Virtual Private Wire Services

Section 1 - ePipe

ePipe SAP Encapsulation

SAP encapsulation provides the router with a way of delineating services

Ethernet encapsulation:

- Null - supports a single service on a port
- Dot1Q (802.1q) - supports multiple services for a single customer or multiple services for multiple customers
- Q-in-Q - provides a way to differentiate between customer services based on Q-tags

VLAN tag is used to determine which service the frame belongs to.

Multple SAPs can be defined on a single port for different services.

Encapsulation type	VLAN tags	SAP syntax
null	no	port Example - port 1/1/1
dot1q	1	port:tag Example - port 1/1/1:10
qinq	2	port:outer-tag.inner-tag Example - port 1/1/1:10.100

Null:

- Service is delimited by the port (SAP 1/1/1)
- The physical port belongs to a single service and a single customer
- VLAN tags are treated as customer data and are transparent on the network.

Dot1Q:

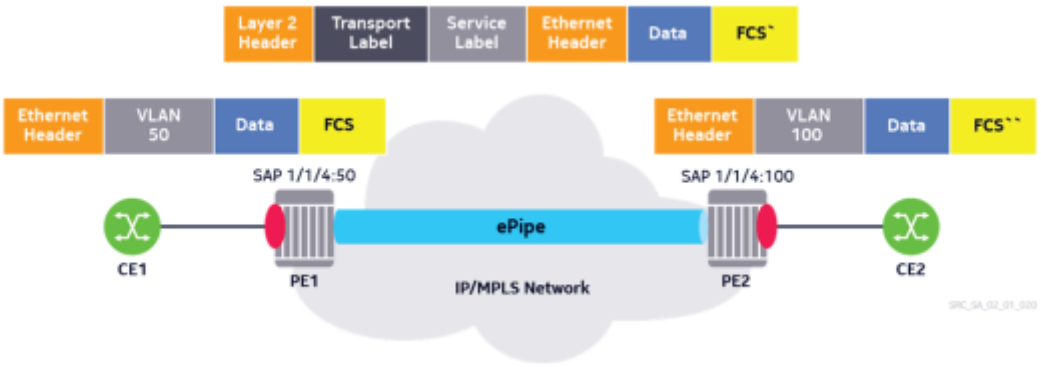
- Service is delimited by the VLAN tag (SAP 1/1/1:10)
- Allows more than one SAP to be configured on each physical port.

Q-in-Q:

- Service is delimited by 2 VLAN tags as port:outer.inter (SAP 1/1/1:10.100)
- Can specify a top and bottom VLAN ID to be matched.

Ethernet Frame Encapsulation in an ePipe Service

Service delimiting VLAN tags are stripped at the SAP ingress along with the Frame Check Sequence (FCS) for the frame.



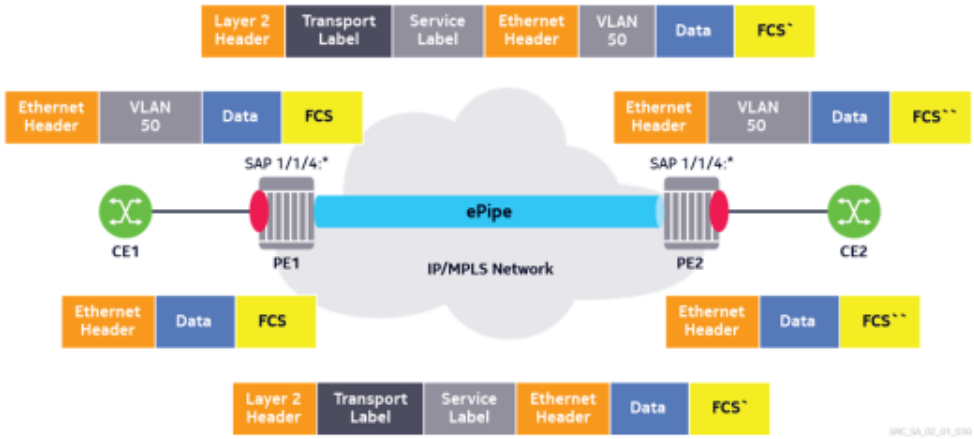
Special SAP Values - dot1q

Default SAP (port:*)

- Receives all untagged frames and any frames with tag values that are not used as a service-delimiting value on another SAP
- VLAN tags are not stripped and are passed transparently
- e.g sap 1/1/3:*

Ethernet Frame Encapsulation - Default (port:*) SAP Example

VLAN tags are not stripped and are passed transparently on a default SAP.



