

3.1. Native Multicast

This Use Case involves end-to-end Native Multicast between the two administrative domains and the peering point is also native multicast enabled - Figure 1.



AD = Administrative Domain (Independent Autonomous System)

AS = Application (e.g., Content) Multicast Source
BR = Border Router
I1 = AD-1 and AD-2 Multicast Interconnection (e.g., MBGP)
I2 = AD-2 and EU Multicast Connection

Figure 1 - Content Distribution via End to End Native Multicast

Advantages of this configuration are:

- o Most efficient use of bandwidth in both domains.
- o Fewer devices in the path traversed by the multicast stream when compared to unicast transmissions.

From the perspective of AD-1, the one disadvantage associated with native multicast into AD-2 instead of individual unicast to every EU in AD-2 is that it does not have the ability to count the number of End Users as well as the transmitted bytes delivered to them. This information is relevant from the perspective of customer billing and operational logs. It is assumed that such data will be collected by the application layer. The application layer mechanisms for generating this information need to be robust enough such that all pertinent requirements for the source provider and the AD operator are satisfactorily met. The specifics of these methods are beyond the scope of this document.

Architectural guidelines for this configuration are as follows:

a. Dual homing for peering points between domains is recommended as a way to ensure reliability with full BGP table visibility.

b. If the peering point between AD-1 and AD-2 is a controlled network environment, then bandwidth can be allocated accordingly by the two domains to permit the transit of non-rate adaptive multicast traffic. If this is not the case, then it is recommended that the multicast traffic should support rate-adaption.

c. The sending and receiving of multicast traffic between two domains is typically determined by local policies associated with each domain. For example, if AD-1 is a service provider and AD-2 is an enterprise, then AD-1 may support local policies for traffic

delivery to, but not traffic reception from AD-2. Another example is the use of a policy by which AD-1 delivers specified content to AD-2 only if such delivery has been accepted by contract.

d. Relevant information on multicast streams delivered to End Users in AD-2 is assumed to be collected by available capabilities in the application layer. The precise nature and formats of the collected information will be determined by directives from the source owner and the domain operators.

e. The interconnection of AD-1 and AD-2 should minimally follow guidelines for traffic filtering between autonomous systems

[BCP38]. Filtering guidelines specific to the multicast control-plane and data-plane are described in section 6.

3.2. Peering Point Enabled with GRE Tunnel

The peering point is not native multicast enabled in this Use Case. There is a Generic Routing Encapsulation Tunnel provisioned over the peering point. In this case, the interconnection I1 between AD-1 and AD-2 in Figure 1 is multicast enabled via a Generic Routing Encapsulation Tunnel (GRE) [RFC2784] and encapsulating the multicast protocols across the interface. The routing configuration is basically unchanged: Instead of BGP (SAFI2) across the native IP multicast link between AD-1 and AD-2, BGP (SAFI2) is now run across the GRE tunnel.

Advantages of this configuration:

- Highly efficient use of bandwidth in both domains although not as efficient as the fully native multicast Use Case.
- Fewer devices in the path traversed by the multicast stream when compared to unicast transmissions.
- Ability to support only partial IP multicast deployments in AD-1 and/or AD-2.
- GRE is an existing technology and is relatively simple to

implement.

Disadvantages of this configuration:

- o Per Use Case 3.1, current router technology cannot count the number of end users or the number bytes transmitted.
- o GRE tunnel requires manual configuration.
- o The GRE must be established prior to stream starting.
- o The GRE tunnel is often left pinned up.

Architectural guidelines for this configuration include the following:

