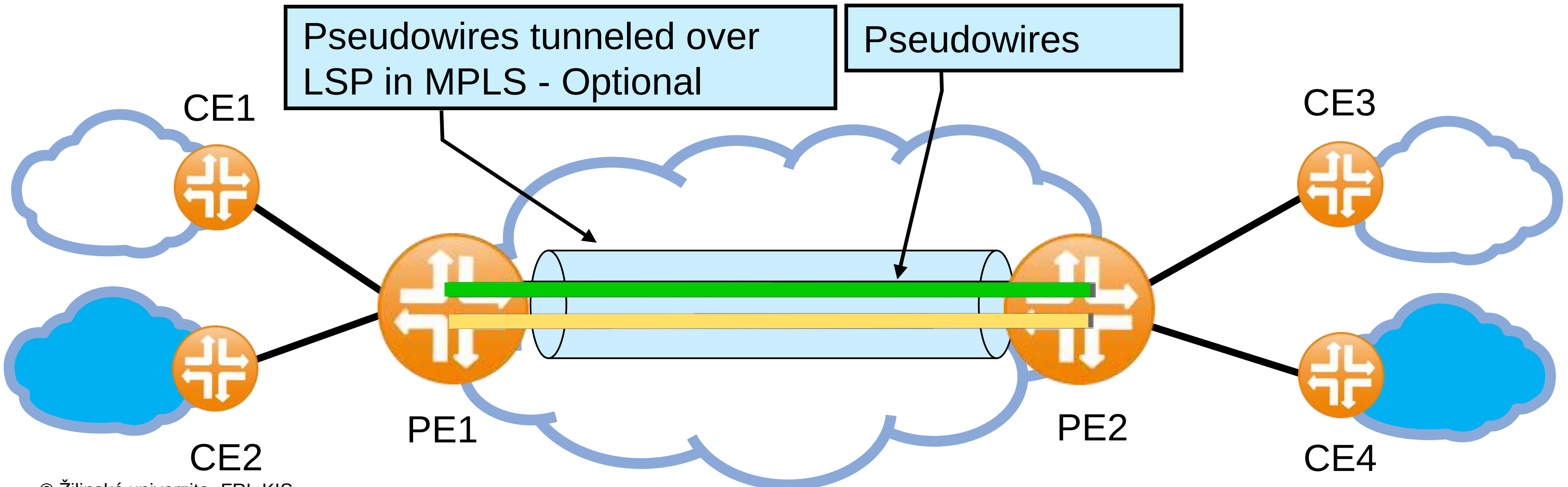
VPLS

L2 VPN types for Ethernet emulation over MPLS

- E-Line or Point2Point
  - a service connecting two customer Ethernet ports over a network
  - The IETF uses **PWs** (pseudowires) encapsulation for an emulated bi-directional point-to-point circuit or **VPWS** (Virtual Private Wire Service) for any point-to-point L2 service (Ethernet, FR, ATM, PPP, etc)
  - E-MPLS - VPWS which emulates Ethernet over MPLS
- E-LAN or Any2Any
  - a multipoint service connecting a set of customer endpoints, giving the appearance to the customer of a bridged Ethernet network connecting the sites
  - The IETF uses **VPLS** (Virtual Private LAN Service) for a multipoint-to-multipoint service
  - The same PW encapsulation is used as for E-Line
- E-Tree or P2MP Service
  - a multipoint service connecting one or more multicast roots and a set of multicast leaves
  - VPLS + Multicast LSPs

Pseudo Wire Reference Model

- A Pseudowire (PW) is a bidir logical connection between two provider edge devices connecting two attachment circuits (ACs)
- In MPLS core a Pseudowire may use one or two MPLS labels in a stack
  - VC (Virtual Circuit) Label identifying unidirectional pseudowire circuit (tunneled or not)
  - Unidirectional Tunnel LSP between PE routers to transport PW PDU from PE to PE using tunnel label(s)
    - Transport tunnel offers better scalability



Ethernet PW Tunnel Encapsulation

	0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1			
Tunnel Encaps Optional	**LSP Tunnel Label (LDP,RSVP signaling)**	**EXP**	**0**	**TTL**
PW Demux	**VC Label (VC)**	**EXP**	**1**	**TTL (set to 2)**
Control Word	**0 0 0 0**	**Reserved**	**Sequence Number**	
	Layer-2 PDU			

- VC Label (inner label) used by receiving PE
  - to determine the Virtual Routing Instance (VRF)
  - Egress interface for L2PDU forwarding (Port based)
  - Egress VLAN used on the CE facing interface (VLAN Based)
- EXP can be set to the values received in the L2 frame
- Control Word is Optional (as per RFC)
  - First 4 bits set to 0 to indicates PW data
  - sequencing capability to detect out of order packets - optional

PW Frame (no transport tunnel)

```
⊞ Ethernet II, Src: JuniperN_04:8b:ac (5c:5e:ab:04:8b:ac), Dst: JuniperN_04:8b:ae (5c:5e:ab:04:8b:ae)
⊟ 802.1Q Virtual LAN, PRI: 0, CFI: 0, ID: 100
    000. .... .... .... = Priority: Best Effort (default) (0)
    ...0 .... .... .... = CFI: Canonical (0)
    .... 0000 0110 0100 = ID: 100
    Type: MPLS label switched packet (0x8847)
⊟ MultiProtocol Label Switching Header, Label: 262148, Exp: 0, S: 1, TTL: 255
    MPLS Label: 262148
    MPLS Experimental Bits: 0
    MPLS Bottom Of Label Stack: 1
    MPLS TTL: 255
⊞ Ethernet II, Src: JuniperN_04:8b:95 (5c:5e:ab:04:8b:95), Dst: JuniperN_04:8b:93 (5c:5e:ab:04:8b:93)
⊞ Internet Protocol Version 4, Src: 172.16.1.1 (172.16.1.1), Dst: 172.16.1.3 (172.16.1.3)
⊟ Internet Control Message Protocol
    Type: 0 (Echo (ping) reply)
    Code: 0
    Checksum: 0x0abe [correct]
    Identifier (BE): 23058 (0x5a12)
    Identifier (LE): 4698 (0x125a)
    Sequence number (BE): 2 (0x0002)
    Sequence number (LE): 512 (0x0200)
    [Response To: 255]
    [Response Time: 0.298 ms]
```

Virtual Private LAN Service (VPLS)

- VPLS defines an architecture allows MPLS networks offer Layer 2 multipoint Ethernet Services
- SP emulates an Ethernet bridge network (broadcast domain)
- Virtual Bridges linked with MPLS Pseudo Wires
- Full Mesh required

- There are two standards for VPLS control plane:
  - One uses BGP for auto-discovery and signaling of PWs (RFC 4761)
  - The other one uses LDP for signaling of PWs (RFC 4762)

- The data plane scheme used by both these mechanisms is same:
  - Flooding of unknown unicast, learning / aging MAC addresses
  - A key notion in the data plane is of split-horizon forwarding

Control Plane - MPLS PW Types

0x0001 Frame Relay DLCI (Martini Mode)
0x0002 ATM AAL5 SDU VCC transport
0x0003 ATM transparent cell transport
0x0004 Ethernet Tagged Mode (VLAN)
0x0005 Ethernet (Port)
0x0006 HDLC
0x0007 PPP
0x0008 SONET/SDH Circuit Emulation
0x0009 ATM n-to-one VCC cell transport
0x000A ATM n-to-one VPC cell transport
0x000B IP Layer2 Transport
0x000C ATM one-to-one VCC Cell Mode
0x000D ATM one-to-one VPC Cell Mode

0x000E ATM AAL5 PDU VCC transport
0x000F Frame-Relay Port mode
0x0010 SONET/SDH Circ. Emu. over Packet
0x0011 Structure-agnostic E1 over Packet
0x0012 Structure-agnostic T1 over Packet
0x0013 Structure-agnostic E3 over Packet
0x0014 Structure-agnostic T3 over Packet
0x0015 CESoPSN basic mode
0x0016 TDMoIP AAL1 Mode
0x0017 CESoPSN TDM with CAS
0x0018 TDMoIP AAL2 Mode
0x0019 Frame Relay DLCI

Virtual Connection Distribution mechanism via LDP

- VC labels are exchanged across a targeted LDP session between PE routers
  - Generic Label TLV within LDP Label Mapping Message
- LDP FEC element defined to carry VC information
  - Such PW Type (RFC 4446) and VCID
- VC information exchanged using Downstream Unsolicited label distribution procedures
- Separate “MAC List” TLV for VPLS

1. Xconnect command entered on ingress interface, PE1 starts targeted LDP session with PE2
2. PE1 allocates VC label for interface & binds to configured VC ID
3. PE1 sends VC label mapping message containing VC FEC TLV, VC label TLV
4. PE2 receives it and matches local VC ID
5. PE2 repeats it as so that bidir VC mapping is established

