Design and Simulation of IPv6-Based VLAN Networks with Switch virtual interface and EIGRPv6 Routing Protocol

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ARTICLE INFO

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Received: 29-006-2025
Accepted: 14-07-2025
Published: 20-09-2025

Keywords. IPV6, IPV4, SVI, EIGRPv6, VLAN, GNS3 , Wireshark**.**

ABSTRACT

In contemporary network infrastructure, logical segmentation and efficient routing are crucial for optimizing performance, security, and scalability. This paper presents the design and implementation of VLAN segmentation using Switched Virtual Interfaces (SVIs) in conjunction with EIGRP for IPv6 (EIGRPv6) within a simulated environment using GNS3. VLANs are configured to separate network traffic based on departmental or functional requirements, thereby reducing broadcast traffic and enhancing network organization. SVIs enable inter-VLAN communication by providing Layer 3 interfaces for each VLAN on multilayer switches. EIGRPv6 is implemented as the dynamic routing protocol to ensure efficient routing of IPv6 traffic between VLANs across different network segments. The simulation is carried out using GNS3, evaluating key performance parameters such as convergence time, scalability, and fault tolerance. The results validate the effectiveness of combining IPv6, SVIs, and EIGRPv6 in creating a robust and future-ready network infrastructure.

INTRODUCTION

As network demands continue to grow in both complexity and scale, ensuring efficient traffic management and secure communication between devices has become a critical priority for organizations. VLAN (Virtual Local Area Network) technology plays a key role in logically segmenting networks, reducing broadcast domains, and enhancing security by isolating traffic between different departments or functions. However, VLANs require proper routing mechanisms to enable communication between isolated segments.

Switched Virtual Interfaces (SVIs) allow Layer 3 switches to perform inter-VLAN routing by providing logical interfaces that connect each VLAN. When combined with a dynamic routing protocol like EIGRPv6, the network benefits from fast convergence, scalability, and efficient handling of IPv6 traffic.

This project aims to design and implement VLAN segmentation integrated with SVI and EIGRPv6 in a simulated environment using GNS3. By doing so, it showcases how advanced routing and segmentation techniques can improve network performance, organization, and future scalability. [2].

This paper focuses on VLANs and Switch Virtual Interface (SVI) routing using IPv6. An SVI is a virtual interface associated with a VLAN on a switch, enabling inter-VLAN routing Each SVI is assigned an IP address and acts as a gateway for its VLAN. When devices in different VLANs communicate, traffic is routed through the respective SVIs [2][3].

Related Work:

2.1 Internet Protocol version 6

IPv6 is the latest Internet Protocol version and the successor to IPv4. IPv6 aims to fulfill the need for more IP addresses, the main issue of the previous IP. Another common name for IPv6 is **IPng (Internet Protocol next generation)**.[4]

Unlike its predecessor, IPv6 uses 128-bit hexadecimal IP addresses. This model enables **2^128 unique addresses** (over 340 undecillion, which is 340 with 36 zeros).

IPv6 addresses are significantly longer than IPv4 variants (eight 16-bit blocks with groups of four symbols, often called **hextets** or **quartets**) and are alphanumeric. Also, whereas IPv4 relies on periods for formatting, IPv6 uses colons, such as in this example:

2001:0db8:0000:0001:0000: ff00:0032:7879.

The model omits leading zeros (like in IPv4), and you'll sometimes find IP addresses that have a double colon (::) that designate any number of 0 bits (such as 1201:2db7::fa00:0040:6669, in which the third, fourth, and fifth hextets are 0000).

2.2 Virtual Local Area Networks (VLANs)

Virtual Local Area Networks (VLANs) have become a crucial component in modern networking. VLANs provide a way to segment network traffic and create logical networks that can improve network security, reduce network congestion, and improve network performance. By dividing a physical network into multiple logical networks, VLANs can help organizations to simplify network management, control network access, and increase the efficiency of network resources.

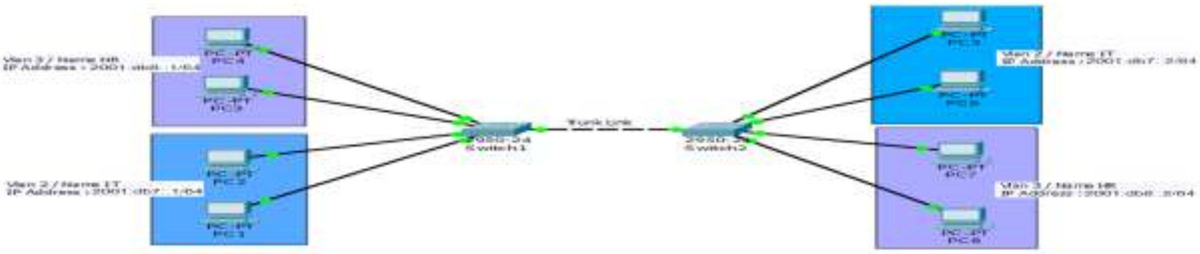


Figure 1.1: Virtual Local Area Network (VLAN)

a. Layer 3 Switch Method

Layer 3 switches are another method of inter VLAN routing. Layer 3 switches are switches that are capable of routing traffic between VLANs. They have multiple physical interfaces, each of which can be assigned to a different VLAN. Layer 3 switches can route traffic between VLANs using hardware, which makes them faster than router-on-a-stick. This method of inter VLAN routing is more expensive than router-on-a-stick, but it is also more scalable and provides better performance.