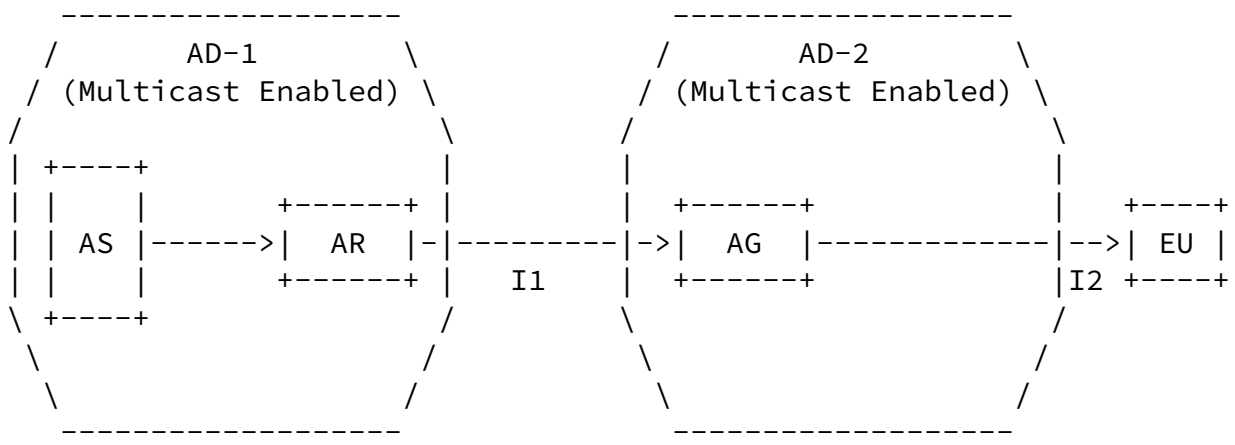
Guidelines (a) through (d) are the same as those described in Use Case 3.1. Two additional guidelines are as follows:

e. GRE tunnels are typically configured manually between peering points to support multicast delivery between domains.

f. It is recommended that the GRE tunnel (tunnel server) configuration in the source network is such that it only advertises the routes to the application sources and not to the entire network. This practice will prevent unauthorized delivery of applications through the tunnel (e.g., if application - e.g., content - is not part of an agreed inter-domain partnership).

3.3. Peering Point Enabled with an AMT - Both Domains Multicast Enabled

Both administrative domains in this Use Case are assumed to be native multicast enabled here; however the peering point is not. The peering point is enabled with an Automatic Multicast Tunnel. The basic configuration is depicted in Figure 2.



AR = AMT Relay
AG = AMT Gateway
I1 = AMT Interconnection between AD-1 and AD-2
I2 = AD-2 and EU Multicast Connection

Figure 2 - AMT Interconnection between AD-1 and AD-2

Advantages of this configuration:

- o Highly efficient use of bandwidth in AD-1.
- o AMT is an existing technology and is relatively simple to implement. Attractive properties of AMT include the following:
  - o Dynamic interconnection between Gateway-Relay pair across the peering point.
  - o Ability to serve clients and servers with differing policies.

Disadvantages of this configuration:

- o Per Use Case 3.1 (AD-2 is native multicast), current router technology cannot count the number of end users or the number of bytes transmitted to all end users.
- o Additional devices (AMT Gateway and Relay pairs) may be introduced into the path if these services are not incorporated in the existing routing nodes.

o Currently undefined mechanisms for the AG to automatically select the optimal AR.

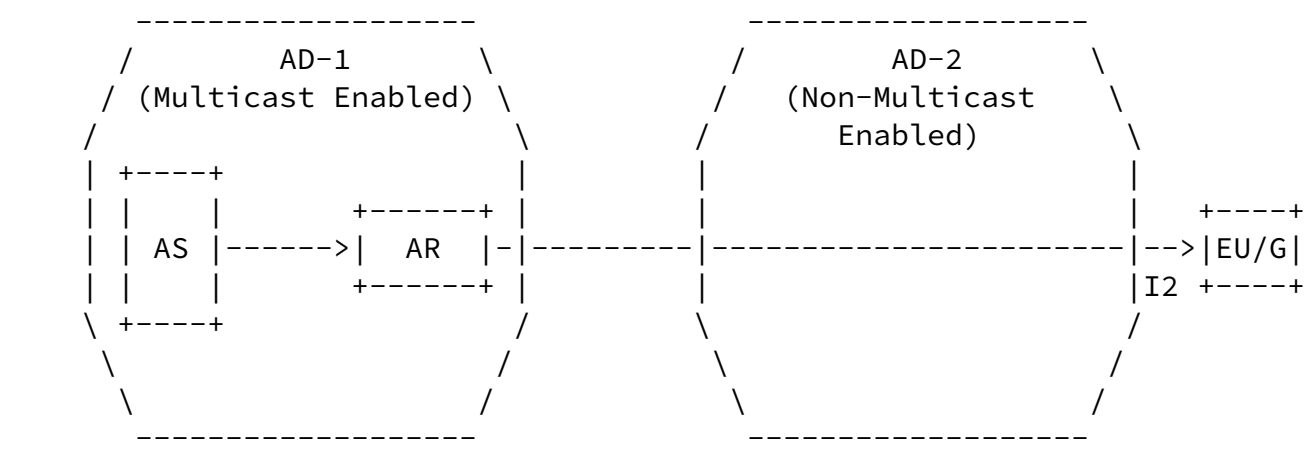
Architectural guidelines for this configuration are as follows:

Guidelines (a) through (d) are the same as those described in Use Case 3.1. In addition,

e. It is recommended that AMT Relay and Gateway pairs be configured at the peering points to support multicast delivery between domains. AMT tunnels will then configure dynamically across the peering points once the Gateway in AD-2 receives the (S, G) information from the EU.