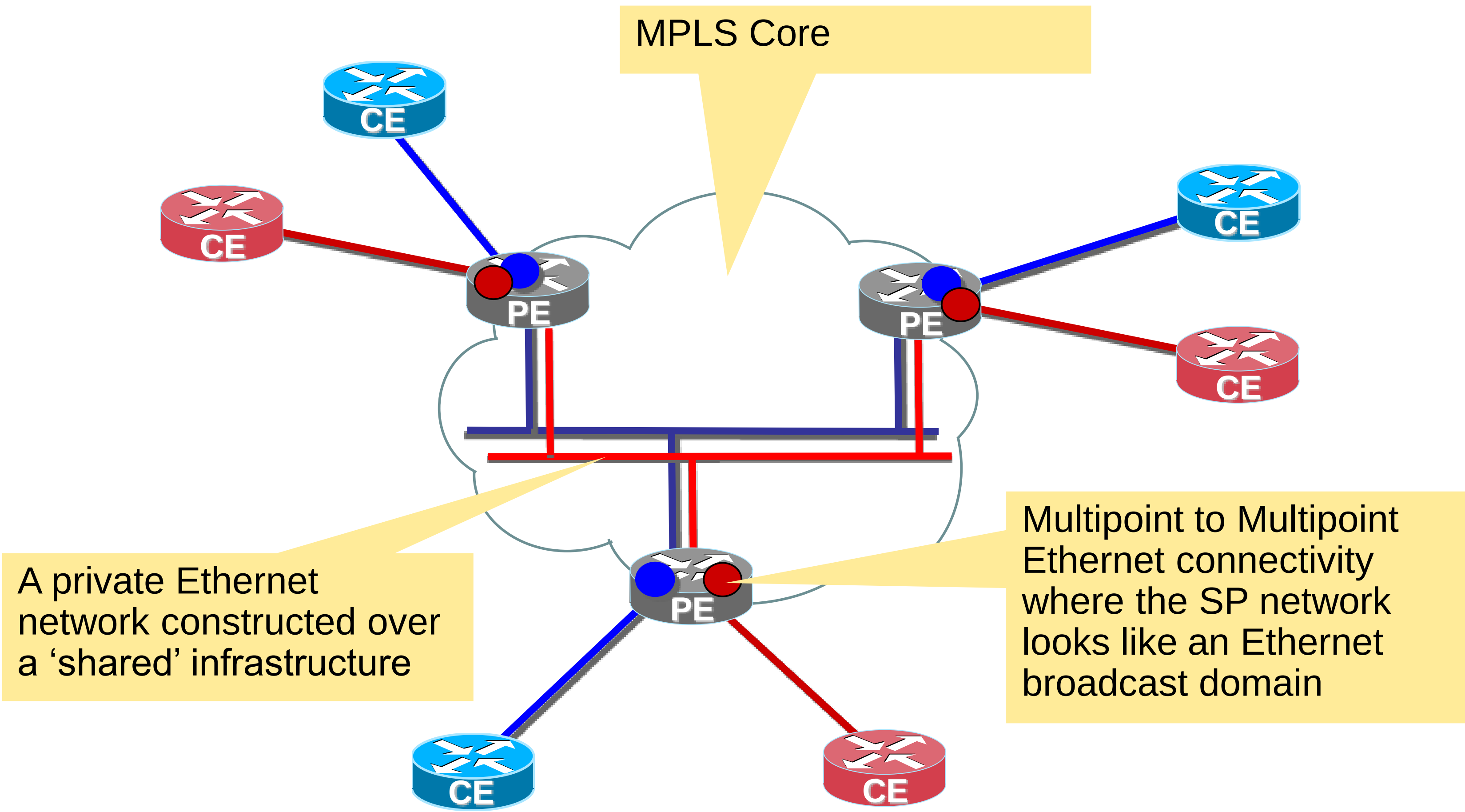
LDP label distribution

```
⊟ Label Distribution Protocol
    Version: 1
    PDU Length: 46
    LSR ID: 10.255.255.3 (10.255.255.3)
    Label Space ID: 0
  ⊟ Label Mapping Message
      0... .... = U bit: Unknown bit not set
      Message Type: Label Mapping Message (0x400)
      Message Length: 36
      Message ID: 0x00000008
    ⊟ Forwarding Equivalence Classes TLV
        00.. .... = TLV Unknown bits: Known TLV, do not Forward (0x00)
        TLV Type: Forwarding Equivalence Classes TLV (0x100)
        TLV Length: 20
      ⊟ FEC Elements
        ⊟ FEC Element 1 VCID: 10
            FEC Element Type: Virtual Circuit FEC (128)
            0... .... = C-bit: Control Word NOT Present
            .000 0000 0000 0101 = VC Type: Ethernet (0x0005)
            VC Info Length: 12
            Group ID: 0
            VC ID: 10
          ⊞ Interface Parameter: MTU 1500
          ⊟ Interface Parameter: VCCV
              ID: VCCV (0x0c)
              Length: 4
            ⊟ CC Type
                .... ...0 = PWE3 Control Word: False
                .... ..1. = MPLS Router Alert: True
                .... .1.. = MPLS Inner Label TTL = 1: True
            ⊞ CV Type
    ⊟ Generic Label TLV
        00.. .... = TLV Unknown bits: Known TLV, do not Forward (0x00)
        TLV Type: Generic Label TLV (0x200)
        TLV Length: 4
        Generic Label: 262148
```

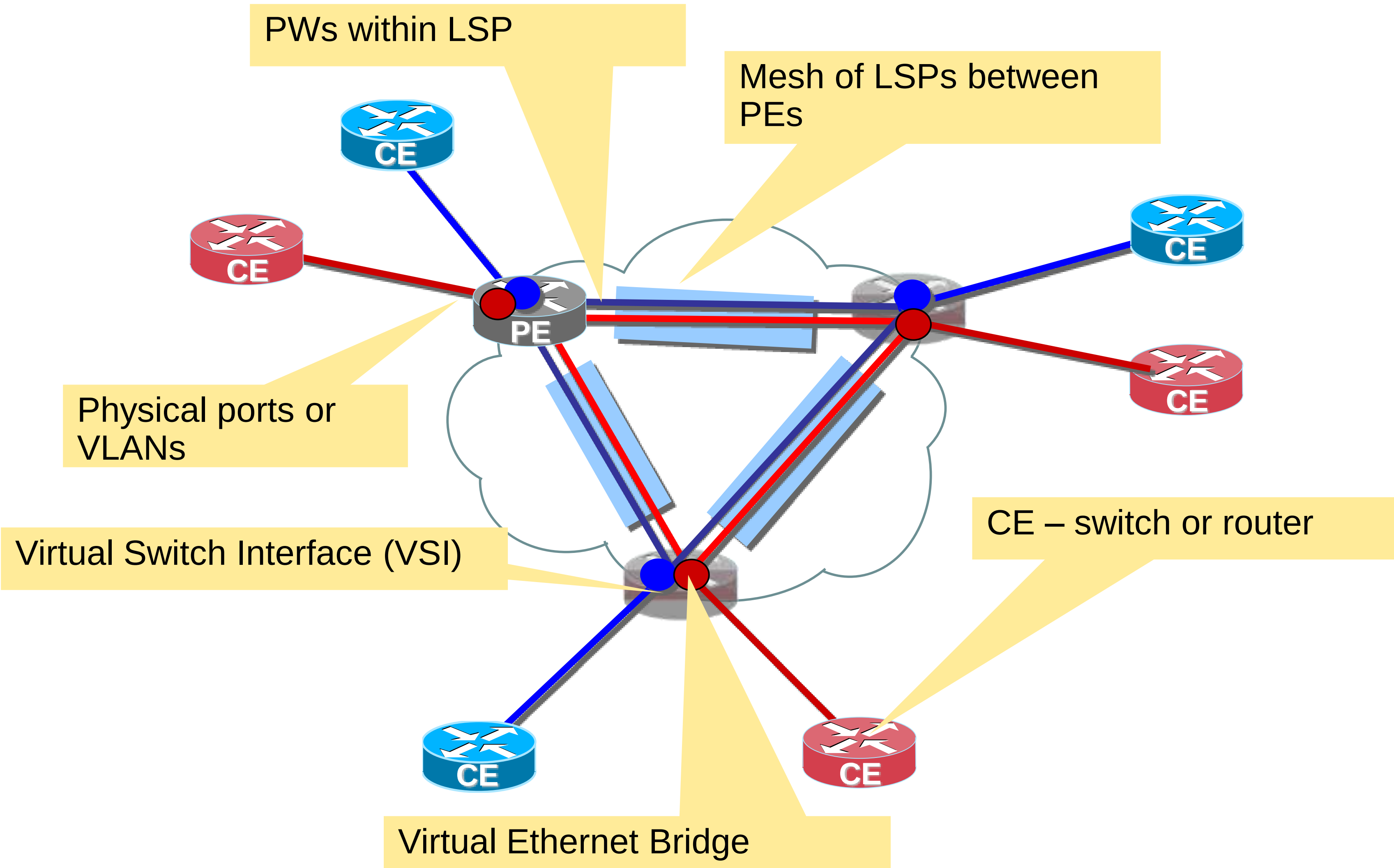
BGP Label distribution

```
⊞ Ethernet II, Src: JuniperN_04:8b:ae (5c:5e:ab:04:8b:ae), Dst: JuniperN_04:8b:ac (5c:5e:ab:04:8b:ac)
⊞ 802.1Q Virtual LAN, PRI: 6, CFI: 0, ID: 100
⊞ Internet Protocol Version 4, Src: 10.255.255.3 (10.255.255.3), Dst: 10.255.255.1 (10.255.255.1)
⊞ Transmission Control Protocol, Src Port: 60640 (60640), Dst Port: bgp (179), Seq: 163, Ack: 163, Len: 88
⊟ Border Gateway Protocol
  ⊟ UPDATE Message
      Marker: 16 bytes
      Length: 88 bytes
      Type: UPDATE Message (2)
      Unfeasible routes length: 0 bytes
      Total path attribute length: 65 bytes
    ⊟ Path attributes
      ⊞ ORIGIN: IGP (4 bytes)
      ⊞ AS_PATH: empty (3 bytes)
      ⊞ LOCAL_PREF: 100 (7 bytes)
      ⊟ EXTENDED_COMMUNITIES: (19 bytes)
        ⊞ Flags: 0xc0 (Optional, Transitive, Complete)
          Type code: EXTENDED_COMMUNITIES (16)
          Length: 16 bytes
        ⊟ Carried Extended communities
            UnknownRoute Target: 100:201
          ⊞ UnknownLayer 2 Information: Unknown, Control Flags: none, MTU: 0 bytes
      ⊟ MP_REACH_NLRI (32 bytes)
        ⊞ Flags: 0x90 (Optional, Non-transitive, Complete, Extended Length)
          Type code: MP_REACH_NLRI (14)
          Length: 28 bytes
          Address family: Layer-2 VPN (25)
          Subsequent address family identifier: VPLS (65)
        ⊟ Next hop network address (4 bytes)
            Next hop: IPv4=10.255.255.3 (4)
          Subnetwork points of attachment: 0
        ⊟ Network layer reachability information (19 bytes)
            RD: 100:0.0.0.203, CE-ID: 3, Label-Block Offset: 1, Label-Block Size: 8 Label Base 262401 (bottom)
```

VPLS Customer’s View



VPLS Components



VPLS Virtual Switch Instance Functions

- Virtual Switch Instance/Interface (VSI) is an Ethernet bridge function entity of a VPLS instance on a PE. It emulates legacy bridging by forwarding Layer 2 frames based on MAC address and VLAN tag