In summary, router-on-a-stick, Layer 3 switches, and RVIs are all methods of inter VLAN routing that can be used in a network. The choice of method will depend on the specific requirements of the network, including cost, performance, and scalability. In Fig 1.2 shown the SVI Switch Virtual Interface using multilayer switch

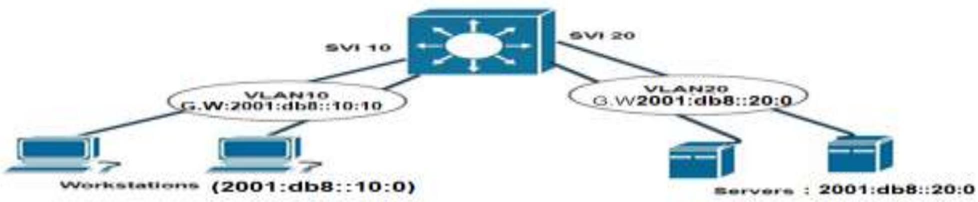


Fig 1.2 SVI Switch Virtual Interface using multilayer switch

SVIs are typically configured with an IP address, subnet mask, and VLAN ID. When a host in a VLAN sends traffic to a different subnet, the traffic is forwarded to the SVI for that VLAN, which routes the traffic to the appropriate VLAN using the routing table.

2.6. Routing Protocol:

Routing occurs at Layer 3 (the network layer) of OSI model and it is the process of forwarding packets from sender to destination by making the routers examine destination IP address (Layer 3) and consults the routing table to find the best path to destination. The routing table preserves a record of the routes to various network destinations based on network topology. Routing protocols can be classified as static and dynamic routing. In static routing approach configuring the routing tables in the routers within a network is done prior to the network's operation whereas in dynamic routing the routers construct their individual routing tables through information exchanged with each other during the network's operation. However, dynamic routing is used in medium to large networks and scale well to large networks. Moreover, it has the capability to do rerouting in event of network topology's modifications, network congestion, or link failures. Dynamic routing can be further classified into link-state and distance-vector routing protocols. [8]

2. 3. CLASSIFICATION

Routing is classified broadly into two types to create a routing table.

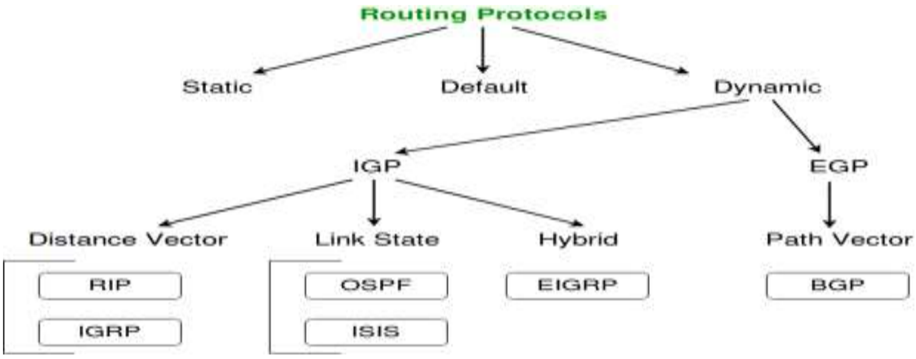


Figure 1.3: Classification of Routing Protocols

- EIGRPv6

The Enhanced Interior Gateway Routing Protocol (EIGRPv6) is considered a hybrid protocol because it has link state protocol properties, [8]. EIGRP runs by taking routing decisions according to a group of cost metrics associated with router interfaces, which are computed using the Diffusing Update Algorithm (DUAL) to determine the best route to a destination. This algorithm is considered faster than algorithms used by other routing protocols like the Distributed Bellman-Ford, while creating less CPU overhead than link state counterparts. Tor each link connected to the router, the metrics are bandwidth, load, reliability, delay and Maximum Transmission Unit (MTU). EIGRPv6 which is designed to operate in IPv6 environment behaves much like its EIGRPv4 IPv4 counterpart Many similarities exist between EIGRPv6 and EIGRPv4 except for a few differences. [9]

METHODS

3.1. Implementation IPv6 Addressing

IPv6 is a network layer protocol that allows communication to take place over the network. Each device on the topology has a unique IP address used to identify it and figure out where it is.

Table (1.1) shows a list of devices, together with their related ports and functionality.

Table (1.2) includes a detailed listing of all IP addresses used in the network setup.

Table (1.1) : IPv6 Address Allocated to End Devices

Devices	IP Address	Default Gateway	Task
PC-1	2001:db8:2::10	2001:db8:2::100	End Device,vlan 100
PC-2	2001:db8:3::10	2001:db8:3::100	End Device,vlan 200
PC-3	2001:db8:1::10	2001:db8:1::100	End Device,vlan 300
PC-4	2001:db7:3::10	2001:db7:3::100	End Device,vlan 100
PC-5	2001:db7:2::10	2001:db7:2::100	End Device,vlan 200
PC-6	2001:db7:1::10	2001:db7:31::100	End Device,vlan 300
PC-7	2001:db9:1::10	2001:db9:1::100	End Device,vlan 100
PC-8	2001:db9:2::10	2001:db7:2::100	End Device,vlan 200
PC-9	2001:db9:3::10	2001:db7:3::100	End Device,vlan 300

