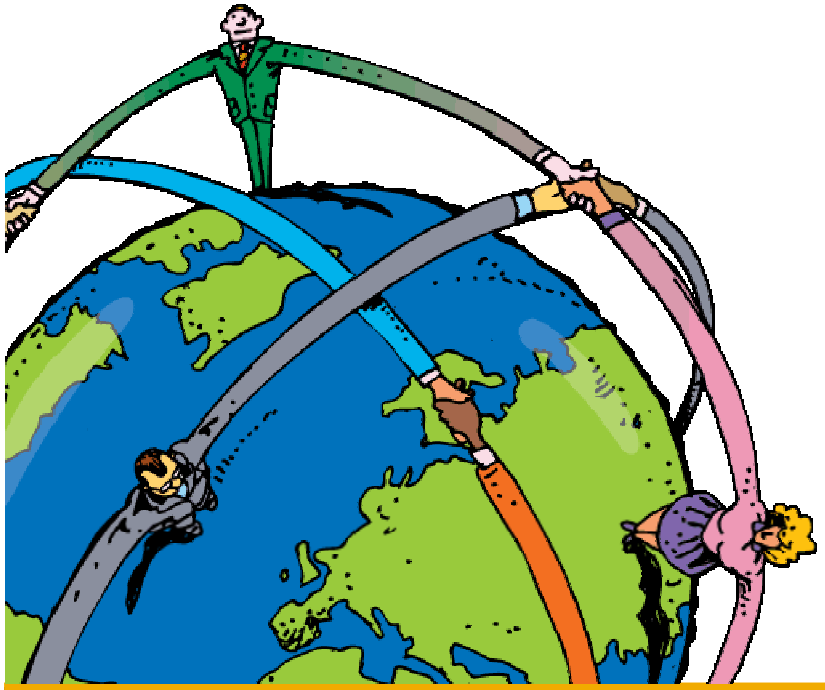

Video and Multicast Services over MPLS

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MPLS Multicast Applications & Services

- **Multicast in VPLS**
  - VPLS as a service
  - VPLS as infrastructure for delivering other services
- **Multicast in BGP-MPLS VPN**
  - BGP-VPN as a service
  - BGP-VPN as infrastructure for delivering other services
- **Broadcast Video Transport / IPTV Service**
- **Internet Multicast**

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Exploring the Commonalities

- **Common architecture for VPLS Multicast and BGP-MVPNs**
  - Inclusive Trees
  - Selective Trees
- **Common mechanisms for VPLS Multicast and BGP-MVPNs**
  - BGP for Auto-Discovery
  - BGP for exchanging customer multicast routing information among PEs
  - P2MP RSVP-TE or P2MP LDP for P-Tunnel signaling

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Agenda

- *Multicast in VPLS*
- Multicast in BGP-MPLS VPN
- MPLS Multicast Data Plane for NGEN MVPN and VPLS Multicast
- Broadcast Video Transport / IPTV Service

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VPLS Multicast - Agenda

- VPLS Multicast Architecture
- P2MP LSPs for Intra-AS VPLS Control Plane
- P2MP LSPs for Intra-AS VPLS Data Plane

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NGEN VPLS Multicast Architecture

- **VPLS Auto-Discovery**
  - Use existing BGP VPLS auto-discovery mechanisms with enhancements
- **Enable the use of P-multicast Trees for VPLS multicast traffic**
  - Draft-ietf-l2vpn-vpls-mcast-02.txt
  - Inclusive Trees or Selective Trees
- **Elimination of flooding for VPLS IP multicast traffic is desirable**
  - Further technical work is required

