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Implementation of MPLS L2.5 VPN in an Enterprise Network Environment

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Abstract: Telecommunication service providers used different type of services like TDM technologies for real time voice, frame relay and ATM for private network services which all are out-dated. Nowadays the enterprise networks needed Layer 2.5 Multiprotocol Label Switching (MPLS) and Virtual Private Networks (VPN). This will reduce downtime and so prevents the revenue loss by forming future proof network architecture includes Software Defined Networking (SDN). This forms flexible solution topology to give better changing in business requirements. Using MPLS as a backbone encapsulation is not needed because VPN provides fully independent architecture and transparent to other customer. The MPLS router performs routing by using Label values and completes the routing operation. Hence research was done for this layer 2.5 network and a scenario made by using real CISCO IOS image in GNS3 software and labels were captured by using WIRESHARK.

Keywords: Multiprotocol Label Switching, Virtual Private Networks, Software Defined Networking, GNS3 software, Wireshark.

1. INTRODUCTION

Historically, telecommunications service providers have deployed completely separate network to provide different type of services, such as time division multiplexing (TDM) technologies for real-time voice, Frame Relay and ATM for private network services with specific service levels and IP for best effort data services. Factors that influence service providers to evolve to single network infrastructure that support delivery of wide range of telecommunication services are high cost of maintaining & operating discrete legacy network, service provider desire to continue to support high revenue legacy services like frame relay, TDM, consumer demand for new services like wireless data & streaming videos, demand for high bandwidth services at decreasing prices.

Virtual private network (VPN) is a network in which a service provider shared infrastructure is used to provide private services to its customers. It is known as virtual private network as it do not require physical separation hence logical and hence known as virtual & private in the sense that customer can maintain their own addressing & routing schemes fully independent of & transparent to other customer. A service is a logical globally unique entity that provides a uniform, end-to-end configuration, management & billing model for provisioning either internet or VPN connectivity between customer access points which can be either local or distributed.

2. METHODOLOGY

There are different types of routers used for services specific functions in a network, they are as: Service routers which function as PE router in a service network. An MPLS router that performs routing based only on the label is called a label switch router (LSR) or transit router. A label edge router (LER, also known as edge LSR) is a router that operates at the edge of an MPLS network and acts as the entry and exit points for the network.

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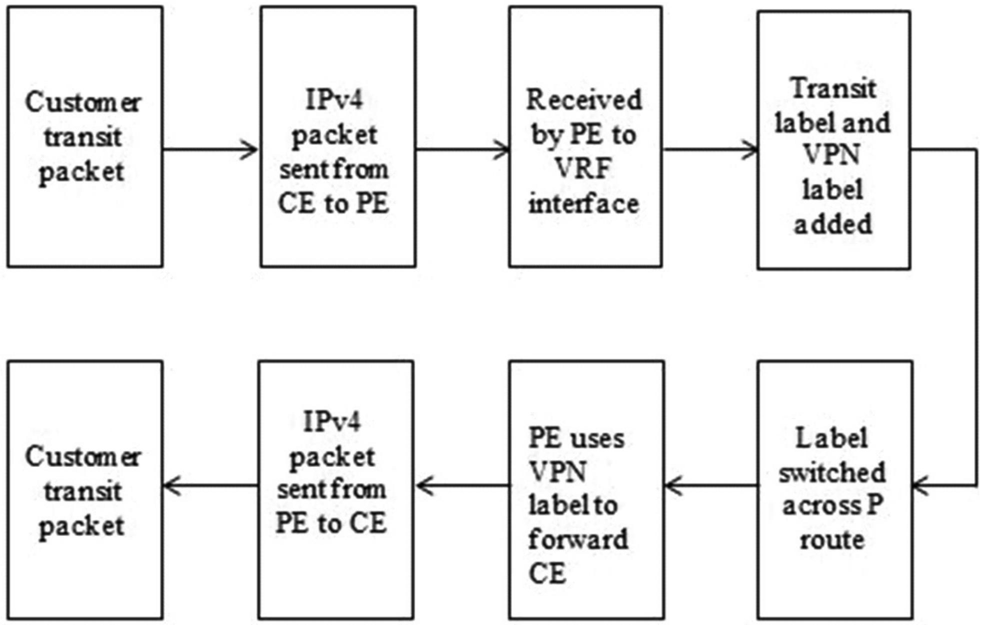
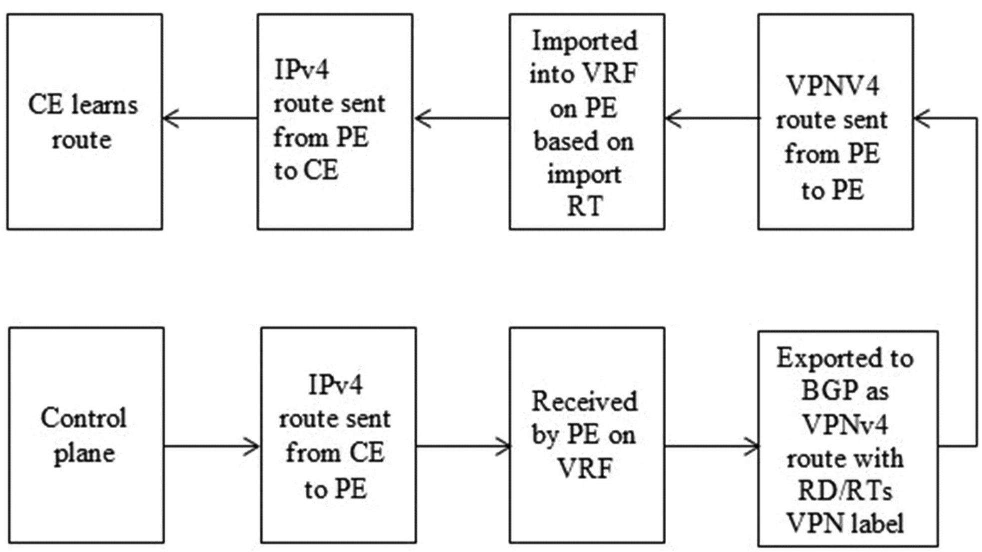
A label edge router (LER, also known as edge LSR) is a router that operates at the edge of an MPLS network and acts as the entry and exit points for the network. LERs respectively, push an MPLS label onto an incoming packet and pop it off the outgoing packet. By having PHP for an LER done on the LSRs connected to it, the load is effectively distributed among its neighbor routers. PHP functionality is achieved by the LER advertising a label with a value of 3 to its neighbors.