Table (1.2): IPv6 Address and interface Allocated to Intermedia Devices

Devices	IP Address	Interface	Task
R1	2001:db2:12::1/64	s2/0	Ip routing
R1	2001:db2:13::1/64	s2/1	Ip routing
R1	2001:ABC:1::2/64	F0/0	Ip routing
R2	2001:db2:12::2/64	s2/1	Ip routing
R2	2001:db2:23::2/64	s2/0	Ip routing
R2	2001:ABC:2::2/64	F0/0	Ip routing
R3	2001:db2:23::3/64	s2/1	Ip routing
R3	2001:db2:13:3/64	s2/0	Ip routing
R3	2001:ABC:3::2/64	F0/0	Ip routing
ESW1	2001:db8:1::100/64	F1/1	SVI , Gateway Vlan 100
ESW1	2001:db8:2::100/64	F1/2	SVI , Gateway Vlan 200
ESW1	2001:db8:3::100/64	F1/3	SVI , Gateway Vlan 300
ESW1	2001:ABC:1::2/64	F0/0	Ip routing
ESW2	2001:db7:1::100/64	F1/1	SVI , Gateway Vlan 100
ESW2	2001:db7:2::100/64	F1/2	SVI , Gateway Vlan 200
ESW2	2001:db7:3::100/64	F1/3	SVI , Gateway Vlan 300
ESW2	2001:ABC:3::1/64	F0/1	Ip routing
ESW3	2001:db9:1::100/64	F1/1	SVI , Gateway Vlan 100
ESW3	2001:db9:2::100/64	F1/2	SVI , Gateway Vlan 200
ESW3	2001:db9:3::100/64	F1/3	SVI , Gateway Vlan 300
ESW3	2001:ABC:2::1/64	F0/0	Ip routing

One feature of EIGRP is that it uses various factors to calculate the metric for its path. EIGRP metric values, by default, utilize bandwidth value and delay value but also consider interface load and reliability.

Cost Calculation - Composite matrix is used to calculate the cost and also used for neighbourship discovery purpose. It has values:

K1(bandwidth)= 1

K2(load)= 0

K3(delay) =1

K4(reliability)= 0

K5(MTU)=0

As only bandwidth and delay is used to calculate the cost. The formula used for cost calculation is:

EIGRP Metric = 256*((K1*Bandwidth) + (K2*Bandwidth)/(256-Load) + K3*Delay)*(K5/(Reliability + K4)))

As values of K1 and K3 are set to 1, and K2, K4 and K5 are set to 0. Therefore the formula becomes:

Metric = 256*(Bandwidth +Sum of all Delay)

Where the bandwidth = (10^7/least bandwidth) and

Delay = (sum of all delays /10)

The bandwidth is the lowest bandwidth between the source and destination and the delay is the cumulative interface delay along a path between source and destination.

Table (1.3): Attributes of IPv6

Type	Distance Vector
Algorithms	DUAL
Internal AD	90
External AD	170
Standard	Cisco Proprietary
Transport	IP/88
Authentication	MD5
Multicast IP	224.0.0.10 FF02::A
Hello Timers	5/60

This table summarizes EIGRPv6's core parameters, including administrative distance and multicast addressing.

EIGRPv6 Inter-Router Communication

• EIGRP packets are identified using the well-known protocol ID 88 for both IPv4 and IPv6.

• When EIGRPv6 is enabled, the routers communicate with each other using the interface's IPv6 link-local address as the source. The destination address may be either a unicast link local address or the multicast link-local address FF02::A. Table (3.8) shows the source and destination addresses for the EIGRP packet types:

RESULTS AND DISCUSSION:

4.1. Evaluation of Networks Topology and Protocol:

This part presents the analysis of the results obtained from the implementing a network topology interconnecting three separate branches using IPv6, multi-VLAN configuration, and EIGRP for IPv6 dynamic routing.

The topology was simulated using GNS3. Additionally, Wireshark was utilized to capture and analyze real-time packet exchanges, including EIGRPv6 neighbor discovery and route advertisement processes.

The network architecture employed multiple VLANs with Switched Virtual Interfaces (SVIs) providing Layer 3 gateway functionality on a Layer 3 switches. Each branch was assigned a unique VLAN and IPv6 subnet. EIGRP for IPv6 was configured across all routers and Layer 3 devices to enable automatic propagation of routing information and ensured seamless connectivity among the three branches.

The analysis focuses on verifying the network design's effectiveness through:

- Ping tests confirming IPv6 connectivity,
- Traceroute validating routing paths,
- EIGRPv6 neighbor and route table inspections, and
- Wireshark packet captures for protocol-level verification.

The discussion is structured around the verification of core network functions such as SVI configuration, VLAN segmentation, inter-VLAN routing, and EIGRPv6 operations. Results from these tests confirm whether the objectives of secure, efficient, and scalable IPv6-based communication among branches were successfully achieved. fig.(1.4) illustrates the implemented topology.

