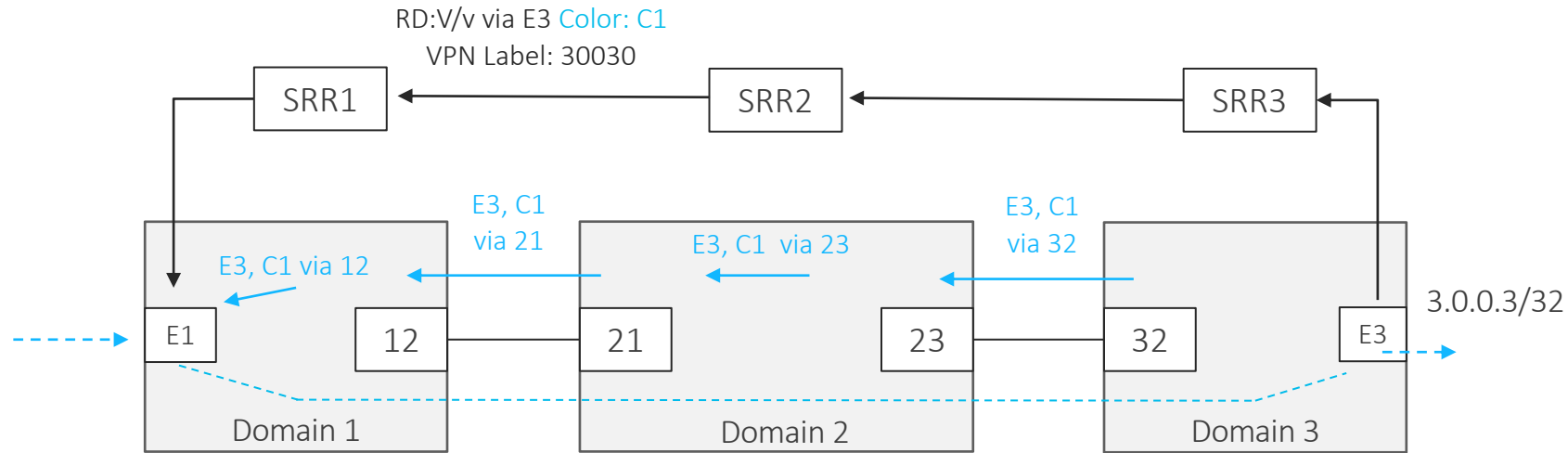# BGP Color-Aware Routing (CAR)

draft-dskc-bess-bgp-car-03

D. Rao, Cisco Systems
S. Agrawal, Cisco Systems
C. Filsfils, Cisco Systems
K. Talaulikar
L. Jalil, Verizon
Y. Su, Alibaba
D. Steinberg, Steinberg Consulting
K. Patel, Arrcus
H. Wang, Huawei
J. Guichard, Futurewei
B. Decraene, Orange

BGP Color-Aware Routing

- Define BGP based routing solution to establish end-to-end intent-aware paths across a multi-domain network environment
    - Intent : Example – low-latency path between two PEs

