Point to Multipoint Traffic Engineering with MPLS

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CHALLENGES...for Video Multicast Distribution

- It has to be there all the time - availability
  - In most cases only a few frames or 10s of ms of loss can be tolerated
- You can't send it again - integrity
- Timing constraints - continuity
  - End to end latency requirements are stringent
- Bandwidth Requirements
  - Compressed few kbit/s-80Mbit/s
  - Uncompressed 270Mbit/s
- Video multicast distribution from a broadcaster’s video head-end to receiving sites
- Video multicast distribution from a receiving site to the end users
Typical Network Design To Date

- **Video Multicast Backbone Network**
  - Analogue connections – coax, radio & fibre
  - Digital SDH/PDH native mappings
  - ATM packet-based PVCs and S-PVCs

- **Video Multicast Access Network**
  - RF Distribution
Typical Emerging Network Design

- **Video Multicast Backbone Network**
  - IP/MPLS
  - Motivated by “converged” infrastructure

- **Video Multicast Access Network**
  - RF Distribution
  - IP/MPLS Access Network
    - Aggregation network may be L2 or MPLS
MPLS Converged Backbone Design

- More traffic on a network is more cost effective.
- Solutions exist for migrating ATM and Frame Relay data to MPLS.
- If multicast/unicast video can be incorporated as well it will be able to benefit from the cost savings.
Backbone Network
Is IP Multicast Sufficient?

- Network convergence on failure can take up to a few seconds or more
  - NOT sufficient for Real Time Video

- No Traffic Engineering
  - Desirable to guarantee QoS without significant over-subscription

- Lack of Control
  - Desirable to have the flexibility to set up explicitly routed redundant paths
  - Desirable to set up minimum cost paths
Summary Slide

- What is a P2MP TE LSP?
- RSVP-TE vs PIM
- Solution Terminology
- Solution Mechanisms
- Applications
- Configuration examples
- Conclusion
What is a P2MP TE LSP?

- **Point to Multipoint Label Switched Path (LSP)**
  - Efficient traffic replication in the network
  - Application agnostic

- **Set up with TE constraints**
  - May involve resource reservations throughout the network
  - Determine path of these P2MP TE LSPs

- **RSVP-TE Signaling**
  - Enhancements to P2P (GMPLS) RSVP-TE
What is P2MP MPLS TE?

Source : PE1
Destinations: PE2, PE3, PE4, PE5
P1, P2 : Branch nodes

Diagram:
- Source: PE1
- Destinations: PE2, PE3, PE4, PE5
- Branch nodes: P1, P2
- P1, P2, P3, P4, P5
Why RSVP-TE?

- What are the choices?
  - RSVP-TE
  - PIM
- Why is RSVP-TE a better fit?
RSVP-TE vs PIM

**RSVP-TE**
- Has resource reservation mechanisms
- Supports explicit routing along paths different from hop-by-hop IP routing
- P2MP LSP is signaled by the root and hence allows flexible P2MP computation algorithms
- Fast reroute and Make before-break capabilities

**PIM**
- No resource reservation mechanisms
- No equivalent support
- Receiver initiated trees are limited in tree computation flexibility
  - Do not support Minimum cost trees
- No such capabilities. PIM is NOT a TE protocol!
Problem Statement

- The practical problem is to introduce multicast functionality in the MPLS data plane
  - Optimize data plane for high volume multicast
- P2MP TE is performed in the data plane
- Control plane uses P2MP sub-LSPs as building blocks
- Minimize changes to existing P2P RSVP-TE
Problem Statement - Solution Simplicity

- **Operational simplicity**
  - P2P RSVP-TE is deployed and understood
  - Leverage the existing control plane model

- **Protocol simplicity**
  - Minimize complex protocol changes

- **Implementation simplicity**
  - Minimize changes to existing software: Less Bugs!
Solution Mechanisms

- Building blocks
  - P2MP Tunnel
  - P2MP LSP
  - P2P sub-LSP
- Path Messages
- Resv Messages
- Fast-reroute
- Make-before-break
Solution Mechanism: P2MP Tunnel

- May comprise multiple P2MP LSP Tunnels
- Identified by the P2MP SESSION Object which includes
  - P2MP ID: Logical 32 bit identifier of the P2MP tunnel
  - Tunnel ID: 16 bit identifier
  - Extended Tunnel ID: IPv4/IPv6 Address Source Address or left unspecified
Solution Mechanism: P2MP LSP Tunnel

