MPLS

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Purpose

The lab is performed with the intent to learn the definition and the basic configuration of *Multiprotocol Label Switching (MPLS)*. Us students would show multiple results to our instructor to get this lab checked off and to ensure a proper functioning of MPLS, which in turn would further our understanding on the topic. We would ping the routers that were assumed to be end hosts to each other; we would show *MPLS forwarding table* on all the switches orchestrating MPLS, which also shows the *LDP labels*; after all of that, we would show *LDP label packets* on a protocol analyzer. We would use Wireshark in this scenario.

Background Information

Multiprotocol Label Switching (MPLS) is a routing technique in telecommunications networks that directs data from one node to the next based on short path labels rather than long network addresses, thus avoiding complex lookups in a routing table and speeding traffic flows. The name “Multiprotocol” in the acronym is derived from the MPLS’ ability to possess the ability to encapsulate packets from various networking protocols. MPLS combines the performance and capabilities of Layer 2 (data link layer) switching with the proven scalability of Layer 3 (network layer) routing, thus giving itself a nickname, “Layer 2.5 protocol.” The MPLS architecture is flexible and can be employed in any combination of Layer 2 technologies. MPLS support is offered for all Layer 3 protocols, and scaling is possible well beyond that typically offered in today’s networks. There are certain terms used to call the nodes in an MPLS topology: -

1. *LSR (Label Switch Router)* is a node that performs routing based only on the label. 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.
2. 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. When forwarding an IP datagram into the MPLS domain, an LER uses routing information to determine the appropriate label to be affixed, labels the packet accordingly, and then forwards the labeled packet into the MPLS domain. Likewise, upon receiving a labeled packet which is destined to exit the MPLS domain, the LER strips off the label and forwards the resulting IP packet using normal IP forwarding rules.

MPLS uses a certain protocol known as *Label Distribution Protocol (LDP).*

Label Distribution Protocol (LDP) is a protocol in which routers capable of Multiprotocol Label Switching (MPLS) exchange label mapping information. Two routers with an established session are called LDP peers and the exchange of information is bi-directional. LDP is used to build and maintain LSP databases that are used to forward traffic through MPLS networks. LDP relies on the underlying routing information provided by an IGP to forward label packets. The router forwarding information base, or FIB, is responsible for determining the hop-by-hop path through the network. Unlike traffic engineered paths, which use constraints and explicit routes to establish end-to-end Label Switched Paths (LSPs), LDP is used only for signaling best-effort LSPs. In order for the nodes to form adjacencies and exhibit label packets on Wireshark, we would use *Border Gateway Protocol (BGP)*.

Border Gateway Protocol (BGP) is a standardized exterior gateway protocol designed to exchange routing and reachability information among autonomous systems (AS) on a network. The protocol is classified as a path vector protocol. The Border Gateway Protocol makes routing decisions based on paths, network policies, or rule-sets configured by a network administrator and is involved in making core routing decisions. When MPLS is utilized at core, BGP can be deployed at the network edges with the core routers carrying just the information about the BGP’s next step. BGP establishes loop-free routes and share routing information among the group of routers (ASs). MPLS does not scatter BGP across the network. MPLS provides end to end transport for BGP routes.

Lab Summary

The lab commenced as per our instructor’s provided topology. MPLS was a new territory for us and so, we needed to gain enough knowledge about the subject before beginning the lab. After collecting usable information from the world wide web, we began functioning the lab on the nodes. We used OSPF to form adjacencies among each node in the topology and then, orchestrated BGP among the switches as they would operate MPLS. We, later, executed a few MPLS specific commands on the switches to accomplish a signoff on the lab. Although this lab was, for the most part, tension-free, we faced a few problems while researching and collecting data on the internet and while showing results to our instructor.

Topology and IP Addressing Scheme

A picture containing sky, indoor, table, skiing

Description generated with high confidence

Configurations

Step 1: -

Begin the lab by replicating the physical topology and the IP addressing scheme given in the topology diagram. Use the Interface *{interface-id}* and IP address *{IP address and subnet mask}* command to do so. One might also need to initiate the no switchport command on the interface of the switches to feed an IP address on that interface.