- *Network Resources:*

- 3 cisco 7200 routers
- 3 cisco layer 3 switches
- 9 pcs (configured as servers with IPv6 address)
- Cables (or other interconnection methods for device communication)

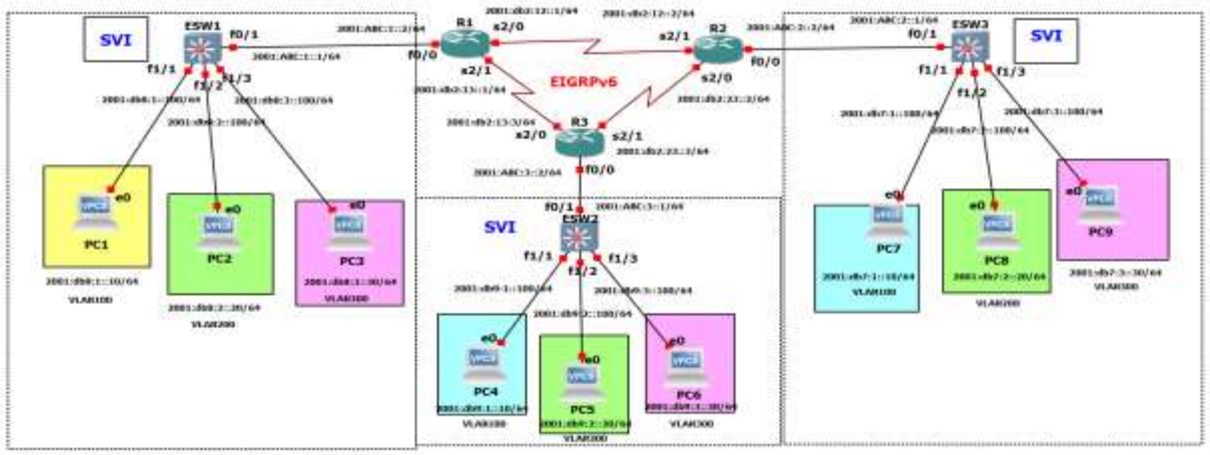


Figure (1.4): the project network topology

4.1.1. Verification of VLANs Configuration:

As shown in figure (1.5) the command displays all configured VLANs, including their names, statuses, and assigned ports. The result confirms that VLAN 100, VLAN 200 and VLAN 300 have been successfully created and are active, with appropriate ports assigned.

```
ESW1#show vlan-switch

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    Fa1/0, Fa1/4, Fa1/5, Fa1/6
                                                Fa1/7, Fa1/8, Fa1/9, Fa1/10
                                                Fa1/11, Fa1/12, Fa1/13, Fa1/14
                                                Fa1/15
100  Communiction                     active    Fa1/1
200  Data-Center                      active    Fa1/2
300  IT                               active    Fa1/3
1002 fddi-default                     act/unsup
1003 token-ring-default               act/unsup
1004 fddinet-default                  act/unsup
1005 trnet-default                    act/unsup
```

Figure (1.5): Display VLANS on Switches

4.1.2 Routing, Neighbor, and Topology Tables in EIGRP for IPv6:

The EIGRP for IPv6 routing table contains the best routes to each destination network, derived from the topology table based on the lowest metric path. In the simulation, each router's IPv6 routing table displayed the active routes installed by EIGRP, marked with the letter "D" (denoting an EIGRP-derived route). This section, discusses the operation and structure of the **routing table**, **neighbor table**, and **topology table** in the context of EIGRP for IPv6, as observed in the simulation results.

a. Routing table

The EIGRP for IPv6 routing table contains the optimal routes to each destination network, calculated from the topology table. In the simulation, each router's IPv6 routing table displayed the EIGRP –installed active routes. figures (1.6),(1.7) and (1.8) illustrate the routing tables on layer 3 switches (ESW1, ESW2 and ESW3) in the topology.

```
ESW1#show ipv6 route eigrp
IPv6 Routing Table - 20 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route, M - MIPv6
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       D - EIGRP, EX - EIGRP external
D   2001:ABC:2::/64 [90/2198016]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:ABC:3::/64 [90/2198016]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB2:12::/64 [90/2195456]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB2:13::/64 [90/2195456]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB2:23::/64 [90/2707456]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB7:1::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB7:2::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB7:3::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB9:1::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB9:2::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
D   2001:DB9:3::/64 [90/2200576]
     via FE80::C801:60FF:FE3C:0, FastEthernet0/1
ESW1#
```

Figure (1.6): EIGRP Configured Routing Table in ESW1

```
ESW2#show ipv6 route eigrp
IPv6 Routing Table - 20 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route, M - MIPv6
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       D - EIGRP, EX - EIGRP external
D   2001:ABC:1::/64 [90/2174976]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:ABC:2::/64 [90/2174976]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB2:12::/64 [90/2684416]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB2:13::/64 [90/2172416]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB2:23::/64 [90/2172416]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB7:1::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB7:2::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB7:3::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB8:1::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB8:2::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
D   2001:DB8:3::/64 [90/2177536]
     via FE80::C803:7BFF:FE24:0, FastEthernet0/1
ESW2#
```

Figure (1.7) : EIGRP Configured Routing Table in ESW2

```
ESW3#show ipv6 route eigrp
IPv6 Routing Table - 20 entries
Codes: C - Connected, L - Local, S - Static, R - RIP, B - BGP
       U - Per-user Static route, M - MIPv6
       I1 - ISIS L1, I2 - ISIS L2, IA - ISIS interarea, IS - ISIS summary
       O - OSPF intra, OI - OSPF inter, OE1 - OSPF ext 1, OE2 - OSPF ext 2
       ON1 - OSPF NSSA ext 1, ON2 - OSPF NSSA ext 2
       D - EIGRP, EX - EIGRP external
D   2001:ABC:1::/64 [90/2198016]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:ABC:3::/64 [90/2198016]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB2:12::/64 [90/2195456]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB2:13::/64 [90/2707456]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB2:23::/64 [90/2195456]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB8:1::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB8:2::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB8:3::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB9:1::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB9:2::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
D   2001:DB9:3::/64 [90/2200576]
     via FE80::C802:44FF:FE30:0, FastEthernet0/1
ESW3#
```