Null SAP (port:0)

- Receives all untagged frames and all frames with a VLAN tag of 0
- e.g sap 1/1/3:0

Null and defaulat SAP are mutually exlusive on a port.

Special SAP Values - Q-in-Q

Wildcard SAP (port:x.*)

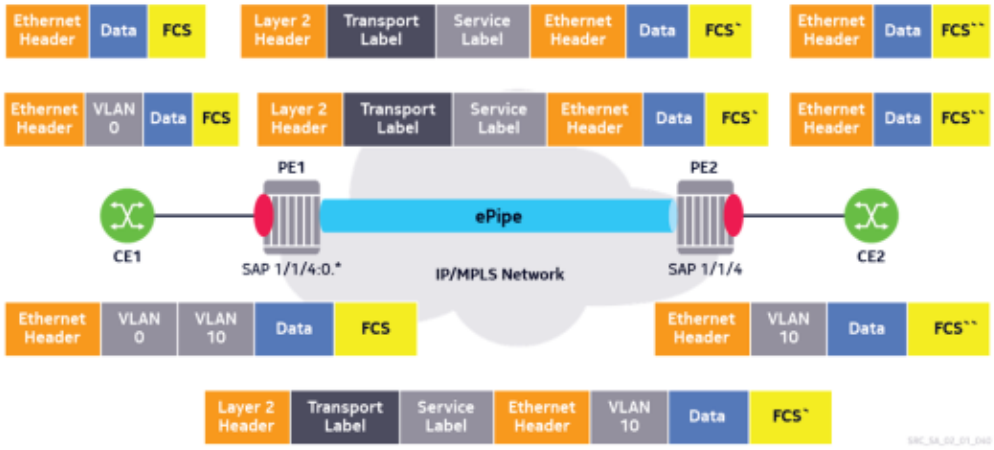
- Receives all frames with outer tag value x, regardless of the inner tag
- Outer tag is stripped, and the inner tag is passed transparently.
- E.G - sap 1/1/3:10*

Null SAP (port:0.*)

- Receives all untagged frames and/or any frames with an outer VLAN tag of 0
- E.G - sap 1/1/3:0*

Ethernet Frame Encapsulation - Null SAP (port:0.*) Example

Null SAP will pass untagged frames, frames with one VLAN tag of 0, or double-tags where the outer VLAN tag is 0.



Null bottom SAP (port:x.0)

- Receives all frames with outer tag value x and inner tag of 0, or no bottom tag.
- E.G sap 1/1/3:10.0

An encapsulation of (port:. or port:*.x) is not valid on Nokia 750 SR

Ethertype Values

IEEE 802.1Q specifies a hex value of 0x8100 in the Ethertype field to identify the frame as a tagged frame.

Can be configured as seen below:

```
(gl)[/configure port 1/1/1 ethernet]
A:admin@PE1# dot1q-etype
 dot1q-etype <number>
 <number>  - <0x600..0xffff>
 Default   - 33024
    Ethertype expected if port encapsulation type is dot1q

(gl)[/configure port 1/1/1 ethernet]
A:admin@PE1# qinq-etype
 qinq-etype <number>
 <number>  - <0x600..0xffff>
 Default   - 33024
    Ethertype for QinQ encapsulation
```

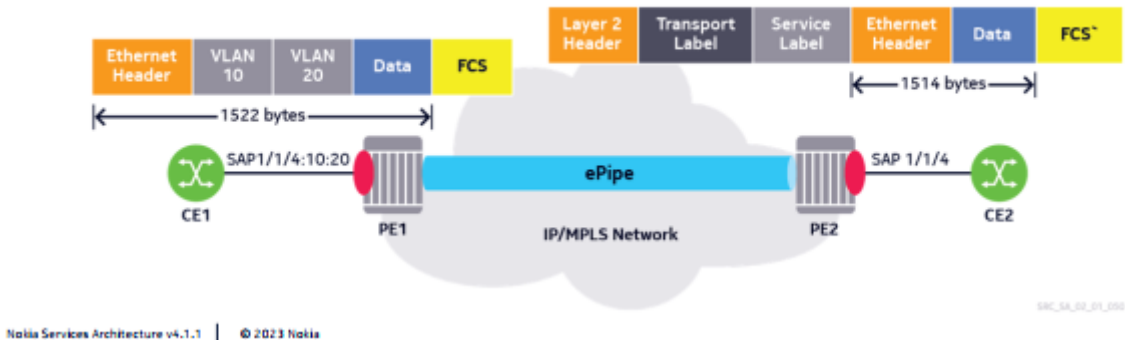
Frames with non-matching Ethertypes are treated as untagged frames.