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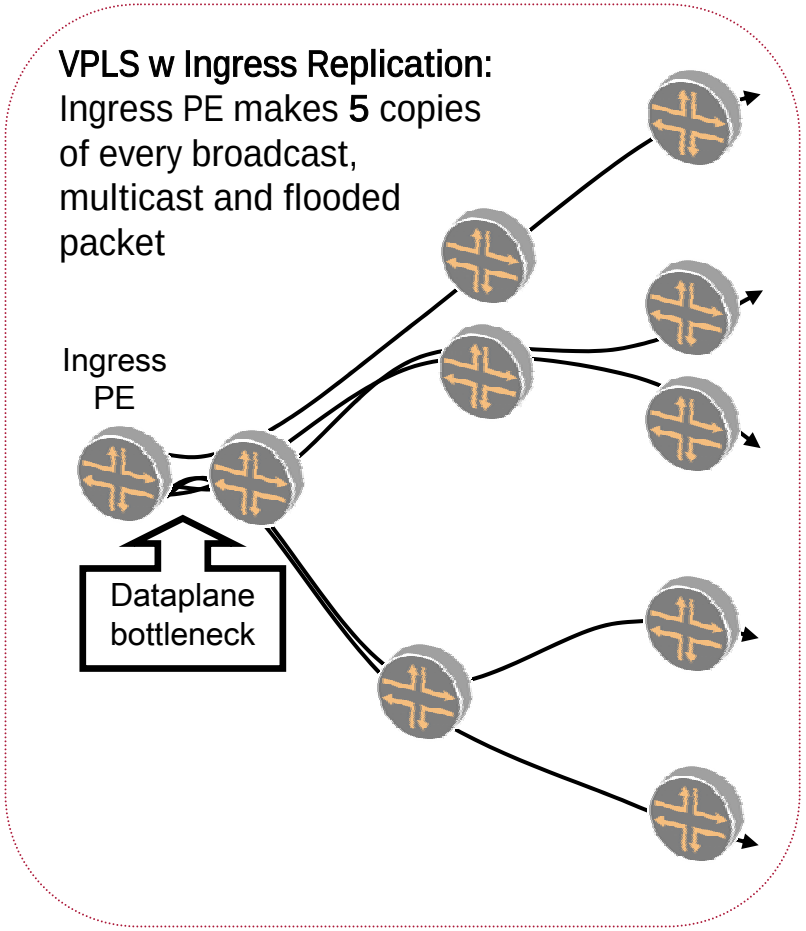
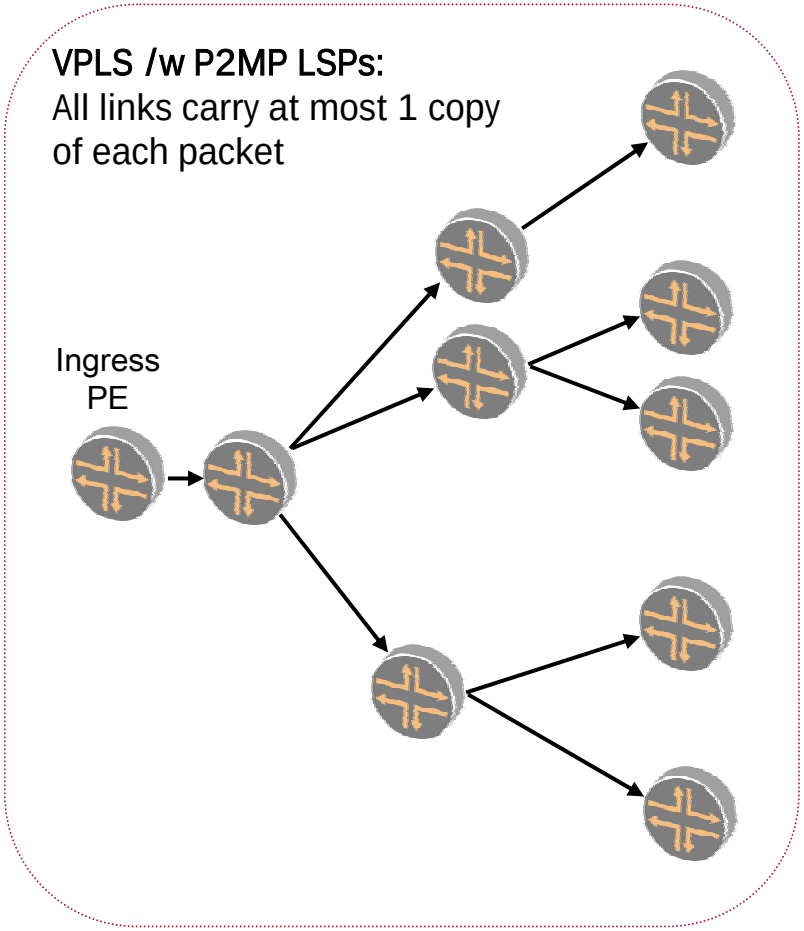
VPLS Multicast : Ingress Replication vs P2MP LSPs





