Multicast in SR Networks

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For Whom This Is Interesting?

- *For an operator with multicast need, what are the options if Segment Routing is being deployed/considered?*
- *Multicast is for distributing information from a single source to multiple receivers*
  - *Has been in use for a long time for many use cases*
    - *IPTV – from video source through core/edge to home subscribers*
    - *Video distribution – in broadcast industry or for content studios*
    - *Financial services – market information distributed to massive subscribers*
      - *Not only BW savings, but also fairness in terms of time of delivery*
    - *Enterprise internal use for multiple-point delivery*
  - *Will become more important with more real-time large-scale distribution of high data rate content*

Agenda

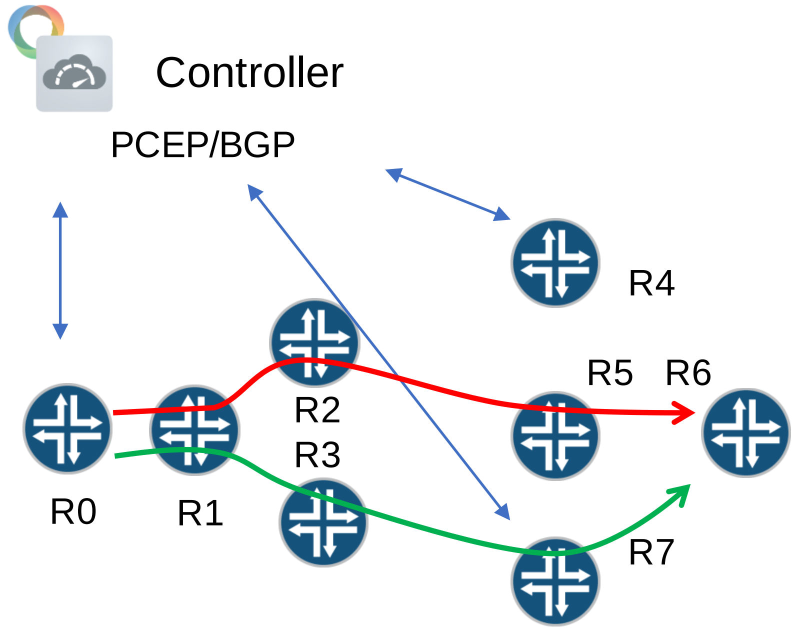
- *SR principles and Multicast Options*
- *Controller Signaled P2MP*
  - *PCEP/BGP-signaled SR-P2MP*
  - *BGP-signaled mLDP*
- *BGP Signaled Multicast*
  - *Both IP multicast and P2MP*
  - *With or without controllers*
- *E2E Inter-region Multicast*
- *Multicast with Classful Transport*

Multicast Technologies

- *IP Multicast Flows*
  - *Identified by (Source, group) address pair, forwarded along a tree typically set up by PIM protocol specifically for that flow*
  - *Each flow is typically for a separate piece of content to be distributed to multiple receivers*
    - *E.g., a TV channel, a blob of financial information*
- *Multicast Tunnels*
  - *A single multicast tunnel can be used to transport multiple multicast flows through part of a network*
  - *IP Multicast, RSVP-TE/mLDP-P2MP, Ingress Replication, BIER tunnels*
- *MVPN – customer/overlay multicast over a provider/underlay network*
  - *Rosen-MVPN & BGP-MVPN*
  - *PE-PE signaling of customer multicast state*
  - *PE-PE forwarding of customer multicast traffic via tunnels*

Segment Routing Principles

1. *No per-flow/tunnel state inside network*
    - *Packets have embedded segment list for traffic steering*
2. *Optional/preferred use of controllers*
    - *To instruct ingress to embed segment list in packets for per-flow/tunnel traffic steering*