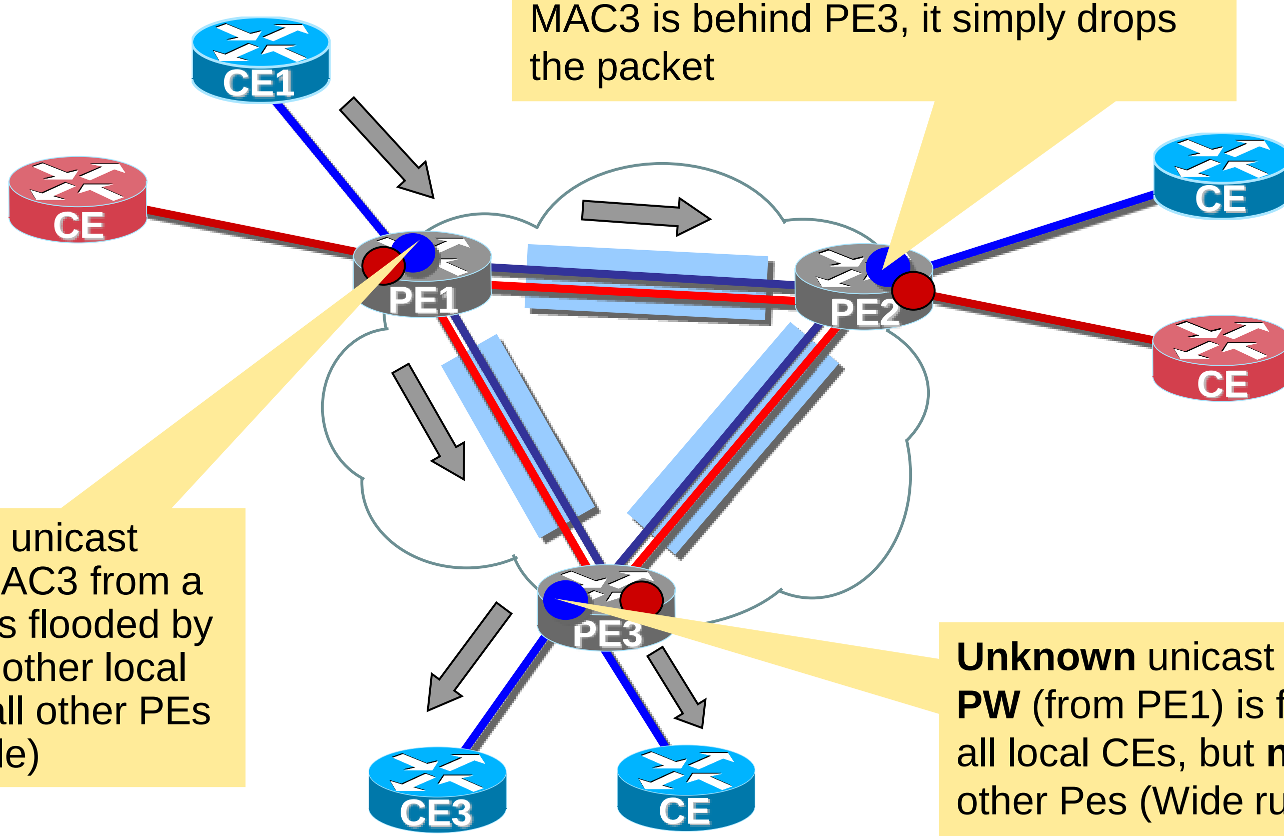
- **Flooding / Forwarding**
  - MAC table instances per customer (port/vlan) for each PE
  - Forwarding Instance (VFI) will participate in learning and forwarding process
  - Associate ports to MAC, flood unknowns to all other ports
- **Address Learning / Aging**
  - LDP enhanced with additional MAC List TLV (label withdrawal)
  - MAC timers refreshed with incoming frames
- **Loop Prevention**
  - Create full-mesh of Pseudo Wire VCs (EoMPLS)
  - Unidirectional LSP carries VCs between pair of PEs
  - A VPLS use “split horizon” concepts to prevent loops

Split Horizon Semantics

Two types of split horizon

- “Narrow”
  - receive from one CE, send to all other CEs
  - don’t send to CE from which the packet came
  - Forwards to all PWs within VPLS instance
- “Wide”
  - receive from a device in a VPLS instance, don’t send to any device in that VPLS instance, just to local CEs

Split Horizon Example



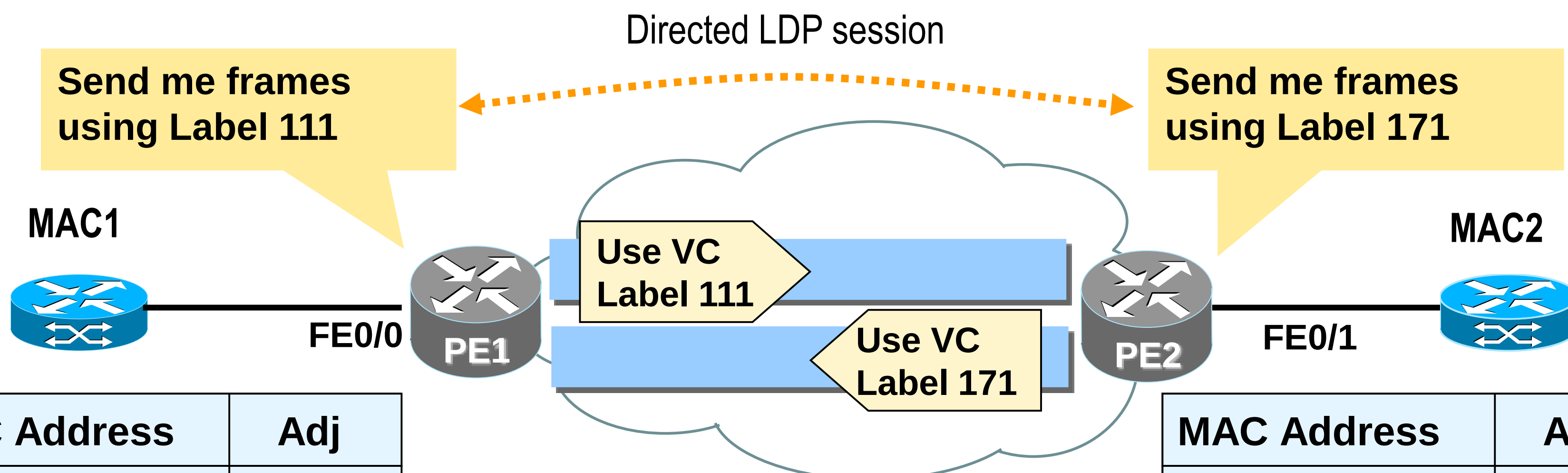
Known unicast also has to follow the split-horizon rule: if PE2 gets a packet for destination MAC3, and knows that MAC3 is behind PE3, it simply drops the packet

Unknown unicast MAC1->MAC3 from a **local CE** is flooded by PE1 to all other local CEs and all other PEs Narrow rule)

Unknown unicast **from a PW** (from PE1) is flooded to all local CEs, but **not** to other Pes (Wide rule)

MAC Address Learning and Forwarding

- Broadcast, Multicast, and Unknown Unicast are learned via the received label associations
- Two unidir LSPs associated with a VC (Tx & Rx)
- If inbound or outbound LSP is down then the entire Pseudowire is considered down

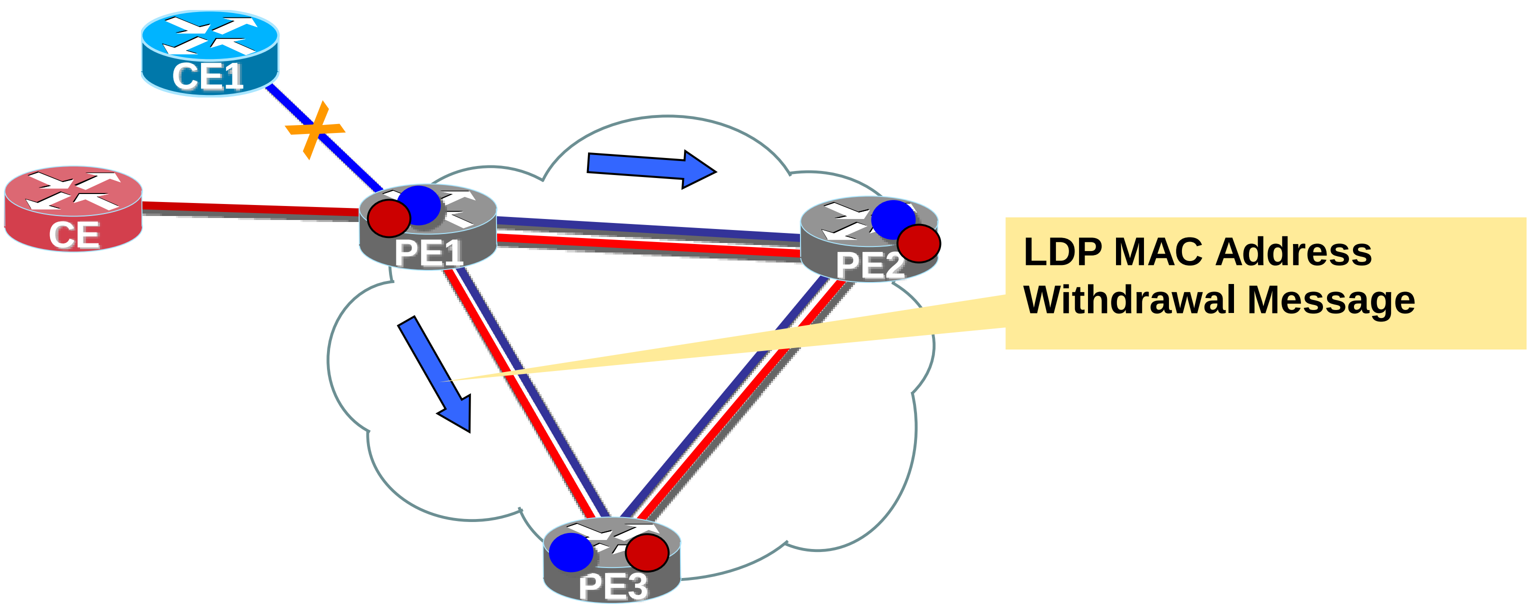


MAC Address	Adj
MAC 2	171
MAC 1	E0/0

MAC Address	Adj
MAC 2	E0/1
MAC 1	111

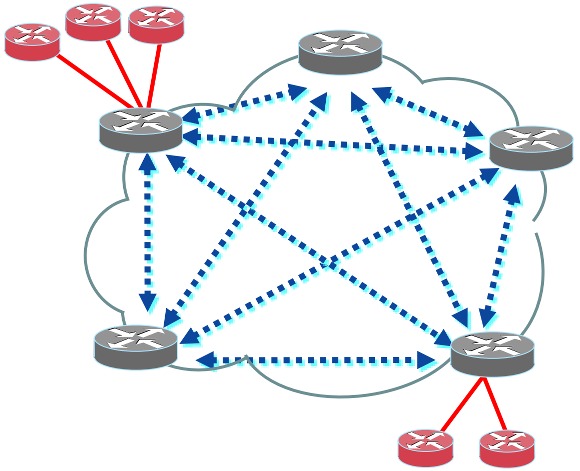
LDP MAC Address Withdrawal Message

- Message speeds up convergence process
- otherwise PE relies on MAC Address Aging Timer
- Upon failure PE removes locally learned MAC addresses
- Send LDP Address Withdrawal Message to remote PEs in VPLS (using LDP session)
    - New MAC List TLV (type-length-value) is used to withdraw addresses