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P2MP LSPs for Intra-AS VPLS

- **LDP-VPLS with BGP Auto-Discovery or BGP-VPLS**
- **VPLS support for P2MP LSPs as described in draft-ietf-l2vpn-vpls-mcast-01.txt**
  - Enhances BGP Auto-Discovery (AD)
- **Each PE with a site in a VPLS is the root of a P2MP LSP other PEs in the AS that have sites in that VPLS**
  - One P2MP LSP per VPLS (Inclusive Tree)
  - Possibility of “Aggregation” leaves headroom for growth
    - Upstream assigned labels (draft-ietf-mpls-upstream-label

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P2MP LSPs for Intra-AS VPLS…

- **All the multicast/broadcast/unknown unicast traffic received from the VPLS site is sent over the P2MP LSP**
  - Inclusive Tree
- **BGP P-Tunnel Attribute, carried in the BGP-VPLS updates, signals the VPLS-P2MP LSP binding**
  - From the root of the P2MP LSP to the leaves of the P2MP LSP
  - Same P-Tunnel Attribute is used in BGP-MVPN (more on this later)
- **An egress PE MUST be able to determine the sender PE (root of the P2MP LSP) in order to perform learning**

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Inter-AS VPLS Multicast Segmented Inter-AS Trees

- **Inter-AS Tunnel rooted at the source PE**
  - Other ASs are nodes on this inter-AS tunnel
  - One Inter-AS tunnel for one <VPLS, PE> i.e. one Inter-AS tunnel Per VE ID
- **Inter-AS Tunnel comprises "segments"**
  - AS-AS tunnel segments that connect ASs together on the inter-AS tunnel
  - Intra-AS tunnel segment used by an AS to deliver traffic to PEs/ASBRs within an AS on the inter-AS tunnel
- **Inter-AS tunnels constructed by stitching intra-AS tunnel segments**
  - **Independent P-Tunneling technology per AS**
- **Propagation of BGP-VPLS AD routes from the source AS to other ASs results in the creation of the inter-AS tunnel**
  - In conjunction with specific tunnel signaling protocols

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VPLS Multicast
Elimination of Flooding

- **PE - CE Flooding**
  - Problem - PE sends an IP multicast packet to all the CEs in the VPLS
  - Solution – IGMP snooping or PIM snooping
- **PE – PE Flooding**
  - Problem – PE sends an IP multicast packet to all PEs in the VPLS
  - Solution – Selective VPLS Multicast Trees
    - Propagate “snooped” IP multicast state in BGP to other PEs
      - IGMP/PIM snooping on PWs may not be scalable
    - Draft-raggarwa-l2vpn-vpls-mcast-ctrl would need to be matured

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Agenda

- **Multicast in VPLS**
- ***Multicast in BGP-MPLS VPN***
- **MPLS Multicast Data Plane for NGEN MVPN and VPLS Multicast**
- **Broadcast Video Transport / IPTV Service**

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NGEN-MVPN Solution Goals

- **Extend 2547 VPN service offering to include support for IP multicast for 2547 VPN customers**
- **Follow the same architecture/model as 2547 VPN unicast**
  - No need to have the PIM/GRE Virtual Router model for multicast (i.e. draft-rosen) and the BGP/MPLS 2547 model for unicast
- **Re-use 2547 VPN unicast mechanisms, with extensions, as necessary**
  - No need to restrict multicast to only IP/GRE data plane while unicast uses MPLS LSPs
- **Retain as much as possible the flexibility and scalability of 2547 VPN unicast**

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NGEN-MVPN Intra-AS Control Plane Functionality

- **Using BGP for auto-discovery and binding P-Tunnels to customer multicast streams**
  - Provides common mechanism for both Inclusive and for Selective P-Tunnels
    - As both Inclusive and Selective P-Tunnels are needed
- **Using BGP to provide (constrained) C-multicast routing information exchange among PEs**
  - C-PIM-SM in SSM mode using BGP C-Multicast Source Tree routes
  - C-PIM-SM in ASM mode using BGP C-Multicast Source Tree routes and Source Active Auto-discovery routes
    - Results in Inter-site traffic always flowing on Shortest Path Trees
  - C-Control traffic exchange through the SP network is out-of-band from the C-Data traffic exchange