3.4. Peering Point Enabled with an AMT - AD-2 Not Multicast Enabled

In this AMT Use Case, the second administrative domain AD-2 is not multicast enabled. This implies that the interconnection between AD-2 and the End User is also not multicast enabled as depicted in Figure 3.



AS = Application Multicast Source

AR = AMT Relay
EU/G = Gateway client embedded in EU device
I2 = AMT Tunnel Connecting EU/G to AR in AD-1 through Non-Multicast Enabled AD-2.

Figure 3 - AMT Tunnel Connecting AD-1 AMT Relay and EU Gateway

This Use Case is equivalent to having unicast distribution of the application through AD-2. The total number of AMT tunnels would be equal to the total number of End Users requesting the application. The peering point thus needs to accommodate the total number of AMT tunnels between the two domains. Each AMT tunnel can provide the data usage associated with each End User.

Advantages of this configuration:

- Highly efficient use of bandwidth in AD-1.
- AMT is an existing technology and is relatively simple to implement. Attractive properties of AMT include the following:
  - Dynamic interconnection between Gateway-Relay pair across the peering point.
  - Ability to serve clients and servers with differing policies.
- Each AMT tunnel serves as a count for each End User and is also able to track data usage (bytes) delivered to the EU.

Disadvantages of this configuration:

- Additional devices (AMT Gateway and Relay pairs) are introduced into the transport path.
- Assuming multiple peering points between the domains, the EU Gateway needs to be able to find the "correct" AMT Relay in AD-1.

Architectural guidelines for this configuration are as follows:

Guidelines (a) through (c) are the same as those described in Use

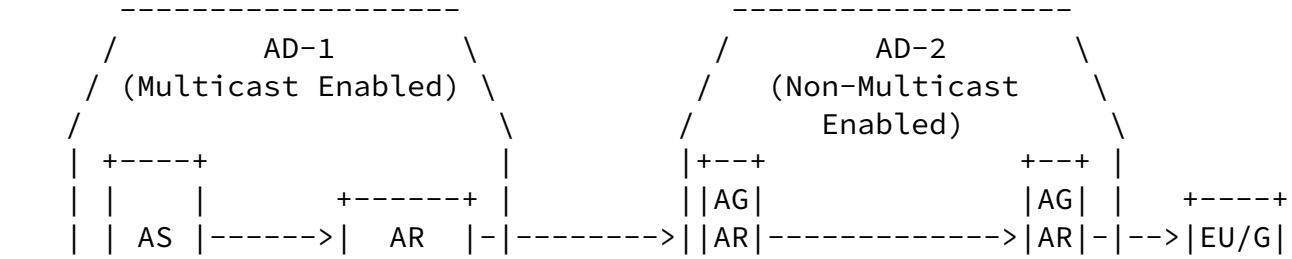
Case 3.1.

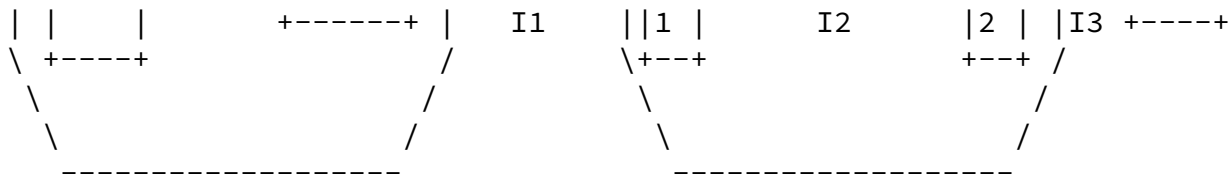
d. It is recommended that proper procedures are implemented such that the AMT Gateway at the End User device is able to find the correct AMT Relay in AD-1 across the peering points. The application client in the EU device is expected to supply the (S, G) information to the Gateway for this purpose.

e. The AMT tunnel capabilities are expected to be sufficient for the purpose of collecting relevant information on the multicast streams delivered to End Users in AD-2.

