Digital Egypt Pioneers Initiative

Track: Fortinet Cybersecurity

Enterprise Network Infrastructure and Security

The Modern Blueprint

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ABSTRACT

This project presents the complete design, implementation, and validation of a secure, scalable, and fully segmented enterprise network architecture. The environment integrates a centralized Headquarters (HQ), multiple remote branch sites, a dedicated DMZ zone, an IT Management network, and advanced security services to simulate a real-world enterprise infrastructure. The project aims to deliver end-to-end security, high availability, identity-based access control, and optimized WAN connectivity across all sites.

The methodology includes structured IP subnetting, VLAN-based segmentation, dynamic routing using OSPF, gateway redundancy with HSRP, and enhanced Layer 2 security controls. FortiGate NGFW devices were deployed as the primary security layer, enabling next-generation firewall policies, NAT, IPS, antivirus, web filtering, SD-WAN optimization, and IPsec VPN connectivity. A full Active-Passive HA cluster ensures continuous service availability. The DMZ hosts essential services such as IIS, SMTP, FTP, DNS, NTP, and Syslog, with strict segmentation enforced through firewall policies.

Centralized authentication is achieved using Cisco ISE, providing RADIUS/TACACS+ identity management, user access control, and secure AAA integration with Active Directory. Server infrastructure—built on Windows Server 2016—supports AD DS, DHCP, DNS, CA, NTP, FTP, and monitoring services. Extensive penetration testing validated the security posture, identifying and mitigating vulnerabilities such as SMBv1 (MS17-010), weak RDP controls, and misconfigurations.

All components were deployed and tested in a GNS3 virtualized lab that replicates enterprise operations. The final results confirm a resilient, secure, and fully functional multi-site enterprise network meeting modern cybersecurity and operational standards.

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PROJECT OVERVIEW & OBJECTIVES

Project Scope :

The scope of this project covers the complete design, configuration, implementation, and validation of a secure multi-site enterprise network integrating the Headquarters (HQ), remote branch offices, a dedicated DMZ zone, and an IT Management segment. The scope includes all network, security, routing, authentication, and high-availability components required to build a fully functional enterprise environment.

1. Network Architecture & Design

- Design a fully segmented enterprise network using VLANs for HR, Sales, Finance, Media, and IT.
- Implement identical VLAN structures across all branch offices.
- Allocate proper subnetting, addressing plans, and gateway assignments for HQ and all remote sites.
- Design routed WAN links using /30 point-to-point networks between HQ and branches.

2. Firewall & Security Implementation

- Deploy FortiGate NGFW devices as the primary security and routing layer.
- Configure inter-VLAN routing, NAT, security policies, service profiles, and traffic inspection.
- Apply IPS, AV, Web Filtering, and logging for threat protection.
- Implement secure access rules to DMZ servers and internal resources.

3. WAN & Branch Connectivity

- Establish WAN connectivity between HQ and all branch sites via routed interfaces.
- Ensure branches can securely access HQ resources, DMZ servers, and IT Management systems.
- Prevent unauthorized communication between branch sites.
- Apply SD-WAN or policy-based routing where required.

4. DMZ Deployment

Build a dedicated DMZ network (10.20.20.0/27) hosting:

- Web Server
- SMTP Server
- DHCP Server
- NTP Server
- FTP
- SMB Services
- Syslog Server

Apply strict firewall segmentation between DMZ and internal networks.

Log and monitor all traffic entering or leaving the DMZ.

5. Centralized Authentication (Cisco ISE)

- Deploy Cisco ISE within the 192.168.10.0/24 IT Management zone.
- Configure authentication, authorization, and accounting (AAA) services.
- Integrate network devices (firewalls, routers, switches) with ISE for identity-based access.
- Enforce security policies and user access control across the enterprise.

6. DHCP & Network Services

- Configure DHCP scopes for all HQ and branch VLANs.
- Automate IP addressing, DNS assignment, and lease management.
- Ensure stable and uniform device onboarding across all departments.

7. High Availability (HA) Implementation

- Deploy a FortiGate Active-Passive HA cluster at HQ.
- Configure heartbeat links, synchronization, and failover logic.
- Validate automatic failover with zero manual intervention.
- Ensure uninterrupted operation of routing, DMZ services, WAN links, and authentication systems.

8. System Integration & Testing

- Validate inter-VLAN communication based on policies.
- Test branch-to-HQ reachability.
- Confirm DMZ accessibility and security.
- Test DHCP distribution, ISE authentication, and firewall policies.

- Validate HA failover and recovery with no service interruption.

9. Documentation & Delivery

- Produce full project documentation including:
- Network topology diagrams
- Addressing plan
- VLAN and routing tables
- Security policies
- HA configuration details
- Testing results
- Deliver a structured and comprehensive final report suitable for enterprise submission.

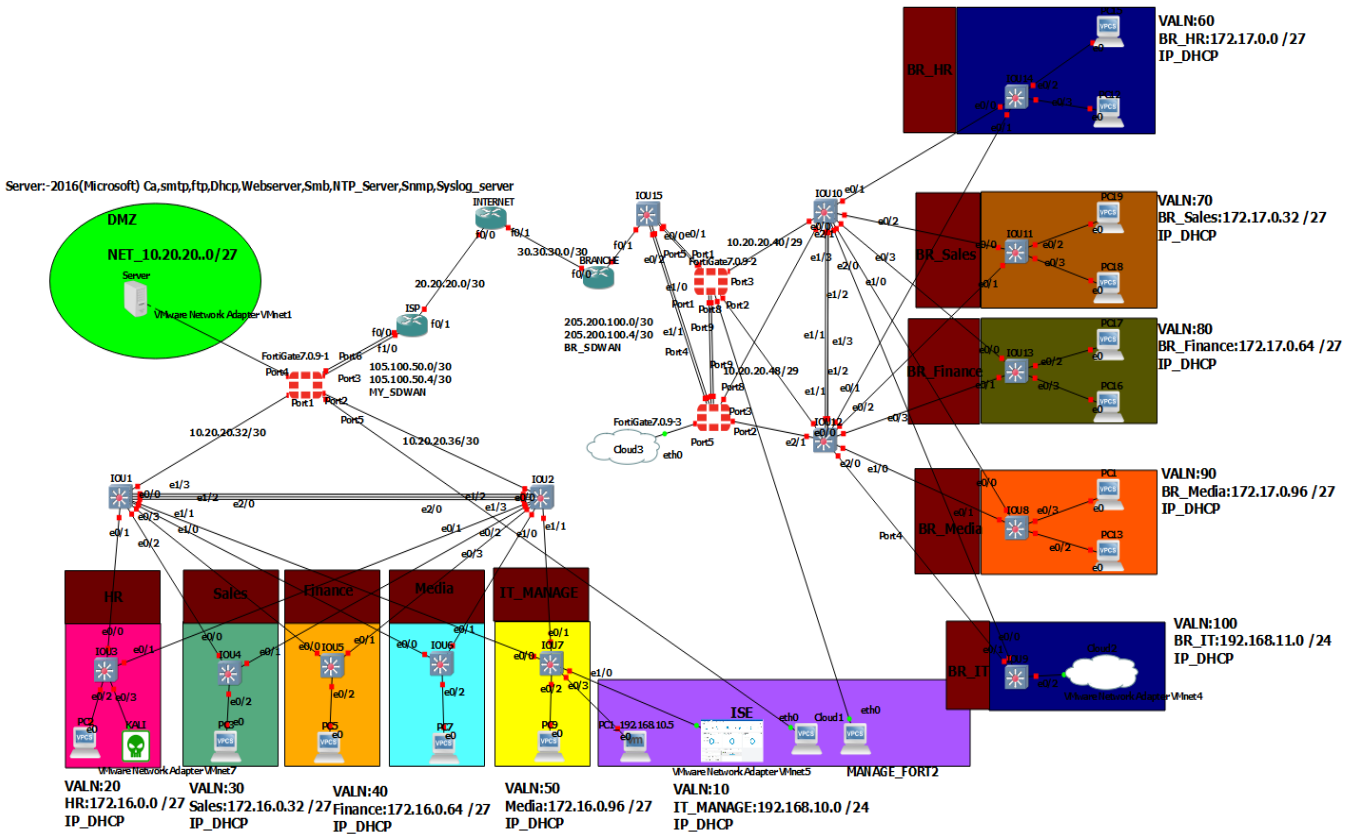


Figure 1: Complete Network Security Infrastructure

LAB ENVIRONMENT

The entire enterprise network infrastructure in this project was built and tested using the **GNS3 emulator**. GNS3 provided a highly flexible and reliable platform for simulating all components of the designed environment, including the Headquarters (HQ), remote branch offices, DMZ services, the IT Management zone, and the FortiGate High Availability (HA) cluster. Its capability to integrate multiple virtual devices enabled accurate emulation of real-world enterprise scenarios.

