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Implementation of Layer 3 Vpns over Layer 2 Vpn Topologies Using Gns3 Software

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ABSTRACT:

To implement VPNs to connect geographically separated customer sites. VPNs were originally introduced to enable service providers to use common physical infrastructure to implement emulated point-to-point links between customer sites. A customer network implemented with any VPN technology would contain distinct regions under the customer's control called the customer sites connected to each other via the service provider network. The peer-to-peer model was developed to overcome the drawbacks of the Overlay model and provide customers with optimal data transport via the Service Provider backbone. Hence, the service provider would actively participate in customer Layer 3 routing. Customer Layer 3 routing information is carried between routers in the provider network and customer network. The peer-to-peer model, consequently, does not require the creation of virtual circuits. Layer 3 VPNs implemented on MPLS backbone of service providers are referred as "MPLS L3 VPNs".

I.INTRODUCTION:

Multiprotocol Label Switching (MPLS) has evolved from being a buzzword in the networking industry to a widely deployed technology in service provider (SP) networks. In recent years, MPLS has also been adopted by the enterprise and federal market segments. MPLS is a contemporary solution to address a multitude of problems faced by present-day networks: speed, scalability, quality of service (QoS) management, and traffic engineering. Service providers are realizing larger revenues by the implementation of service models based on the flexibility and value adds provided by MPLS solutions. MPLS also provides an elegant solution to satisfy the bandwidth management and

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service requirements for next-generation IP based backbone networks.

II.LITERATURE SURVEY:

In traditional IP networks, routing protocols are used to distribute Layer 3 routing information. The network 172.16.10.0/24 is propagated using an IP routing protocol. Regardless of the routing protocol, packet forwarding is based on the destination address alone. Therefore, when a packet is received by the router, it determines the next-hop address using the packet's destination IP address along with the information from its own forwarding/routing table. This process of determining the next hop is repeated at each hop (router) from the source to the destination except in the case of policy-based routing where a certain outbound policy might affect packet forwarding.

III.PROPOSED METHOD: In MPLS enabled networks, packets are forwarded based on labels. These labels might correspond to IP destination addresses or to other parameters, such as QoS classes and source address. Labels are generated per router (and in some cases, per interface on a router) and bear local significance to the router generating them. Routers assign labels to define paths called Label Switched Paths (LSP) between endpoints. Because of this, only the routers on the edge of the MPLS network perform a routing lookup.

The routers in MPLS network R1, R2, and R3 propagate updates for 172.16.10.0/24 network via an IGP routing protocol just like in traditional IP networks, assuming no filters or summarizations are not configured. This leads to the creation of an IP forwarding table. Also, because the links connecting the routers are MPLS enabled, they assign local labels for destination 172.16.10.0 and propagate them upstream to their directly connected peers using a label distribution protocol; for example, R1 assigns a local label L1 and propagates it to the upstream neighbor R2. R2 and R3 similarly assign labels and propagate the same to upstream neighbors R3 and R4, respectively. Consequently, as illustrated in Figure 1-2, the routers now maintain a label forwarding table to enable labeled packet forwarding in addition to the IP routing table. The concept of upstream and downstream is explained in greater detail in the section "MPLS Terminology."

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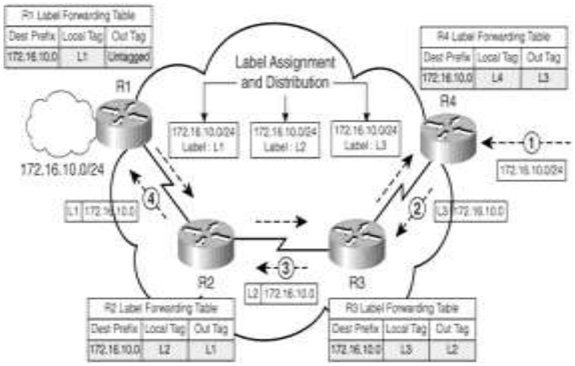

Figure 1.1: Forwarding in the MPLS Domain

As shown in Figure 1.1, the following process takes place in the data forwarding path from R4 to R1:

1.R4 receives a data packet for network 172.16.10.0 and identifies that the path to the destination is MPLS enabled. Therefore, R4 forwards the packet to next-hop Router R3 after applying a label L3 (from downstream Router R3) on the packet and forwards the labeled packet to R3.