3.5. AD-2 Not Multicast Enabled - Multiple AMT Tunnels Through AD-2

This is a variation of Use Case 3.4 as follows:





AS = Application Source
AR = AMT Relay in AD-1
AGAR1 = AMT Gateway/Relay node in AD-2 across Peering Point
I1 = AMT Tunnel Connecting AR in AD-1 to GW in AGAR1 in AD-2
AGAR2 = AMT Gateway/Relay node at AD-2 Network Edge
I2 = AMT Tunnel Connecting Relay in AGAR1 to GW in AGAR2
EU/G = Gateway client embedded in EU device
I3 = AMT Tunnel Connecting EU/G to AR in AGAR2

Figure 4 - AMT Tunnel Connecting AD-1 AMT Relay and EU Gateway

Use Case 3.4 results in several long AMT tunnels crossing the entire network of AD-2 linking the EU device and the AMT Relay in AD-1 through the peering point. Depending on the number of End Users, there is a likelihood of an unacceptably large number of AMT tunnels - and unicast streams - through the peering point. This situation can be alleviated as follows:

- o Provisioning of strategically located AMT nodes at the edges of AD-2. An AMT node comprises co-location of an AMT Gateway and an AMT Relay. One such node is at the AD-2 side of the peering point (node AGAR1 in Figure 4).

- o Single AMT tunnel established across peering point linking AMT Relay in AD-1 to the AMT Gateway in the AMT node AGAR1 in AD-2.

- o AMT tunnels linking AMT node AGAR1 at peering point in AD-2 to other AMT nodes located at the edges of AD-2: e.g., AMT tunnel I2

linking AMT Relay in AGAR1 to AMT Gateway in AMT node AGAR2 in Figure 4.

- o AMT tunnels linking EU device (via Gateway client embedded in

device) and AMT Relay in appropriate AMT node at edge of AD-2: e.g., I3 linking EU Gateway in device to AMT Relay in AMT node AGAR2.

The advantage for such a chained set of AMT tunnels is that the total number of unicast streams across AD-2 is significantly reduced thus freeing up bandwidth. Additionally, there will be a single unicast stream across the peering point instead of possibly, an unacceptably large number of such streams per Use Case 3.4. However, this implies that several AMT tunnels will need to be dynamically configured by the various AMT Gateways based solely on the (S,G) information received from the application client at the EU device. A suitable mechanism for such dynamic configurations is therefore critical.

Architectural guidelines for this configuration are as follows:

Guidelines (a) through (c) are the same as those described in Use Case 3.1.

d. It is recommended that proper procedures are implemented such that the various AMT Gateways (at the End User devices and the AMT nodes in AD-2) are able to find the correct AMT Relay in other AMT nodes as appropriate. The application client in the EU device is expected to supply the (S, G) information to the Gateway for this purpose.

e. The AMT tunnel capabilities are expected to be sufficient for the purpose of collecting relevant information on the multicast streams delivered to End Users in AD-2.

4. Supporting Functionality

Supporting functions and related interfaces over the peering point that enable the multicast transport of the application are listed in this section. Critical information parameters that need to be exchanged in support of these functions are enumerated along with guidelines as appropriate. Specific interface functions for consideration are as follows.

4.1. Network Interconnection Transport and Security Guidelines

The term "Network Interconnection Transport" refers to the interconnection points between the two Administrative Domains. The following is a representative set of attributes that will need to be agreed to between the two administrative domains to support multicast delivery.

- Number of Peering Points.
- Peering Point Addresses and Locations.
- Connection Type - Dedicated for Multicast delivery or shared with other services.
- Connection Mode - Direct connectivity between the two AD's or via another ISP.
- Peering Point Protocol Support - Multicast protocols that will be used for multicast delivery will need to be supported at these points. Examples of protocols include eBGP [RFC4271] and MBGP [RFC4271].
- Bandwidth Allocation - If shared with other services, then there needs to be a determination of the share of bandwidth reserved for multicast delivery. When determining the appropriate bandwidth allocation, parties should consider that design of a multicast protocol suitable for live video streaming which is consistent with Congestion Control Principles [BCP41], especially in the presence of potentially malicious receivers, is still an open research problem.
- QoS Requirements - Delay/latency specifications that need to be specified in an SLA.
- AD Roles and Responsibilities - the role played by each AD for provisioning and maintaining the set of peering points to support multicast delivery.

4.2. Routing Aspects and Related Guidelines

The main objective for multicast delivery routing is to ensure that the End User receives the multicast stream from the "most optimal" source [INF_ATIS_10] which typically:

- Maximizes the multicast portion of the transport and minimizes any unicast portion of the delivery, and

- Minimizes the overall combined network(s) route distance.