Figure 3: GNS3

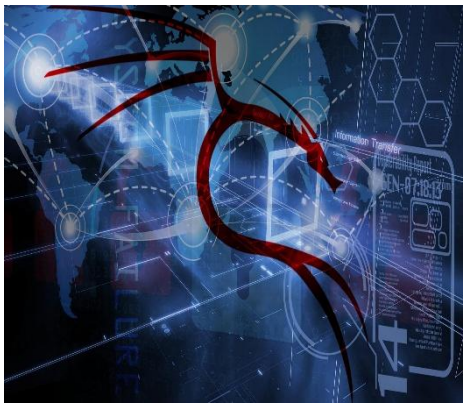


Figure 2:KALI

Figure 5:Windows_Server

Figure 4:FORTI

Figure 6:Cisco_Ise

- Easy Deployment of VMs - It simplifies deploying virtual machines for Windows, Linux, Fortinet firewalls, switches, and routers.
- Simple Internet Connectivity - The VMs can easily connect to the internet.
- Open Source - Being open source makes it easily accessible for download.

NOTE That:

The only challenge is that sometimes the firewall requires specific configuration adjustments to work optimally with **GNS3**, such as modifying interface types, adjusting IP settings, or tuning certain virtual hardware parameters to ensure stable performance.

Design and Network (HQ First, Then Branches)

Network Design Concepts

The Headquarters represents the core of the enterprise network and hosts the main infrastructure services, security systems, and internal departmental segments. The HQ network is fully segmented using VLANs to isolate each department and apply strict access control.

IP Addressing and Subnetting

The network uses a structured IP addressing scheme with separate subnets for each department and service zone. Subnetting is designed to isolate traffic, improve security, and ensure efficient allocation of addresses across HR, Sales, Finance, Media, IT, DMZ, and Management networks.

Subnetting.

Network Subnets and IP Distribution.

Device name	IP	Subnet Mask	Wild Card
IOU1 - e0/0 HQ-Forti - Port1	10.20.20.33 10.20.20.34	255.255.255.252	0.0.0.3
IOU2 - e0/0 HQ-Forti - Port2	10.20.20.37 10.20.20.38	255.255.255.252	0.0.0.3
IOU3 PC2 Kali SVI-SSH	Network ID: 172.16.0.0 DHCP 172.16.0.11 172.16.0.13	255.255.255.224	0.0.0.31
IOU4 PC3	Network ID: 172.16.0.32 DHCP	255.255.255.224	0.0.0.31
IOU5 PC4	Network ID: 172.16.0.64 DHCP	255.255.255.224	0.0.0.31
IOU6 PC7	Network ID: 172.16.0.96 DHCP	255.255.255.224	0.0.0.31
IOU7 PC9 Client1 ISE SVI-SSH	Network ID: 192.168.10.0 DHCP 192.168.10.5 192.168.10.118 192.168.10.35	255.255.255.0	0.0.0.255

Figure 7:Subnnet_IP1

HQ_Forti - Port3 ISP - F0/0	105.100.50.2 105.100.50.1	255.255.255.252	0.0.0.3
HQ_Forti - Port6 ISP - F1/0	105.100.50.6 105.100.50.5	255.255.255.252	0.0.0.3
ISP - F0/1 Internet - F0/0	20.20.20.2 20.20.20.1	255.255.255.252	0.0.0.3
Internet - F0/1 Branch_ISP - F0/0	30.30.30.1 30.30.30.2	255.255.255.252	0.0.0.3
Branch_ISP - F0/1 Branch_Forti - Port1	205.200.100.1 205.200.100.2	255.255.255.252	0.0.0.3
Branch_ISP - F0/1 Branch_Forti - Port5	205.200.100.5 205.200.100.6	255.255.255.252	0.0.0.3
Branch_Forti - Port3 IOU10 - e0/0	10.20.10.42 10.20.10.41	255.255.255.252	0.0.0.3
Branch_Forti - Port2 IOU12- e0/0	10.20.10.45 10.20.10.46	255.255.255.252	0.0.0.3
IOU14 PC15 PC12	Network ID: 172.17.0.0 DHCP DHCP	255.255.255.224	0.0.0.31
IOU11 PC19 PC18	Network ID: 172.17.0.32 DHCP DHCP	255.255.255.224	0.0.0.31

Figure 8:Subnet_ip2

IOU13 PC17 PC16	Network ID: 172.17.0.64 DHCP DHCP	255.255.255.224	0.0.0.31
IOU8 PC1 PC13	Network ID: 172.17.0.96 DHCP DHCP	255.255.255.224	0.0.0.31
IOU9 Cloud	Network ID: 192.168.11.0 192.168.11.5	255.255.255.0	0.0.0.255
SVI- VLANs - IOU1 VLAN10 VLAN20 VLAN30 VLAN40 VLAN50	 192.168.10.3 172.16.0.3 172.16.0.34 172.16.0.66 172.16.0.98	 255.255.255.0 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.224	 0.0.0.255 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.31
SVI- VLANs - IOU2 VLAN10 VLAN20 VLAN30 VLAN40 VLAN50	 192.168.10.2 172.16.0.2 172.16.0.35 172.16.0.67 172.16.0.99	 255.255.255.0 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.224	 0.0.0.255 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.31
SVI- VLANs - IOU10 VLAN60 VLAN70 VLAN80 VLAN90 VLAN100	 172.17.0.3 172.17.0.35 172.17.0.67 172.17.0.99 192.168.11.3	 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.0	 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.255
SVI- VLANs - IOU12 VLAN60 VLAN70 VLAN80 VLAN90 VLAN100	 172.17.0.2 172.17.0.34 172.17.0.66 172.17.0.98 192.168.11.2	 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.224 255.255.255.0	 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.31 0.0.0.255

Figure 9:IP_Subnet3

2. VLAN Segmentation

Each department at HQ is assigned a dedicated VLAN to separate broadcast domains and apply role-based access control. VLANs ensure isolation between departments and provide a scalable structure for internal traffic management

HQ VLANs (Sorted & Clean Format)

VLAN Name	VLAN ID	Purpose
HQ-HR	10	HR Department Users
HQ-SALES	20	Sales Department Users
HQ-FINANCE	30	Finance Department Users
HQ-MEDIA	40	Media & Marketing Users
HQ-IT	50	IT Department Users

Branch VLANs (Same Structure for Consistency)

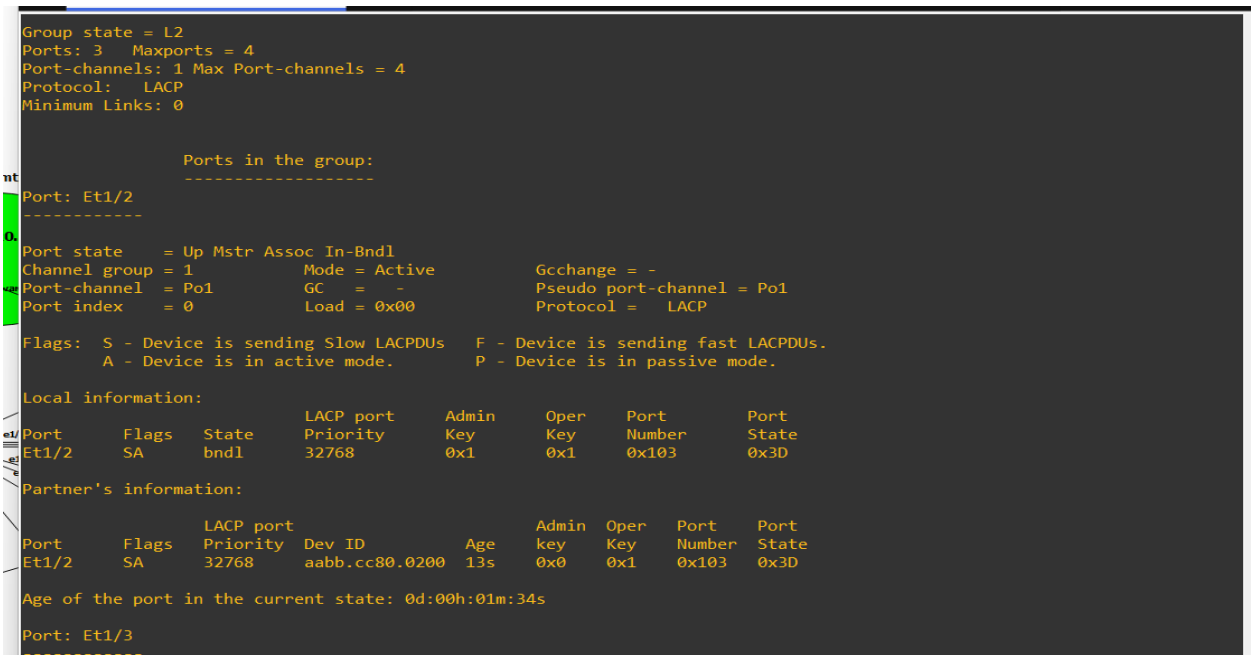
VLAN Name	VLAN ID	Purpose
BR-HR	60	HR Department
BR-SALES	70	Sales Department
BR-FINANCE	80	Finance Department
BR-MEDIA	90	Media Department
BR-IT	100	IT Department