2.R3 receives the labeled packet with label L3 and swaps the label L3 with L2 and forwards the packet to R2.

3.R2 receives the labeled packet with label L2 and swaps the label L2 with L1 and forwards the packet to R1.

4.R1 is the border router between the IP and MPLS domains; therefore, R1 removes the labels on the data packet and forwards the IP packet to destination network 172.16.10.0.

MPLS functionality on Cisco devices is divided into two main architectural blocks:

1.Control plane – Performs functions related to identifying reachability to destination prefixes. Therefore, the control plane contains all the Layer 3 routing information, as well as the processes within, to exchange reachability information for a specific Layer 3 prefix. Common examples of control plane functions are routing protocol information exchange like in OSPF and BGP. Hence, IP routing information exchange is a control plane function. In addition, all protocol functions that are responsible for the exchange of labels between neighboring routers function in the control plane as in label distribution protocols (explained in detail in section "LDP Session Establishment").

2.Data plane – Performs the functions relating to forwarding data packets. These packets can be either Layer 3 IP packets or labeled IP packets. The information in the data plane, such as label values, are derived from the control plane.

A.MPLS TERMINOLOGY:

This section provides an overview of the common MPLS-related terminology used :

- Forwarding Equivalence Class (FEC) – As noted in RFC 3031(MPLS architecture), this group of packets are forwarded in the same manner (over the same path with the same forwarding treatment).
- MPLS Label Switch Router (LSR) – Performs the function of label switching; the LSR receives a labeled packet and swaps the label with an outgoing label and forwards the new labeled packet from the appropriate interface. The LSR, depending on its location in the MPLS domain, can either perform label disposition (removal, also called pop), label imposition (addition, also called push) or label swapping (replacing the top label in a label stack with a new outgoing label value). The LSR, depending on its location in the MPLS domain, might also perform label stack imposition or disposition. The concept of a label stack is explained later in this section. During label swapping, the LSR replaces only the top label in the label stack; the other labels in the label stack are left untouched during label swapping and forwarding operation at the LSR.
- MPLS Edge-Label Switch Router (E-LSR) – An LSR at the border of an MPLS domain. The ingress Edge LSR performs the functions of label imposition (push) and forwarding of a packet to destination through the MPLS-enabled domain. The egress Edge LSR performs the functions of label disposition or removal (pop) and forwarding an IP packet to the destination. Note that the imposition and disposition processes on an Edge

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LSR might involve label stacks versus only labels.

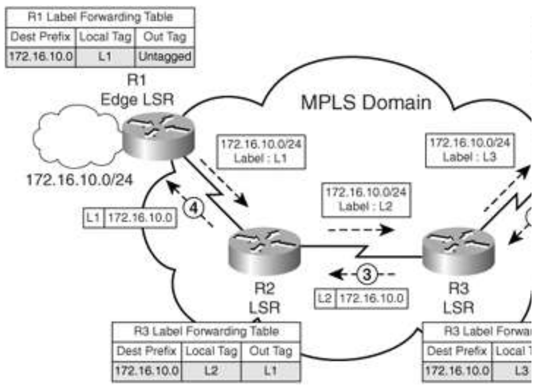

Figure 1.2: LSR and Edge LSR

- MPLS Label Switched Path (LSP) – The path from source to destination for a data packet through an MPLS-enabled network. LSPs are unidirectional in nature. The LSP is usually derived from IGP routing information but can diverge from the IGP's preferred path to the destination (as in MPLS traffic engineering, which is discussed in Chapter 9, "MPLS Traffic Engineering"). In Figure 1-4, the LSP for network 172.16.10.0/24 from R4 is R4-R3-R2-R1.
- Upstream and downstream – The concept of downstream and upstream are pivotal in understanding the operation of label distribution (control plane) and data forwarding in an MPLS domain. Both downstream and upstream are defined with reference to the destination network: prefix or FEC. Data intended for a particular destination network always flows downstream. Updates (routing protocol or label distribution, LDP/TDP) pertaining to a specific prefix are always propagated upstream. This is depicted in Figure 1-5 where downstream with reference to the destination prefix 172.16.20.0/24 is in the path R1-R2-R3, and downstream with reference to 172.16.10.0/24 is the path R3-R2-R1. Therefore, in Figure 1-5, R2 is downstream to R1 for destination 172.16.20.0/24, and R1 is downstream to R2 for destination 172.16.10.0/24.