Figure (1.8) : EIGRP Configured Routing Table in ESW3

The observed routing tables confirm that EIGRPv6 successfully computed optimal paths and populated the routing table accordingly.

b. Neighbor Table

The **neighbor table** maintains a list of adjacent routers that have established EIGRP relationship. In EIGRP for IPv6, these relationships are formed through Hello packets exchanged via link-local addresses. The simulation results confirmed that each router successfully established EIGRP neighbor adjacencies with directly connected routers. Each neighbor table entry includes: the neighbor's link-local address, the local interface used to reach the neighbor, hold time and uptime values, and queue counts for pending updates.

Additionally, figures (1.9),(1.10) and (1.11) illustrate the neighbor tables for the Tripoli, Benghazi and Sabha routers, showing learned dynamically learned neighbors via their link-local address.

```
Tripoli-Branch#show ipv6 eigrp neighbors
EIGRP-IPv6 Neighbors for AS(100)
H   Address                 Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                   (sec)         (ms)        Cnt Num
2   Link-local address:     Se2/1                    14 00:13:32   22   132  0  14
    FE80::C803:7BFF:FE24:0
1   Link-local address:     Se2/0                    11 00:13:32   36   216  0  24
    FE80::C802:44FF:FE30:0
0   Link-local address:     Fa0/0                    13 00:13:43   25   150  0  5
    FE80::C004:6DFF:FE78:1
Tripoli-Branch#
```

Figure (1.9): EIGRP Neighbors Table in Tripoli-Branch

```
Banghazi-Branch#show ipv6 eigrp neighbors
EIGRP-IPv6 Neighbors for AS(100)
H   Address                 Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                   (sec)         (ms)        Cnt Num
3   Link-local address:     Se2/0                    13 00:15:37   32   192  0  15
    FE80::C801:60FF:FE3C:0
2   Link-local address:     Se2/1                    12 00:15:42   36   216  0  23
    FE80::C802:44FF:FE30:0
0   Link-local address:     Fa0/0                    10 00:15:46   22   132  0  3
    FE80::C005:3DFF:FEA4:1
Banghazi-Branch#
```

Figure (1.10): EIGRP Neighbors Table in Banghazi-Branch

```
Sabha-Branch#show ipv6 eigrp neighbors
EIGRP-IPv6 Neighbors for AS(100)
H   Address                  Interface              Hold Uptime   SRTT   RTO  Q  Seq
                                                    (sec)         (ms)       Cnt Num
2   Link-local address:      Se2/1                   13 00:14:57   33    198  0  14
    FE80::C801:60FF:FE3C:0
1   Link-local address:      Se2/0                   10 00:15:01   31    186  0  17
    FE80::C803:7BFF:FE24:0
0   Link-local address:      Fa0/0                   11 00:15:06   28    168  0  5
    FE80::C006:37FF:FED8:1
Sabha-Branch#
```

Figure (1.11): EIGRP Neighbors Table in Sabha-Branch

The observed neighbor's tables confirm that EIGRPv6 successfully established direct neighbor relationships and populated in the table accordingly.

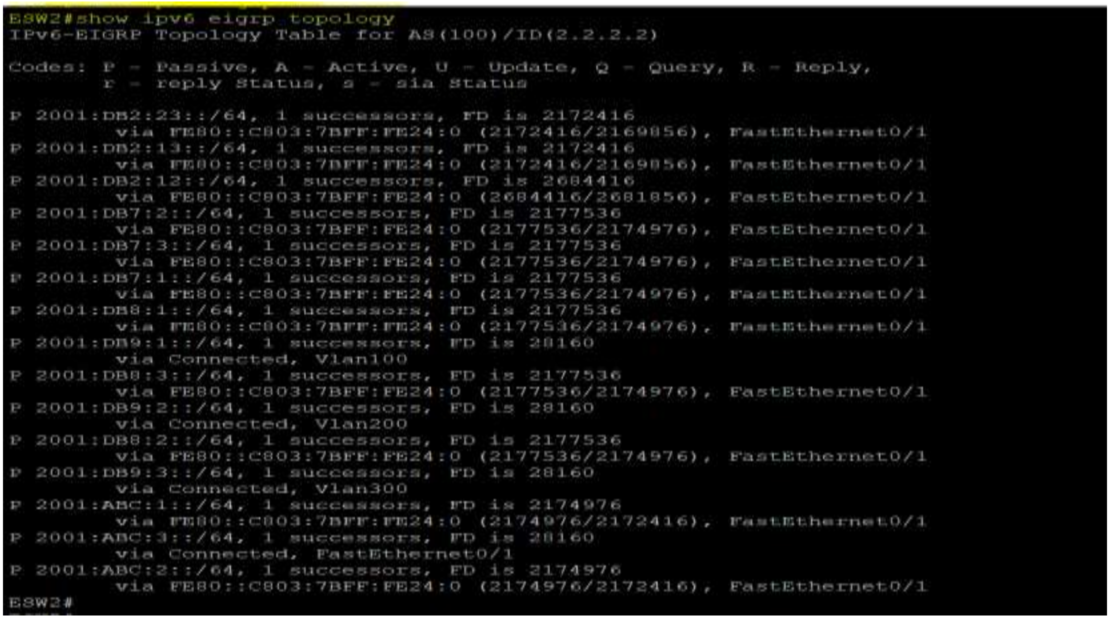
These adjacencies are critical for routing information exchange. If a neighbor is lost, EIGRP triggers a topology recalculation, potentially leading to route updates in the routing table.

c. Topology Table

The topology table is a fundamental component of EIGRP, storing all routes advertised by neighbors, even those not selected as optimal paths. Each entry includes: the destination network prefix, the reported distance (RD) from the advertised neighbor, and the feasible distance (FD), representing the lowest calculated metric to reach the destination. Figures (1.12), (1.13) and (1.14) present the topology tables for layer 3 switches (ESW1, ESW2 and ESW3) in the topology.