- Color represents intent in signaling

    - draft-ietf-spring-segment-routing-policy

    - draft-ietf-idr-segment-routing-te-policy

    - Color is the standard way to represent intent

BGP Color-Aware Route & Automated Steering

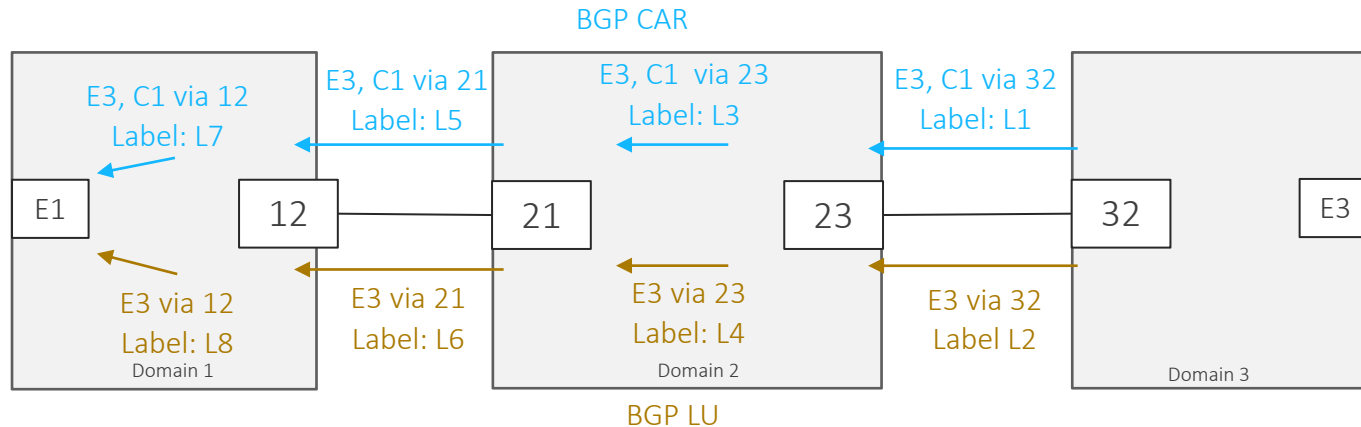RD:V/v via E3 Color: C1
VPN Label: 30030

- E3, C1 is a Color-Aware BGP route in underlay that provides intent-aware path to E3

- A C1 Colored service route RD:V/v from E3 is automatically steered onto a Color-Aware path (E3, C1)

BGP CAR Overview (Refresher)

- Solution draft describe the following aspects
  - New SAFI in BGP
  - Desired Data Model
  - Multiple encapsulations, their signaling and validation
  - Efficient and extensible NLRI
  - Handling of multiple color domains
  - Route resolution & steering mechanisms
  - Scale Analysis

New SAFI in BGP

- Need ability to signal multiple instances of the same prefix for each color (i.e., intent)

- Evolution of best effort BGP-LU SAFI

- Functional and operational consistency with BGP-LU

- No VPN constructs and machinery used for transport

BGP CAR

| E3, C1 via 12 Label: L7 | E3, C1 via 21 Label: L5 | E3, C1 via 23 Label: L3 | E3, C1 via 32 Label: L1 |

| E1 | 12 | 21 | 23 | 32 | E3 |

| E3 via 12 Label: L8 | E3 via 21 Label: L6 | E3 via 23 Label: L4 | E3 via 32 Label L2 |