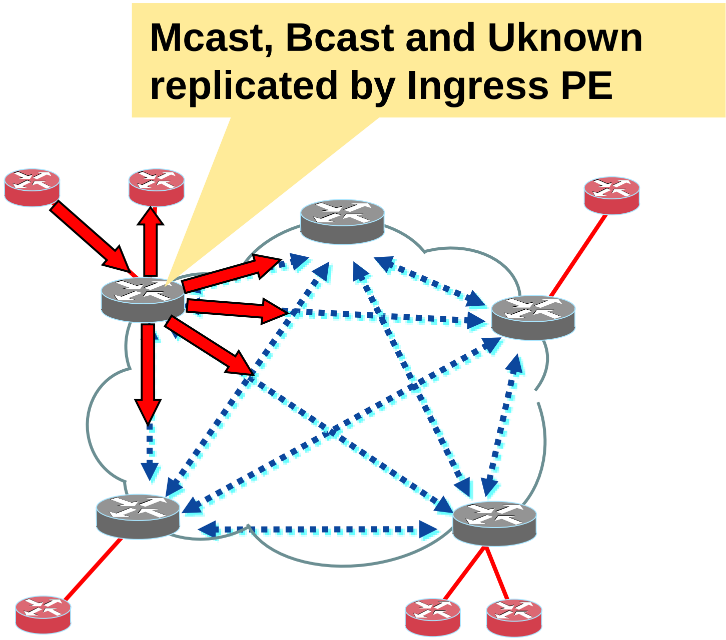
Single Domain VPLS Scalability

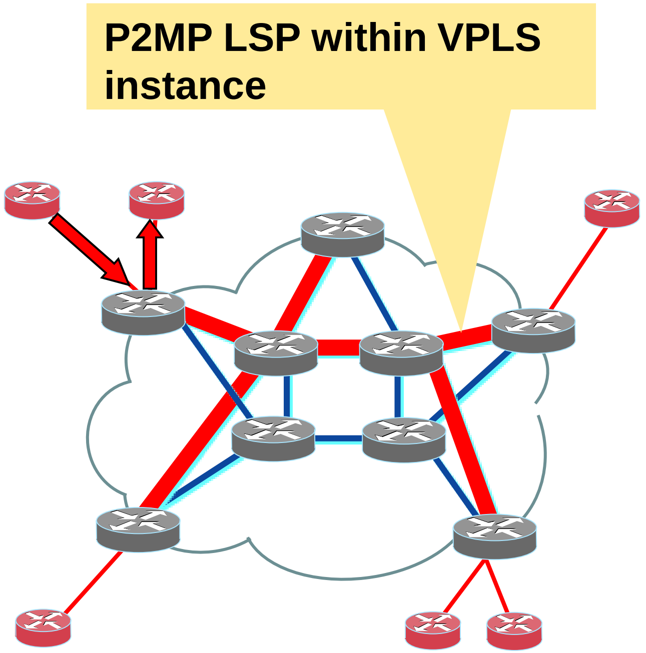
- Suitable for simple/small implementations
- Full mesh of PWs required (for both LDP and BGP based)
  - N*(N-1)/2 Pseudo Wires
  - For LDP based full mesh of directed LDP sessions required
  - For LDP based manual configuration & provisioning issues
- No hierarchical scalability
- Stability / Recovery issues
- Potential packet replication overhead
  - PE-to-PE flooding used to use ingress replication of unknowns, broadcast and multicast
  - CPU overhead for replication



Ingress Replication versus P2MP LSPs

- Some vendors integrate into VPLS point-to-multipoint LSPs in such a way that broadcast, multicast, and unknown unicast will be forwarded using point-to-multipoint LSP instead of ingress replicating





Control Plane

Characteristic	LDP VPLS	BGP VPLS
Full-mesh requirement	Alleviated only somewhat by H-VPLS, though at the expense of introducing changes and additional overhead in the dataplane	Solved by the use of BGP Route Reflector hierarchy
Provisioning task of adding or removing PE router	Only somewhat simplified by H-VPLS	Highly simplified by use of Route Reflector
Provisioning task of adding or changing VPLS cutomer sites	Manual or through provisioning	Automated by BGP'd autodiscovery
VPLS with P2MP LSP integration to scale forwarding and data planes	Currently still not fully standardized, based on mLDP draft-ietf-l2vpn-vpls-mcast-13.txt	Already implemented by some vendors using RSVP-TE signalling
Signaling overhead	Increases in proportion to the total number of PWs in the network	Minimal because each signaling update can be used to establish multiple PWs

Multi-Domain VPLS

- **Hierarchical LDP** based VPLS (H-VPLS)
  - Consists of two levels in a Hub and Spoke topology
  - Hub or N-PE (Network facing PE router) consists of full mesh VPLS Pseudo Wires in MPLS core
  - Spokes or U-PE (User facing PE router) consist of a single or pair of PWs connecting to VPLS (Hub) PEs

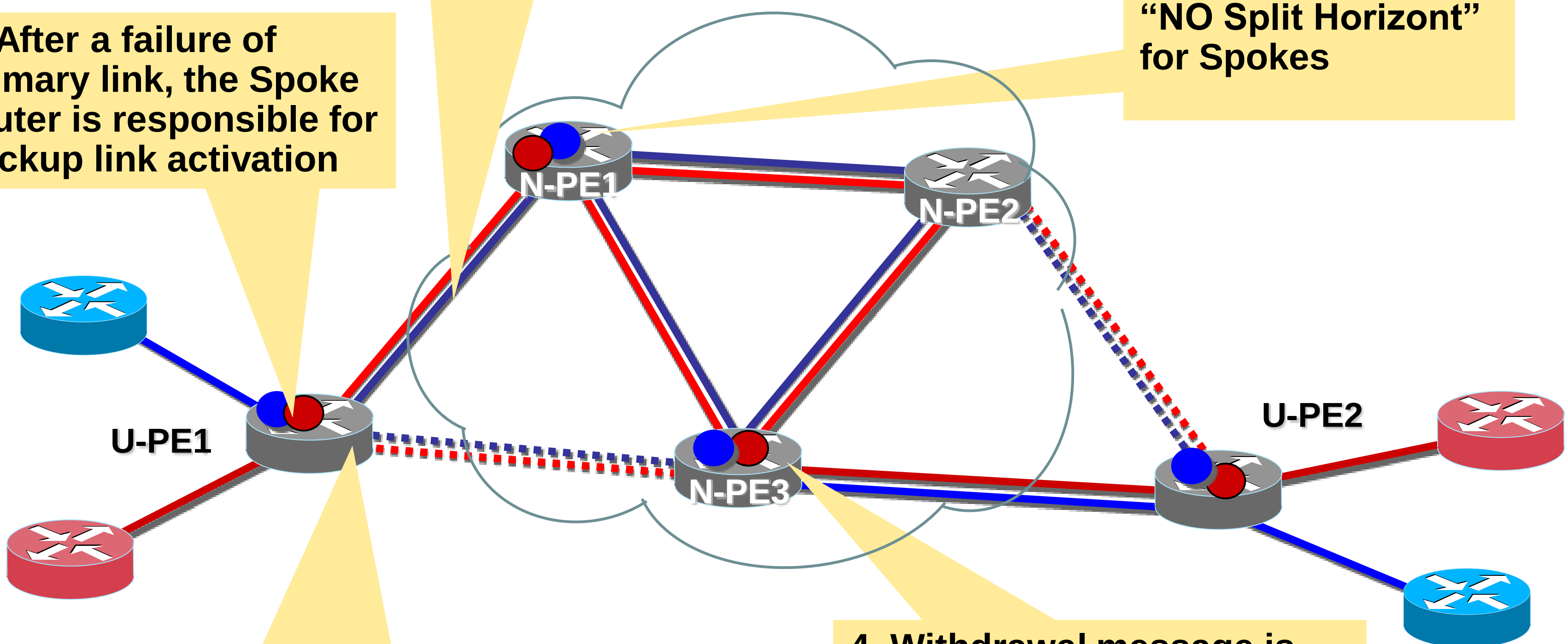
- **Multi domain concept** with BGP VPLS in the core
  - BGP VPLS domain in the core
  - Typically LDP VPLS domains in the aggregation part of the network
    - The reason for LDP in aggregation might be lack of BGP on edge PE routers - LDP is considered as a less complex technology
  - From the perspective of BGP VPLS, the LDP VPLS domain is equivalent to a CE
  - The LDP VPLS domain can be multihomed to redundant interworking BGP VPLS PE routers
  - LDP VPLS domain has no idea about core BGP VPLS domain