Maximum Transmission Unit (MTU)

- Important in Layer 2 and 3 services
- For IP/MPLS networks, the following MTUs must be considered:
  - Access port or SAP MTU
  - Service MTU and ip-mtu (vc-mtu)
  - SDP path MTU
  - Network port MTU
- Oversized frames arriving at a Layer 2 interface are not fragmented
- Layer 3 services will fragment oversized packets for transmission but only for IPv4 traffic, since IPv6 does not fragment.

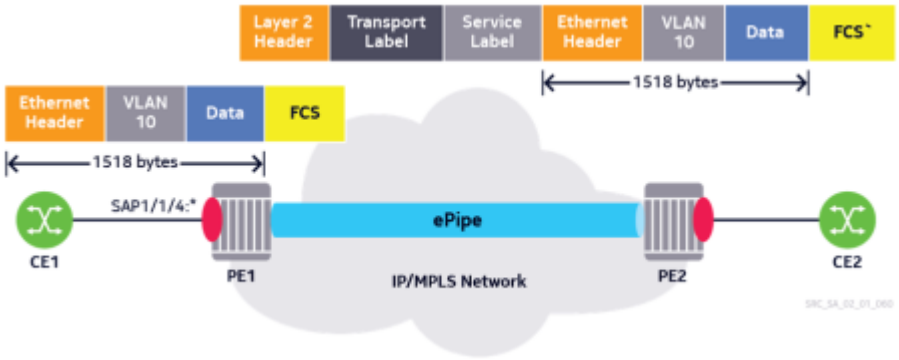
SAP MTU

- Defines the max packet size that can be handled by a SAP
- Can be changed by configuriing the access port MTU
- NULL encapsulated SAP has a default MTU of 1514
- dot1q encapsulated SAP has a default MTU of 1518
- Q-in-Q encapsulated SAP has a default MTU of 1522
- When VLAN tags are service delimiting, they are stripped at the SAP



Service MTU

- Defines max customer payload carried in a Layer 2 service
- Default service MTU for an Ethernet VPN service is 1514 bytes:
  - 1514 bytes = 14 bytes Layer 2 header + 1500 bytes (payload)
- SAP MTU must be > or = service MTU
- When VLAN tags are not service delimiting, they are not stripped at the SAP



SDP Path MTU

- Max packet size that can be sent over the SDP
- By default, SDP path MTU is derived from the network port MTU
  - SDP path MTU = network port MTU - MPLS overhead - Layer 2 Header
- Can be changed by configuring the network port MTU or SDP MTU
- SDP path MTU does not have to match on both sides of the SDP
- SDP path MTU >= service MTU

SDP Path and Network Port MTU Example

- gigabit Ethernet network port has a network port MTU of 9212 (default on Nokia 7750)
- if SDP uses MPLS encapsulation:
  - SDP path MTU = 9212 (net port MTU) - 14 (Ethernet header) - 4 (transport label) - 4 (service label) = 9190 bytes
- GRE encapsulation:
  - SDP path MTU = 9212 (net port MTU) - 14 (Ethernet header) - 20 (IP header) - 4(GRE header) - 4 (service label) = 9170 bytes

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SDP Path MTU Configuration

Two options to change the SDP Path MTU:

1. Configure the network port MTU (this change impacts all SDPs traversing the port):

```
A:admin@PE1# port <slot/mda/port> ethernet mtu
 mtu <number>
 <number>  - <512..9800>  - bytes
    Maximum payload MTU size for the Ethernet port
```

2. Configure the path MTU for a single SDP:

```
(g1)[/configure service]
A:admin@PE1# sdp <sdp-id> path-mtu
 path-mtu <number>
 <number>  - <576..9782>  - bytes
```

The command oam sdp-mtu can be used to determine the effective path MTU of an SDP.