Domain 1   Domain 2   Domain 3
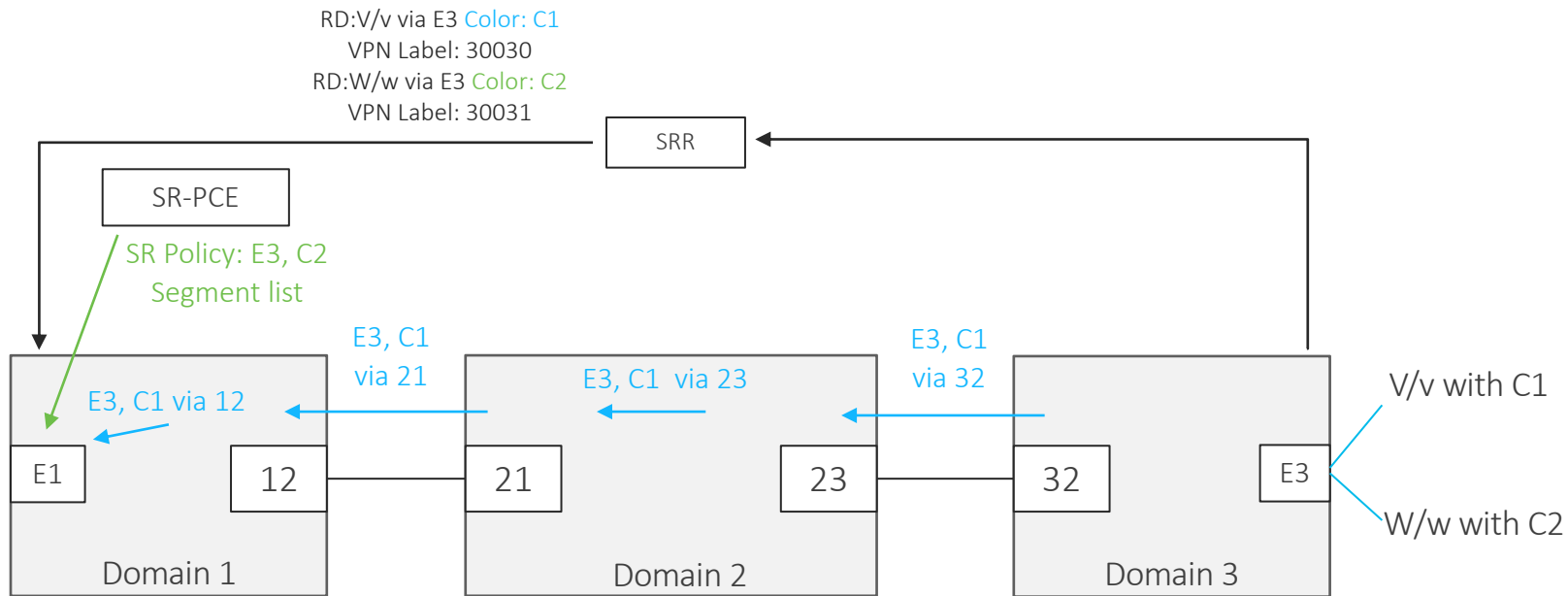
BGP LU

CAR NLRI Proposal

- NLRI Key – E, C
  - E   : IPv4 or IPv6 Endpoint Prefix (Network-wide Unique)
  - Color   : 32-bit value (same as SR-TE Policy)

- Color distinguishes per-intent instances of same prefix

- Color also indicates intent provided by route

- Color is same as in BGP Color Extended-Community

- Color is consistent across devices within a "color domain"

- Optimal for 99% deployments under admins with consistent color mapping

CAR NLRI – E, C

- Simplest data model, precise

- Identical routing semantics as BGP IPv4/v6, BGP-LU
  - Efficient route processing, storage
  - No need for VPN import/export each underlay hop

- Inherently provides ECMP-aware/backup paths at every hop
  - Faster, localized convergence
  - No need for VPN import to bring diverse path together with complex workarounds