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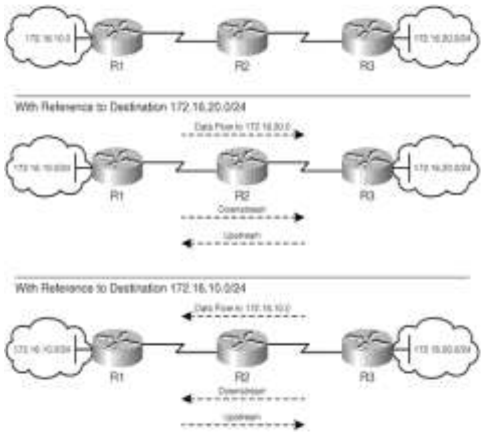

Figure 1.3: Upstream and Downstream

- MPLS labels and label stacks – An MPLS label is a 20-bit number that is assigned to a destination prefix on a router that defines the properties of the prefix as well as forwarding mechanisms that will be performed for a packet destined for the prefix.

A label stack is an ordered set of labels where each label has a specific function. If the router (Edge LSR) imposes more than one label on a single IP packet, it leads to what is called a label stack, where multiple labels are imposed on a single IP packet. Therefore, the bottom-of-stack indicator identifies if the label that has been encountered is the bottom label of the label stack.

The TTL field performs the same function as an IP TTL, where the packet is discarded when the TTL of the packet is 0, which prevents looping of unwanted packets in the network. Whenever a labeled packet traverses an LSR, the label TTL value is decremented by 1.

The label is inserted between the Frame Header and the Layer 3 Header in the packet. Figure 1-7 depicts the label imposition between the Layer 2 and Layer 3 headers in an IP packet.

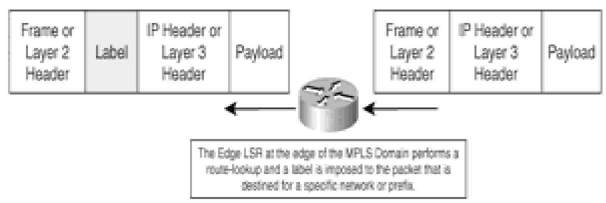

Figure 1.4: MPLS Label Imposition

If the value of the S bit (bottom-of-stack indicator) in the label is 0, the router understands that a label stack implementation is in use. As previously mentioned, an LSR swaps only the top label in a label stack. An egress Edge LSR, however, continues label disposition in the label stack until it finds that the value of the S bit is set to 1, which denotes a bottom of the label stack. After the router encounters

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the bottom of the stack, it performs a route lookup depending on the information in the IP Layer 3 Header and appropriately forwards the packet toward the destination. In the case of an ingress Edge LSR, the Edge LSR might impose (push) more than one label to implement a label stack where each label in the label stack has a specific function.

Label stacks are implemented when offering MPLS-based services such as MPLS VPN or MPLS traffic engineering. In MPLS VPN (see Chapter 3, "Basic MPLS VPN Overview and Configuration"), the second label in the label stack identifies the VPN. In traffic engineering (see Chapter 9), the top label identifies the endpoint of the TE tunnel, and the second label identifies the destination. In Layer 2, VPN implementations over MPLS, such as AToM (see Chapter 11, "Any Transport over MPLS [AToM]") and VPLS (see Chapter 12, "Virtual Private LAN Service [VPLS]), the top label identifies the Tunnel Header or endpoint, and the second label identifies the VC. All generic iterations of the label stack implementation are shown in Figure 1-8.