Port MTU Default Values

Port Type	Mode	Encap Type	Default (Bytes)
Ethernet	access	null	1514
Ethernet	access	Dot1Q	1518
Ethernet	access	Q-in-Q	1522
Fast Ethernet	Data	-	1514
Gigabit Ethernet	Data	-	9212

VC-MTU for Layer 2 services

- Maximum IP payload size to be carried in the service tunnel
- Derived from the service MTU
  - VC-MTU = service MTU - 14 (Ethernet overhead)
- Default L2 service MTU is 1514
- Negotiated by T-LDP and should match the router on the other side

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VC MTU for Layer 3 services

- Layer 3 services do not have the concept of service MTU
- VC-MTU is derived from the SDP path MTU
  - VC-MTU = SDP path MTU - 14 (Ethernet overhead)
- VC-MTU can be manually set by configuring the IP-MTU for the Layer 3 service interface

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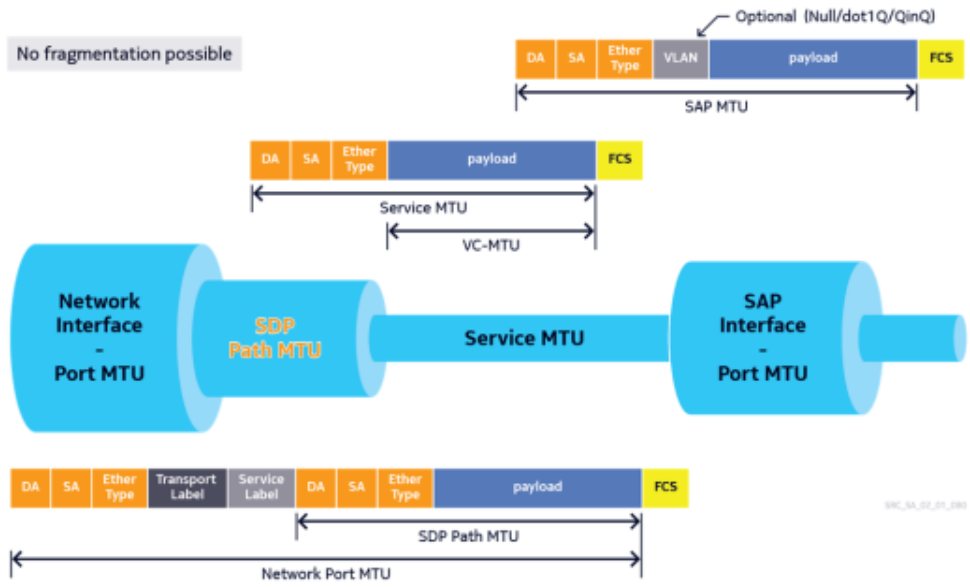
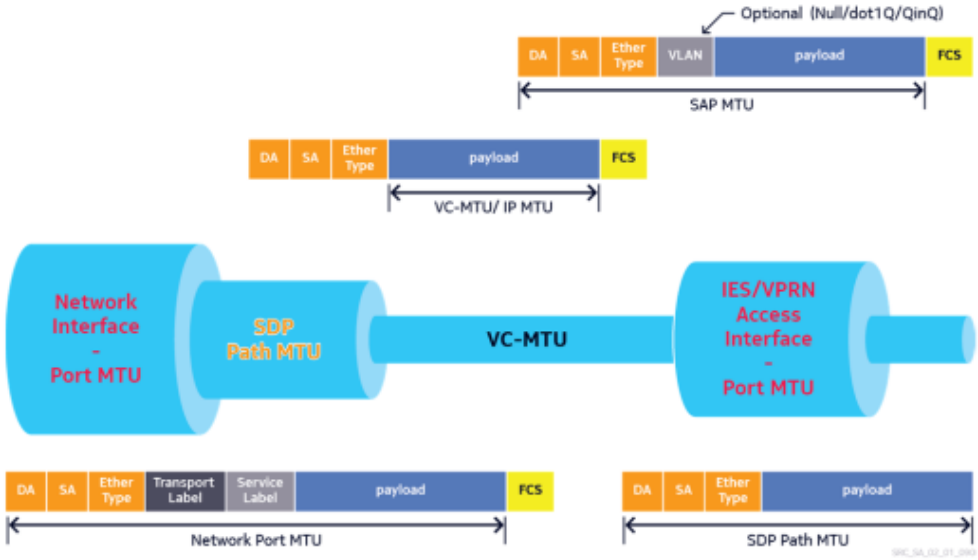
Relationship between MTUs (L2 Services)