Block Diagram 1: Control Plane

The control plane is responsible for exchanging layer 3 routing informations and labels. Control plane consists complex mecanism to exchange routing information such as OSPF, EIGRP, BGP and to exchange labels such as LDP and BGP.



Block Diagram 2: Data Plane

The data plane is responsible for forward packet based on label and IP header. Data plane has simple forwarding engine it maintains LFIB and FIB.

Penultimate hop popping is a function performed in an MPLS enabled network refers to the process whereby the outermost label of an MPLS tagged packet is removed by a Label Switch Router, before the packet is passed to an adjacent which reduces the load on the LER. An MPLS router that performs routing based only on the label is called a label switch router (LSR) or transit router. This is a type of router located in the middle of an MPLS network. It is responsible for switching the labels used to route packets. When an LSR receives a packet, it uses the label included in the packet header as an index to determine the next hop on the label-switched path (LSP) and a corresponding label for the packet from a lookup table. The old label is then removed from the header and replaced with the new label before the packet is routed forward.

VRF may be implemented in a network device by distinct routing tables known as forwarding information bases (FIBs), one per routing instance IBGP uses extended community attributes in a common routing table to differentiate the customers' routes with overlapping IP addresses. BGP extensions advertise routes in the IPv4 VPN address family, which are of the form of 12-byte strings, beginning with an 8-byteRoute Distinguisher (RD) and ending with a 4-byte IPv4 address. RDs disambiguate otherwise duplicate addresses in the same PE. PEs understands the topology of each VPN, which are interconnected with MPLS tunnels, either directly or via P routers. In MPLS terminology, the P routers are Label Switch Routers without awareness of VPNs. Here Figure 1 shows the labeled routing scenario for this MPLS VPN networks.