3. EtherChannel

Link aggregation (EtherChannel) is implemented between switches to increase bandwidth, provide redundancy, and prevent single-link failure. It enhances switch-to-switch connectivity and stabilizes the core switching environment

```
HQ-MLSW1#show etherchannel summary
Flags:  D - down        P - bundled in port-channel
        I - stand-alone s - suspended
        H - Hot-standby (LACP only)
        R - Layer3      S - Layer2
        U - in use      N - not in use, no aggregation
        f - failed to allocate aggregator

        M - not in use, minimum links not met
        m - not in use, port not aggregated due to minimum links not met
        u - unsuitable for bundling
        w - waiting to be aggregated
        d - default port

        A - formed by Auto LAG


Number of channel-groups in use: 1
Number of aggregators:           1

Group  Port-channel  Protocol    Ports
------+-------------+-----------+-----------------------------------------------
1      Po1(SU)         LACP      Et1/2(P)    Et1/3(P)    Et2/0(P)
```

Figure 10:EtherChannel



```
Group state = L2
Ports: 3   Maxports = 4
Port-channels: 1 Max Port-channels = 4
Protocol:   LACP
Minimum Links: 0


               Ports in the group:
               -------------------
Port: Et1/2
------------

Port state    = Up Mstr Assoc In-Bndl
Channel group = 1           Mode = Active          Gcchange = -
Port-channel  = Po1         GC   =   -             Pseudo port-channel = Po1
Port index    = 0           Load = 0x00            Protocol =   LACP

Flags:  S - Device is sending Slow LACPDUs   F - Device is sending fast LACPDUs.
        A - Device is in active mode.        P - Device is in passive mode.

Local information:
                           LACP port     Admin     Oper    Port        Port
Port      Flags   State    Priority      Key       Key     Number      State
Et1/2     SA      bndl     32768         0x1       0x1     0x103       0x3D

Partner's information:

                 LACP port                       Admin  Oper   Port    Port
Port      Flags  Priority  Dev ID          Age    key    Key    Number  State
Et1/2     SA     32768     aabb.cc80.0200  13s    0x0    0x1    0x103   0x3D

Age of the port in the current state: 0d:00h:01m:34s

Port: Et1/3
```

Figure 11:ETherChannel2

4. HSRP (Gateway Redundancy)

HSRP is deployed for gateway redundancy, allowing two routers/switches to act as a virtual default gateway. This ensures continuous Layer 3 availability for user VLANs in case one device fails.

```
HQ-MLSW1#show standb
HQ-MLSW1#show standby bri
HQ-MLSW1#show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State   Active          Standby         Virtual IP
Vl10        10   100 P Active  local           192.168.10.2    192.168.10.1
Vl20        20   200 P Active  local           172.16.0.2      172.16.0.1
Vl30        30   200 P Active  local           172.16.0.35     172.16.0.33
Vl40        40   200 P Active  local           172.16.0.67     172.16.0.65
Vl50        50   200 P Active  local           172.16.0.99     172.16.0.97
```

Figure 12:HSRP_Active

```
HQ-MLSW2#show stan
HQ-MLSW2#show standby bri
HQ-MLSW2#show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State   Active          Standby         Virtual IP
Vl10        10   100 P Standby 192.168.10.3    local           192.168.10.1
Vl20        20   120 P Standby 172.16.0.3      local           172.16.0.1
Vl30        30   120 P Standby 172.16.0.34     local           172.16.0.33
Vl40        40   120 P Standby 172.16.0.66     local           172.16.0.65
Vl50        50   120 P Standby 172.16.0.98     local           172.16.0.97
HQ-MLSW2#
```

Figure 13:HSRP_Standby

5. MST (Multiple Spanning Tree)

MST is configured to prevent Layer 2 loops, optimize traffic flow, and map VLANs to specific spanning tree instances. This improves convergence time and enhances stability across the HQ switching environment.

```
HQ-MLSW2#show sp
HQ-MLSW2#show spanning-tree

MST0
  Spanning tree enabled protocol mstp
  Root ID    Priority    32768
             Address     aabb.cc00.0100
             Cost        0
             Port        65 (Port-channel1)
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

  Bridge ID  Priority    32768  (priority 32768 sys-id-ext 0)
             Address     aabb.cc00.0200
             Hello Time   2 sec  Max Age 20 sec  Forward Delay 15 sec

Interface           Role Sts Cost      Prio.Nbr Type
------------------- ---- --- --------- -------- --------------------------------
Et0/1               Desg FWD 2000000   128.2    P2p
Et0/2               Desg FWD 2000000   128.3    P2p
Et0/3               Desg FWD 2000000   128.4    P2p
Et1/0               Desg FWD 2000000   128.5    P2p
Et1/1               Desg FWD 2000000   128.6    P2p
Et2/1               Desg FWD 2000000   128.10   P2p
Et2/2               Desg FWD 2000000   128.11   P2p
Et2/3               Desg FWD 2000000   128.12   P2p
Et3/0               Desg FWD 2000000   128.13   P2p
Et3/1               Desg FWD 2000000   128.14   P2p
Et3/2               Desg FWD 2000000   128.15   P2p
Et3/3               Desg FWD 2000000   128.16   P2p
Po1                 Root FWD 666660    128.65   P2p


MST1
  Spanning tree enabled protocol mstp
  Root ID    Priority    24577
```

Figure 14:MST1

```
HQ-MLSW2#
HQ-MLSW2#show spann
HQ-MLSW2#show spanning-tree ro
HQ-MLSW2#show spanning-tree root

                                        Root    Hello Max Fwd
MST Instance          Root ID           Cost    Time  Age Dly  Root Port
--------------- ------------------- --------- ----- --- ---  ------------
MST0            32768 aabb.cc00.0100         0    2   20  15  Po1
MST1            24577 aabb.cc00.0100    666660    2   20  15  Po1
```

Figure 15:Root_Spanning

7. NTP (Time Synchronization)

NTP is implemented to synchronize time across HQ devices, including routers, switches, servers, and ISE. Accurate time is essential for logs, security monitoring, AAA authentication, and troubleshooting.

```
  status        NTP status

HQ-MLSW2#show ntp sta
HQ-MLSW2#show ntp status
Clock is unsynchronized, stratum 16, no reference clock
nominal freq is 250.0000 Hz, actual freq is 250.0000 Hz, precision is 2**10
ntp uptime is 119600 (1/100 of seconds), resolution is 4000
reference time is 00000000.00000000 (00:00:00.000 UTC Mon Jan 1 1900)
clock offset is 0.0000 msec, root delay is 0.00 msec
root dispersion is 17.94 msec, peer dispersion is 0.00 msec
loopfilter state is 'FSET' (Drift set from file), drift is 0.000000000 s/s
system poll interval is 8, never updated.
```

Figure 16:NTP

8. OSPF Routing

OSPF is deployed as the dynamic routing protocol within the HQ infrastructure. It provides fast convergence, supports multi-area designs, and ensures efficient route exchange between core routers and distribution switches.

```
HQ-MLSW2#show ip route
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, H - NHRP, l - LISP
       a - application route
       + - replicated route, % - next hop override, p - overrides from PfR

Gateway of last resort is 10.20.20.38 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 10.20.20.38
      10.0.0.0/8 is variably subnetted, 3 subnets, 2 masks
O        10.20.20.32/30 [110/11] via 172.16.0.98, 00:23:01, Vlan50
                        [110/11] via 172.16.0.66, 00:22:51, Vlan40
                        [110/11] via 172.16.0.34, 00:22:18, Vlan30
                        [110/11] via 172.16.0.3, 00:22:18, Vlan20
C        10.20.20.36/30 is directly connected, Ethernet0/0
L        10.20.20.37/32 is directly connected, Ethernet0/0
      172.16.0.0/16 is variably subnetted, 8 subnets, 2 masks
C        172.16.0.0/27 is directly connected, Vlan20
L        172.16.0.2/32 is directly connected, Vlan20
C        172.16.0.32/27 is directly connected, Vlan30
L        172.16.0.35/32 is directly connected, Vlan30
C        172.16.0.64/27 is directly connected, Vlan40
L        172.16.0.67/32 is directly connected, Vlan40
C        172.16.0.96/27 is directly connected, Vlan50
L        172.16.0.99/32 is directly connected, Vlan50
      192.168.10.0/24 is variably subnetted, 2 subnets, 2 masks
C        192.168.10.0/24 is directly connected, Vlan10
L        192.168.10.2/32 is directly connected, Vlan10
HQ-MLSW2#
HQ-MLSW2#
HQ-MLSW2#
```

Figure 17:Routing_Table

9. Default Route

A default route is configured to forward all non-internal traffic toward the next-hop device that connects HQ to external networks or the firewall layer. It simplifies routing configuration and ensures proper traffic flow.