This routing objective applies to both Native and AMT; the actual methodology of the solution will be different for each. Regardless, the routing solution is expected to be:

- Scalable,

- Avoid/minimize new protocol development or modifications, and

- Be robust enough to achieve high reliability and automatically adjust to changes/problems in the multicast infrastructure.

For both Native and AMT environments, having a source as close as possible to the EU network is most desirable; therefore, in some cases, an AD may prefer to have multiple sources near different peering points, but that is entirely an implementation issue.

4.2.1 Native Multicast Routing Aspects

Native multicast simply requires that the Administrative Domains coordinate and advertise the correct source address(es) at their network interconnection peering points(i.e., border routers). An example of multicast delivery via a Native Multicast process across two administrative Domains is as follows assuming that the interconnecting peering points are also multicast enabled:

- Appropriate information is obtained by the EU client who is a subscriber to AD-2 (see Use Case 3.1). This information is in the form of metadata and it contains instructions directing the EU client to launch an appropriate application if necessary, and also additional information for the application about the source location and the group (or stream) id in the form of the "S,G" data. The "S" portion provides the name or IP address of the source of the multicast stream. The metadata may also contain alternate delivery information such as specifying the unicast address of the stream.

- The client uses the join message with S,G to join the multicast stream [RFC4604].

To facilitate this process, the two AD's need to do the following:

- o Advertise the source id(s) over the Peering Points.
- o Exchange relevant Peering Point information such as Capacity and Utilization.
- o Implement compatible multicast protocols to ensure proper multicast delivery across the peering points.

4.2.2 GRE Tunnel over Interconnecting Peering Point

If the interconnecting peering point is not multicast enabled and both ADs are multicast enabled, then a simple solution is to provision a GRE tunnel between the two ADs - see Use Case 3.2.2. The termination points of the tunnel will usually be a network engineering decision, but generally will be between the border routers or even between the AD 2 border router and the AD 1 source (or source access router). The GRE tunnel would allow end-to-end native multicast or AMT multicast to traverse the interface. Coordination and advertisement of the source IP is still required.

The two AD's need to follow the same process as described in 4.2.1 to facilitate multicast delivery across the Peering Points.

4.2.3 Routing Aspects with AMT Tunnels

Unlike Native (with or without GRE), an AMT Multicast environment is more complex. It presents a dual layered problem because there are two criteria that should be simultaneously met:

- o Find the closest AMT relay to the end-user that also has multicast connectivity to the content source, and
- o Minimize the AMT unicast tunnel distance.

There are essentially two components to the AMT specification:

- o AMT Relays: These serve the purpose of tunneling UDP multicast traffic to the receivers (i.e., End Points). The AMT Relay will receive the traffic natively from the multicast media source and will replicate the stream on behalf of the downstream AMT Gateways, encapsulating the multicast packets into unicast packets and sending them over the tunnel toward the AMT Gateway.

In addition, the AMT Relay may perform various usage and activity statistics collection. This results in moving the replication point closer to the end user, and cuts down on

traffic across the network. Thus, the linear costs of adding unicast subscribers can be avoided. However, unicast replication is still required for each requesting endpoint within the unicast-only network.

- o AMT Gateway (GW): The Gateway will reside on an on End-Point - this may be a Personal Computer (PC) or a Set Top Box (STB). The AMT Gateway receives join and leave requests from the Application via an Application Programming Interface (API). In this manner, the Gateway allows the endpoint to conduct itself as a true Multicast End-Point. The AMT Gateway will encapsulate AMT messages into UDP packets and send them through a tunnel (across the unicast-only infrastructure) to the AMT Relay.

The simplest AMT Use Case (section 3.3) involves peering points that are not multicast enabled between two multicast enabled ADs. An AMT tunnel is deployed between an AMT Relay on the AD 1 side of the peering point and an AMT Gateway on the AD 2 side of the peering point. One advantage to this arrangement is that the tunnel is established on an as needed basis and need not be a provisioned element. The two ADs can coordinate and advertise special AMT Relay Anycast addresses with each other - though they may alternately decide to simply provision Relay addresses, though this would not be an optimal solution in terms of scalability.