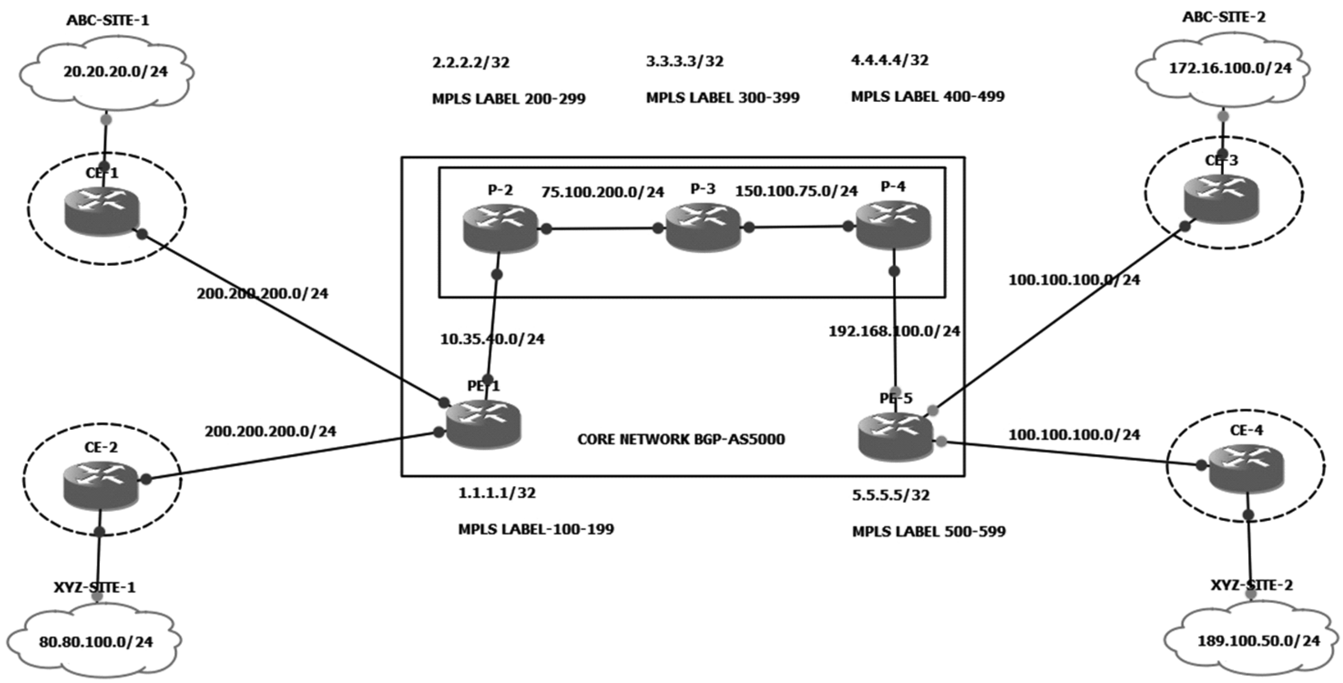


Figure 1: MPLS VPN Scenario

3. SIMULATION RESULT

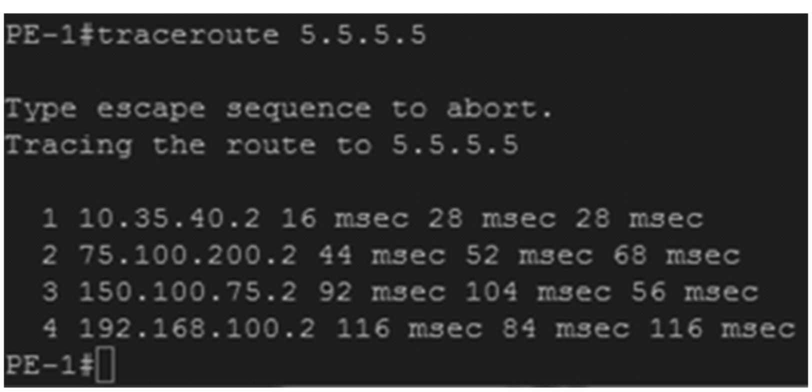


Figure 2: PE Traceroute Before MPLS

This Figure 2 shows that normal OSPF protocol is used which is a form of multivendor and uses layer three communications.

```
PE-1#traceroute 5.5.5.5

Type escape sequence to abort.
Tracing the route to 5.5.5.5

  1 10.35.40.2 [MPLS: Label 203 Exp 0] 400 msec 112 msec 100 msec
  2 75.100.200.2 [MPLS: Label 303 Exp 0] 124 msec 100 msec 88 msec
  3 150.100.75.2 [MPLS: Label 403 Exp 0] 88 msec 48 msec 112 msec
  4 192.168.100.2 120 msec 84 msec 108 msec
PE-1#
```

Figure 3: PE Traceroute After MPLS

This Figure 3 shows that instead of normal routing protocol, MPLS is used at provider edge router is traced which shows the manually assigned label values to other routers.

```
⊞ Frame 1: 122 bytes on wire (976 bits), 122 bytes captured (976 bits) on interface 0
⊞ Ethernet II, Src: EganMach_33:33:33 (00:00:33:33:33:33), Dst: Castelle_44:44:44 (00:00:44:44:44:44)
⊟ MultiProtocol Label Switching Header, Label: 403, Exp: 0, S: 0, TTL: 252
    0000 0000 0001 1001 0011 .... .... .... = MPLS Label: 403
    .... .... .... .... .... 000. .... .... = MPLS Experimental Bits: 0
    .... .... .... .... .... ...0 .... .... = MPLS Bottom Of Label Stack: 0
    .... .... .... .... .... .... 1111 1100 = MPLS TTL: 252
⊟ MultiProtocol Label Switching Header, Label: 510, Exp: 0, S: 1, TTL: 254
    0000 0000 0001 1111 1110 .... .... .... = MPLS Label: 510
    .... .... .... .... .... 000. .... .... = MPLS Experimental Bits: 0
    .... .... .... .... .... ...1 .... .... = MPLS Bottom Of Label Stack: 1
    .... .... .... .... .... .... 1111 1110 = MPLS TTL: 254
⊞ Internet Protocol Version 4, Src: 200.200.200.2 (200.200.200.2), Dst: 172.16.100.1 (172.16.100.1)
⊟ Internet Control Message Protocol
    Type: 8 (Echo (ping) request)
    Code: 0
    Checksum: 0x399d [correct]
    Identifier (BE): 0 (0x0000)
```