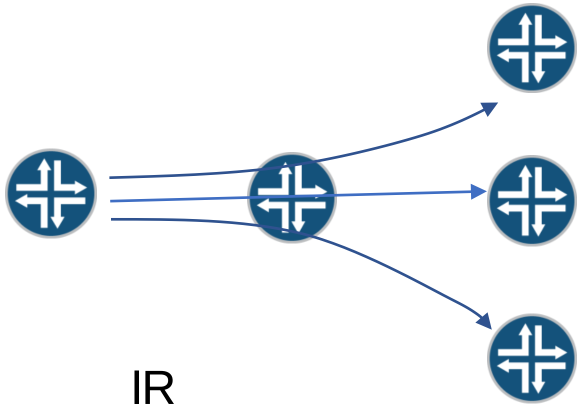


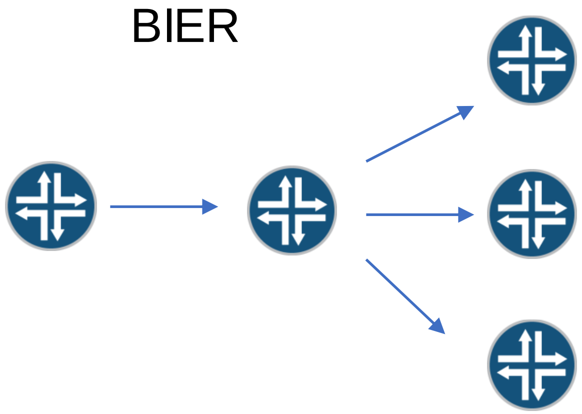
R2	R5	payload	Flow 1 packets
R3	R7	payload	Flow 2 packets

Multicast per SR Principle #1

1. *No per-tree state inside network*
   - *Ingress Replication (IR)*
     - *Inefficient but applicable for certain use cases*
   - *BIT Indexed Explicit Replication (BIER)*
     - *Packets carrying a BitString indicating the targeted edge routers*
       - *With BIER-TE, the BitString can also specify transit routers*
     - ***Best** multicast technology though with a new forwarding plane*
       - *Not covered in this presentation*

Both per SR principle yet independent of SR



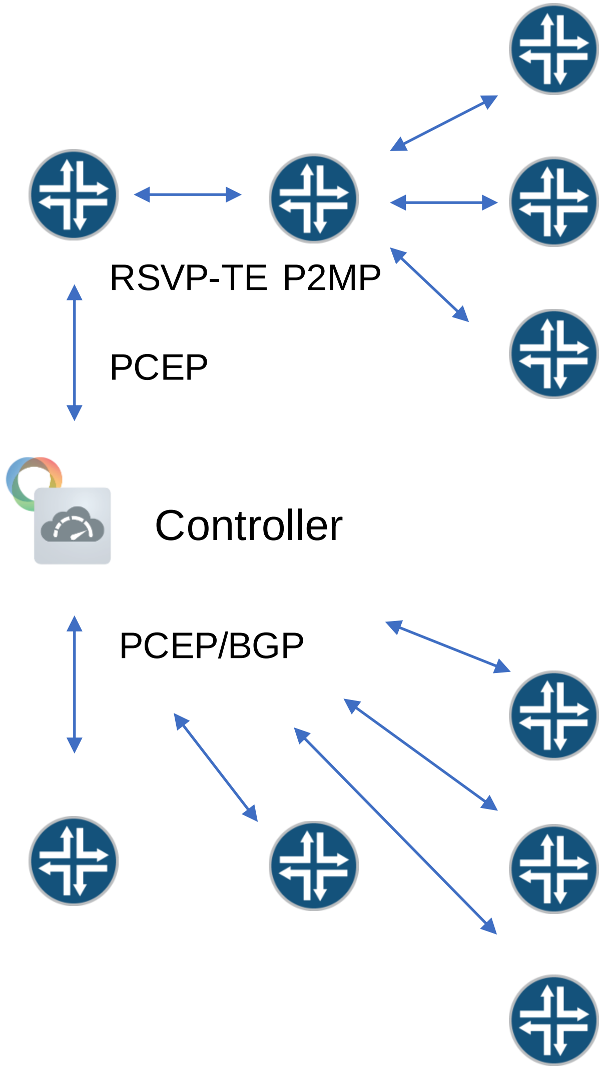


Multicast per SR Principle #2

2. *Use of controllers*
   - *Controller calculated RSVP-TE P2MP*
     - *Signaled by RSVP-TE from ingress*
   - *Controller calculated and signaled:*
     - *SR-P2MP (aka tree-sid)*
     - *mLDP (signaled via BGP)*

All have identical forwarding plane

- *As with legacy mLDP/RSVP-TE P2MP*
- *Per-tunnel state inside the network*
- *Label in -> replicated label out*