- A specific instance of a P2MP Tunnel
- May comprise multiple P2P sub-LSPs
- Identified by the P2MP Tunnel SESSION and P2MP SENDER_TEMPLATE object combination

P2MP SENDER_TEMPLATE
  - Identifies the sender (ingress)
  - Includes
    - Source IPv4/IPv6 address
    - LSP ID
Solution Mechanism: P2MP Sub-LSP

- LSP from the ingress LSR to a particular egress LSR
- A P2MP LSP Tunnel comprises multiple P2MP sub-LSPs
- A P2MP sub-LSP is represented by
  - P2P sub-LSP object
  - ERO or sub ERO
Solution Mechanism: P2P Sub-LSP

- P2P sub-LSP object
  - Identifies a P2P Sub-LSP
  - Egress LSR Destination address
  - P2P sub-LSP identifier (sub-LSP ID)
- Sub-Explicit route
  - Represents the explicit route from ingress LSR to the egress LSR
  - May be compressed
Solution Mechanism: Path message

- One P2MP Tunnel LSP can be signaled using multiple Path messages.
- Each such Path message can signal multiple P2P sub-LSPs.
- Limiting cases:
  - A separate Path message for each P2P sub-LSP.
  - A single Path message for all P2P sub-LSPs.
Multiple Path Messages: Example

P2MP Tunnel: ID_1 {PE2, PE3, PE4}

P2MP LSP Tunnel: {PE1; ID_1}
P2P sub-LSP list: [PE2, PE3, PE4]
Applications

- Layer 2 Multicast over P2MP MPLS TE
- IP Multicast over P2MP MPLS TE
- Multicast VPNs (MVPNs) over P2MP MPLS TE
- VPLS Multicast over P2MP MPLS TE
Layer 2 Multicast over P2MP TE LSP

P2MP MPLS TE LSP

PE1

PE2

PE3

PE4

PE5

Layer 2 Multicast Video Source

Layer 2 Multicast Video Receiver

L2 Traffic

R1

R2

R3

R4

MPLS

L2 Traffic
Layer 2 Multicast over P2MP TE LSP

- Goal is to retain all the functionality available to layer 2 services as they migrate to IP/MPLS
  - P2MP functionality is offered by ATM networks
  - P2MP TE is a missing piece in the layer 2 service migration to IP/MPLS
- A Layer 2 interface can be cross-connected to a P2MP LSP
- TE requirement
  - QoS guarantees: strict SLAs for broadband video traffic
  - Protection: Fast reroute
IP Multicast Over P2MP MPLS TE LSP

P2MP MPLS TE LSP

PE1

Multicast Video Source

PE2

R2

PE3

R3

PE4

R4

PE5

R1

Multicast Video Receiver
IP Multicast Over P2MP MPLS TE LSP

- TE for broadband video multicast traffic
  - QoS for content distribution
  - Protection: Fast Reroute
- Multicast (PIM-SM) free core
  - Keeping multicast routes out of the core
- Eliminates the need to use BGP in the core to distribute unicast routes used by multicast RPF
  - Particularly useful if the core is BGP free for unicast routing (e.g. by running RSVP-TE)
MVPNs over P2MP MPLS TE LSP
2547 Multicast Over P2MP MPLS TE

Advantages

- Core can be PIM-SM free
- Core can be BGP free
- A P2MP LSP can be used per VPN
  - Similar to the per VPN Multicast Domain (MD) Group in the existing PIM-SM based solution
- MD Group provisioning overhead is alleviated
- Possible to have multiple P2MP LSPs per VPN
  - A separate LSP for a high b/w stream
- TE benefits
VPLS Multicast over P2MP MPLS TE LSP

The same (multicast) packet traverses the link only once

Links
- Aggregate P2MP MPLS TE LSP for VPLS A and VPLS B
- Upstream label for VPLS A
- Upstream label for VPLS B
Coupling traffic into a p2mp LSP

- Three cases supported today:
  - CCC
  - IP unicast (statically routed)
  - IP multicast (statically routed)
Conclusion - MPLS Multicast Deployments/Status/Future

- A large Broadcast TV over P2MP MPLS TE deployment in British Telecom
- Other large broadcaster/MSO/ISP pilots and deployments networks
- Ongoing work in the areas of resiliency, scalability, P2MP MPLS TE, IP multicast integration, MVPN and VPLS integration
- Proposed solution should be applicable to GMPLS (e.g. SONET/SDH carrying video stream)
- MPLS Multicast TE is real!!
Thank You!