10. Layer 2 Security on Switches

L2 security mechanisms are implemented on HQ switches to protect against common attacks, including:

- Port Security
- DHCP Snooping
- Dynamic ARP Inspection (DAI)
- BPDU Guard
- Root Guard

These features enhance the security posture of the HQ LAN environment.

```
!
interface Ethernet0/2
 switchport access vlan 20
 switchport mode access
 switchport port-security violation protect
 switchport port-security mac-address sticky
 switchport port-security mac-address sticky 0050.7966.6800
 switchport port-security
 spanning-tree portfast edge
!
```

Figure 18:Port_Security

11. Access Lists (ACLs)

ACLs are used to restrict unnecessary communication between VLANs and limit access to sensitive segments such as Management and DMZ. They enforce traffic filtering at both Layer 2 and Layer 3 levels.

```
HS-SW#show access-lists
Standard IP access list 2
    10 permit 192.168.10.0, wildcard bits 0.0.0.255
    20 deny   any
Extended IP access list CISCO-CWA-URL-REDIRECT-ACL
    100 deny udp any any eq domain
    101 deny tcp any any eq domain
    102 deny udp any eq bootps any
    103 deny udp any any eq bootpc
    104 deny udp any eq bootpc any
    105 permit tcp any any eq www
Extended IP access list preauth_ipv4_acl (per-user)
    10 permit udp any any eq domain
    20 permit tcp any any eq domain
    30 permit udp any eq bootps any
    40 permit udp any any eq bootpc
    50 permit udp any eq bootpc any
    60 deny ip any any
IPv6 access list preauth_ipv6_acl (per-user)
    permit udp any any eq domain sequence 10
    permit tcp any any eq domain sequence 20
    permit icmp any any nd-ns sequence 30
    permit icmp any any nd-na sequence 40
    permit icmp any any router-solicitation sequence 50
    permit icmp any any router-advertisement sequence 60
    permit icmp any any redirect sequence 70
    permit udp any eq 547 any eq 546 sequence 80
    permit udp any eq 546 any eq 547 sequence 90
    deny ipv6 any any sequence 100
HS-SW#
HS-SW#
```

Figure 19:Acl

12. Cisco ISE Integration

Cisco ISE is deployed in the HQ management network to provide centralized authentication, authorization, and accounting. It ensures identity-based access control for users and devices.

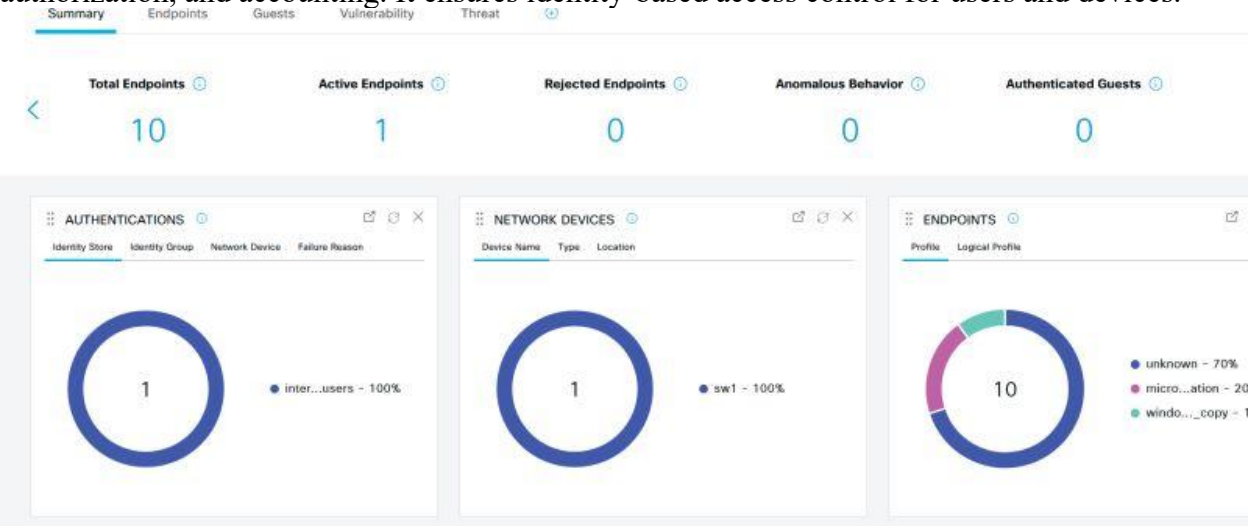


Figure 20:ISE_Server

13. RADIUS and TACACS+

RADIUS is used for network access authentication (802.1X), while TACACS+ is implemented for device administration. Both are fully integrated with ISE to enforce authentication policies and secure login to switches, routers, and management systems.

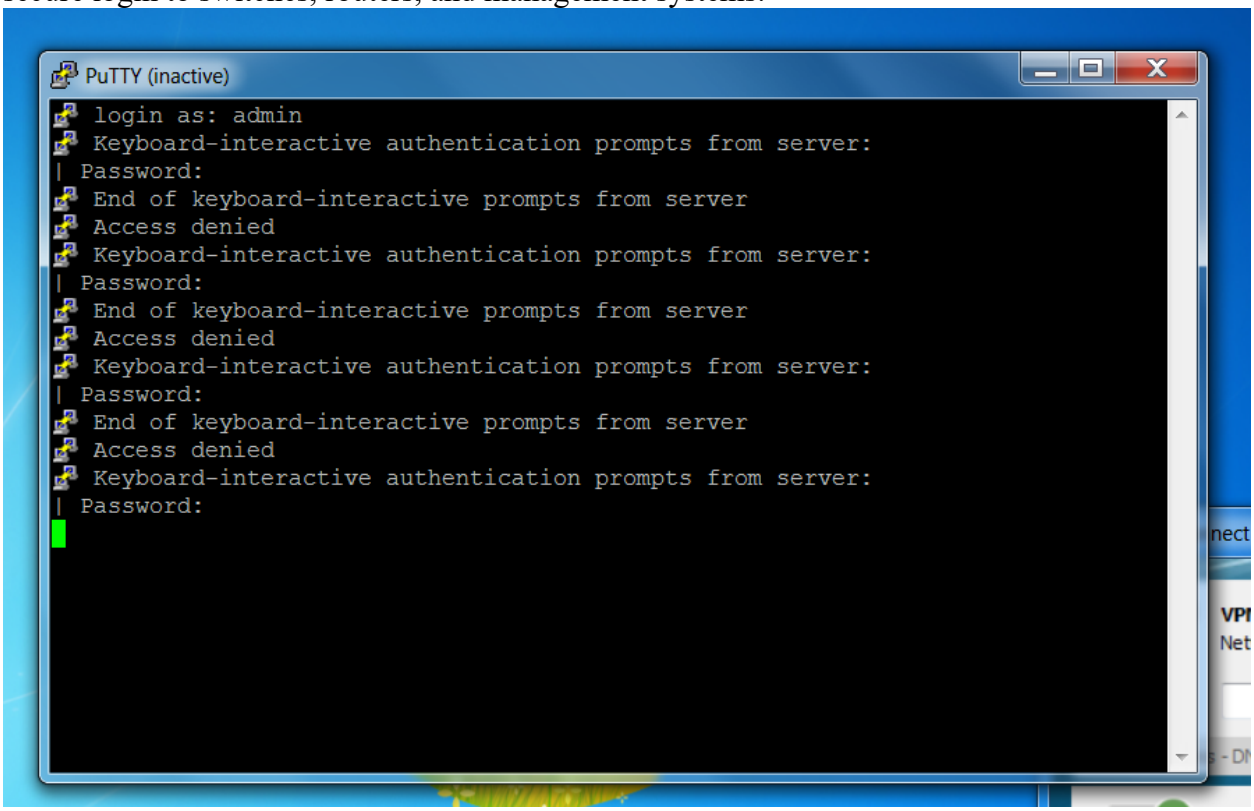


Figure 21:Tacacs+

Figure 22:Raduis

Summary

This section covers the complete internal HQ design concepts—addressing, VLANs, routing, redundancy, switching security, and AAA services—forming a stable and secure foundation before introducing the FortiGate layer in the next section

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FortiGate HQ Configuration

This section provides a comprehensive and professionally structured summary of all configurations implemented on the Headquarters (HQ) FortiGate firewall. The configuration covers interfaces, routing, SD-WAN, security policies, VIPs, identity services, and protection mechanisms

1. Interface Configuration

The HQ FortiGate appliance is configured with multiple interfaces to segment and secure network traffic across WAN, LAN, DMZ, and management domains.