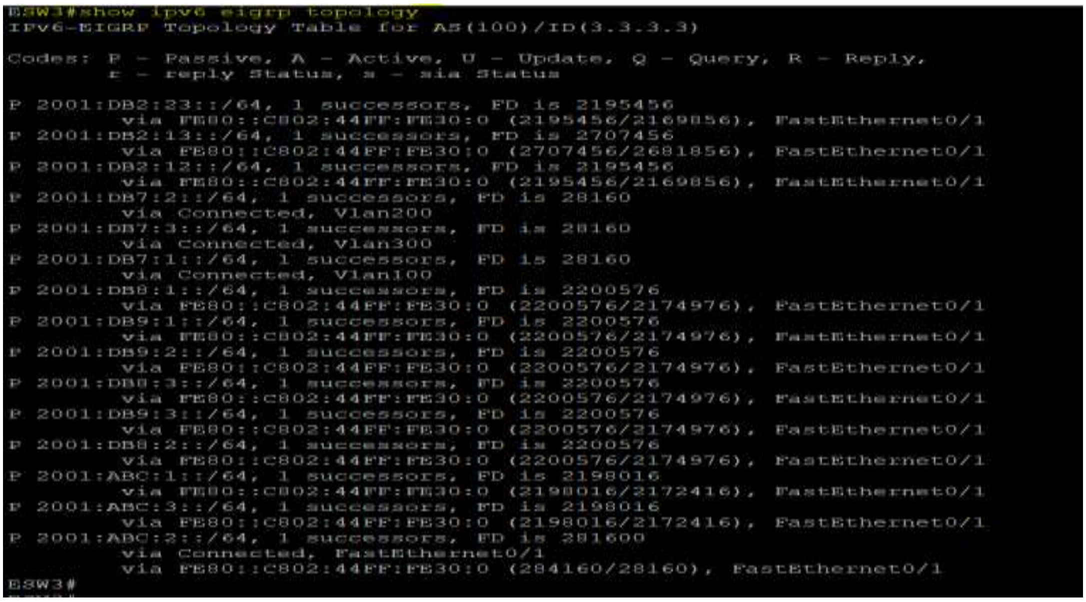
```
ESW1#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS(100)/ID(1.1.1.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 2001:DB2:23::/64, 1 successors, FD is 2707456
        via FE80::C801:60FF:FE3C:0 (2707456/2681856), FastEthernet0/1
P 2001:DB2:13::/64, 1 successors, FD is 2195456
        via FE80::C801:60FF:FE3C:0 (2195456/2169856), FastEthernet0/1
P 2001:DB2:12::/64, 1 successors, FD is 2195456
        via FE80::C801:60FF:FE3C:0 (2195456/2169856), FastEthernet0/1
P 2001:DB7:2::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB7:3::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB7:1::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB8:1::/64, 1 successors, FD is 28160
        via Connected, Vlan100
P 2001:DB9:1::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB9:2::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB8:3::/64, 1 successors, FD is 28160
        via Connected, Vlan300
P 2001:DB9:3::/64, 1 successors, FD is 2200576
        via FE80::C801:60FF:FE3C:0 (2200576/2174976), FastEthernet0/1
P 2001:DB8:2::/64, 1 successors, FD is 28160
        via Connected, Vlan200
P 2001:ABC:1::/64, 1 successors, FD is 281600
        via Connected, FastEthernet0/1
        via FE80::C801:60FF:FE3C:0 (284160/28160), FastEthernet0/1
P 2001:ABC:3::/64, 1 successors, FD is 2198016
        via FE80::C801:60FF:FE3C:0 (2198016/2172416), FastEthernet0/1
P 2001:ABC:2::/64, 1 successors, FD is 2198016
        via FE80::C801:60FF:FE3C:0 (2198016/2172416), FastEthernet0/1
ESW1#
```

Figure (1.12): EIGRP Topology Table in ESW



```
ESW2#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS(100)/ID(2.2.2.2)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 2001:DB2:23::/64, 1 successors, FD is 2172416
         via FE80::C803:7BFF:FE24:0 (2172416/2169856), FastEthernet0/1
P 2001:DB2:13::/64, 1 successors, FD is 2172416
         via FE80::C803:7BFF:FE24:0 (2172416/2169856), FastEthernet0/1
P 2001:DB2:12::/64, 1 successors, FD is 2684416
         via FE80::C803:7BFF:FE24:0 (2684416/2681856), FastEthernet0/1
P 2001:DB7:2::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB7:3::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB7:1::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB8:1::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB9:1::/64, 1 successors, FD is 28160
         via Connected, Vlan100
P 2001:DB8:3::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB9:2::/64, 1 successors, FD is 28160
         via Connected, Vlan200
P 2001:DB8:2::/64, 1 successors, FD is 2177536
         via FE80::C803:7BFF:FE24:0 (2177536/2174976), FastEthernet0/1
P 2001:DB9:3::/64, 1 successors, FD is 28160
         via Connected, Vlan300
P 2001:ABC:1::/64, 1 successors, FD is 2174976
         via FE80::C803:7BFF:FE24:0 (2174976/2172416), FastEthernet0/1
P 2001:ABC:3::/64, 1 successors, FD is 28160
         via Connected, FastEthernet0/1
P 2001:ABC:2::/64, 1 successors, FD is 2174976
         via FE80::C803:7BFF:FE24:0 (2174976/2172416), FastEthernet0/1
ESW2#
```