H-VPLS

MPLS/L2/L3 tunnels connecting to VPLS

1. Hub routers use “NO Split Horizont” for Spokes

2. After a failure of primary link, the Spoke router is responsible for backup link activation

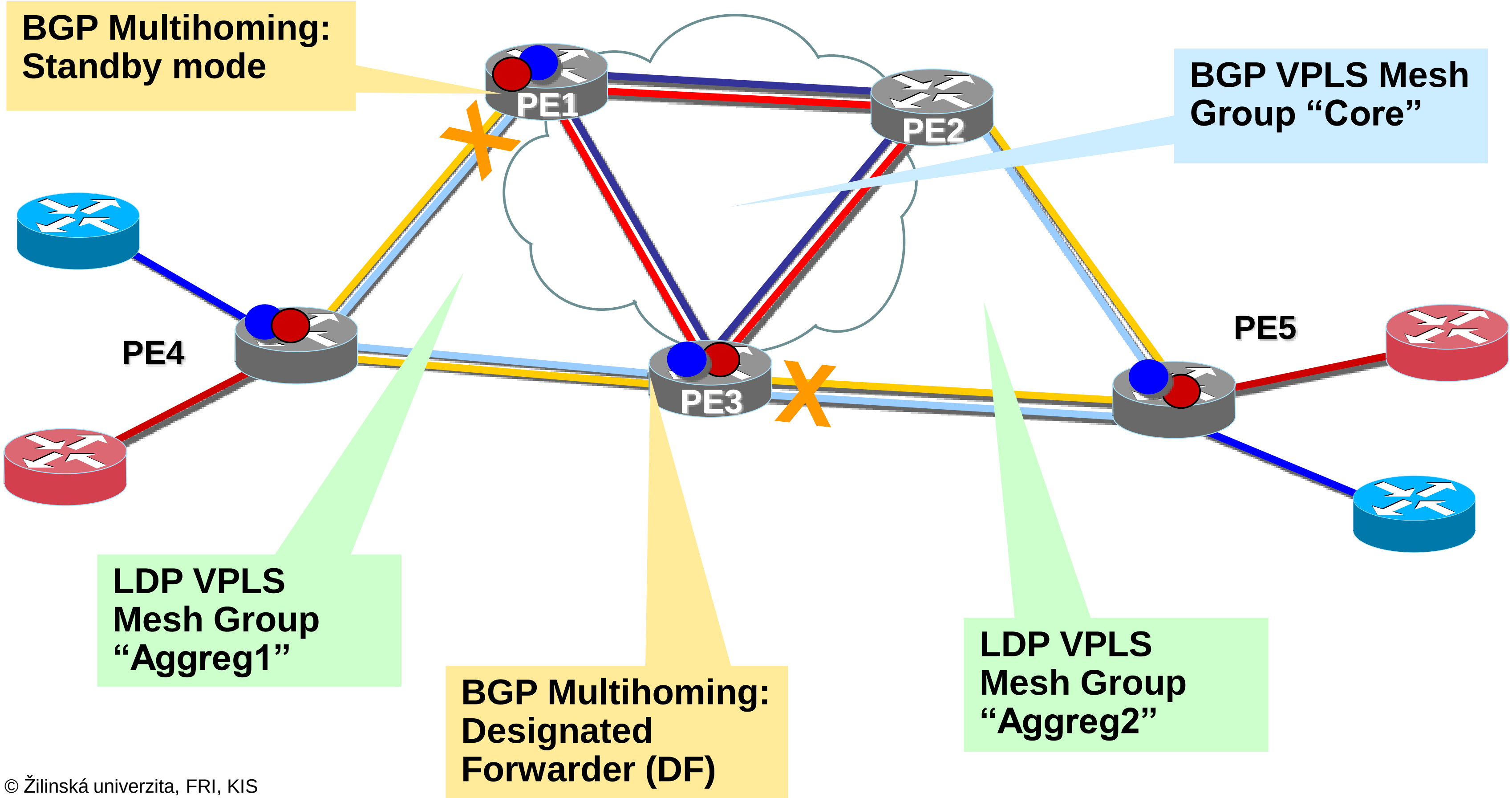


3. Typically the Spoke router is responsible for sending MAC withdraw message. It is sent only after activating the backup link. Hub router will process

4. Withdrawal message is flooded and may contain an empty list. All Hubs then has to remove all MACs associated with the VPLS instance except MACs learned over the PW over which the message was received.

Core BGP VPLS interconnected to Access LDP ones

- In JunOS for instance (Juniper), domain or “mesh-group” construct can be used to create any of both mentioned 2-level hierarchy
- The mesh-groups is notion in regards to split-horizon rules in VPLS which introduce “no split horizon” rule



Multi Domain Split Horizon

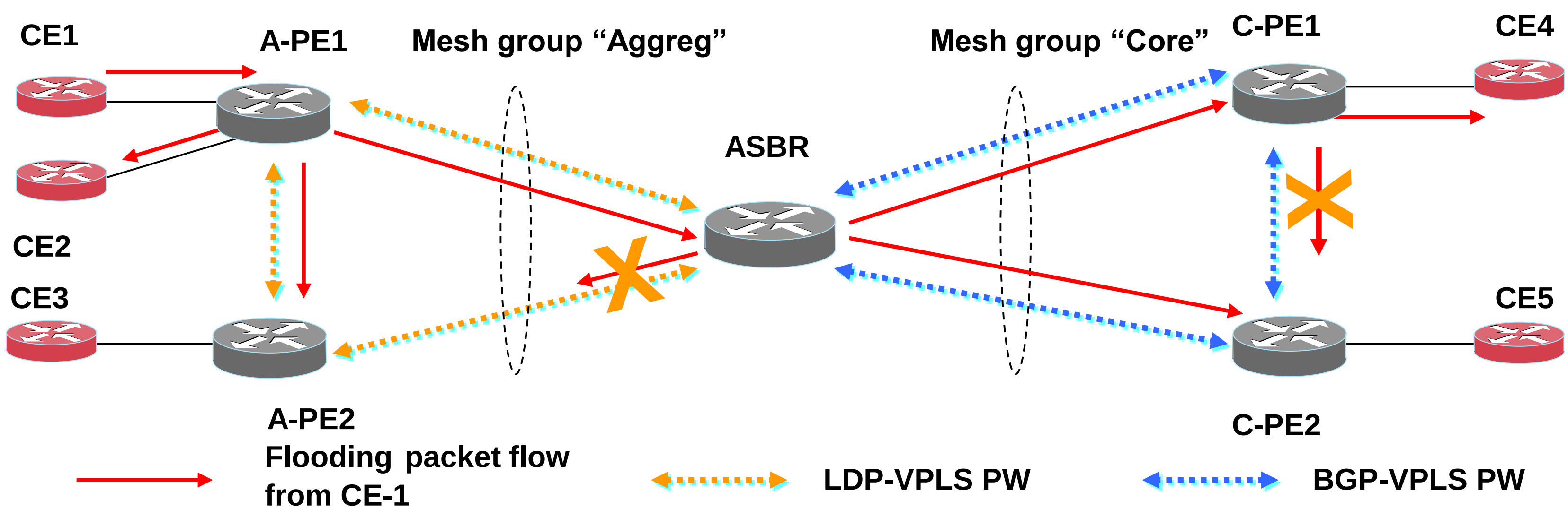
- ASBR (autonomous-system-boundary) PE router hosts more than one mesh groups (any combination of LDP and BGP based)

- Split-horizon is much more complex now:
  - PE border router must not forward packets received from mesh gr 1 back to mesh gr 1, or from mesh gr 2 to mesh gr 2, or from core to core
  - But forwards in case of different mesh groups

- For a multi-homed site, a PE can be a designated forwarder only if the site hosted on it is operationally UP

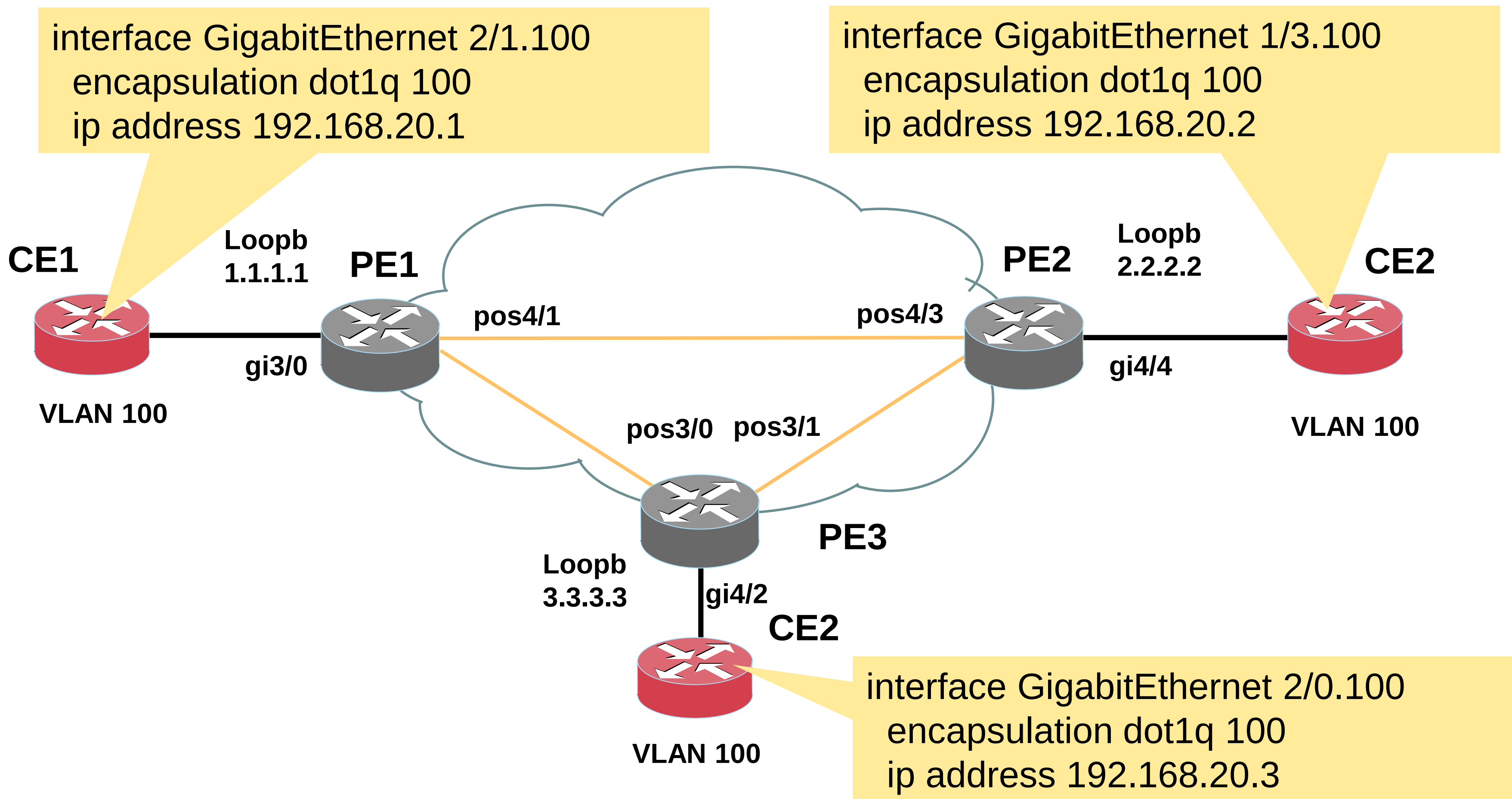
Mesh Groups: Flooding example

- Assume CE-1 sends a broadcast ARP request packet. It will be flooded by APE1, to all PEs in “Aggreg” domain (including ASBR) as it’s fully-meshed.
- ASBR receives this packet from APE1 and forwards it to all the mesh-groups (PWs) except the one in which packet is received, as a result packet is forwarded on all PWs part of mesh-group “Core”.
- Upon receiving this packet from APE1, ASBR learns the CE1 MAC address via APE1 PW.