1.1 WAN Interfaces

- **WAN-ISP (port3)**
  - Type: Physical interface
  - Services enabled: PING, HTTPS, SSH
  - Primary internet/ISP connection
- **WAN2 (port6)**
  - Type: Physical interface
  - Services enabled: PING, HTTPS, SSH
  - Secondary WAN link for redundancy

1.2 Internal LAN Interfaces

- **LAN-Core (port1)**
  - Connected to HQ core switching
  - Handles Finance, HR, Media, Sales, and IT subnets
  - Services enabled: PING, HTTPS, SSH

- **LAN-Core2 (port2)**
  - Additional uplink to HQ switching
  - Services enabled: PING, HTTPS, SSH

1.3 DMZ Interface

- **DMZ (port4)**
  - IP: **10.20.20.1/27**
  - Hosts critical public-facing servers (Web, FTP, DNS, Syslog, NTP, SMTP)
  - Services enabled: PING, HTTPS, SSH, SNMP, RADIUS Accounting

1.4 Management Interface

- **Management (port5)**
  - IP: **192.168.1.10/26**
  - Dedicated for administrative access
  - Services enabled: PING, HTTPS, SSH, SNMP

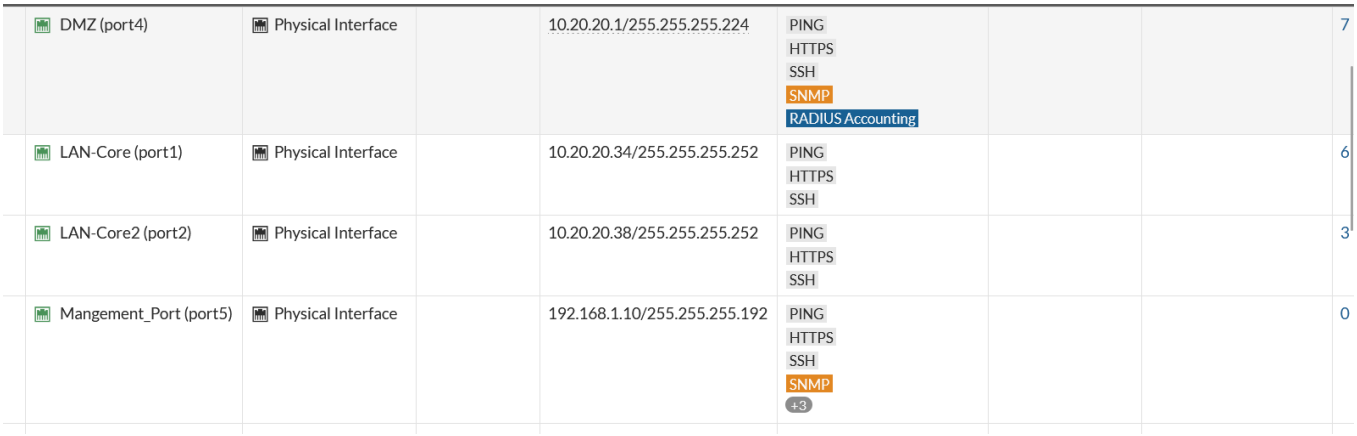

Figure 23:Interfaces_1

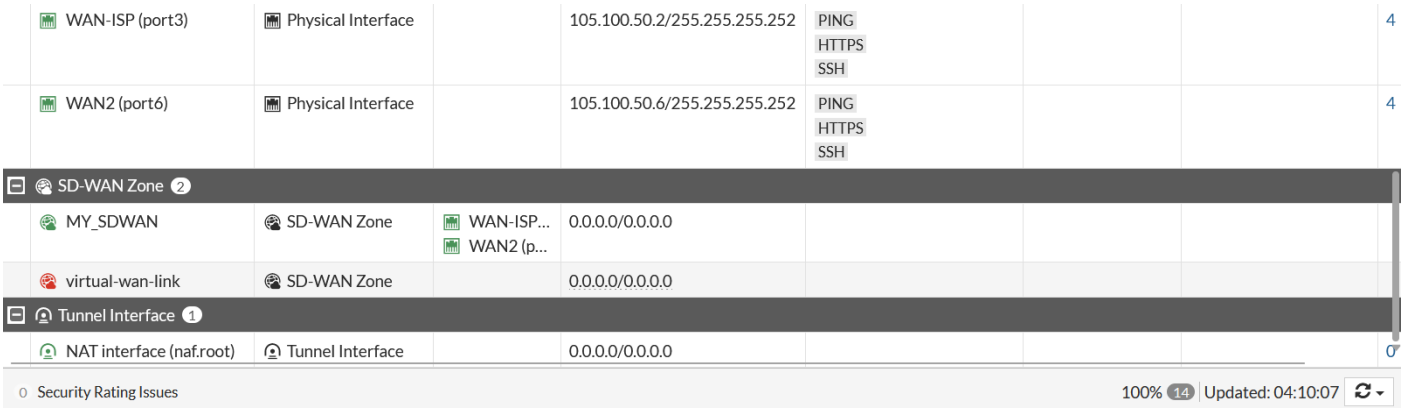

Figure 24:Interfaces_2

2. SD-WAN Configuration

2.1 SD-WAN Zone

An SD-WAN zone named **MY_SDWAN** aggregates the two WAN circuits:

- WAN-ISP (port3)
- WAN2 (port6)

2.2 Traffic Distribution

- Both WAN links configured with equal **cost = 10** for balanced load sharing
- SD-WAN continuously monitors link health and performance

2.3 Active Session Monitoring

- SD-WAN dashboard displays active session distribution across both links

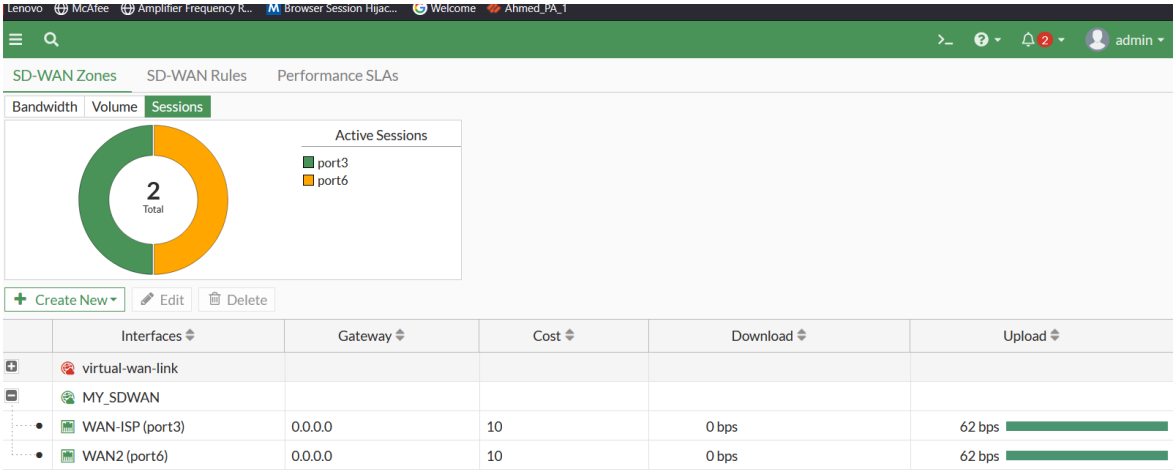

Figure 25:SD_WAN

3. Routing Configuration

3.1 OSPF Dynamic Routing

- **Router ID:** 3.2.1.4
- **OSPF Area:** 0.0.0.0
- Advertised networks include:
  - 10.20.20.0/27
  - 10.20.20.32/30
  - 10.20.20.36/30
  - 192.168.10.0/24
  - Branch WAN subnets