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Exchange of C-Multicast Routes using BGP…

- **Let us focus on customers running PIM-SM in SSM mode**
  - Only Source Tree Join C-Multicast routes required
    - Semantically similar to PIM Join (C-S, C-G)
- **PIM-SM in ASM mode can be supported with a few enhancements to the procedures for PIM-SM in SSM mode**

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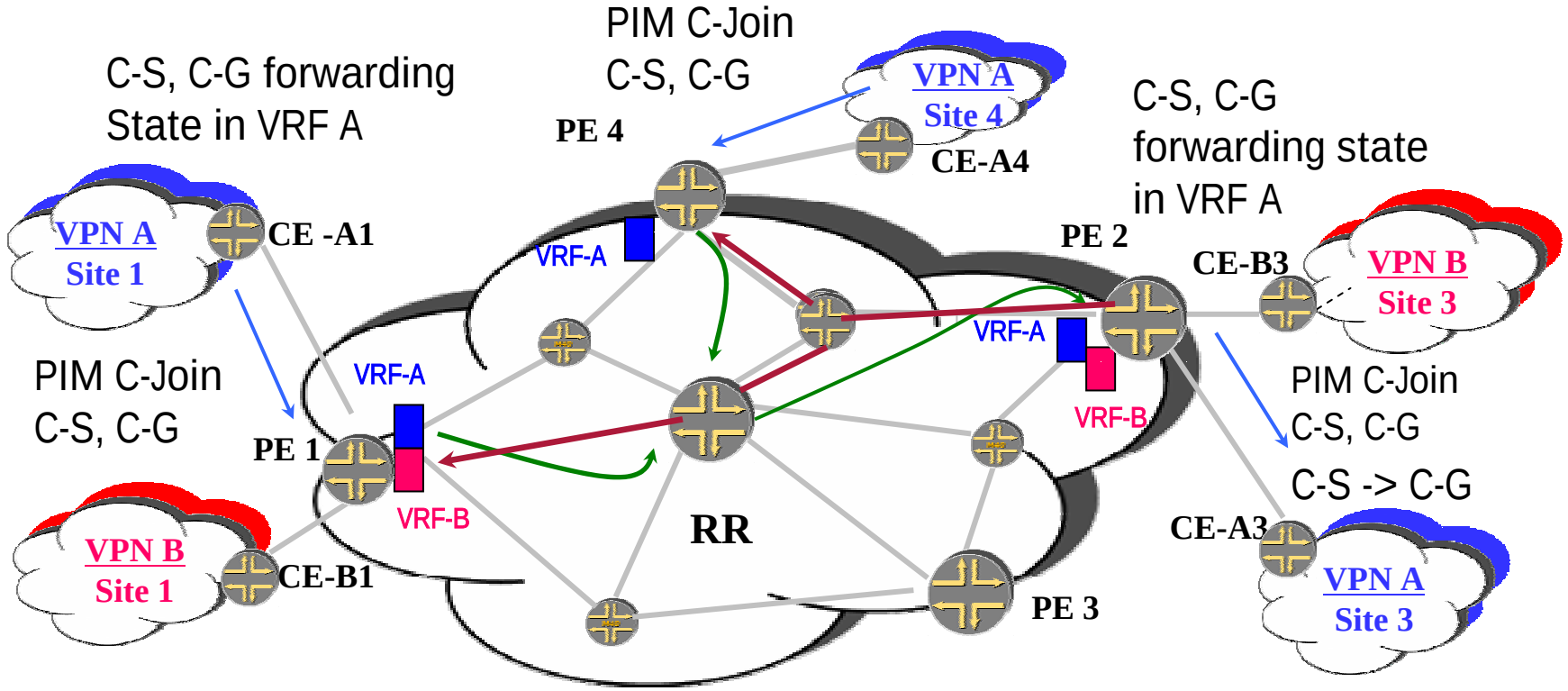
NGEN MVPN Intra-AS
Putting it Together (PIM-SM in SSM Mode)



BGP MVPN C-Mcast Routing Information:
<RD, C-S, C-G, PE2's VRF A Route Import RT>