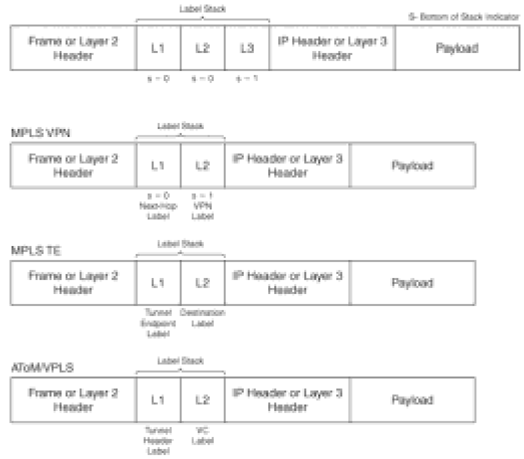

Figure 1.5: MPLS Label Stack

B. MPLS CONTROL AND DATA PLANE COMPONENTS:

Cisco Express Forwarding (CEF) is the foundation on which MPLS and its services operate on a Cisco router. Therefore, CEF is a prerequisite to implement MPLS on all Cisco platforms except traditional ATM switches that support only data plane functionality. CEF is a proprietary switching mechanism used on Cisco routers that enhances the simplicity and the IPv4 forwarding performance of a router manifold.

The LIB functions in the control plane and is used by the label distribution protocol where IP destination prefixes in the routing table are mapped to next-hop labels that are received from downstream

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neighbors, as well as local labels generated by the label distribution protocol.

The LFIB resides in the data plane and contains a local label to next-hop label mapping along with the outgoing interface, which is used to forward labeled packets.

Information about reachability to destination networks from routing protocols is used to populate the Routing Information Base (RIB) or the routing table. The routing table, in turn, provides information for the FIB. The LIB is populated using information from the label distribution protocol and from the LIB along with information from the FIB that is used to populate the LFIB.

IV. BASIC MPLS CONFIGURATION:

A. FRAME-MODE MPLS CONFIGURATION AND VERIFICATION:

In frame mode, MPLS uses a 32-bit label that is inserted between the Layer 2 and Layer 3 headers. Layer 2 encapsulations like HDLC, PPP, Frame Relay, and Ethernet are frame-based except for ATM, which can operate either in frame mode or cell mode.

Basic Frame-Mode MPLS Overview, Configuration, and Verification

Figure 2-1 shows a frame-based MPLS provider network providing MPLS services to sites belonging to Customer A. The frame-based provider's network consists of routers R1, R2, R3, and R4. R1 and R4 function as Edge Label Switch Routers (LSRs) while R2 and R3 serve as LSRs.

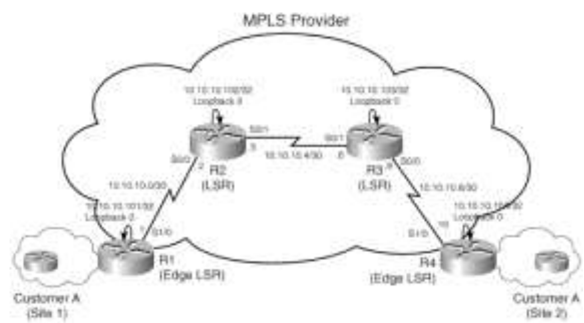

Figure 1.6: Frame-Mode MPLS Provider Network

V. PE-CE ROUNTING PROTOCAL-STATIC AND RIP:

A. PE-CE ROUNTING PROTOCAL-STATIC AND RIP:

Configuring MPLS VPNs is an integral function in service provider environments and enterprise networks. Preceding chapters provided you with basic concepts related to MPLS label distribution and propagation, and MPLS VPN concepts like route distinguisher, route targets,

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multiprotocol BGP, and label propagation in VPN networks.

This follows as :

- Static PE-CE routing overview, configuration, and verification
- RIPv2 PE-CE routing overview, configuration, and verification
- RIPv1 PE-CE routing configuration and verification

B.STATIC PE-CE CONFIGURATION, AND VERIFICATION:

Static PE to CE routing is one of the most common routing techniques used in MPLS VPN deployments. Static PE-CE routing is an optimal solution for sites either having a single PE-CE connection or limited number of subnets in the customer edge (CE) network or both. Static PE to CE routing also prevents the customer or the service provider from intentionally or accidentally flooding each other with false routing information. The service provider therefore retains control over customer routing. Static PE-CE routing might increase the provider's operational and administrative overheads to maintain static routes. This is because static PE-CE routing does not provide dynamic rerouting and therefore requires additional configuration for every new prefix on the PE routers and possibly on the CE router in the absence of a default route.