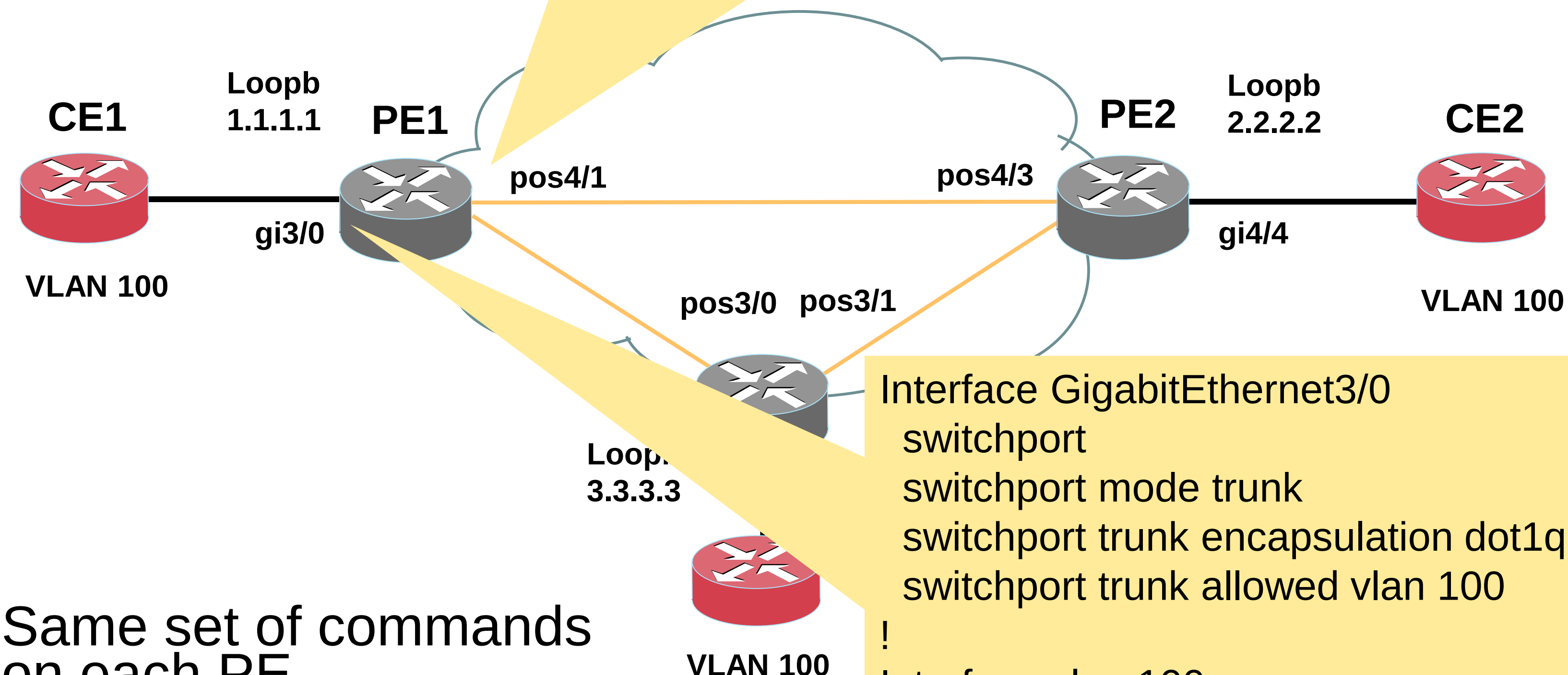
Simple VPLS Configuration Example (c7600)

- CEs are all part of same VPLS instance (VCID = 56)
- CE router connects using VLAN 100 over sub-interface
- Can also be just port based (no VLAN)



Simple VPLS Configuration Example

```
l2 vfi VPLS-A manual
  vpn id 56
  neighbor 2.2.2.2 encapsulation mpls
  neighbor 3.3.3.3 encapsulation mpls
```

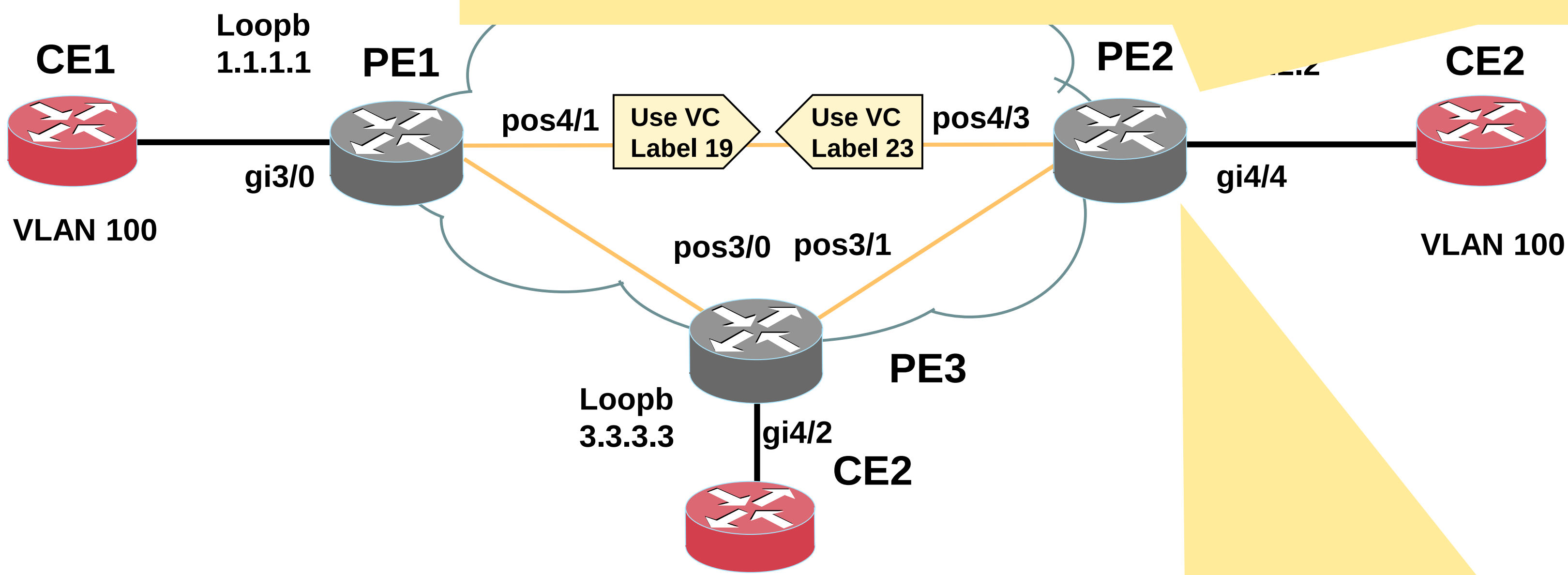



```
Interface GigabitEthernet3/0
  switchport
  switchport mode trunk
  switchport trunk encapsulation dot1q
  switchport trunk allowed vlan 100
!
Interface vlan 100
  no ip address
  xconnect vfi VPLS-A
!
vlan 100
  state active
```

- Same set of commands on each PE
- VLAN based configuration
- VLAN100 = VCID 56

show mpls l2

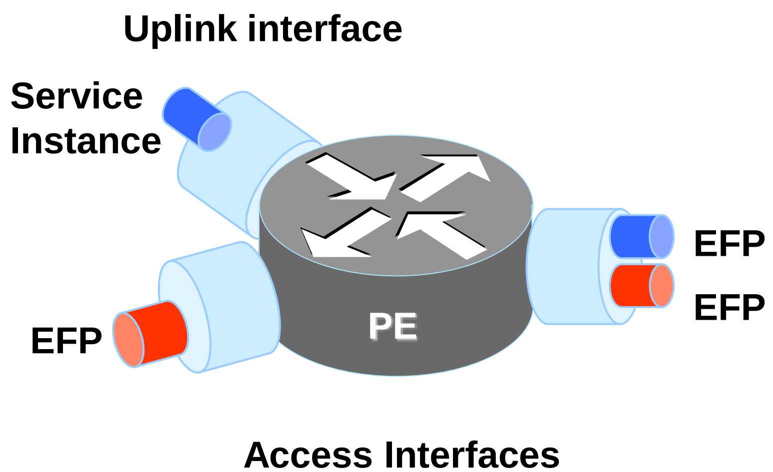
```
PE2#show mpls l2 vc detail
Local interface: VFI VPLS-A up
  Destination address: 1.1.1.1, VC ID: 56, VC status: up
    Tunnel label: imp-null, next hop 156.50.20.1
    Output interface: POS4/3, imposed label stack {19}
  Create time: 1d07h, last status change time: 00:40:14
  Signaling protocol: LDP, peer 1.1.1.1:0 up
    MPLS VC labels: local 23, remote 19
```




```
NPE-A#show mpls l2 vc
Local intf      Local circuit Dest address  VC ID  Status
-------------   ------------- ------------- ------ ------
VFI VPLS-A      VFI           1.1.1.1       56     UP
VFI VPLS-A      VFI           3.3.3.3       56     UP
```

Providing a Service on an Access Port

- EFP (Ethernet Flow Point) Overview on VLAN or port
  - interface fe-slot/port.<sub-intf no.> l2transport
  - <match criteria commands> (VLAN tags, MAC, Ethtype)
  - <rewrite commands> (VLAN tags pop/push/translation)
  - <feature commands> (QoS, ACL, etc.)