Figure (1.13): EIGRP Topology Table in ESW2

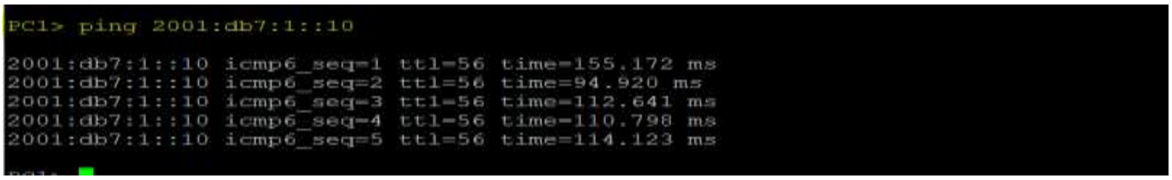


```
ESW3#show ipv6 eigrp topology
IPv6-EIGRP Topology Table for AS(100)/ID(3.3.3.3)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 2001:DB2:23::/64, 1 successors, FD is 2195456
         via FE80::C802:44FF:FE30:0 (2195456/2169856), FastEthernet0/1
P 2001:DB2:13::/64, 1 successors, FD is 2707456
         via FE80::C802:44FF:FE30:0 (2707456/2681856), FastEthernet0/1
P 2001:DB2:12::/64, 1 successors, FD is 2195456
         via FE80::C802:44FF:FE30:0 (2195456/2169856), FastEthernet0/1
P 2001:DB7:2::/64, 1 successors, FD is 28160
         via Connected, Vlan200
P 2001:DB7:3::/64, 1 successors, FD is 28160
         via Connected, Vlan300
P 2001:DB7:1::/64, 1 successors, FD is 28160
         via Connected, Vlan100
P 2001:DB8:1::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:DB9:1::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:DB9:2::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:DB8:3::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:DB9:3::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:DB8:2::/64, 1 successors, FD is 2200576
         via FE80::C802:44FF:FE30:0 (2200576/2174976), FastEthernet0/1
P 2001:ABC:1::/64, 1 successors, FD is 2198016
         via FE80::C802:44FF:FE30:0 (2198016/2172416), FastEthernet0/1
P 2001:ABC:3::/64, 1 successors, FD is 2198016
         via FE80::C802:44FF:FE30:0 (2198016/2172416), FastEthernet0/1
P 2001:ABC:2::/64, 1 successors, FD is 281600
         via Connected, FastEthernet0/1
         via FE80::C802:44FF:FE30:0 (284160/28160), FastEthernet0/1
ESW3#
```

Figure (1.14): EIGRP Topology Table in ESW3

4.1.3 End-to-End IPv6 Connectivity:

The **end-to-end IPv6 Connectivity** test was successfully conducted using the *ping* command across multiple routers in WAN topology. Figures (1.15),(1.16) and (1.17) demonstrate successful IPv6 connectivity tests between designed nodes.



```
PC1> ping 2001:db7:1::10

2001:db7:1::10 icmp6_seq=1 ttl=56 time=155.172 ms
2001:db7:1::10 icmp6_seq=2 ttl=56 time=94.920 ms
2001:db7:1::10 icmp6_seq=3 ttl=56 time=112.641 ms
2001:db7:1::10 icmp6_seq=4 ttl=56 time=110.798 ms
2001:db7:1::10 icmp6_seq=5 ttl=56 time=114.123 ms
```

Figure (1.15): PC1 sends a Ping to PC7 successfully.

```
PC2> ping 2001:db9:2::20

2001:db9:2::20 icmp6_seq=1 ttl=56 time=156.684 ms
2001:db9:2::20 icmp6_seq=2 ttl=56 time=123.871 ms
2001:db9:2::20 icmp6_seq=3 ttl=56 time=156.443 ms
2001:db9:2::20 icmp6_seq=4 ttl=56 time=94.055 ms
2001:db9:2::20 icmp6_seq=5 ttl=56 time=125.305 ms

PC2>
```

Figure (1.16): PC2 sends a Ping to PC5 successfully

4.1.4 Traceroute Path Verification:

The traceroute command validated end-to-end IPv6 connectivity within an EIGRPv6-enabled network. The routing path were logical, efficient, and confirmed proper of EIGRPv6 neighbor adjacency and route propagation. This verification ensures the robustness of the IPv6 and VLAN design. In the Figure 4.17: PC1 successfully traces the route to PC4, demonstrating correct path selection.

```
PC1> trace 2001:db9:2::20

trace to 2001:db9:2::20, 64 hops max
 1 2001:db8:1::100    14.913 ms  15.165 ms  14.667 ms
 2 2001:abc:1::2    47.058 ms  47.400 ms  48.226 ms
 3 2001:db2:13::3    77.702 ms  78.782 ms  77.810 ms
 4 2001:abc:3::1    94.770 ms  107.402 ms  108.314 ms
 5 2001:db9:2::20    124.012 ms  126.791 ms  108.424 ms

PC1>
```

Figure (1.17): PC1 tracing route to PC5 successfully.