3.2 Default Static Route

- **0.0.0.0/0 → MY_SDWAN**
- Ensures all outbound traffic uses the SD-WAN bundle

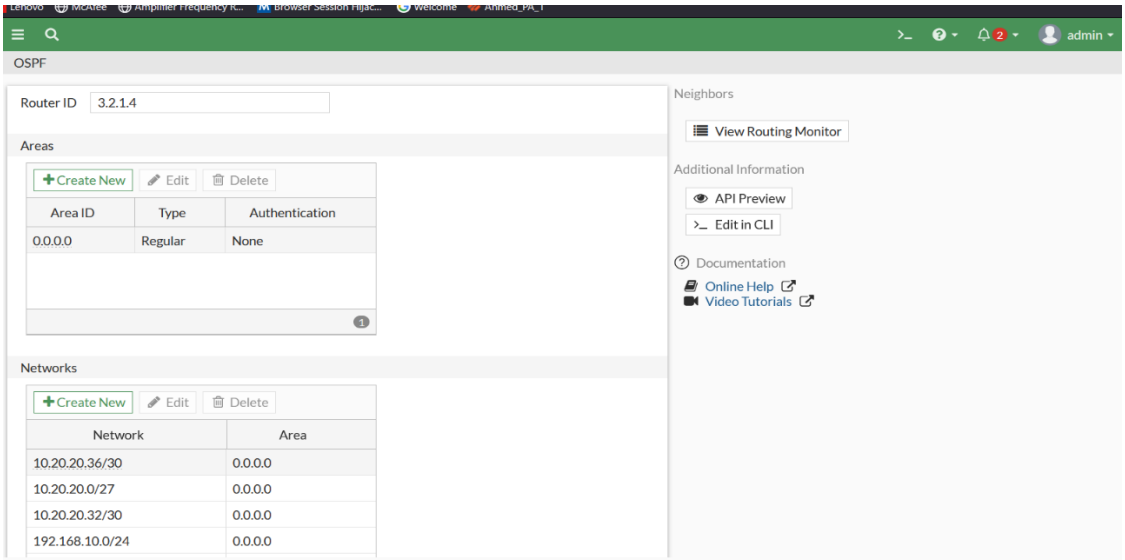

Figure 26:Ospf_1

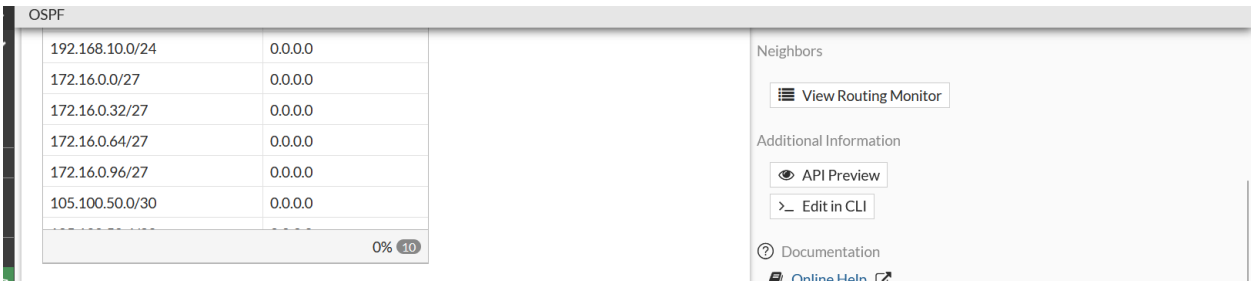

Figure 27:Ospf_2

4. Firewall Policy Configuration

4.1 Branch-to-DMZ Policies (Allow Rules)

Allow_Traffic / Allow_Traffic2

- From: WAN-ISP or WAN2
- Source: BR_F, BR_H, BR_IT, BR_M, BR_S
- Destination: **DMZ-NET**
- Services allowed: DNS, HTTP, HTTPS, FTP, SMTP, POP3, IMAP, SNMP, Syslog, NTP, PING
- Action: ACCEPT

4.2 Internet Access Policies

Allow_Internet / Allow_Internet2

- From: LAN-Core or LAN-Core2
- To: MY_SDWAN
- Source: Finance, HR, Media, Sales, LAN1-NET
- NAT: Enabled
- SSL inspection: No-inspection

4.3 Internal HQ to DMZ

LAN-to-DMZ / LAN2-to-DMZ

- From: LAN-Core / LAN-Core2
- To: DMZ
- Source: all internal networks
- NAT: Disabled
- Action: ACCEPT

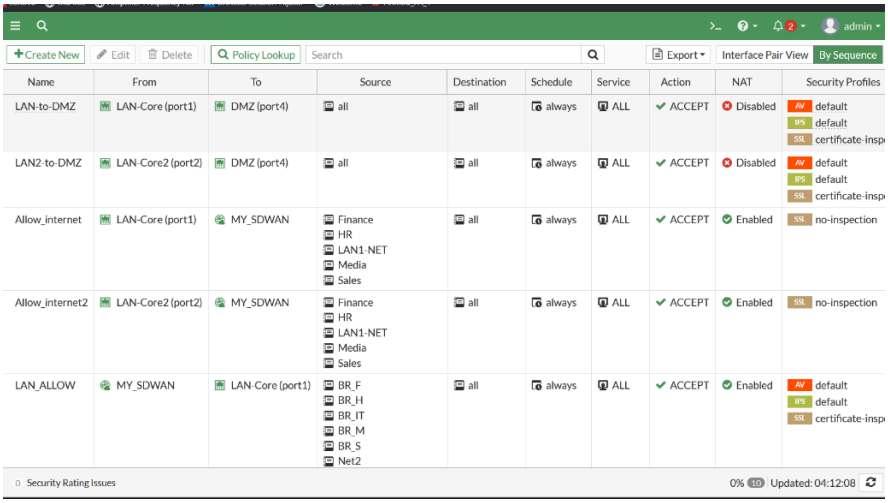

Figure 28:Policy_1

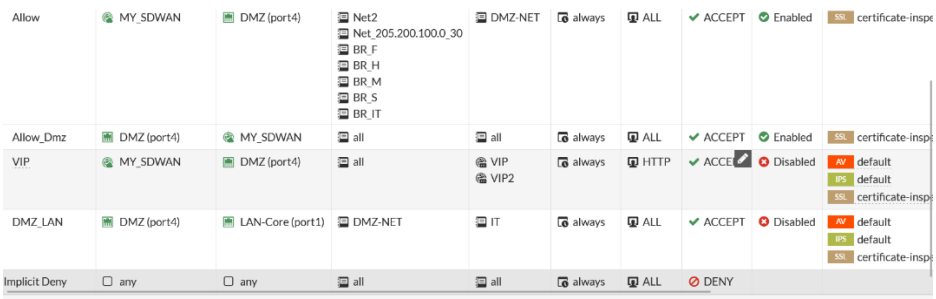

Figure 29:Policy_2

5. Security Protection Policies.

5.1 DDoS Mitigation

- **Deny_ddos / Deny_DDOS**
    - From: WAN2 / WAN-ISP
    - To: DMZ-NET
    - Source: all
    - Service: ALL
    - Action: DENY
    - Prevents DDoS attempts from external networks

5.2 Anti-Scan / Anti-Reconnaissance

- **LAN_Deny_NMapandDOS**
    - From: LAN-Core
    - Source: Finance, HR, Media, Sales
    - To: DMZ-NET
    - Service: ALL
    - Action: DENY
    - Protects against internal Nmap scanning and reconnaissance attacks