VLAN Manipulation / Rewriting

- Provides port isolation allowing multiple customers single switch to have same internal VLANs
- Flexibility for Service Provider to choose VLANs to pass over core
- Does NOT require mixing of Customer and Provider VLANs

PE (config-subif)#**rewrite ingress tag ?**
pop Remove one or more tags
push Push one or more tags
translate Replace tags with other tags

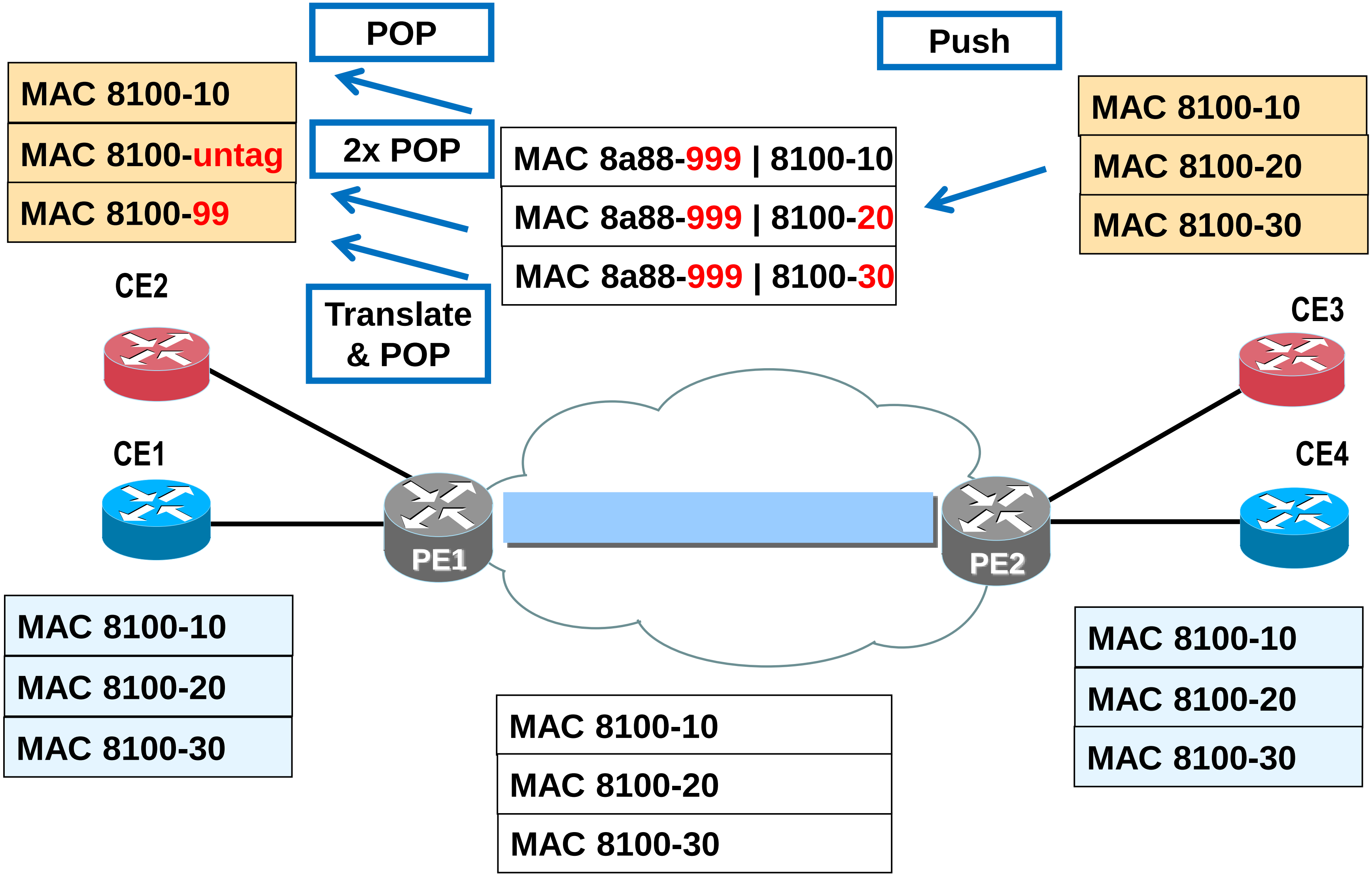
PE (config-subif)#**rewrite ingress tag pop ?**
1 Remove outer tag only
2 Remove two outermost tags

PE (config-subif)#**rewrite ingress tag push ?**
dot1ad Push a Dot1ad tag
dot1q Push a Dot1Q tag

PE (config-subif)#**rewrite ingress tag push dot1q 100 ?**
second-dot1q Push another Dot1Q tag
symmetric All rewrites must be symmetric

PE(config-subif)#**rewrite ingress tag translate ?**
1-to-1 Replace the outermost tag with another tag
1-to-2 Replace the outermost tag with two tags
2-to-1 Replace the outermost two tags with one tag
2-to-2 Replace the outermost two tags with two other tags

QinQ Mapping over SP's Network Example



VPLS LDP based example - JunOS

```
lab@MX80# run show vpls mac-table logical-system R1
Logical system    : R1
Routing instance : VPLS-LDP-1
 Bridging domain : __VPLS-LDP-1__, VLAN : none
   MAC                   MAC       Logical
   address               flags     interface
   5c:5e:ab:04:8b:91     D         lsi.17827078
   5c:5e:ab:04:8b:93     D         lsi.17827079
   5c:5e:ab:04:8b:95     D         ge-1/2/0.101



lab@MX80# run show arp logical-system R101
MAC Address       Address         Name                      Interface           Flags
5c:5e:ab:04:8b:91 172.16.1.2      172.16.1.2                ge-1/2/5.101        none
5c:5e:ab:04:8b:93 172.16.1.3      172.16.1.3                ge-1/2/5.101        none
Total entries: 2
```

```
lab@MX80# run show configuration
instance-type vpls;
vlan-id none;
interface ge-1/2/0.101;
protocols {
    vpls {
        no-tunnel-services;
        vpls-id 10;
        neighbor 10.255.255.2;
        neighbor 10.255.255.3;
    }
}

lab@MX80# run show vpls connections logical-system R1
Layer-2 VPN connections:
Instance: VPLS-LDP-1
  VPLS-id: 10
    Neighbor                  Type  St     Time last up          # Up trans
    10.255.255.2(vpls-id 10)  rmt   Up     Apr 16 10:15:45 2013           1
      Remote PE: 10.255.255.2, Negotiated control-word: No
      Incoming label: 262145, Outgoing label: 262145
      Negotiated PW status TLV: No
      Local interface: lsi.17827078, Status: Up, Encapsulation: ETHERNET
        Description: Intf - vpls VPLS-LDP-1 neighbor 10.255.255.2 vpls-id 10
    10.255.255.3(vpls-id 10)  rmt   Up     Apr 16 10:15:50 2013           1
      Remote PE: 10.255.255.3, Negotiated control-word: No
      Incoming label: 262146, Outgoing label: 262145
      Negotiated PW status TLV: No
      Local interface: lsi.17827079, Status: Up, Encapsulation: ETHERNET
        Description: Intf - vpls VPLS-LDP-1 neighbor 10.255.255.3 vpls-id 10
```

VPLS BGP based example - JunOS

```
lab@MX80# run show configuratio
instance-type vpls;
vlan-id none;
interface ge-1/2/0.201;
route-distinguisher 100:201;
vrf-target target:100:201;
protocols {
    vpls {
        site-range 20;
        no-tunnel-services;
        site CE1 {
            site-identifier 1;
            interface ge-1/2/0.201;
        }
    }
}

lab@MX80# run show vpls connections logical-system R1
Layer-2 VPN connections:
Instance: VPLS-BGP-2
  Local site: CE1 (1)
    connection-site           Type  St     Time last up          # Up trans
    2                         rmt   Up     Apr 16 11:27:28 2013           1
      Remote PE: 10.255.255.2, Negotiated control-word: No
      Incoming label: 262402, Outgoing label: 262401
      Local interface: lsi.17827081, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls VPLS-BGP-2 local site 1 remote site 2
    3                         rmt   Up     Apr 16 11:27:27 2013           1
      Remote PE: 10.255.255.3, Negotiated control-word: No
      Incoming label: 262403, Outgoing label: 262401
      Local interface: lsi.17827080, Status: Up, Encapsulation: VPLS
        Description: Intf - vpls VPLS-BGP-2 local site 1 remote site 3
```

```
lab@MX80# run show vpls mac-table logical-system R1
Logical system   : R1
Routing instance : VPLS-BGP-2
 Bridging domain : __VPLS-BGP-2__, VLAN : none
   MAC                 MAC      Logical
   address             flags    interface
   5c:5e:ab:04:8b:91   D        lsi.17827081
   5c:5e:ab:04:8b:93   D        lsi.17827080
   5c:5e:ab:04:8b:95   D        ge-1/2/0.201

[edit]
lab@MX80# run show arp logical-system R201
MAC Address       Address         Name                      Interface           Flags
5c:5e:ab:04:8b:91 172.16.2.2      172.16.2.2                ge-1/2/5.201        none
5c:5e:ab:04:8b:93 172.16.2.3      172.16.2.3                ge-1/2/5.201        none
Total entries: 2
```

Deployment Issues

- MTU Size
  - Core MTU ≥ Edge MTU + Transport Header + AToM Header + (MPLS Label Stack * MPLS Header Size)

	Edge	Transport	AToM	MPLS Stack	MPLS Header	Total
EoMPLS Port Mode	1500	14	4 [0]	2	4	1526 [1522]
EoMPLS VLAN Mode	1500	18	4 [0]	2	4	1530 [1526]
EoMPLS Port w/ TE FRR	1500	14	4 [0]	3	4	1530 [1526]

- Broadcast Handling
  - Ethernet switches replicate broadcast/multicast flows once per output interface, VPLS may duplicate packets over the same physical egress interface – for each PW

Deployment Issues

- Router or a Switch as a CPE?
  - Router
    - Single MAC, SPT iteractions, no broadcast storms
    - BUT does not provide direct L2 connectivity but
  - Switch
    - Too many MAC addresses can exist within VPLS
    - High exposure to broadcast storms
    - Non-predictable and excessive number of Unknown, Broadcast and Multicast frames could behave as a series of “packet bombs”
    - High MAC address learning rate -> CPU issues

- Solution: Ingress Threshold Filters on U-PE or N-PE
  - How to selectively choose which Ethernet Frames to discard?
  - How to avoid dropping Routing and Keepalives (control)
  - How many MAC addresses allowed?
  - Does SP really want to take this responsibility?