4.1.5 Wireshark Analysis Verification:

Wireshark was employed to verify the EIGRPv6 operations, including neighbor formation, route advertisements, and nodes communication.

Key findings include : correct exchange of EIGRPv6 Hello and Update packets using link-local IPv6 addresses, Hello packets were multicast to ff02::a , confirming proper multicast handling. In fig.(4.18) Wireshark capture of EIGRPv6 hello packets and CDP protocol.

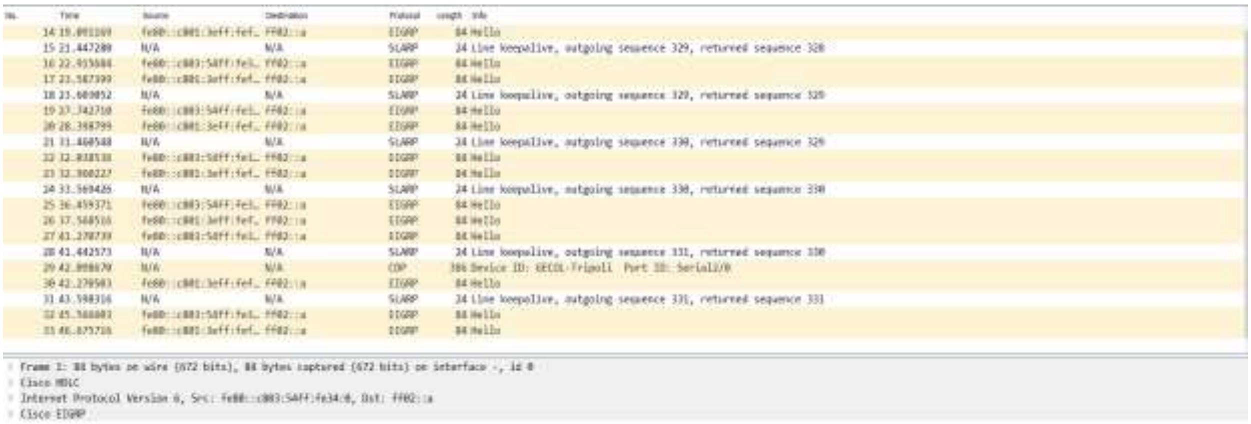


Figure (1.18): Wireshark capture Hello Packet in EIGRPv6

In fig.(1.19) Wireshark capture of a successful ping communication, validating routing and host reachability in the EIGRP IPv6 domain.

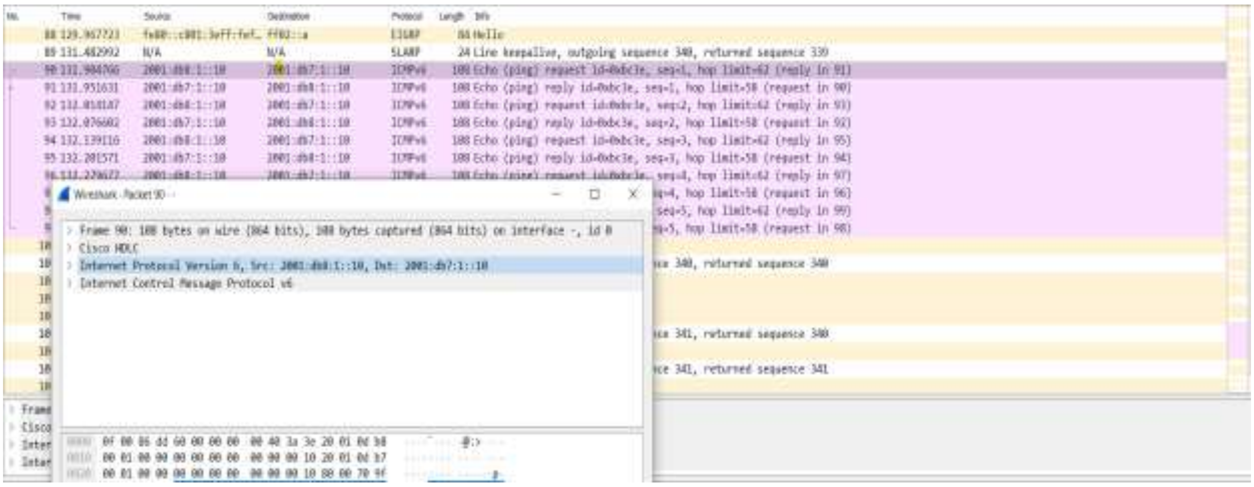


figure (1.19): Wireshark Capture successful ping communication

5.1 Conclusion:

The simulation and analysis of the IPv6-based VLAN network with SVIs and EIGRPv6 demonstrate a successful deployment of a scalable and efficient Layer 3 enterprise network. The use of SVIs provides seamless inter-VLAN communication without the need for external routers, while EIGRPv6 ensures dynamic and optimized routing with rapid convergence. This approach not only supports the growing demand for IP addresses through IPv6 but also enhances network segmentation, security, and manageability. The paper highlights the practical feasibility and advantages of transitioning to IPv6 with advanced routing and switching techniques, making it a valuable reference for modern network design in enterprise environments.

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