Static PE-CE routing involves the following:

On a CE router:

a.Configuring static routes to specific remote CE networks in the same VPN or

b.Configuring a static default route

On a PE router:

- Configuring a static VRF route to reach the connected CE router's networks. This static VRF route is redistributed in MP-iBGP and propagated as a VPNv4 prefix to the remote PE router.

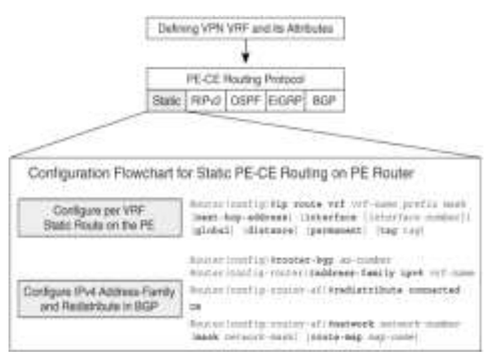

Figure 1.7: Configuration Flowchart to Configure Static PE-CE Routing

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VI. RESULT :

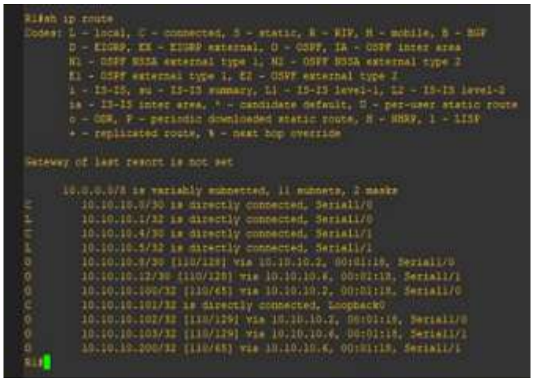

Fig1:IP Route command

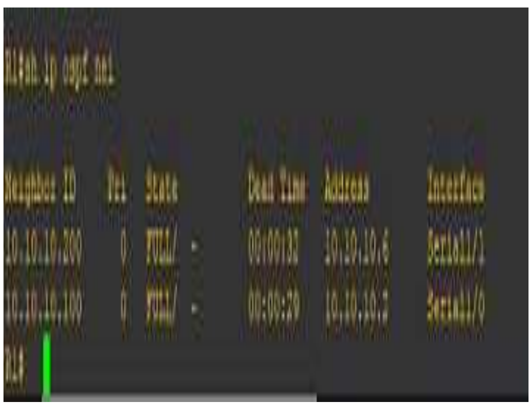

Fig2:OSPF neibour

VI. COMMAND REFERENCE:

Table 4-2 provides the RIP PE-CE routing configuration command summary.

Command	Description
Router(config)#router rip	Configures the RIP routing process.
Router(config-router)#version {1 | 2}	Used to specify RIPv1 or RIPv2 routing protocol.
Router(config-router)#address-family ipv4 [unicast] vrf vrf-name	The address-family command puts the router in address family configuration submode (prompt: (config-router-af)#). Within this submode, you can configure address family specific parameters for routing protocols, such as RIP and BGP, that can accommodate multiple Layer 3 address families.
Router(config-router-af)#network ip-address	Specifies a list of networks for RIP routing process. The command is used in router configuration mode. In an MPLS VPN environment, the command is configured in

Command	Description
	address-family mode.
Router(config-router-af)#no auto-summary	Disables the default behavior of automatic summarization of subnet routes into network-level routes. RIP Version 1 always uses automatic summarization. If you are using RIP Version 2, you can turn off automatic summarization by specifying the no auto-summary command. Disable automatic summarization if you must perform routing between disconnected subnets. When automatic summarization is off, subnets are advertised.
Router(config-router-af)# redistribute bgp as-number [metric] [transparent]	Redistributes MP-BGP routes into RIP. The transparent option is used when the RIP metric needs to be preserved across the MPLS VPN network for RIP VPN sites.
Router(config)#router bgp as-number	Configures the BGP routing process.

Table 1.1:Routing Command Reference

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