- Most efficient for subscription
  - [E, C] direct lookup

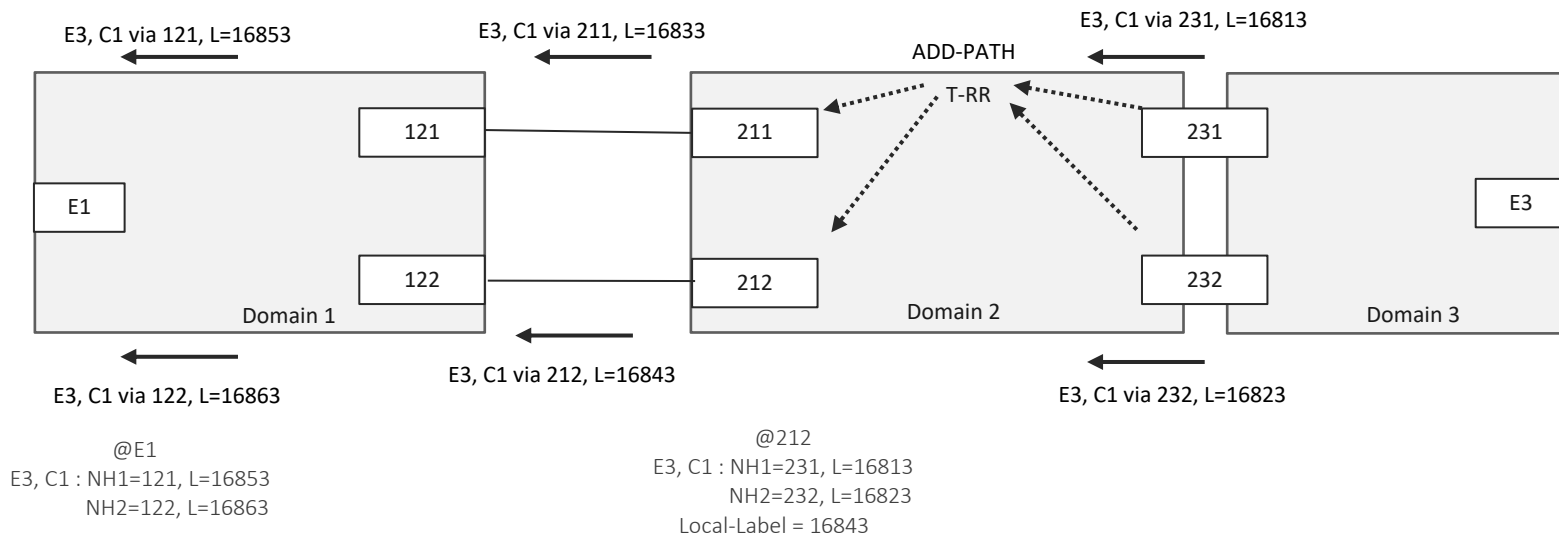- Consistent with SR Policy data model

Seamless BGP CAR and SR Policy co-existence with E,C model

RD:V/v via E3 Color: C1
VPN Label: 30030
RD:W/w via E3 Color: C2
VPN Label: 30031

SRR

SR-PCE

SR Policy: E3, C2
Segment list

E3, C1 via 12

E3, C1
via 21

E3, C1 via 23

E3, C1
via 32

V/v with C1

W/w with C2

E1 | 12

Domain 1

21 | 23

Domain 2

32 | E3

Domain 3

E1 automatically steers the received service routes as follows:

- V/v via (E3, C1) provided by BGP CAR

- W/w via (E3, C2) provided by SR Policy

Path Availability & Domain-local Convergence

E3, C1 via 121, L=16853

E3, C1 via 211, L=16833

E3, C1 via 231, L=16813

ADD-PATH

T-RR

| 121 | | 211 | | 231 |

E1

E3

| 122 | | 212 | | 232 |

Domain 1

Domain 2

Domain 3

E3, C1 via 122, L=16863

E3, C1 via 212, L=16843

E3, C1 via 232, L=16823

@E1
E3, C1 : NH1=121, L=16853
NH2=122, L=16863

@212
E3, C1 : NH1=231, L=16813
NH2=232, L=16823
Local-Label = 16843

- (E, C) NLRI provides ECMP or backup paths at each hop (single label entry)

- Localized convergence with Next-Hop Self

  - E.g., 231 failure is handled locally within domain, churn is not propagated beyond 212 and 211

- BGP ADD-PATH at T-RR for redundant path availability

Extensible, Future-Proof NLRI Encoding

- New SAFI allows opportunity for better NLRI design
  - Existing SAFIs carry key (prefix) and non key information(eg: label in VPN,BGP-LU, EVPN)
    - Hard coded in per SAFI specification
  - BGP CAR provides structure to this non-key information for future extensibility and flexibility
    - No good reason to inherit constraints of current SAFIs, e.g., only a MPLS label field in NLRI

- Encode a NLRI (Route) Type

- Encode a key length

- Encode non-key TLVs

- Per route unique data in NLRI non-key TLVs; rest in Attribute
  - Provides packing efficiency for BGP updates

Encapsulations

- Multiple encapsulations supported for a CAR route
  - Signaled via Non-Key TLVs
    - MPLS Label(s), Label-Index, SRv6 SID(s) etc
  - Separate "label" values for different encapsulations
  - Beneficial for co-existence, migration & interworking
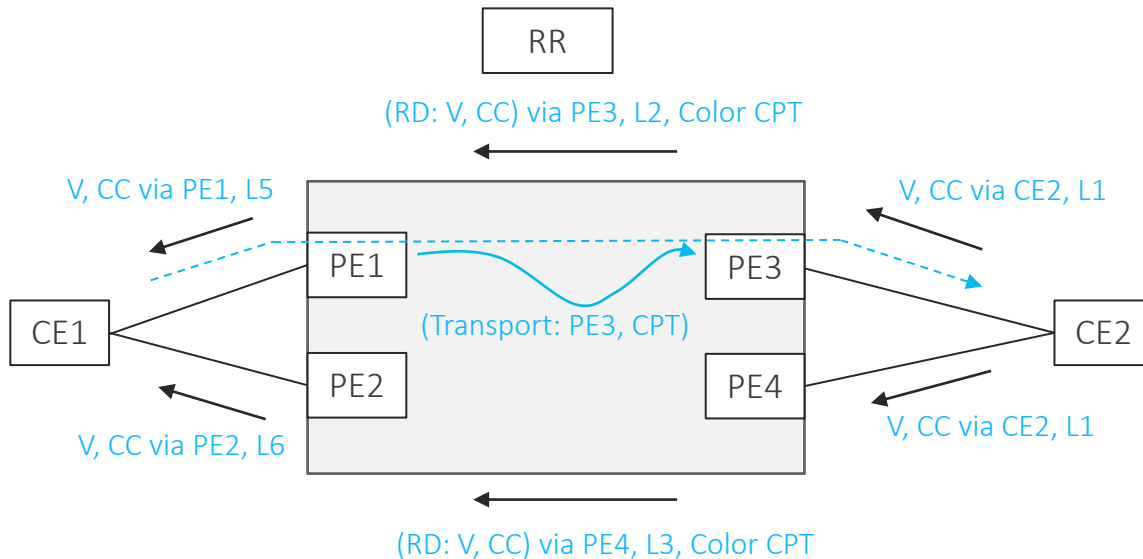   - Efficient signaling, operational simplicity

