Networks ready for video

Multicast VPN
- live demo

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Agenda

- Multicast routing - PIM
- MVPN – PIM
- MVPN - MPLS
Multicast Routing
- PIM
Multicast Distribution Trees

Shortest Path or Source Tree

Notation: \((S, G)\)
- \(S\) = Source
- \(G\) = Group

Source 1

Source 2

Receiver 1

Receiver 2

Most often used for video delivery
Multicast Distribution Trees

Shared Tree

Notation: (*, G)
* = All Sources
G = Group

Source 1

Receiver 1

Source 2

Receiver 2

PIM Rendezvous Point

Shared Tree

Source Tree
Anatomy of routing
show ip route

- Where is destination?
- Look in to destination address
- If it is not on outgoing interface
- Check all polices, routemaps, filters etc..
- Send!

R6#sh ip route
Gateway of last resort is not set
1.0.0.0/8 is variably subnetted, 14 subnets, 3 masks
0 routes from 0 networks
1.1.1.0/28 [110/2] via 1.6.7.7, 00:00:01, FastEthernet1/1
Anatomy of multicast routing

show ip mroute

- How to replicate
- Only 1 incoming interface
- Mcast packets entering on non defined interface are dropped

Router# show ip mroute

(10.20.1.15, 230.13.13.1), 00:14:31/00:01:40, flags:CJT
Incoming interface:GigabitEthernet4/8, RPF nbr 10.15.1.20, RPF-MFD

Outgoing interface list:
- GigabitEthernet4/9, Forward/Sparse-Dense, 00:14:31/00:00:00, H
- GigabitEthernet4/7, Forward/Sparse-Dense, 1d02h/00:02:39,H
Anatomy of multicast routing
Where to replicate – Outgoing list

- How to build Outgoing list
  - Manual configuration
  - IGMP requests
  - Multicast routing requests
Anatomy of multicast routing

Where send request to?

- We know who is interested (list of outgoing interfaces)
- We know what they want (S,G) (Source address, mcast Group address), alternatively we should assume RP

- Where to send request?
- Which interface should be declared Incoming?
Anatomy of multicast routing
Where send request to?

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- Where to send request?
- Which interface should be declared Incoming?

Hint: We know Source address! find the Source!!

Process of looking for the source in order to find incoming interface is called Reverse Path Forwarding check. (we are looking for path from which we are expecting traffic – reverse to unicast path forwarding)
The best way to find IP host in IP network is to use `ip routing table`!!
This method is routing protocol type independent thus the name Protocol Independent Multicast (but it is totally dependent on routing)
Routers are establishing peering

```
R7#sh ip pim neighbor
PIM Neighbor Table
Mode: B - Bidir Capable, DR - Designated Router, N - Default DR Priority,
P - Proxy Capable, S - State Refresh Capable
Neighbor Interface Uptime/Expires Ver DR
Address
1.6.7.6 FastEthernet1/0 02:15:29/00:01:30 v2 1 / S P
1.5.7.5 FastEthernet1/1 02:15:39/00:01:16 v2 1 / S P
```
PIM is easy to configure

- Assignee addresses
- Start routing
- Rest is auto-magic

- If host do not know the source (*,G) requests on IGMPv2 we might need to add mapping
- Otherwise requests go to RP

```plaintext
router ospf 1
  network x.y.0.0 area 0
ip multicast-routing
ip igmp ssm-map ...

interface A1
  ip address x.y.z1.1 Mask
  ip pim sparse-mode

interface B1
  ip address x.y.z2.2 Mask
  ip pim sparse-mode
```
PIM is easy to configure
But not trivial in operation

1. Establish peering and discovery neighbours
   Hello on local multicast address 224.0.0.13

2. Interact with IGMP

3. Build the tree
   Many different cases, e.g. common connection to L2 networks on routing side and receiver side,
   RP interaction, election/discovery, source registration (when RP),

L2 – connection:

Designated Router (DR) selection:
Who is the router sending IGMP queries, joins?
Automatic selection based on ip address (highest wins)
MVPN - PIM
MPLS use cases

- High scale virtualization
  - Separate traffic coming from different customers or services
  - VPNs

- Traffic engineering
  - Distribute traffic in desired pattern

- High Availability
  - Assure fast convergence (50ms)
Virtualization VPN’s Design

- Unicast VPNs

CE (Customer Edge)

PE (Provider Edge) service creation points and interconnection for CE

P (Provider) Routers – just interconnects PE

Traffic is send in ‘full mesh”

P Routers – minimum state to maintain, critical for network stability and scalability
Virtualization VPN’s Design

- **Unicast VPNs**

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  Works perfect but …

- **Send the same traffic to many neighbours (multicast)**
Virtualization VPN’s Design