Multicast Options in SR Networks

- *BIER*
  - *If you care about effective replication with no-state inside the network, and,*
  - *Most routers support BIER*
- *Traditional Multicast (PIM/P2MP/IR)*
  - *If it works well for you*
    - *You don't need controller, and,*
    - *You don't mind running PIM/mLDP/RSVP in your SR network for multicast*
      - *Perfectly ok to run PIM/mLDP/RSVP for multicast while running SR unicast*
- *Controller Signaled Multicast*
  - *If you need controller-calculated trees, and/or,*
  - *You want to remove PIM/mLDP/RSVP*
  - *Note that you will still have per-tree/tunnel state inside the network*

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SR-P2MP

- *Previously known as Tree-SID*
  - *Being specified in IETF SPRING/PIM/BESS/PCEP WGs*
- *Controller signals per <tree, node> Replication Segments to each tree node:*
  - *Forwarding state identification*
    - *<root, tree-id, candidate-path, targeted-node>*
  - *Forwarding information*
    - *incoming label, outgoing label and branches*
- *PCEP/BGP-MCAST/BGP-SRTE signaling*
  - *This presentation focuses on BGP-MCAST*

Controller/BGP Signaled mLDP

- *Labeled forwarding just like SR-P2MP and legacy mLDP*
- *mLDP FEC as tree identification in control plane*
  - *This is the only relevance to mLDP*
    - *LDP signaling not used*
  - *Flexible/extensible identification due to opaque structure*
  - *Easy transition from existing mLDP deployment, e.g. BGP-MVPN with mLDP*
    - *no change on MVPN part; just mLDP tunnels signaling changed to BGP*
- *Signaling via BGP-MCAST*
  - *From controllers, or*
  - *Hop-by-hop from leaves towards root*

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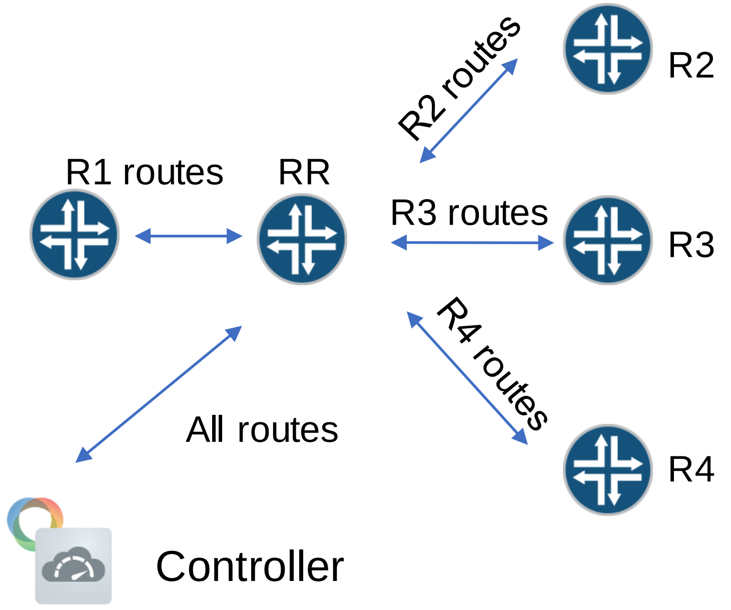
BGP-MCAST Signaling

- *Using BGP MCAST-TREE SAFI to signal for:*
  - *SR-P2MP, mLDP*
  - *IP Multicast*
    - *forwarding and tree identification by (source, group)*
  - *Any potential future types – just using different NLRI types*
    - *E.g. tree identification by label directly*
- *Signaling from controllers*
  - *draft-ietf-bess-bgp-multicast-controller*
- *Hop-by-hop leaf → root signaling*
  - *draft-ietf-bess-bgp-multicast*

Essence of BGP Signaling From Controllers

- *NLRI encodes the following*
  - *Tree identification (with different NLRI route types)*
    - *IP Multicast: source, group*
    - *SR-P2MP: Candidate Path (via RD), root-ID, tree-ID*
    - *mLDP: mLDP FEC*
  - *Targeted Router*
- *Tunnel Encapsulation Attribute (TEA) encodes forwarding information*
  - *TEA encodes a list of “tunnels”*
  - *A “tunnel” identifies the upstream or a downstream replication branch*
- *A Route Target controls the propagation and importation of the route*

TEA	Route Target	NLRIs



Tunnel Encapsulation Attribute

- *Encodes a list of tunnels (maybe of different types)*
- *Already specified for unicast*
    - *Traffic ECMP'ed out of one of the tunnels*
- *Extended for BGP-MCAST*
    - *Traffic replicated out of all the "tunnels"*
    - *A tunnel can be of type "AnyEncap"*
        - *Any way of getting to a downstream node*
            - *Native, MPLS, GRE, SR Path, whatever*
    - *A tunnel may have the following:*
        - *"RPF" sub-tlv, indicating it is for receiving traffic from upstream*
        - *"Tree Label" sub-tlv, for incoming/outgoing tree-label*
        - *"Endpoint address", identifying downstream node/link*
        - *Maybe other information for more complicated scenarios*