Relationship between MTUs (L3 Services)



Page 124 - 141 for Case study

SDP and VC Type

- RFC 4448 defines two VC types for the Ethernet pseudowire
- VC type is specified when the SDP is bound to the service and is signaled by T-LDP.
  - Ether - specifies raw mode (default)
    - service delimiting VLAN tag is stripped at the ingress and is not carried across the ePipe
- VLAN - specifies tagged mode
  - VALN tag is carried in the Frame

- Supported on Nokia 7750 SR, mainly for interoperability with systems that only support tagged mode

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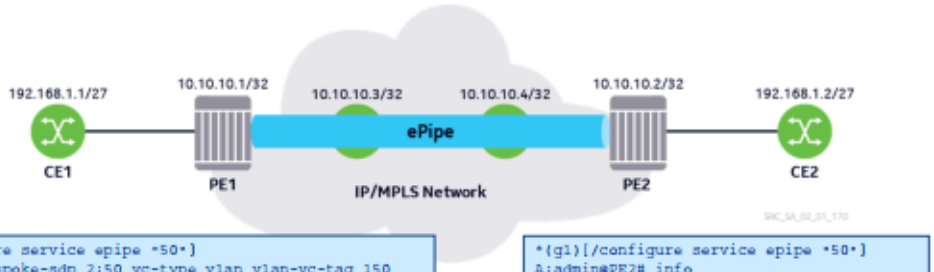
VC Type Configuration

- The ePipe on PE1 is configured with type VLAN
- On PE2, the ePipe is still using type Ether (default mode)




```
(gl)[/configure service epipe "50"]
A:admin@PE1# spoke-sdp 2:50 vc-type vlan vlan-vc-tag 150
*(gl)[/configure service epipe "50"]
A:admin@PE1# commit
(gl)[/configure service epipe "50"]
A:admin@PE1# info
    admin-state enable
    customer "100"
    spoke-sdp 2:50 {
        vlan-vc-tag 150
        vc-type vlan
    }
    sap 1/1/4:50 {
    }
```

```
*(gl)[/configure service epipe "50"]
A:admin@PE2# info
    admin-state enable
    customer "100"
    spoke-sdp 2:50 {
    }
    sap 1/1/4:50 {
    }
```

T-LDP requires the VC-ID , VC-Type and VC MTU to match.

```
A:admin@PE1# /show service service-using epipe

===============================================================
Services [epipe]
===============================================================
ServiceId    Type      Adm  Opr  CustomerId Service Name
---------------------------------------------------------------
50           Epipe     Up   Down 100        50
---------------------------------------------------------------
Matching Services : 1
---------------------------------------------------------------
```

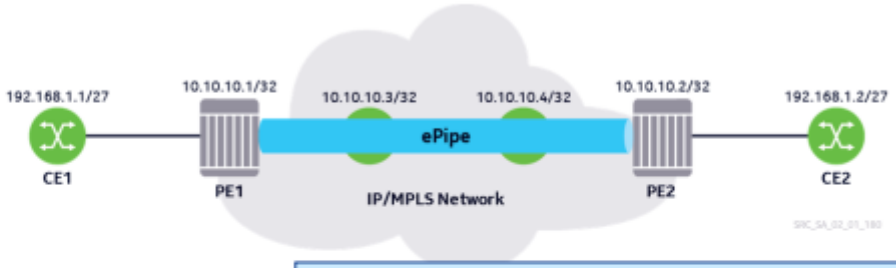
```
A:admin@PE1# /show service id 50 base

===============================================================================
Service Basic Information
===============================================================================
Service Id        : 50                  Vpn Id            : 0
Service Type      : Epipe
MACSec enabled    : no
Name              : 50
Description       : (Not Specified)
Customer Id       : 100                 Creation Origin   : manual
Last Status Change: 11/12/2022 02:01:30
Last Mgmt Change  : 11/12/2022 01:59:34
Test Service      : No
Admin State       : Up                  Oper State        : Down
MTU               : 1514
Vc Switching      : False
SAP Count         : 1                   SDP Bind Count    : 1
Per Svc Hashing   : Disabled
Vxlan Src Tep Ip  : N/A
Force QTag Fwd    : Disabled
Oper Group        : <none>

-------------------------------------------------------------------------------
Service Access & Destination Points
-------------------------------------------------------------------------------
Identifier                                Type         AdmMTU  OprMTU  Adm  Opr
-------------------------------------------------------------------------------
sap:1/1/4:50                              q-tag        9004    9004    Up   Up
sdp:2:50 S(10.10.10.2)                    Spok         0       9190    Up   Down
```

```
A:admin@PE2# /show service id 50 sdp 2 detail
SDP Id              : 2:50                      Type              : Spoke
Spoke Descr     : (Not Specified)
VC Type             : Ether                     VC Tag            : n/a
Admin Path MTU      : 0                         Oper Path MTU     : 9190
Delivery            : MPLS
Far End             : 10.10.10.1                Tunnel Far End    : n/a
Oper Tunnel Far End: 10.10.10.1
LSP Types           : RSVP
Hash Label          : Disabled                  Hash Lbl Sig Cap  : Disabled
-------
Admin State         : Up                        Oper State        : Down
MinReqd SdpOperMTU : 1514
Acct. Pol           : None                      Collect Stats     : Disabled
Ingress Label       : 524279                    Egress Label      : None
-------
Last Status Change : 11/12/2022 02:01:30        Signaling         : TLDP
Last Mgmt Change    : 11/12/2022 01:59:20
Endpoint            : N/A                       Precedence        : 4
PW Status Sig       : Enabled
Force Vlan-Vc       : Disabled                  Force Qinq-Vc     : none
Class Fwding State : Down
Flags               : NoEgrVCLabel
Local Pw Bits       : None
```