Step 2: -

After replicating the physical and the logical topology, one should proceed to configure OSPF among all the nodes. To avoid making the overall configuration complicated, one must configure single-area OSPF. The network implementer should use the backbone area in the OSPF configuration. One should use the router ospf *{process-id}* and network *{network ip address} {wildcard mask}* area 0 commands to initiate the OSPF process among all the nodes present in the topology. To gain more information on the operation of OSPF, kindly refer to the OSPF Area Types Lab.

Step 3: -

This is the step when one would begin lodging MPLS specific commands on the switches. There, however, is a step that needs to be completed prior to this. The first step in accomplishing the goal is to force the command, ip cef distributed on the switches. The command ensures that the Cisco Express Forwarding on the route processor card is enabled. Since we are using LDP as the MPLS backbone and the default mechanism used by Cisco nodes is *TDP*, one must change the protocol by using the mpls label protocol ldp command. Now the administrator can configure the LDP router ID using the command mpls ldp router-id Loopback0 force. Although this step is optional, it can make the troubleshooting process easier if you are able to easily identify TDP/LDP routers in the network. After executing all the previous commands on the switches, the user must now enable MPLS on the interface by performing the mpls ip command on that specific interface.

Step 4: -

At this point, all the MPLS configuration should be completed. Now it is time to progress to the BGP configuration. To initiate Global BGP parameters, the network architect must initiate the router bgp *{AS number}*. The LERs must now advertise the networks connected to the routers to the BGP database by deploying the network *{network address}* under the BGP config mode. Loopbacks are very essential to the MPLS operation. In this part of the step, the administrator must make the Loopback the update source for all the mpls operation and then tie it with the Autonomous system. Use the commands to achieve that aim: neighbor *{Loopback IP Address}* update-source *{loopback interface id}* and neighbor *{loopback IP Address}* remote-as *{AS number}*. These steps must be repeated on all the LERs.