Tunnel Encap Attribute

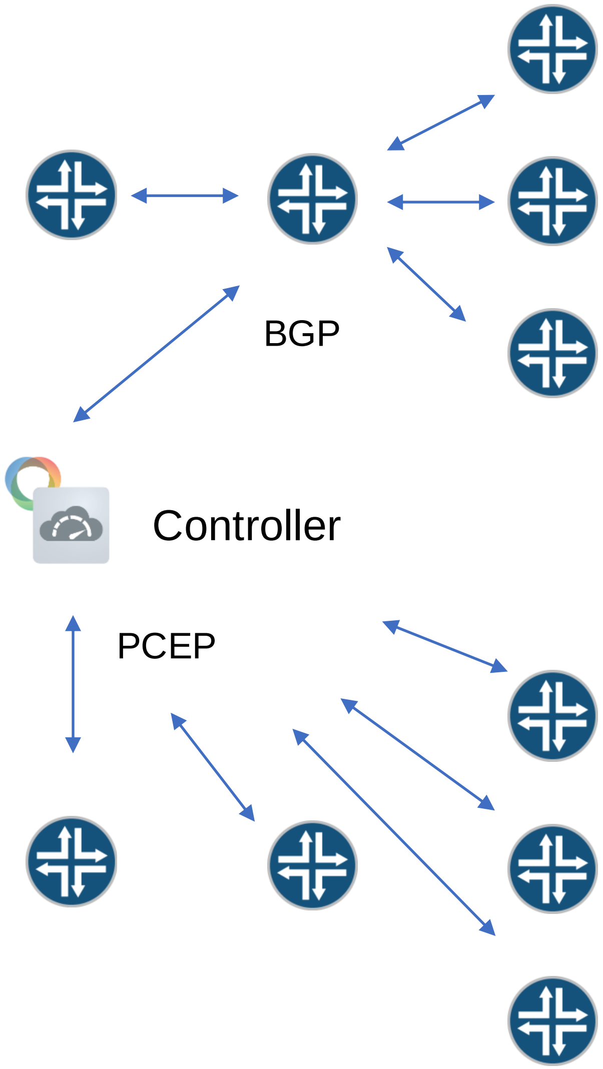
RPF (upstream) 10.1.1.1 Tree Label 100	tunnel1
10.2.1.1 Tree Label 100	tunnel2
10.3.1.1 Tree Label 100	tunnel3
10.4.1.1 Tree Label 200	tunnel4

SR-MPLS vs. SRv6

- *SR/mLDP-P2MP works with both MPLS and SRv6*
    - *Minimum differences/extensions in TEA for SRv6*
- *MPLS forwarding plane*
    - *Forwarding on a branch uses a <transport labels, tree label> stack*
        - *Transport labels get the packets to the downstream node*
            - *Explicitly encoded in a TEA tunnel or derived from the tunnel endpoint*
        - *Transport labels may be empty*
            - *Upstream and downstream nodes connected directly or via a non-MPLS tunnel*
        - *Transport labels can be for an SR path*
        - *Transport label can also represent a p2mp (sub-)tree*
- *SRv6 forwarding plane*
    - *Above mentioned label stack becomes an IPv6 address*
        - *Locator part represents the downstream – corresponding to the transport labels*
        - *Func/Arg part represents the tree – corresponding to the tree label*

Why BGP-MCAST Is the Best Option

- *Single session from controller to* ***one*** *of the BGP speakers in the network*
  - *Vs. one PCEP session to* ***every*** *tree node*
- *Great coverage and extensibility*
  - *Same procedure for both underlay tunnels and overlay multicast*
    - *IP multicast, SR-P2MP, mLDP …*
    - *BGP-MVPN replacement in certain scenarios*
  - *Support bidirectional trees*
  - *Hop-by-hop or Controller-driven*
  - *E2E inter-region support*
  - *Integration with classful transport*



