MPLS/VPN

Introduction:

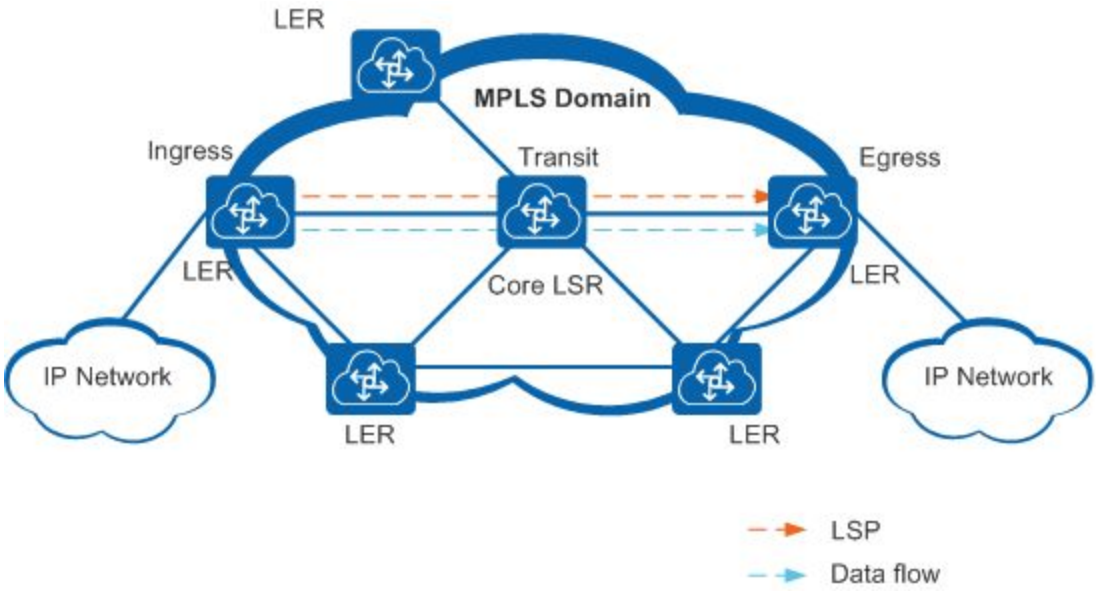
Multi-protocol label switching(MPLS) is a routing method in which packets are sent from one node to another on the basis of short path labels rather than long-distance network addresses thus avoiding complex lookups to the routing table and hence speeding up the flow of traffic.

Problem Statement:

To implement Multi-Protocol Label Switching with VPN in Layer 2

Literature Survey:

The MPLS framework supports traffic engineering and the creation of virtual private networks (VPNs).



Basic MPLS architecture

Label Switched Paths(LSP) are unidirectional routes through a network or Autonomous Systems. In normal IP routing, Packet doesn't have a predetermined

path. Instead each router forwards the packet to the next hop address stored in its forwarding table .

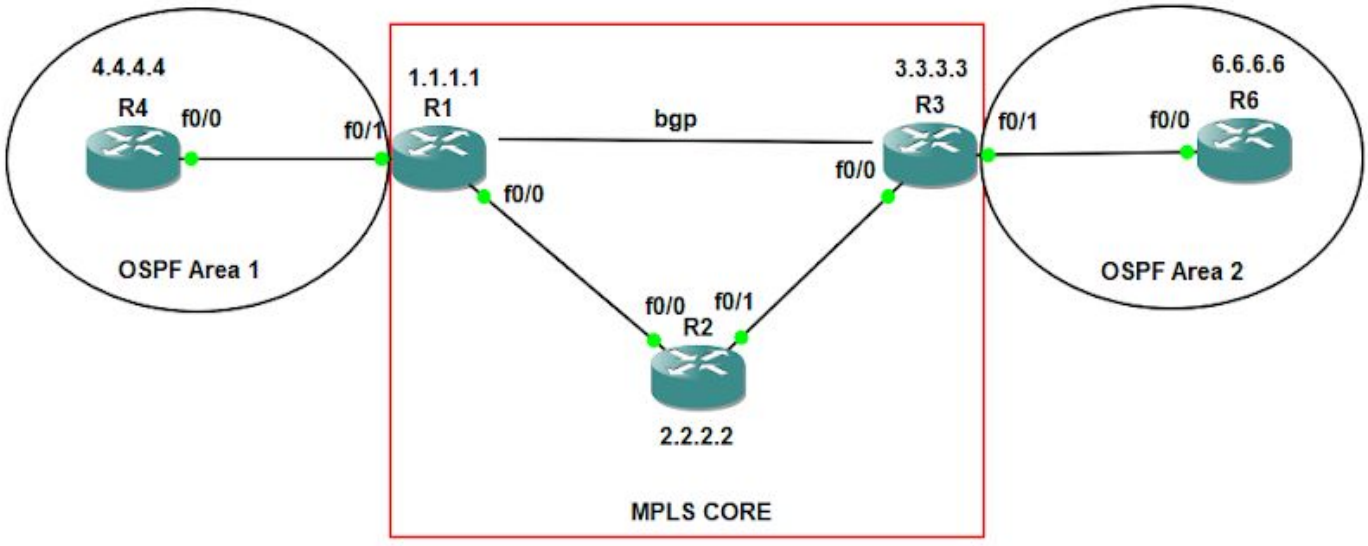
In contrast, MPLS routers within an AS determine paths through a network through the exchange of MPLS traffic engineering information. Using these paths, the routers direct traffic through the network along an established route.