Figure 4: VPN Output For ABCSite1 to ABC Site 2

This Figure 4 is the Wireshark tool's captured image for MPLS and VPN details. For MPLS label:403 bottom of label stack is 0 which means still label remains for further connection and for MPLS label:510 having the bottom of label stack as 1 which means its the last label or the router target in that layer 3 VPN device.

```
R4#show mpls ldp bindings 5.5.5.5 32
  lib entry: 5.5.5.5/32, rev 10
        local binding:  label: 403
        remote binding: lsr: 3.3.3.3:0, label: 303
        remote binding: lsr: 5.5.5.5:0, label: imp-null
R4#show mpls
R4#show mpls for
R4#show mpls forwarding-table 5.5.5.5
Local      Outgoing   Prefix           Bytes Label   Outgoing   Next Hop
Label      Label      or Tunnel Id     Switched      interface
403        Pop Label  5.5.5.5/32       0             Gi4/0      40.40.40.2
R4#
```

Figure 5: MPLS Table at CE

This Figure 5 shows the forwarding mechanism at edge router, its outgoing interface details and next hoping address.

```
PE-1#show ip route vrf 100:ABC

Routing Table: 100:ABC
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, + - replicated route

Gateway of last resort is not set

      20.0.0.0/32 is subnetted, 1 subnets
O        20.20.20.1 [110/2] via 200.200.200.2, 00:10:04, FastEthernet2/0
      100.0.0.0/24 is subnetted, 1 subnets
B        100.100.100.0 [200/0] via 5.5.5.5, 00:02:35
      172.16.0.0/24 is subnetted, 1 subnets
B        172.16.100.0 [200/1] via 5.5.5.5, 00:02:35
      200.200.200.0/24 is variably subnetted, 2 subnets, 2 masks
C        200.200.200.0/24 is directly connected, FastEthernet2/0
L        200.200.200.1/32 is directly connected, FastEthernet2/0
PE-1#
```

Figure 6: PE1 vrf 100-ABC Routing Table

This Figure 6 shows Virtual Routing Forwarding table at Customer Edge router side of ABC network.

From the overall analysis the simulated results explains how the services are provided in an enterprise network. While using OSPF it will check for layer three details but after using MPLS it wont go layer three because of table lookup method. In R4 outgoing level value is mentioned as POP label. This means Penultimate hop popping which is the outermost label of an MPLS tagged packet removed by the Label Switch Router, before the packet is passed to R5 and reduces the load on the LER.

In the Provider Edge section uses the VRF protocol. Between the Provider Edge Routers the VPN labels are transmitted by extended community process. So the route target RT tells the PE routers what VPN a route actually belongs to. As soon as the provider router receives an advertisement from PE, not only does it change the route into a vpnv4 route with the route distinguisher RD tomake it unique.

Table.1
Router Parameter Comparison

Site Details	*R1-PE*	*R5-PE*
	VRF name	
ABC	100: ABC	100: ABC
XYZ	200: XYZ	200: XYZ
	Route Destination	
ABC	1.1.1.1:1	5.5.5.5:1
XYZ	1.1.1.1:2	5.5.5.5:2
	Route Target	
ABC: Export	1.1.1.1:100	5.5.5.5:100
ABC: Import	5.5.5.5:100	1.1.1.1:100
XYZ: Export	1.1.1.1:200	5.5.5.5:200
XYZ: Import	5.5.5.5:200	1.1.1.1:200

This table provides the details about Provider Edge VRF name, Route Destinationat the ABC site networks and XYZ site networks also Route Target IP address list for those sites during import as well as export side.

4. CONCLUSION

This architecture of wireless access network was designed with real CISCO IOS image which meets the network demand of the large enterprise group based on the MPLS VPN technology was experimented. MPLS VPN testing scenario verified successful process of filling up the VRF tables. MP-BGP worked properly and ensured sending VPNv4 prefixes between PE routers. Hence this MPLS technology proved that it speeds up the traffic flow and also provide a better service by using labels for real time applications.

5. FUTURE WORK

In this work service provider with MPLS L3 VPN environment with nine routers (which includes two numbers of provider edge router and two numbers customer edge routers) in ipv4 alone done. So in next step with same IOS image along with services, internet provisioning concepts including ipv6 can also be simulated.

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