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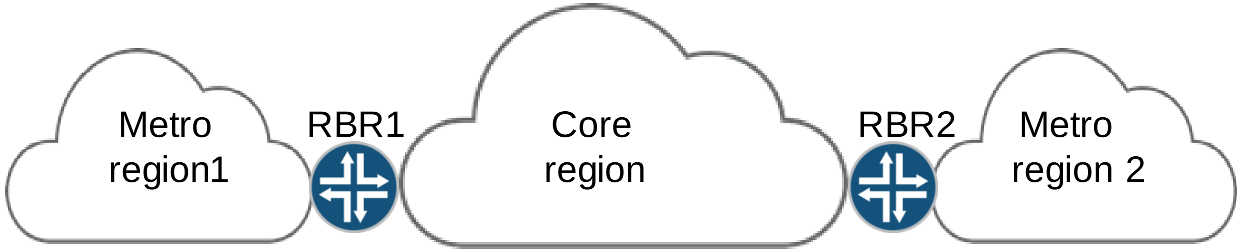
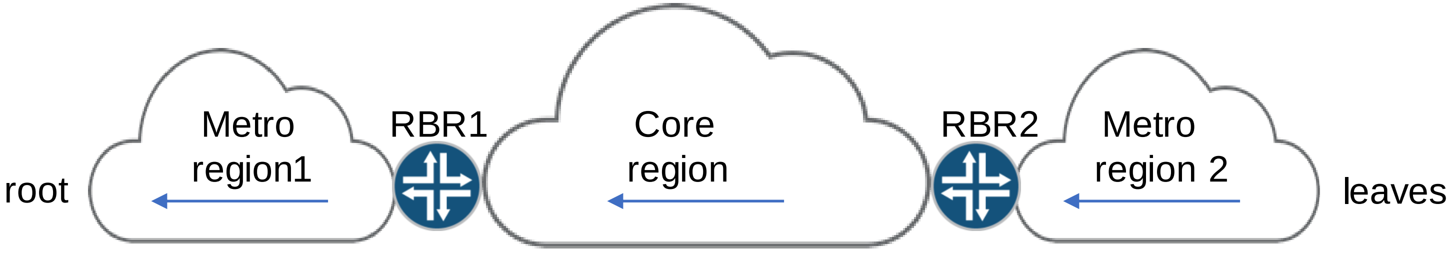
Inter-region Multicast



- *draft-ietf-bess-bgp-multicast, Section 1.2.6*
- *An E2E IP multicast tree or P2MP tunnel can span multiple regions*
  - *A region is an AS or an IGP area*
  - *Different signaling can be used in different regions*
- *Inband signaling across a region*
  - *Internal routers in a region maintain state per E2E tree/tunnel*
- *Overlay signaling over a region*
  - *Internal routers do not keep state for E2E trees*

Inband Signaling across a Region

- *Different methods may be used in different regions*



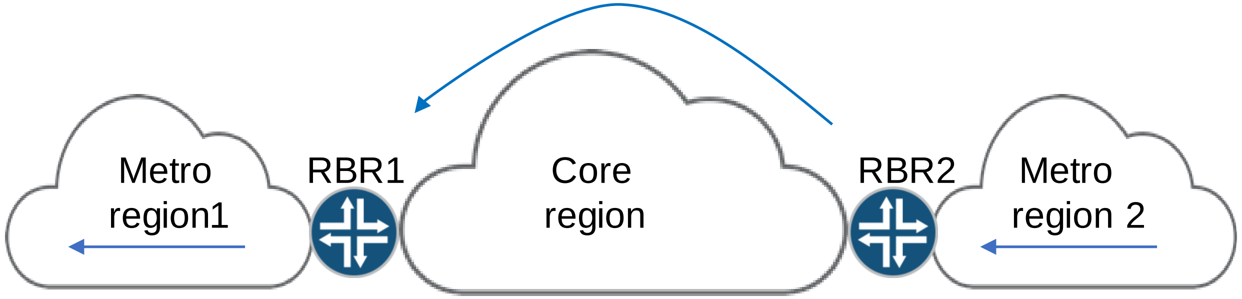
BGP (s,g) signaling
BGP-SRTE SR-P2MP
BGP-Mcast mLDP
(Hop-by-Hop signaling)

mLDP Inband (s,g) signaling
BGP-MCAST SR-P2MP
BGP-Mcast mLDP
(controller signaling)