S1 Configuration: -

hostname Switch

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

vtp domain CCNP

vtp mode transparent

crypto pki trustpoint TP-self-signed-2132837760

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-2132837760

revocation-check none

rsakeypair TP-self-signed-2132837760

crypto pki certificate chain TP-self-signed-2132837760

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

vlan 2

name Data

vlan 10

name voice

vlan 20

name data

vlan 100

vlan 996

name CUSTOMER\_NATIVE

interface Loopback0

ip address 2.2.2.2 255.255.255.255

interface FastEthernet1/0/1

no switchport

ip address 192.168.3.1 255.255.255.0

interface FastEthernet1/0/2

no switchport

ip address 192.168.4.1 255.255.255.0

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

interface GigabitEthernet1/1/2

no switchport

ip address 192.168.1.2 255.255.255.0

speed auto 1000

mpls ip

interface Vlan1

no ip address

shutdown

router ospf 1

network 2.2.2.2 0.0.0.0 area 0

network 192.168.1.0 0.0.0.255 area 0

router bgp 14

bgp log-neighbor-changes

network 192.168.3.0

network 192.168.4.0

redistribute static

neighbor 4.4.4.4 remote-as 14

neighbor 4.4.4.4 update-source Loopback0

no auto-summary

ip http server

ip http secure-server

ip route 3.3.3.3 255.255.255.255 192.168.3.2

ip route 5.5.5.5 255.255.255.255 192.168.4.2

logging esm config

mpls ldp router-id Loopback0 force

line con 0

line vty 0 4

login

line vty 5 15

login

monitor session 1 source interface Gi1/1/2

monitor session 1 destination interface Fa1/0/10

end

S2 Configuration: -

hostname Switch

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

ip cef load-sharing algorithm original

vtp mode transparent

mpls ldp session protection

crypto pki trustpoint TP-self-signed-1928519808

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-1928519808

revocation-check none

rsakeypair TP-self-signed-1928519808

crypto pki certificate chain TP-self-signed-1928519808

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

vlan 996

name CUSTOMER\_NATIVE

interface Loopback0

ip address 1.1.1.1 255.255.255.255

interface FastEthernet1/0/1

interface FastEthernet1/0/2

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

no switchport

ip address 192.168.2.1 255.255.255.0

speed auto 1000

mpls label protocol ldp

mpls ip

interface GigabitEthernet1/1/2

no switchport

ip address 192.168.1.1 255.255.255.0

speed auto 1000

mpls ip

interface Vlan1

no ip address

shutdown

router ospf 1

network 1.1.1.1 0.0.0.0 area 0

network 192.168.1.0 0.0.0.255 area 0

network 192.168.2.0 0.0.0.255 area 0

ip http server

ip http secure-server

logging esm config

line con 0

line vty 0 4

login

line vty 5 15

login

monitor session 1 source interface Gi1/1/2

monitor session 1 destination interface Fa1/0/6

monitor session 2 source interface Gi1/1/1

monitor session 2 destination interface Fa1/0/14

end

S3 Configuration: -

hostname Switch

boot-start-marker

boot-end-marker

no aaa new-model

system mtu routing 1500

ip routing

mpls ldp session protection

crypto pki trustpoint TP-self-signed-3180753792

enrollment selfsigned

subject-name cn=IOS-Self-Signed-Certificate-3180753792

revocation-check none

rsakeypair TP-self-signed-3180753792

crypto pki certificate chain TP-self-signed-3180753792

spanning-tree mode pvst

spanning-tree extend system-id

vlan internal allocation policy ascending

interface Loopback0

ip address 4.4.4.4 255.255.255.255

interface FastEthernet1/0/1

no switchport

ip address 192.168.5.1 255.255.255.0

interface FastEthernet1/0/2

no switchport

ip address 192.168.6.1 255.255.255.0

interface FastEthernet1/0/3

interface FastEthernet1/0/4

interface FastEthernet1/0/5

interface FastEthernet1/0/6

interface FastEthernet1/0/7

interface FastEthernet1/0/8

interface FastEthernet1/0/9

interface FastEthernet1/0/10

interface FastEthernet1/0/11

interface FastEthernet1/0/12

interface FastEthernet1/0/13

interface FastEthernet1/0/14

interface FastEthernet1/0/15

interface FastEthernet1/0/16

interface FastEthernet1/0/17

interface FastEthernet1/0/18

interface FastEthernet1/0/19

interface FastEthernet1/0/20

interface FastEthernet1/0/21

interface FastEthernet1/0/22

interface FastEthernet1/0/23

interface FastEthernet1/0/24

interface GigabitEthernet1/0/1

interface GigabitEthernet1/0/2

interface GigabitEthernet1/1/1

no switchport

ip address 192.168.2.2 255.255.255.0

speed auto 1000

mpls label protocol ldp

mpls ip

interface GigabitEthernet1/1/2

interface Vlan1

no ip address

shutdown

router ospf 1

network 4.4.4.4 0.0.0.0 area 0

network 192.168.2.0 0.0.0.255 area 0

network 192.168.5.0 0.0.0.255 area 0

network 192.168.6.0 0.0.0.255 area 0

router bgp 14

bgp log-neighbor-changes

network 192.168.5.0

network 192.168.6.0

redistribute static

neighbor 2.2.2.2 remote-as 14

neighbor 2.2.2.2 update-source Loopback0

no auto-summary

ip http server

ip http secure-server

ip route 6.6.6.6 255.255.255.255 192.168.5.2

ip route 7.7.7.7 255.255.255.255 192.168.6.2

logging esm config

line con 0

line vty 0 4

login

line vty 5 15

login

end

Marvel1 Configuration: -

hostname Marvel1

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 25

ip cef

no ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX180180M8