P2MP TE Inclusive P-Tnl: PE2 as Root

RR Aggregates C-Multicast Routes
- no explicit tracking by default

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NGEN-MVPN Inter-AS Functionality

- **“Segmented” Inter-AS tunnels constructed by stitching intra-AS tunnel segments**
  - Independent P-Tunneling technology per provider
  - Provided by BGP based inter-AS auto-discovery
- **Routing peerings between ASes/Providers only at ASBRs or RRs**
  - Including exchange of C-Multicast routes
    - Avoids the need to require PEs in different ASes/Providers to have direct PIM peering with each other
- **Works with all three options for inter-AS unicast**

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NGEN MVPN Data Plane

- **Inclusive Trees**
  - Traffic for a particular (C-S, C-G) sent on an Inclusive Tree is received by all the PEs that have a receiver site in the MVPN
- **Selective Trees**
  - Traffic for a particular (C-S, C-G) sent on a Selective Tree is received only by those PEs that have a receiver in (C-S, C-G)
  - May be used for high bandwidth streams
- **A MVPN may use ONLY Selective Trees**
- **Inclusive and Selective Trees may be Aggregate Trees**

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BGP-MVPN IETF Status

- **MVPN architecture draft specifies various options that include BGP-MVPN**
  - Draft-ietf-l3vpn-2547bis-mcast
- **BGP-MVPN draft specifies BGP specific procedures**
  - Draft-ietf-l3vpn-2547bis-mcast-bgp
- **Operational consideration draft [co-authored by several SPs] recommends BGP-MVPN design options**
  - draft-morin-l3vpn-mvpn-considerations

Juniper implements the standards being developed in L3VPN WG

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MVPN Deployment Recommendation

- **Deploy BGP-MVPN based on draft-ietf-l3vpn-2547bis-mcast-bgp and recommendations in draft-morin-l3vpn-mvpn-considerations**
  - Implemented by JunOS

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Agenda

- **Multicast in BGP-MPLS VPN**
- **Multicast in VPLS**
- **MPLS Multicast Data Plane for NGEN MVPN and VPLS Multicast**
- ***Broadcast Video Transport / IPTV Service***

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Broadcast Video Transport / IPTV Service

- Requirements
- P2MP MPLS TE
- The role of NGEN MVPN and VPLS

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Broadcast Video Transport / IPTV Service Requirements

- **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
- **Timing constraints – *continuity***
  - End to end latency and jitter requirements are stringent
- **Bandwidth Requirements**
  - Compressed 5-80Mbit/s
  - Uncompressed 270Mbit/s

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MPLS Multicast Technology for Broadcast Video

Root/source Initiated e.g. P2MP RSVP-TE	Leaf/receiver driven e.g. mLDP
Has resource reservation mechanisms	No resource reservation mechanisms
Supports explicit routing along paths different from hop-by-hop IP routing	No equivalent support
P2MP LSP signalled by the root => allows flexible P2MP computation algorithms SupportS Minimum cost trees	Receiver initiated trees are limited in tree computation flexibility Do not support Minimum cost trees
Fast reroute and Make-before-break capabilities	No such capabilities
Allows various protection mechanisms such as active-active; active-standby (next slide)	No equivalent mechanisms

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Broadcast Video Transport / IPTV Service MPLS Multicast Technology

- **P2MP MPLS TE meets the requirements**
  - State maintenance: aided by RSVP Refresh Reduction
- **P2MP MPLS TE is deployed in several networks**
  - RFC 4875

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Broadcast Video Transport / IPTV Service Availability Paradigms with P2MP MPLS TE

- **Transmit the video stream twice**
  - Diverse end-to-end paths
  - Twice the bandwidth consumption
  - Requires the control and explicit routing of P2MP MPLS TE
  - Special video equipment to “choose” the best stream – potentially at most a few frames lost in any failure case
- **Transmit the video stream once**
  - Reduces the bandwidth consumption
  - Greater capabilities required from the network
  - 10s of ms of failure recovery in majority of cases - Fast-reroute
  - A backup stream that takes over in some cases
    - E.g. Ingress Node Failure
- **These two approaches can co-exist**
  - Different approaches for different streams

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Mapping Broadcast Video Transport / IPTV Service into P2MP MPLS TE LSPs