PIM (s,g) signaling
PCEP SR-P2MP
Native mLDP signaling

- *In case of hop-by-hop signaling:*
  - *A router needs to determine its Reverse Path Forwarding (RPF) neighbor*
    - *The next-hop neighbor towards the tree root*
  - *If internal routers don't have route to the root, RPF is towards the upstream RBR instead*
    - *Encoded as PIM RPF Vector, mLDP Recursive FEC, or BGP-MCAST RPF Address EC*

Overlay Signaling over a Region



- *Internal routers do not keep state for E2E trees*
- *RBR2 signals to RBR1 directly*
  - *BGP-MVPN [RFC6514]*
  - *mLDP over targeted sessions [RFC7060], BGP-MCAST*
    - *Actually no difference between overlay and inband signaling – it's just whether upstream/downstream nodes are directly connected or not*
- *RBR1 tunnels traffic to RBR2 – via Ingress Replication or P2MP*

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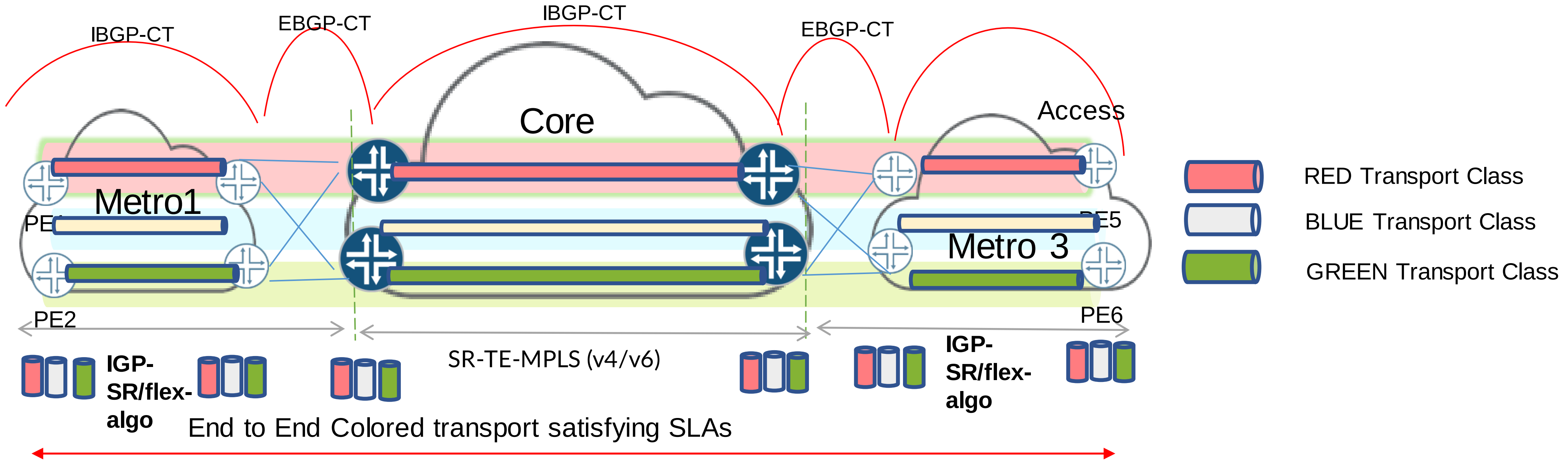
BGP Classful Transport



- *Underlay routes classified into Transport Classes (TCs)*
  - *Advertised via Classful Transport SAFI, with Transport Class Route Target*
    - *The Route Target specifies the TC and controls route propagation and import*
- *Service/overlay routes carry a mapping community*
  - *To map to the TC used to resolve Protocol NH*

Multicast with Classful Transport

- *A multicast tree/tunnel may be:*
  - *an underlay one for a particular TC, or,*
  - *an overlay one using a particular TC*
- *Either way, the BGP-MCAST signaling may carry a mapping community for the TC, which affects:*
  - *path/tunnel selection between an upstream and its downstream nodes*
  - *upstream node selection for a downstream node*

Summary

- *Various options for multicast in SR networks*
    - *Per SR principles or not*
    - *Per deployment considerations*
- *BGP-MCAST is the best none-BIER, non-traditional option*
    - *Single Session from controller to one of the BGP speakers*
    - *Great coverage and extensibility*
    - *Additional benefit for BGP-MCAST signaled mLDP*
        - *Simplifies transition from existing mLDP deployment*
        - *Flexibility and extensibility due to opaque nature of mLDP FEC*
- *E2E inter-region multicast*
    - *Different signaling methods in different regions*
- *BGP-MCAST signaling easily integrates with classful transport*