Routers that are part of the LSP are called Label Switching Routers(LSR). Each LSR is configured with MPLS. Ingress Routers are the only entry point for traffic into MPLS. Each LSP can only have one Ingress Router. Egress Router are the endpoint for LSP. The egress router receives MPLS packet and performs an IP route lookup and forwards the packet to the next hop.

Objectives:

To design a protocol-independent network in which the nodes communicate using MPLS.

Methodology:



Topology:

The above figure depicts the topology of MPLS Network. Here the router R1, R2, R3 constitute the core part of the MPLS Network. Routers R1 and R3 form the edge routers, the Provider Edge (PE) Routers. The PE routers run BGP protocol to communicate among themselves since they form the entry point to the MPLS network. The interfaces which face the CE routers run the Internal Routing Protocol like OSPF or IS-IS to communicate with the customer routers. When the packet is sent from R4 to R1 , the R1 pushes the MPLS label into the packet and then forwards the entry to the next router. The R2 router swaps the label and sends it to the next router R3. The R3 router pops the label and sends it to the intended destination.

Commands:

For the commands used in the configuration of the routers, please check the commands.txt file for more details.

Results:

Note: The naming conventions for the routers used below are with respect to the topology diagram mentioned above

Router R1 :

The diagram below is the screenshot of the terminal of R1. The first table is the BGP Routing Table. It shows its neighbouring BGP router which is 3.3.3.3 i.e Router R3. The second table shows all the IP addresses reachable from that router along with the next hop IP address. Router R1 uses VRF (Virtual Routing and Forwarding) Table to communicate with the MPLS network and the customer network.

```
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
3.3.3.3         4     1     108     108        9    0    0 01:40:04        2
R1#sh ip vrf RED
  Name                              Default RD          Interfaces
  RED                               4:4                 Fa0/1
R1#sh ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
O       4.4.4.4 [110/11] via 192.168.1.4, 01:23:28, FastEthernet0/1
     6.0.0.0/32 is subnetted, 1 subnets
B       6.6.6.6 [200/11] via 3.3.3.3, 01:07:35
C    192.168.1.0/24 is directly connected, FastEthernet0/1
B    192.168.2.0/24 [200/0] via 3.3.3.3, 01:07:35
R1#sh ip bgp vpnv4 vrf RED
BGP table version is 9, local router ID is 1.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 4:4 (default for vrf RED)
*> 4.4.4.4/32       192.168.1.4             11         32768 ?
*>i6.6.6.6/32       3.3.3.3                 11    100      0 ?
*> 192.168.1.0      0.0.0.0                  0         32768 ?
*>i192.168.2.0      3.3.3.3                  0    100      0 ?
R1#
```

Router R2:

The diagram below for router R2 shows the MPLS Forwarding Table for Router R2.

```
R2#sh mpls ldp neigh
    Peer LDP Ident: 1.1.1.1:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 1.1.1.1.646 - 2.2.2.2.28731
        State: Oper; Msgs sent/rcvd: 117/120; Downstream
        Up time: 01:34:14
        LDP discovery sources:
          FastEthernet0/0, Src IP addr: 10.0.0.1
        Addresses bound to peer LDP Ident:
          10.0.0.1        1.1.1.1
    Peer LDP Ident: 3.3.3.3:0; Local LDP Ident 2.2.2.2:0
        TCP connection: 3.3.3.3.20302 - 2.2.2.2.646
        State: Oper; Msgs sent/rcvd: 116/118; Downstream
        Up time: 01:34:01
        LDP discovery sources:
          FastEthernet0/1, Src IP addr: 10.0.1.3
        Addresses bound to peer LDP Ident:
          10.0.1.3        3.3.3.3
R2#trace 3.3.3.3

Type escape sequence to abort.
Tracing the route to 3.3.3.3

  1 10.0.1.3 20 msec 20 msec 24 msec
```

Router R3:

Similar to Router R1, the same information is displayed in the following figure

```
Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
1.1.1.1         4     1     108     108        9    0    0 01:40:24        2
R3#sh ip route vrf RED

Routing Table: RED
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
B       4.4.4.4 [200/11] via 1.1.1.1, 01:07:28
     6.0.0.0/32 is subnetted, 1 subnets
O       6.6.6.6 [110/11] via 192.168.2.6, 01:12:39, FastEthernet0/1
B    192.168.1.0/24 [200/0] via 1.1.1.1, 01:07:28
C    192.168.2.0/24 is directly connected, FastEthernet0/1
R3#sh ip bgp vpnv4 vrf RED
BGP table version is 9, local router ID is 3.3.3.3
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              r RIB-failure, S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete

   Network          Next Hop            Metric LocPrf Weight Path
Route Distinguisher: 4:4 (default for vrf RED)
*>i4.4.4.4/32       1.1.1.1                 11    100      0 ?
*> 6.6.6.6/32       192.168.2.6             11         32768 ?
*>i192.168.1.0      1.1.1.1                  0    100      0 ?
*> 192.168.2.0      0.0.0.0                  0         32768 ?
R3#
```

Router R4:

The below figure shows the IP routing table. The command trace is used to trace the packet from R4 to R6. As it is clear from the picture, the MPLS policy is used to route the packets.

```
R4#sh ip route
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
C       4.4.4.4 is directly connected, Loopback0
     6.0.0.0/32 is subnetted, 1 subnets
O IA    6.6.6.6 [110/21] via 192.168.1.1, 00:56:33, FastEthernet0/0
C    192.168.1.0/24 is directly connected, FastEthernet0/0
O IA 192.168.2.0/24 [110/11] via 192.168.1.1, 00:56:33, FastEthernet0/0
R4#trace 6.6.6.6

Type escape sequence to abort.
Tracing the route to 6.6.6.6

  1 192.168.1.1 12 msec 8 msec 24 msec
  2 10.0.0.2 [MPLS: Labels 17/19 Exp 0] 68 msec 72 msec 88 msec
  3 192.168.2.1 [MPLS: Label 19 Exp 0] 72 msec 44 msec 40 msec
  4 192.168.2.6 76 msec 52 msec 64 msec
R4#
```

Router R6:

Similar to the router R4.

```
R6#sh ip route
Codes: 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

Gateway of last resort is not set

     4.0.0.0/32 is subnetted, 1 subnets
O IA    4.4.4.4 [110/21] via 192.168.2.1, 00:56:23, FastEthernet0/0
     6.0.0.0/32 is subnetted, 1 subnets
C       6.6.6.6 is directly connected, Loopback0
O IA 192.168.1.0/24 [110/11] via 192.168.2.1, 00:56:23, FastEthernet0/0
C    192.168.2.0/24 is directly connected, FastEthernet0/0
R6#trace 4.4.4.4

Type escape sequence to abort.
Tracing the route to 4.4.4.4

  1 192.168.2.1 24 msec 28 msec 20 msec
  2 10.0.1.2 [MPLS: Labels 16/19 Exp 0] 44 msec 36 msec 64 msec
  3 192.168.1.1 [MPLS: Label 19 Exp 0] 12 msec 44 msec 44 msec
  4 192.168.1.4 32 msec 80 msec 12 msec
R6#
```

References:

1. Juniper Label Switching and Label-switched Paths (LSPs)
2. MPLS for Dummies
3. https://www.juniper.net/documentation/en_US/junos/topics/topic-map/mpls-overview.html
4. MPLS Layer 2 VPN Configuration Overview - TechLibrary
5. Configuring a Routing Policy for MPLS Layer 2 VPNs (CLI Procedure) - TechLibrary

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