- T-LDP requires the VC-ID , VC-Type, and VC MTU to match
- Spoke SDP is down because of VC Type mismatch

```
A:admin@PE1# /show router ldp bindings services
===============================================================================
LDP Bindings (IPv4 LSR ID 10.10.10.1)
             (IPv6 LSR ID 2001:db8:a:100::1)
===============================================================================
Label Status:
        U - Label In Use, N - Label Not In Use, W - Label Withdrawn
        S - Status Signaled Up,  D - Status Signaled Down, e - Label ELC
        WP - Label Withdraw Pending, BU - Alternate For Fast Re-Route
------
===============================================================================
LDP Service FEC 128 Bindings
===============================================================================
Type                                        VCId        SDPId             LMTU
Peer                                        SvcId       IngLbl            RMTU
                                                        EgrLbl
-------------------------------------------------------------------------------
E-Vlan                                      50          2                 1500
10.10.10.2:0                                50          524276U           None
                                                          --

?-Eth                                       50          R. Src            None
10.10.10.2:0                                Ukwn          --              1500
                                                        524279S
```

Configure the ePipe on PE2 with a matching VC Type VLAN.

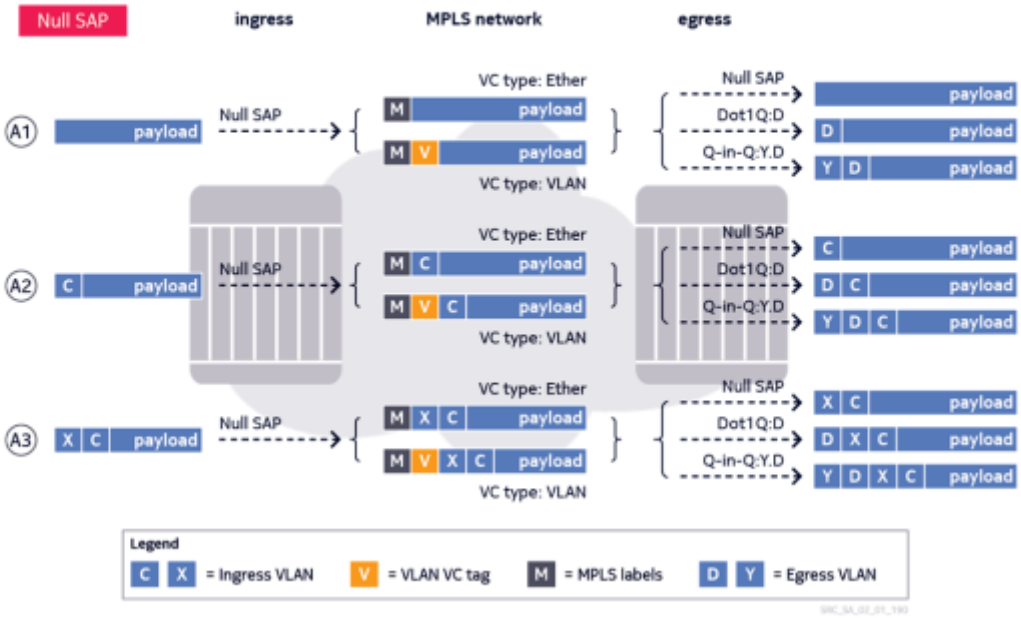



```
(gl)[/configure service epipe "50"]
A:admin@PE2# spoke-sdp 2:50 vc-type vlan vlan-vc-tag 150

*(gl)[/configure service epipe "50"]
A:admin@PE2# commit

(gl)[/configure service epipe "50"]
A:admin@PE2# info
    admin-state enable
    customer "100"
    spoke-sdp 2:50 {
        vlan-vc-tag 150
        vc-type vlan
    }
    sap 1/1/4:50 {
    }
```