Ethernet VPN

- EVPN introduces a new model for delivery of L2VPN services
  - Inheriting a decade of VPLS operational experience in production networks
  - Incorporating flexibility for service delivery over L3 networks
  - Abstracting and separating the control and data planes

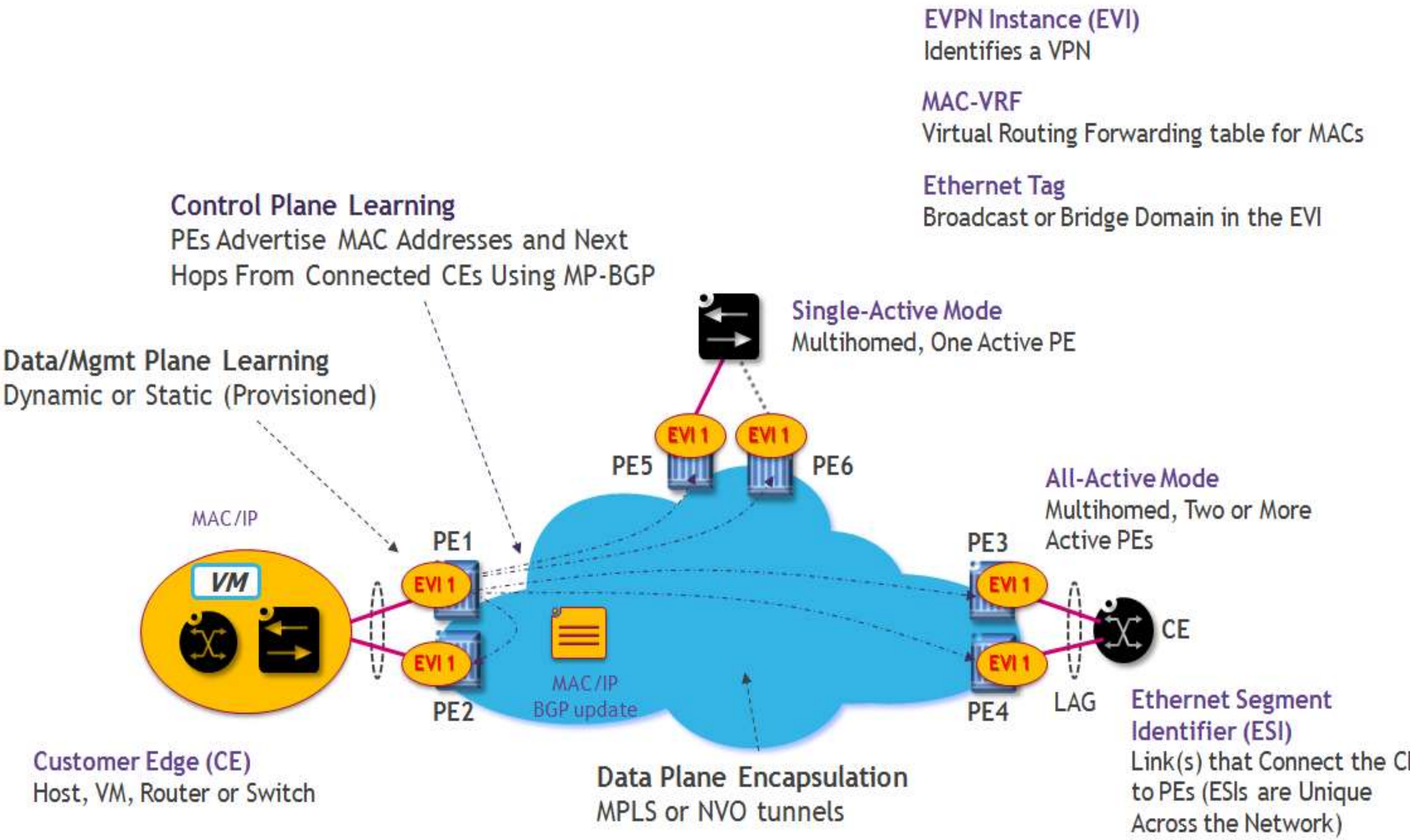
- Allows operators to meet emerging needs in their networks
  - Datacenter Interconnect
  - Cloud and virtualization services and connectivity management
  - Combination services
  - Use of network overlay and underlay technologies to simplify topology, remove protocols from the network

Ethernet VPN

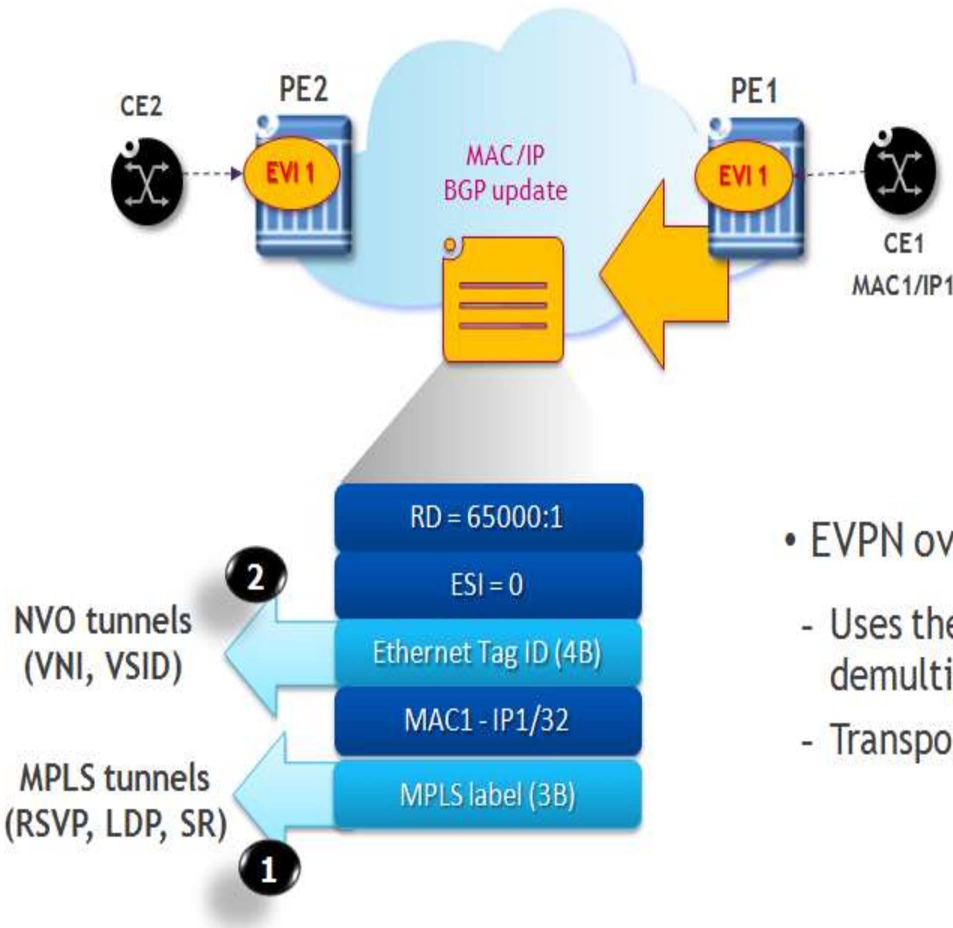
- RFC7209 (EVPN requirements)

- Brings proven and inherent BGP control plane scalability to MAC routes
  - Consistent signaled FDB in any size network instead of flooding
  - Route-reflectors and BGP features available for layer-2
- BGP advertises MACs/IPs for next hop resolution with EVPN NLRI
  - AFI = 25 (L2VPN) and SAFI = 70 (EVPN)
  - Fully supports IPv4 and IPv6
- Offers greater control over MAC learning
  - What is signaled, from where and to whom
  - Ability to apply MAC learning policies
- Maintains virtualization and isolation of EVPN instances
- Enables traffic load balancing for multihomed CEs with ECMP MAC routes
- EVPN supports integrated routing and bridging VPN solutions with MAC/IP mobility over the same VLAN

The main EVPN concept



EVPN operation



- EVPN over MPLS
  - draft-ietf-l2vpn-evpn
  - Uses a service label (no PWs) as EVI demultiplexer
  - Transport: requires IGP, RSVP/LDP/3107 BGP and takes advantage of all the MPLS features

- EVPN over NVO tunnels
  - Uses the Ethernet-tag to signal the NVO demultiplexer
  - Transport: requires IGP only

EVPN requirements and benefits

	VPN Requirements	VPLS	EVPN	What does it do for me?
Address Learning	Control Plane Address Learning in the Core	✘	✔	Greater Scalability and Control
Provisioning	L3VPN-Like Operation	✘	✔	Simpler Provisioning and Automation
	Auto Discovery and Configuration	PEs Only	✔	Simpler Provisioning and Automation
Resiliency	Active-Standby Multihoming (Service-Based Load Balancing)	✔	✔	Standby Redundancy
	All-Active Multihoming (Flow-Based Load Balancing)	✘	✔	Active Redundancy and Link Utilization
Services	VLAN Based Service Interfaces	✔	✔	Virtualization and Advanced Services
	VLAN Aware Bundling Service Interfaces	✘	✔	Virtualization and Advanced Services
	Inter-Subnet Forwarding	✘	✔	Layer 2 and Layer 3 Over the Same Interface
Flow Optimization	ARP/ND Proxy	✘	✔	Security and MAC Provisioning
	MAC Mobility	✘	✔	Virtualization and Advanced Services

Ďakujem za pozornosť

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