Alternative architectures for Broadcast TV/Video Distribution in Metro Ethernet Networks

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Agenda

• L2 vs L3 for the aggregation
• Video Service and QOS Requirements
• Dual Stream Video Architecture
• Conclusion
L2 vs L3 for the aggregation
Why Layer 3 for Video in Distribution Network?

- Better ARP / Forwarding Adjacency Scaling
  - IP Aggregation Interface Requires 1 ARP + 1 Forwarding Entry / STB
  - Example Worst Case Numbers:
    - 400 Video Subscribers / DSLAM, 40 DSLAMs / PE-Agg
    - 10 PE-Agg / L3VPN-PE
  - L2 Aggregation Scaling == 160000 ARP + Forwarding Entries in N-PE
  - L3 Aggregation Scaling == 16000 ARP + Forwarding Entries in PE-Agg

- Simpler VLAN Topology
  - L2 Architecture Uses Separate Video VLAN per PE-Agg in Distribution
    - Needed Due to Bridge Table Scaling Issues in Distribution Network
    - Multicast VLAN Routing Needed to Reduce Multicast B/W in Distribution
  - L3 Architecture Uses Single Video VLAN in Distribution
    - No Bridge Tables in Distribution Network; No Scaling Issues
    - Unicast and Multicast Video Carried in same VLAN
Why Layer 3 for Video in Distribution Network?

• Enables IP Multicast Replication in Distribution Network
  IGMPv2 >> SSM Mapping in PE-Agg
  Source Based Replication (SSM) More Secure

• Enables Anycast for Multicast
  Supports Separate multicast trees for Redundant Encoders
  Allows Fast Fail Over of Redundant Encoders
  Fail Over Occurs within IP reconvergence time

• Enables Multicast Load Balancing
  No Multicast Load Balancing with Dual N-PE Routers with L2 Distribution
  Potential Fail Over Issue as Well
  No Issue If PIM Runs to PE-Agg Router

• PE-Agg Supports Simultaneous L2 and L3 Forwarding
  Some Services Require Layer 2 Distribution Network
  Catalyst Switches Support Different Switching Models on Per VLAN Basis
  Layer 2, Layer 3, Layer 2 + Layer 3 (Switched Virtual Interface)
L3 allows Anycast Based Load Sharing

L3VPN-PE1

Source 1

1.1.1.1

I will send join to the nearest 1.1.1.1/32

PIM join

PE-Agg1

IGMP Report

STB

L3VPN-PE2

Source 2

1.1.1.1

I will send join to the nearest 1.1.1.1/32

PIM join

PE-Agg2

IGMP Report

STB
L3 and Encoder Fail Over Using Anycast

- Source 1: 1.1.1.1
- Source 2: 1.1.1.1

1. IGP Recalc >> PIM join

Network Diagram:
- L3VPN-PE1
- L3VPN-PE2
- PE-Agg1
- PE-Agg2
- STB
- STB

Connection Arrows:
- Green arrows: PIM join
- Black arrows: IGP Recalc
Multicast Convergence with Layer 2 Distribution

- Primary Source (N-PE1)
- Backup Source (N-PE2)
- PIM Designated Router
- IGMP report
- Layer 2 Distribution
- Spanning Tree Loop Avoidance
- PE-Agg1
- PE-Agg2
- STB

PIM Join:
- From Primary Source to Backup Source
- From Backup Source to Primary Source

IGMP Report:
- From STB to PE-Agg2
- From PE-Agg2 to STB
Potential Multicast Convergence Issues with Layer 2 Distribution

Potential Multicast Convergence Issues with Layer 2 Distribution
Video Service and QoS Requirements
Broadcast Video Service Challenges

Contributors to Channel Change Delay @STB

1. Multicast Leave for old Channel (50 msec)
2. Delay for Multicast Stream to Stop (150 msec w/ Fast Leave)
   Delays Due to IGMP Queries / Timeouts on Access Link
   Fast Leave Processing on DSLAM Removes This Delay
3. Multicast Join for New Channel (50 msec – 200 msec)
4. Jitter Buffer Fill (200 msec)
5. I-Frame Delay (500 msec – 1 sec)
Video QoS Requirements

• Video and Voice Have Competing QoS Requirements

  Video QoS Requirements
  Allowed Drop Rate \( \approx 10^{-6} \)
  Allowed Jitter \( \approx 200 \text{ Msec} \)

  Voice QoS Requirements
  Allowed Drop Rate \( \approx 10^{-2} \)
  Allowed Jitter \( \approx 60 \text{ Msec} \)

• Voice Requires Minimal Jitter; Use Priority Queue

• Video Requires Extremely Low Drop Rate

  Low Drop Rate \( \approx \text{Large Buffering} \)

  Requirement Due to Burst Accumulation

  Queue Length Must be \( > \text{Max Expected Jitter to } 10^{-6} \text{ Probability} \)

• Platform Buffering Capacity will be Important for Video in the Future
Dual Stream Video Solution
Video Challenge – Reliability

- Broadcast Source Represents Single Point of Failure for Video
  Failure of Real Time Encoder
  Failure of Link(s) from Real Time Encoder

- Multicast Reroute Can Cause Broadcast Interruption
  Network Must Re-converge in < STB Jitter Buffer Time (200 msec)
  Network Must Buffer All Packets During Reconvergence

- Intelligent Video Processing Enables Hitless Fail Over
  Send Redundant Multicast Streams to Intelligent Video Node
  Intelligent Video Node Builds Single Output from Redundant Inputs
  Instant Fail Over for Broadcast Video
  No Service Disruption in the Event of Failures
Layer 3 based Dual Stream Broadcast TV Solution

- Anti Clockwise Multicast Streams
- Clockwise Multicast Streams
- Routing between VLANs

Diagram showing the Layer 3 based Dual Stream Broadcast TV Solution with N-PE connected to PE-AGG via 10GE Links, and a Broadcast Video Source connected to N-PE.
L3 based Dual Stream Video Redundancy
Dual Stream Redundancy
How it Works?

- Broadcast Stream from Encoder Sent to Two Multicast Groups
- IP Network Configured to Route Streams Separately
  Constrained Reverse Path Look Up
- Multicast streams routed in opposite directions on the ring
- Failure of a link requires PIM Join to adjacent Link receiving the same stream
- Source Specific Multicast Routing to ensure security
- This architecture is fully upgradeable to future solutions