Use Cases 3.4 and 3.5 describe more complicated AMT situations as AD-2 is not multicast enabled. For these cases, the End User device needs to be able to setup an AMT tunnel in the most optimal manner. Using an Anycast IP address for AMT Relays allows for all AMT Gateways to find the "closest" AMT Relay - the nearest edge of the multicast topology of the source. An example of a basic delivery via an AMT Multicast process for these two Use Cases is as follows:

- o Appropriate metadata is obtained by the EU client application. The metadata contains instructions directing the EU client to an ordered list of particular destinations to seek the requested stream and, for multicast, specifies the source location and the group (or stream) ID in the form of the "S,G" data. The "S"

portion provides the URI (name or IP address) of the source of the multicast stream and the "G" identifies the particular stream originated by that source. The metadata may also contain alternate delivery information such as the address of the unicast form of the content to be used, for example, if the multicast stream becomes unavailable.

- o Using the information from the metadata, and possibly information provisioned directly in the EU client, a DNS query is initiated in order to connect the EU client/AMT Gateway to an AMT Relay.

- o Query results are obtained, and may return an Anycast address or a specific unicast address of a relay. Multiple relays will typically exist. The Anycast address is a routable "pseudo-address" shared among the relays that can gain multicast access to the source.

- o If a specific IP address unique to a relay was not obtained, the AMT Gateway then sends a message (e.g., the discovery message) to the Anycast address such that the network is making the routing choice of particular relay - e.g., closest relay to the EU. (Note that in IPv6 there is a specific Anycast format and Anycast is inherent in IPv6 routing, whereas in IPv4 Anycast is handled via provisioning in the network. Details are out of scope for this document.)

- o The contacted AMT Relay then returns its specific unicast IP address (after which the Anycast address is no longer required). Variations may exist as well.

- o The AMT Gateway uses that unicast IP address to initiate a three-way handshake with the AMT Relay.

- o AMT Gateway provides "S,G" to the AMT Relay (embedded in AMT protocol messages).

- o AMT Relay receives the "S,G" information and uses the S,G to join the appropriate multicast stream, if it has not already subscribed to that stream.

o AMT Relay encapsulates the multicast stream into the tunnel between the Relay and the Gateway, providing the requested content to the EU.

Note: Further routing discussion on optimal method to find "best AMT Relay/GW combination" and information exchange between AD's to be provided.

4.3. Back Office Functions - Provisioning and Logging Guidelines

Back Office refers to the following:

o Servers and Content Management systems that support the delivery of applications via multicast and interactions between ADs.
o Functionality associated with logging, reporting, ordering, provisioning, maintenance, service assurance, settlement, etc.

4.3.1 Provisioning Guidelines

Resources for basic connectivity between ADs Providers need to be provisioned as follows:

o Sufficient capacity must be provisioned to support multicast-based delivery across ADs.
o Sufficient capacity must be provisioned for connectivity between all supporting back-offices of the ADs as appropriate. This includes activating proper security treatment for these back-office connections (gateways, firewalls, etc) as appropriate.
o Routing protocols as needed, e.g. configuring routers to support these.

Provisioning aspects related to Multicast-Based inter-domain delivery are as follows.

The ability to receive requested application via multicast is triggered via receipt of the necessary metadata. Hence, this metadata must be provided to the EU regarding multicast URL - and unicast fallback if applicable. AD-2 must enable the delivery of this metadata to the EU and provision appropriate resources for this

purpose.

Native multicast functionality is assumed to be available across many ISP backbones, peering and access networks. If however, native multicast is not an option (Use Cases 3.4 and 3.5), then:

- o EU must have multicast client to use AMT multicast obtained either from Application Source (per agreement with AD-1) or from AD-1 or AD-2 (if delegated by the Application Source).
- o If provided by AD-1/AD-2, then the EU could be redirected to a client download site (note: this could be an Application Source site). If provided by the Application Source, then this Source would have to coordinate with AD-1 to ensure the proper client is provided (assuming multiple possible clients).

- o Where AMT Gateways support different application sets, all AD-2 AMT Relays need to be provisioned with all source & group addresses for streams it is allowed to join.
- o DNS across each AD must be provisioned to enable a client GW to locate the optimal AMT Relay (i.e. longest multicast path and shortest unicast tunnel) with connectivity to the content's multicast source.

Provisioning Aspects Related to Operations and Customer Care are stated as follows.

Each AD provider is assumed to provision operations and customer care access to their own systems.