- **Unicast VPNs**
  - PE service creation points
  - P Routers – just interconnects PE
  - Traffic is send in ‘full mesh’
  - P Routers – minimum state to maintain, critical for network stability and scalability
  - Works perfect but …

- **Send the same traffic to many neighbours (multicast)**

<table>
<thead>
<tr>
<th>Option A: Replicate and send on each virtual link</th>
<th>L2 VPN VPLS</th>
<th>☝️ Easy, P – routers not engaged ☻ Waste of bandwidth – not scalable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Option B: Engage P routers in multicast tree</td>
<td>L3 VPN</td>
<td>☃️ Scalability and efficiency ☀️ P routers participate, MPLS multicast was not ready for long time</td>
</tr>
</tbody>
</table>
Virtualization: VPN’s Design

Core engagement:

- Historically MPLS lacked multicast control functions
- Workaround:
  - Control plane? Use PIM for IP
  - MPLS Encapsulation? Use GRE (IP in IP - Generic Routing Encapsulation)
- Workaround proofed to be efficient and stayed many years
  - Most of the current mVPN deployments uses GRE
Virtualization: VPN’s Design

Core engagement:

- Types of MDT
  
  Default MDT – always present between all PEs belonging to specific VPN
  
  Data MDT – dynamically build between PEs sending high volume of traffic
  
  Private addresses space

- PE + P routers build the tree
- MDT (Multicast Distribution Tree)

```plaintext
(config)# ip vrf cisco
...
(config-vrf)# mdt default <a.b.c.d>
...
```
Virtualization: VPN’s Design

Core engagement:

- Default MDT could be seen as ‘broadcast interface’ – everything is send to other PEs
- If we need high volume traffic send to limited number of nodes we need to build Data MDT

```
(config)# ip vrf cisco
...
(config-vrf)# mdt data .... threshold 1 [list <acl>]
...
```
Multicast Tunnel summary
PIM Adjacencies

PE-P native multicast in core (Global PIM instance)
PE-CE in mVRF (Per VRF PIM instance)
PE-PE in mVRF via MT (Per VRF PIM instance)
MVPN Packet Encapsulation

Forwarding on the MDT uses GRE, C-packet becomes a P-Packet
- **P-Packet**
  - **S address** := PE’s BGP peering address
  - **G address** := MDT-Group address (Default or Data)
  - C-Packet IP TOS will be copied to P-Packet
  - MPLS labels are NOT used in core, only native multicast

But it is not about MPLS…….
MVPN – MPLS
No PIM in MPLS core
But we have to assure backward compatibility

Option A: Traffic Engineering RSVP-TE P2MP

Option B: LDP Extensions (mLDP)
Head-end Router PE5 sends three path messages (one per destination)
- First PATH message: PE5 -> P1 -> PE3
- Second PATH message: PE5 -> P1 -> PE4
- Third PATH message: PE5 -> PE2
Configuring P2MP TE at Head End (Cisco IOS)

```plaintext
ip multicast-routing
!
mls traffic-eng destination list name P2MP-LIST-DST1
  ip 172.16.255.1 path-option 10 explicit name PATH1
  ip 172.16.255.2 path-option 10 dynamic
  ip 172.16.255.3 path-option 10 dynamic
  ip 172.16.255.4 path-option 10 dynamic
!
interface Tunnel1
  description FROM-ROUTER-TO-LIST-DST1
  ip unnumbered Loopback0
  ip pim passive
  ip igmp static-group 232.0.0.1 source 192.168.5.1
  ip igmp static-group 232.0.0.2 source 192.168.5.1
  tunnel mode mpls traffic-eng point-to-multipoint
  tunnel destination list mpls traffic-eng name P2MP-LIST-DST1
  tunnel mpls traffic-eng priority 7 7
  tunnel mpls traffic-eng bandwidth 1000
!
interface Ethernet0/0
  ip address 192.168.5.1 255.255.255.252
  ip pim sparse-mode
!
ip pim ssm default
!
```

- **Enable IPv4 multicast routing**
- **Destination list with path-option per destination**
- **Tunnel as passive PIM interface (historical)**
- **Multicast groups mapped to tunnel**
- **P2MP TE Tunnel**
- **Tunnel destination list**
- **PIM sparse mode on non-MPLS interfaces**
- **Source-specific multicast with default addresses (232/8)**
Option B: mLDP configuration for mVPN

- Similar to PIM based mVPN

```
(config)# ip vrf cisco
...
(config-vrf)# mdt default mldp mp2mp <a.b.c.d>
(config-vrf)# mdt data mldp 100 threshold 1
...
```