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain CCNP

vtp mode transparent

redundancy

interface Loopback0

ip address 3.3.3.3 255.255.255.255

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

no ip address

shutdown

duplex auto

speed auto

interface GigabitEthernet0/1

ip address 192.168.3.2 255.255.255.0

duplex auto

speed auto

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 192.168.3.1

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

DC1 Configuration: -

hostname DC1

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

no ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX180180M5

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Loopback0

ip address 5.5.5.5 255.255.255.0

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

no ip address

shutdown

duplex auto

speed auto

interface GigabitEthernet0/1

ip address 192.168.4.2 255.255.255.0

duplex auto

speed auto

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 192.168.4.1

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

Marvel2 Configuration: -

hostname Marvel2

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

no ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX15208074

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Loopback0

ip address 6.6.6.6 255.255.255.255

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

no ip address

shutdown

duplex auto

speed auto

interface GigabitEthernet0/1

ip address 192.168.5.2 255.255.255.0

duplex auto

speed auto

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 192.168.5.1

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

DC2 Configuration: -

hostname DC2

boot-start-marker

boot-end-marker

no aaa new-model

memory-size iomem 10

ip cef

no ipv6 cef

multilink bundle-name authenticated

voice-card 0

license udi pid CISCO2901/K9 sn FTX1520806E

license accept end user agreement

license boot module c2900 technology-package securityk9

license boot module c2900 technology-package uck9

vtp domain cisco

vtp mode transparent

redundancy

interface Loopback0

ip address 7.7.7.7 255.255.255.255

interface Embedded-Service-Engine0/0

no ip address

shutdown

interface GigabitEthernet0/0

no ip address

shutdown

duplex auto

speed auto

interface GigabitEthernet0/1

ip address 192.168.6.2 255.255.255.0

duplex auto

speed auto

interface Serial0/0/0

no ip address

shutdown

clock rate 2000000

interface Serial0/0/1

no ip address

shutdown

clock rate 2000000

interface GigabitEthernet0/1/0

no ip address

shutdown

duplex auto

speed auto

ip forward-protocol nd

no ip http server

no ip http secure-server

ip route 0.0.0.0 0.0.0.0 192.168.6.1

control-plane

mgcp profile default

gatekeeper

shutdown

line con 0

line aux 0

line 2

no activation-character

no exec

transport preferred none

transport output lat pad telnet rlogin lapb-ta mop udptn v120 ssh

stopbits 1

line vty 0 4

login

transport input all

scheduler allocate 20000 1000

end

Results: -

A screenshot of a cell phone

Description generated with very high confidence

A good network administrator must possess the skills to efficiently utilize a protocol analyzer. A protocol analyzer is mainly used for troubleshooting purposes. We, however, use it to prove our skills to attain a signoff. Labels are crucial to the MPLS process. They, however, cannot be easily viewed on Wireshark. This is where BGP plays an important role. To view the MPLS labels on Wireshark, one must have MPLS configured properly on the node. The network engineer must search for BGP specific captures on Wireshark. The engineer will, then, have to select a capture find a tab that reads “MultiProtocol Label Switching Header,” under the tab, will lie the label that the user might be searching for.

Problems: -

The motive of this lab was hard to accomplish. We had to focus and invest a lot of our time on understanding the definition of the protocol that we would operate in this lab. We faced numerous problems towards the end of the lab. Our instructor asked us to show labels on the nodes in order to verify our worthiness of getting a signoff on the lab. We did not know the proper command to show the desired result and so we could not get the signoff. After that, we invested a little time in researching about the command, and so, we found out, that the command used to show labels on the nodes is, show mpls forwarding-table.

We were advised by a peer to not to configure BGP, and so, we configured the nodes with just OSPF. When we, however, requested a signoff, we could not locate an MPLS Label capture on our Wireshark. After a little research on the internet, we realized the importance of BGP in this lab, and finally configured it. Configuring BGP fixed this problem that we were having, and we were able to get a signoff.

Conclusions: -

The lab was successfully completed and the motive of working on this lab was fulfilled. We learnt about the “Layer 2.5 Protocol,” and operation of deciding the shortest path for a packet to reach its destination. MPLS is soon going to become a widely used networking strategy and is already being adopted by some of the most famous Internet Service Providers (ISPs) is the USA. Having the ability to process such protocol gives us students a crucial knowledge.