AD-1's operations and customer care functions must have visibility to what is happening in AD-2's network or to the service provided by AD-2, sufficient to verify their mutual goals and operations, e.g. to know how the EU's are being served. This can be done in two ways:

- o Automated interfaces are built between AD-1 and AD-2 such that operations and customer care continue using their own systems. This requires coordination between the two AD's with appropriate provisioning of necessary resources.
- o AD-1's operations and customer care personnel are provided access directly to AD-2's system. In this scenario, additional provisioning in these systems will be needed to provide necessary access.

Additional provisioning must be agreed to by the two AD-2s to support this option.

4.3.2 Application Accounting Guidelines

All interactions between pairs of ADs can be discovered and/or be associated with the account(s) utilized for delivered applications. Supporting guidelines are as follows:

- A unique identifier is recommended to designate each master account.
- AD-2 is expected to set up "accounts" (logical facility generally protected by login/password/credentials) for use by AD-1. Multiple accounts and multiple types/partitions of accounts can apply, e.g. customer accounts, security accounts, etc.

4.3.3 Log Management Guidelines

Successful delivery of applications via multicast between pairs of interconnecting ADs requires that appropriate logs will be exchanged between them in support. Associated guidelines are as follows.

AD-2 needs to supply logs to AD-1 per existing contract(s). Examples of log types include the following:

- Usage information logs at aggregate level.
- Usage failure instances at an aggregate level.
- Grouped or sequenced application access. performance/behavior/failure at an aggregate level to support potential Application Provider-driven strategies. Examples of aggregate levels include grouped video clips, web pages, and sets of software download.
- Security logs, aggregated or summarized according to agreement (with additional detail potentially provided during security events, by agreement).
- Access logs (EU), when needed for troubleshooting.
- Application logs (what is the application doing), when needed for shared troubleshooting.
- Syslogs (network management), when needed for shared troubleshooting.

The two ADs may supply additional security logs to each other as agreed to by contract(s). Examples include the following:

- o Information related to general security-relevant activity which may be of use from a protective or response perspective, such as types and counts of attacks detected, related source information, related target information, etc.
- o Aggregated or summarized logs according to agreement (with additional detail potentially provided during security events, by agreement).

4.4. Operations - Service Performance and Monitoring Guidelines

Service Performance refers to monitoring metrics related to multicast delivery via probes. The focus is on the service provided by AD-2 to AD-1 on behalf of all multicast application sources (metrics may be specified for SLA use or otherwise). Associated guidelines are as follows:

- o Both AD's are expected to monitor, collect, and analyze service performance metrics for multicast applications. AD-2 provides relevant performance information to AD-1; this enables AD-1 to create an end-to-end performance view on behalf of the multicast application source.

- o Both AD's are expected to agree on the type of probes to be used to monitor multicast delivery performance. For example, AD-2 may permit AD-1's probes to be utilized in the AD-2 multicast service footprint. Alternately, AD-2 may deploy its own probes and relay performance information back to AD-1.

- o In the event of performance degradation (SLA violation), AD-1 may have to compensate the multicast application source per SLA agreement. As appropriate, AD-1 may seek compensation from AD-2 if the cause of the degradation is in AD-2's network.

Service Monitoring generally refers to a service (as a whole) provided on behalf of a particular multicast application source provider. It thus involves complaints from End Users when service problems occur. EU's direct their complaints to the source provider; in turn the source provider submits these complaints to AD-1. The

responsibility for service delivery lies with AD-1; as such AD-1 will need to determine where the service problem is occurring - its own network or in AD-2. It is expected that each AD will have tools to monitor multicast service status in its own network.

- Both AD's will determine how best to deploy multicast service monitoring tools. Typically, each AD will deploy its own set of monitoring tools; in which case, both AD's are expected to inform each other when multicast delivery problems are detected.

- AD-2 may experience some problems in its network. For example, for the AMT Use Cases, one or more AMT Relays may be experiencing difficulties. AD-2 may be able to fix the problem by rerouting the multicast streams via alternate AMT Relays. If the fix is not successful and multicast service delivery degrades, then AD-2 needs to report the issue to AD-1.

- When problem notification is received from a multicast application source, AD-1 determines whether the cause of the problem is within its own network or within the AD-2 domain. If the cause is within the AD-2 domain, then AD-1 supplies all

necessary information to AD-2. Examples of supporting information include the following:

  - Kind of problem(s).

  - Starting point & duration of problem(s).

  - Conditions in which problem(s) occur.

  - IP address blocks of affected users.

  - ISPs of affected users.

  - Type of access e.g., mobile versus desktop.

  - Locations of affected EUs.