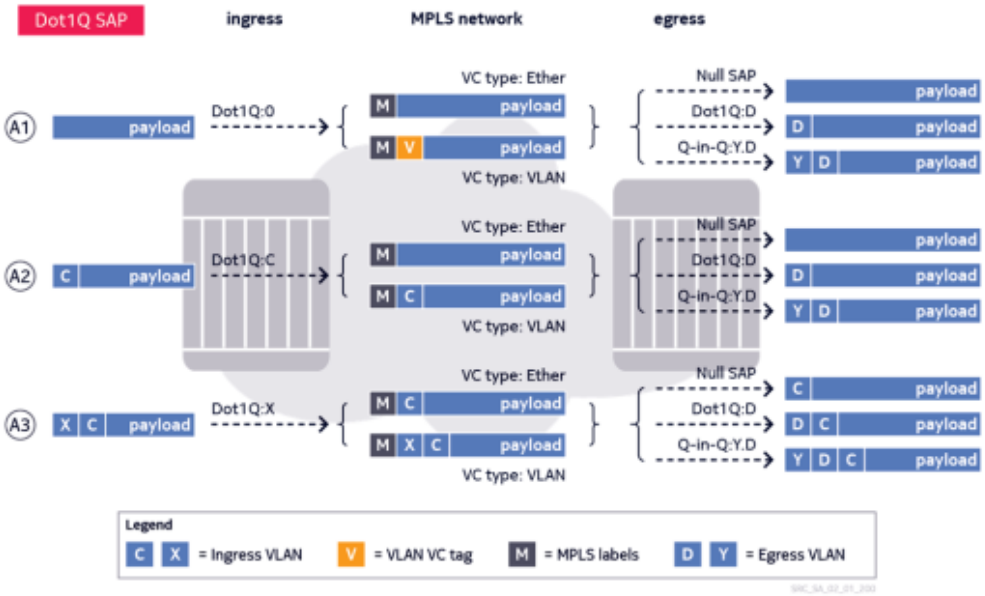
Verify that the ePipe service is Up.

```
A:admin@PE1# /show service id 50 base

===============================================================================
Service Basic Information
===============================================================================
Service Id        : 50                  Vpn Id            : 0
Service Type      : Epipe
MACSec enabled    : no
Name              : 50
Description       : (Not Specified)
Customer Id       : 100                 Creation Origin   : manual
Last Status Change: 11/12/2022 05:28:35
Last Mgmt Change  : 11/12/2022 01:59:34
Test Service      : No
Admin State       : Up                  Oper State        : Up
MTU               : 1514
Vc Switching      : False
SAP Count         : 1                   SDP Bind Count    : 1
Per Svc Hashing   : Disabled
Vxlan Src Tep Ip  : N/A
Force QTag Fwd    : Disabled
Oper Group        : <none>

-------------------------------------------------------------------------------
Service Access & Destination Points
-------------------------------------------------------------------------------
Identifier                                Type         AdmMTU  OprMTU  Adm  Opr
-------------------------------------------------------------------------------
sap:1/1/4:50                              q-tag        9004    9004    Up   Up
sdp:2:50 S(10.10.10.2)                    Spok         0       9190    Up   Up
===============================================================================
```

VLAN Tag Behavior With a Null SAP



VLAN Tag Behavior With a dot1Q SAP



VLAN Tag Behavior With a Q-in-Q SAP