CAR Next-Hop Resolution

- Resolution is recursive and color-aware
  - (E, C) via (N, C)

- (N, C) provided by other color-aware mechanisms
  - SR Policy, IGP Flex-Algo, or BGP CAR itself

- Resolution supports fallback to alternative colors or to best effort
  - Used to traverse domains with less diverse intent or over color-unaware islands

- Resolution will also be mapped to traditional mechanisms
  - RSVP-TE
  - IGP/LDP
  - BGP-LU
  - Supports brownfield, incremental deployment

Multiple Color Domains

- Network domains where color-intent mappings are different

- Local-Color-Mapping (LCM) Extended Community
  - Optional, only used if routes go across a color domain boundary
  - Color re-mapped and rewritten into receiving domain's color at a color domain boundary
  - Color Ext-Comm sent with service routes also gets re-mapped in parallel

- CAR NLRI (E, C) is immutable, preserved e2e
  - Eases tracking of route

- E (Prefix) is unique in inter-domain transport network (e.g., PE)
  - Makes (E, C) unique e2e even if C is local to a color domain

VPN CAR

- Extends CAR to VPN service layer
  - CE − PE BGP Color-aware routing
  - E2E intent (e.g., CE − CE)

Updates (v02)

- Added VPN CAR

- Describe usage of Anycast SID
  - Convergence, Recursion

- Clarify path availability & convergence
  - Covered in earlier slide

- Added J. Guichard as co-author

Updates (v03)

- Clarifies error handling for CAR NLRI SAFI encoding following principle of RFC 7606

- Describes non key TLV handling for recognized and unrecognized types

- Added Bruno Decraene as co-author

BGP CAR sample output (IOS-XR)

RP/0/0/CPU0:ABR# show bgp ipv4 car unicast 10.11.12.13/32 color 3
Sat Jan 22 12:32:46.172 PST
BGP routing table entry for [1][32][10.11.12.13][3]/72
Versions:
  Process   bRIB/RIB SendTblVer
  Speaker   2   2
Paths: (1 available, best #1)
  Not advertised to any peer
  Path #1: Received by speaker 0
  Not advertised to any peer
  Local
    192.168.0.3 (metric 30) from 192.168.0.2 (192.168.0.3)
    Received Label 3
    Origin IGP, localpref 100, valid, internal, best, group-best
    Received Path ID 0, Local Path ID 1, version 2
    Originator: 192.168.0.3, Cluster list: 192.168.1.2
    CAR Non-Key TLVs:
    Label-Index 801
    Unknown TLV:
      04020101

Update dump:
Dump of the BGP CAR update
ffff ffff ffff ffff ffff ffff ffff ffff
0083 0200 0000 6c90 0e00 4c00 0153 04c0
a800 0300 **1a09 0120 0e0e 0e0e 0000 0003**
0103 0000 3102 0400 0003 2103 0201 0116
0901 200e 0e0e 0e00 0000 0201 0300 0031
0204 0000 0321 1009 0120 0e0e 0e0e 0000
0001 0103 0000 3140 0101 0040 0200 4005
0400 0000 6480 0a04 c0a8 0102 8009 04c0
a800 03

Next Steps

- Continue to address use-cases & requirements listed in problem statement

- Request collaboration & review from Working Group

- Problem statement drafts merge effort is ongoing

- 2 known implementations

- Ready for WG adoption