- **Static configuration on ingress LSRs**
  - Static routes or P2MP CCC
  - Deployed in several networks on JunOS platforms
- **NGEN MVPNs with P2MP MPLS TE**
  - Will be delivered by JunOS soon
  - Use NGEN MVPN to provide ***infrastructure***
- **VPLS P2MP TE Support**
  - Shipping in JunOS
  - Use VPLS to provide ***infrastructure***
- **All of these are potential candidates for *both* backbone and metro networks**

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Mapping Video Service into P2MP MPLS TE LSPs Considerations

- **Operational ease**
  - Does static mapping on the ingress suffice ?
- **Ingress PE resiliency**
  - VPLS and MVPN multi-homing is an option
  - Static mapping may need some more functionality that is upcoming in JunOS
- **Does the ingress LSR need to dynamically discover receivers of a particular (C-S, C-G) ?**
  - May be needed if Selective Trees have be dynamically signalled to an egress node if/when it has receivers for a particular (C-S, C-G)
  - NGEN MVPN are a good fit for dynamic selective P2MP TE LSPs.
- **Is there a need to provide backhaul for other services ?**
  - In a metro network, NGEN MVPNs or VPLS may be used for backhaul

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BGP-MVPN and VPLS Multicast MPLS Multicast P-Tunnel Requirements

- **Support for both Inclusive and Selective P-Tunnels**
- **Support for aggregation of P-Tunnels via P2MP LSP hierarchy**
  - Both for Inclusive and Selective P-Tunnels
- **Support for intra-AS segments of an Inter-AS segmented tree**
- **OAM support**
  - LSP-Ping for multicast P-Tunnels
  - BFD for multicast P-Tunnels
- **When needed support for TE, fast-reroute Minimal configuration overhead**
- **Optimized for the most common C-multicast protocols (PIM-SM and PIM-SSM)**

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Additional VPLS Multicast P-Tunnel Requirement

- **Egress PE MUST be able to identify the sender PE in order to perform learning for packets received on the P-tunnel**

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BGP MVPN and VPLS Multicast MPLS P-Tunnel Protocol Choices

- **P2MP RSVP-TE**
- **mLDP**
  - P2MP LDP
  - MP2MP LDP
- **It is important to make an educated choice as the unicast comparison models do not necessarily apply to multicast. E.g.**
  - P2MP RSVP-TE does not require leaf configuration
  - P2MP RSVP-TE and P2MP LDP require the same forwarding state
- **P2MP LSPs (RSVP-TE or LDP) are required**
  - E..g. Selective Trees
- **MP2MP LDP LSPs does not meet certain essential requirements currently**
  - Procedures to identify the sender PE for VPLS not specified
  - Does not allow a MVPN to run in Selective Tree only mode

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P2MP TE as the Data Plane for VPLS Multicast and NGEN MVPN

- **Meets the requirements**
- **Advantages to using P2MP RSVP-TE to meet all the requirements of various services with a single protocol**
  - Instead of using P2MP RSVP-TE for broadcast video / IPTV and other protocols (e.g. P2MP LDP) for VPLS multicast and NGEN MVPN

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Internet Multicast

- **Use BGP-MVPNs as infrastructure for internet multicast service**
  - Use the internet unicast table to determine reachability to the multicast sources
  - Carry C-multicast routes in BGP allowing the ingress PEs to determine the receivers
  - BGP and PIM free core
  - Choice of P2MP RSVP-TE or P2MP LDP

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Internet Multicast…

- **Use of BGP-MVPNs has several other benefits**
  - Uniform PE-PE control plane based on BGP as for VPLS multicast, BGP-MVPN and broadcast video service
  - The option to use a combination of Inclusive and selective trees to allow trading off bandwidth with state
    - There could be a single Inclusive tree by default for all internet multicast traffic !
  - BGP control plane scaling benefits
  - Supports both C-PIM-SSM and C-PIM-SM

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Conclusion

- Technology for delivering multicast and video services over MPLS is mature
- Video over MPLS is deployed in several networks using P2MP RSVP-TE
- A BGP based control plane and MPLS data plane provides a scalable and operationally uniform solution for various unicast and multicast services
- There is shipping code with BGP MVPN and VPLS P2MP LSPs
- Advantages to using a single protocol, P2MP RSVP-TE, as the data plane for all MPLS multicast services

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