- Both AD's conduct some form of root cause analysis for multicast service delivery problems. Examples of various factors for consideration include:

- Verification that the service configuration matches the product features.

- Correlation and consolidation of the various customer problems and resource troubles into a single root service problem.

- Prioritization of currently open service problems, giving consideration to problem impact, service level agreement, etc.

- Conduction of service tests, including one time tests or a series of tests over a period of time.

- Analysis of test results.

- Analysis of relevant network fault or performance data.

- Analysis of the problem information provided by the customer (CP).

- Once the cause of the problem has been determined and the problem has been fixed, both AD's need to work jointly to verify and validate the success of the fix.

- Faults in service could lead to SLA violation for which the multicast application source provider may have to be compensated by AD-1. Subsequently, AD-1 may have to be compensated by AD-2 based on the contract.

4.5. Client Reliability Models/Service Assurance Guidelines

There are multiple options for instituting reliability architectures, most are at the application level. Both AD's should work those out with their contract/agreement and with the multicast application source providers.

Network reliability can also be enhanced by the two AD's by provisioning alternate delivery mechanisms via unicast means.

5. Troubleshooting and Diagnostics

Any service provider supporting multicast delivery of content should have the capability to collect diagnostics as part of multicast troubleshooting practices and resolve network issues accordingly. Issues may become apparent or identified either through network monitoring functions or by customer reported problems as described in section 4.4.

It is expected that multicast diagnostics will be collected according to currently established practices [MDH-04]. However, given that inter-domain creates a significant interdependence of proper networking functionality between providers there does exist a need for providers to be able to signal/alert each other if there are any issues noted by either one.

Service providers may also wish to allow limited read-only administrative access to their routers via a looking-glass style router proxy to facilitate the debugging of multicast control state and peering status. Software implementations for this purpose is readily available [Traceroute], [draft-MTraceroute] and can be easily extended to provide access to commonly-used multicast troubleshooting commands in a secure manner.

The specifics of the notification and alerts are beyond the scope of this document, but general guidelines are similar to those described in section 4.4 (Service Performance and Monitoring). Some general communications issues are stated as follows.

- Appropriate communications channels will be established between the customer service and operations groups from both AD's to

facilitate information sharing related to diagnostic troubleshooting.

- A default resolution period may be considered to resolve open issues. Alternately, mutually acceptable resolution periods could be established depending on the severity of the identified trouble.

6. Security Considerations

From a security perspective, normal security procedures are expected to be followed by each AD to facilitate multicast delivery to

registered and authenticated end users. Additionally:

- Encryption - Peering point links may be encrypted per agreement if dedicated for multicast delivery.

- Security Breach Mitigation Plan - In the event of a security breach, the two AD's are expected to have a mitigation plan for shutting down the peering point and directing multicast traffic over alternated peering points. It is also expected that appropriate information will be shared for the purpose of securing the identified breach.

DRM and Application Accounting, Authorization and Authentication should be the responsibility of the multicast application source provider and/or AD-1. AD-1 needs to work out the appropriate agreements with the source provider.

Network has no DRM responsibilities, but might have authentication and authorization obligations. These though are consistent with normal operations of a CDN to insure end user reliability, security and network security.

AD-1 and AD-2 should have mechanisms in place to ensure proper accounting for the volume of bytes delivered through the peering point and separately the number of bytes delivered to EUs. For example, [BCP38] style filtering could be deployed by both AD's to ensure that only legitimately sourced multicast content is exchanged between them.

Authentication and authorization of EU to receive multicast content is done at the application layer between the client application and the source. This may involve some kind of token authentication and is done at the application layer independently of the two AD's. If there are problems related to failure of token authentication when

end-users are supported by AD-2, then some means of validating proper working of the token authentication process (e.g., back-end servers querying the multicast application source provider's token authentication server are communicating properly) should be considered. Implementation details are beyond the scope of this document.

7. IANA Considerations

8. Conclusions

This Best Current Practice document provides detailed Use Case scenarios for the transmission of applications via multicast across peering points between two Administrative Domains. A detailed set of guidelines supporting the delivery is provided for all Use Cases.

For Use Cases involving AMT tunnels (cases 3.4 and 3.5), it is recommended that proper procedures are implemented such that the various AMT Gateways (at the End User devices and the AMT nodes in AD-2) are able to find the correct AMT Relay in other AMT nodes as appropriate. Section 4.3 provides an overview of one method that finds the optimal Relay-Gateway combination via the use of an Anycast IP address for AMT Relays.

9. References

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10. Acknowledgments

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