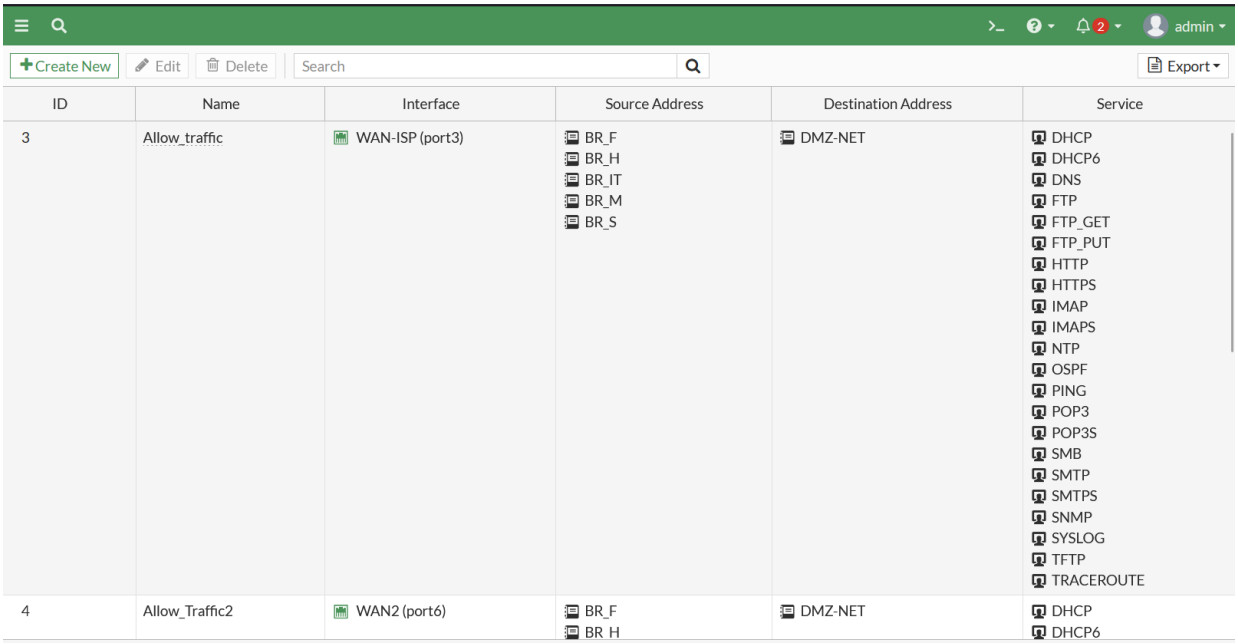

Figure 30:DDOS_Policy_1

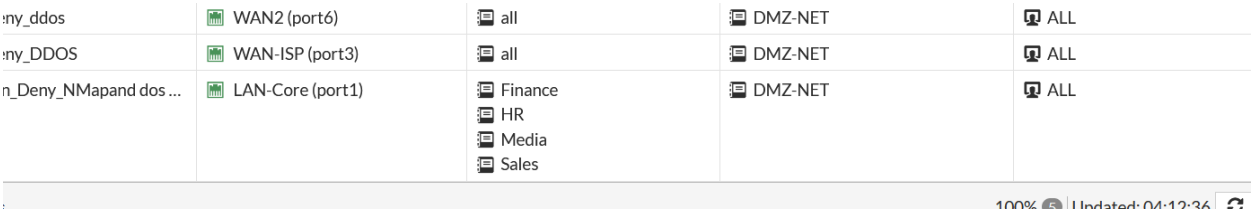

Figure 31:DDOS_Policy_2

6. Virtual IP (VIP) Configuration

VIPs enable external users to access internal DMZ servers.

VIP

- Public IP: **105.100.50.2 → 10.20.20.5 (TCP/80)**

VIP2

- Public IP: **105.100.50.6 → 10.20.20.5 (TCP/80)**

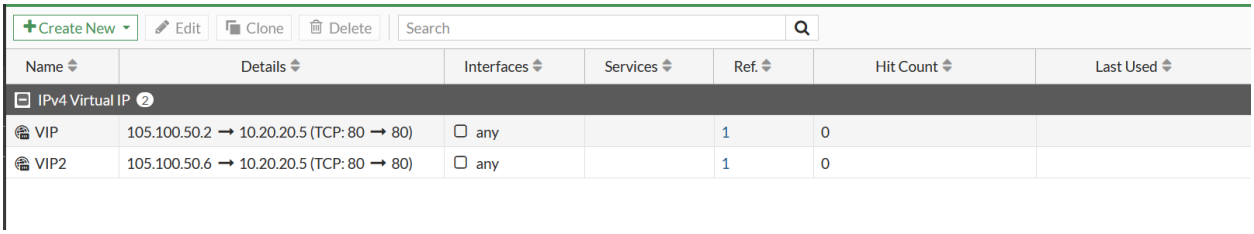

Figure 32:VIP

7. Authentication & Identity Services

7.1 RADIUS Server (Cisco ISE Integration)

- **Radius_Server1**
    - IP: **192.168.10.118**
    - Used for AAA authentication
    - Referenced in admin access policies

7.2 User & Identity Groups

- **AI_GROUP** → RADIUS users
- **FSSO_Group** → AD-based FSSO users
- **Guest-group** → Guest access
- **SSO_Guest_Users** → FSSO guest identities

7.3 FSSO Agent Integration

- Windows AD FSSO agent configured
- Provides user-identity awareness for policy enforcement

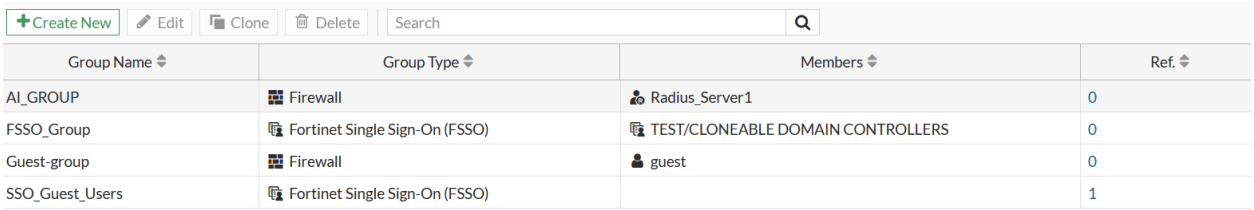

Figure 33:Groups

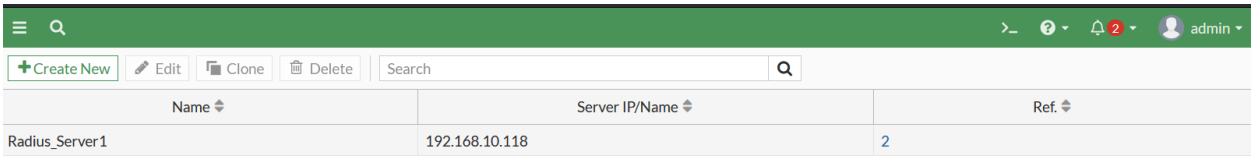

Figure 34:Raduis_Server

Figure 35:FSSO

FortiGate Branch Configuration

This section provides a complete and professionally organized summary of all configurations applied on the Branch FortiGate appliance. The configuration includes interfaces, SD-WAN, routing, security policies, HA (if present), SNMP, and service access control.

1. Interface Configuration

The Branch FortiGate is configured with multiple interfaces to support LAN connectivity, WAN connectivity, management access, and HA links (if used).

1.1 Branch LAN Interfaces

- **LAN-BR (port2)**
    - IP: **10.20.20.50/29**
    - Services enabled: PING, HTTPS, SSH, HTTP
    - Connected to the branch switching fabric

- **LAN-BR (port3)**
    - IP: **10.20.20.42/29**
    - Services enabled: PING, HTTPS, SSH, HTTP
    - Used as a secondary LAN link

1.2 Management Interface

- **Management (port4)**
    - IP: **192.168.1.100/24**
    - Services enabled: PING, HTTPS, SSH, HTTP, FMG-Access
    - Dedicated for administrative access (FortiManager / GUI / SSH)

1.3 WAN Interfaces

- **WAN-BR-ISP (port1)**
    - IP: **205.200.100.2/30**
    - Services enabled: PING, HTTPS, SSH, SNMP
    - Primary WAN connection
    - DHCP Relay → 10.20.20.5
- **Wan2 (port5)**
    - IP: **205.200.100.10/30**
    - Services enabled: PING, HTTPS, SSH, FMG-Access, FTM
    - Secondary WAN link for backup

1.4 HA Interfaces (If HA was used in the branch)

- **HA_1 (port8)** – IP: **192.168.12.1/24**
- **HA_2 (port9)** – IP: **192.168.13.1/24**
- Services: PING only
- Used for cluster synchronization

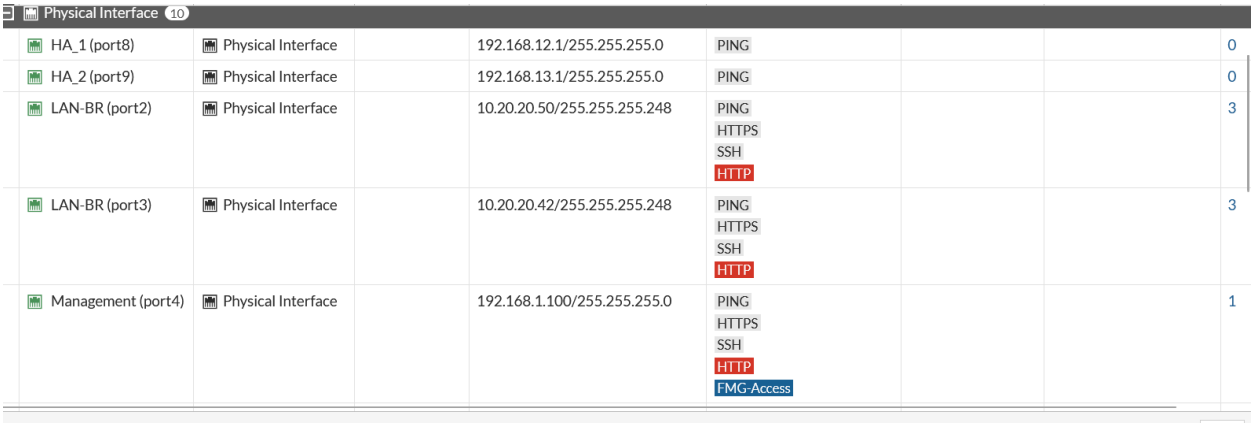

Figure 36:interfaces

2. SD-WAN Configuration

2.1 SD-WAN Zone

A branch SD-WAN zone is configured as **MY_SDWAN**, combining:

- WAN-BR-ISP (port1)
- Wan2 (port5)

2.2 SD-WAN Routing Metrics

- Both WAN links configured with equal **cost = 10**
- SD-WAN ensures link redundancy, failover, and load distribution

2.3 Traffic Monitoring

- SD-WAN session statistics show active sessions on both WAN links
- Real-time upload/download metrics displayed per interface

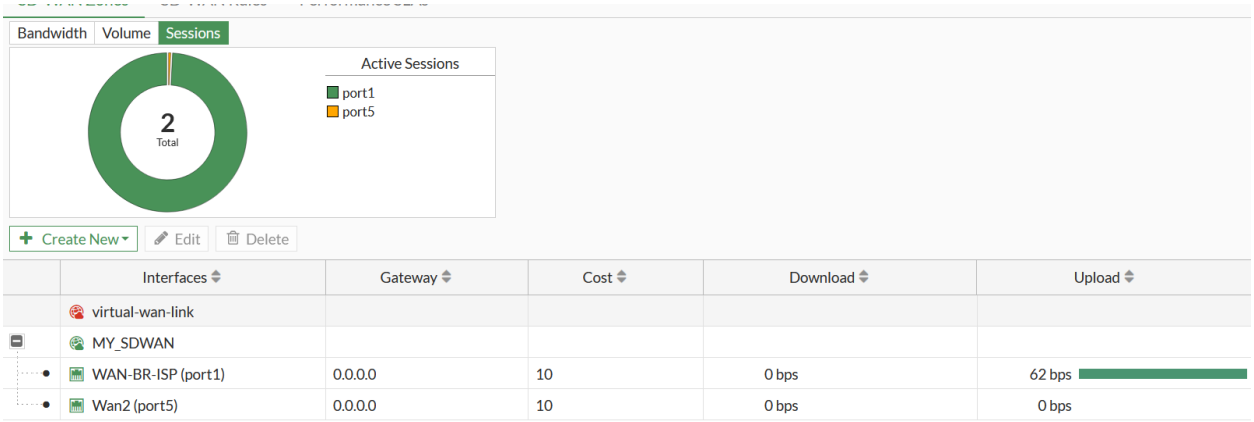

Figure 37:Sd_WAN

3. Routing Configuration

3.1 OSPF Dynamic Routing

- **Router ID: 3.3.3.4**
- **Area: 0.0.0.0**
- Advertised networks:
    - 10.20.20.40/29
    - 10.20.20.44/30
    - 10.20.20.48/29
    - Branch VLANs:
        - 172.17.0.0/27
        - 172.17.0.32/27
        - 172.17.0.64/27
        - 172.17.0.96/27
    - WAN networks:
        - 205.200.100.0/30
        - 205.200.100.4/30

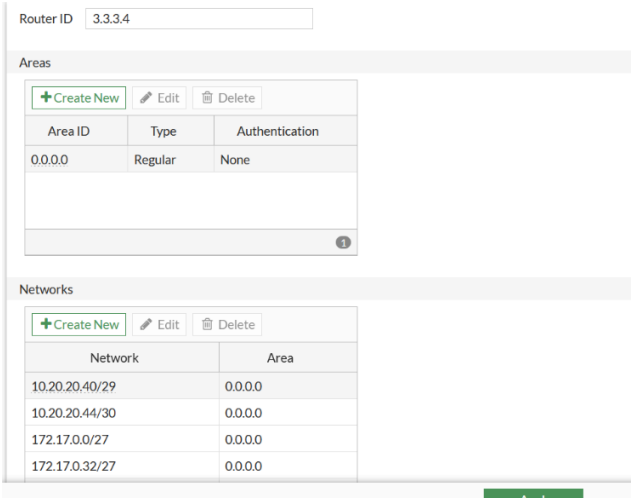

Figure 38:OSPF_1

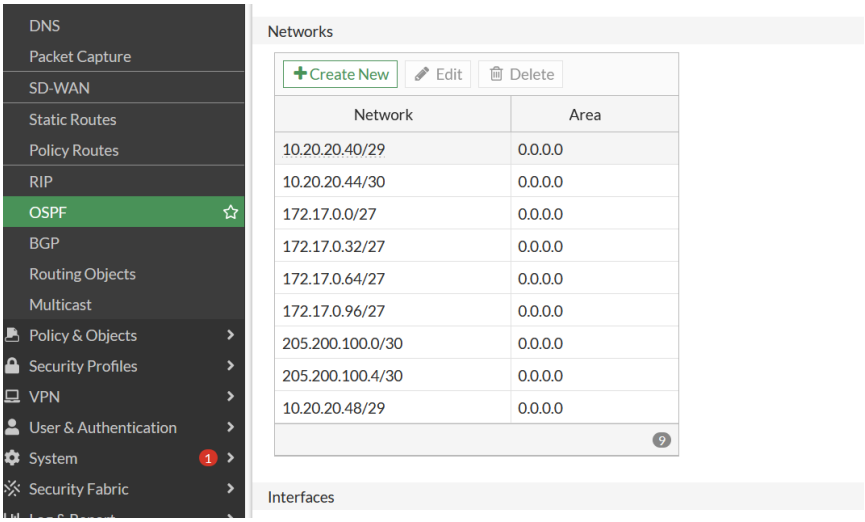

Figure 39:OSPF_2

4. Firewall Policies (Branch)

4.1 Internet Access Policies

- **Allow_internet1 (port2 → MY_SDWAN)**
- **Allow_internet2 (port3 → MY_SDWAN)**
- Source zones:
    - BR_Finance
    - BR_HR
    - BR_IT
    - BR_Media
    - BR_Sales
- Destination: all
- NAT: Enabled
- Security Profiles: certificate-inspection
- Action: ACCEPT

4.2 Inter-Branch / Inter-LAN Policies

- **LAN-to-Branch**
    - From: any
    - To: any
    - Source: all
    - Destination: all
    - NAT: Disabled
    - Action: ACCEPT
    - (Used for internal management, failover testing, or branch-to-branch communication)

4.3 Implicit Deny

- Final rule denying all traffic not explicitly allowed
- Action: DENY

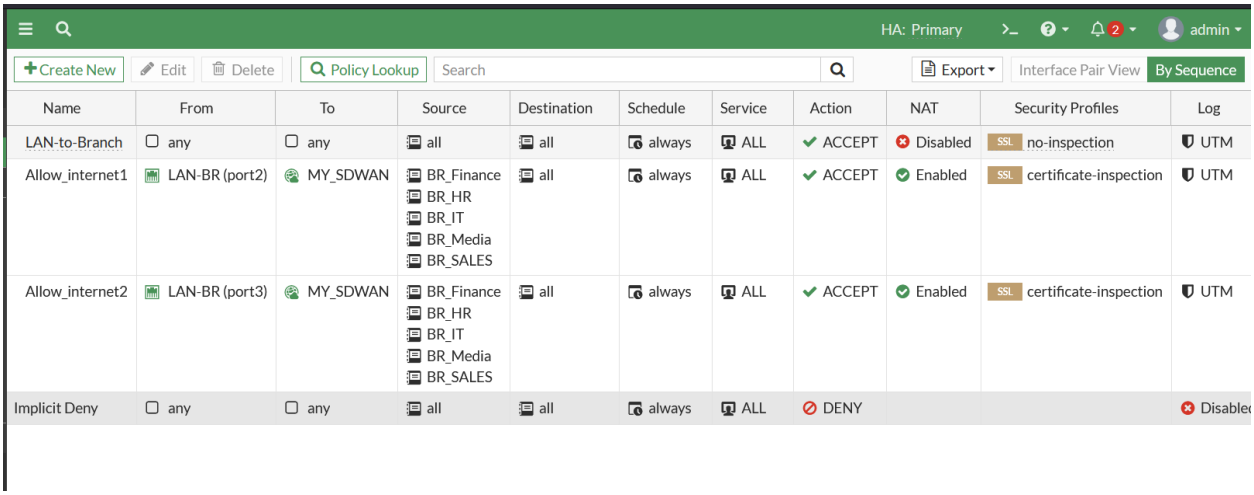

Figure 40:POLICIES

5. High Availability (HA) Status

The branch FortiGate cluster is configured in an Active–Passive HA pair.

5.1 Cluster Overview

- **Primary node:**
    - Hostname: Forti_Ahmed2

- Priority: 150
- Status: Synchronized

- **Secondary node:**
  - Hostname: FortiGate-VM64-H
  - Priority: 128
  - Status: Synchronized

5.2 Cluster Health

- Both nodes show synchronized configuration
- Real-time session & throughput monitoring available
- Automatic failover supported

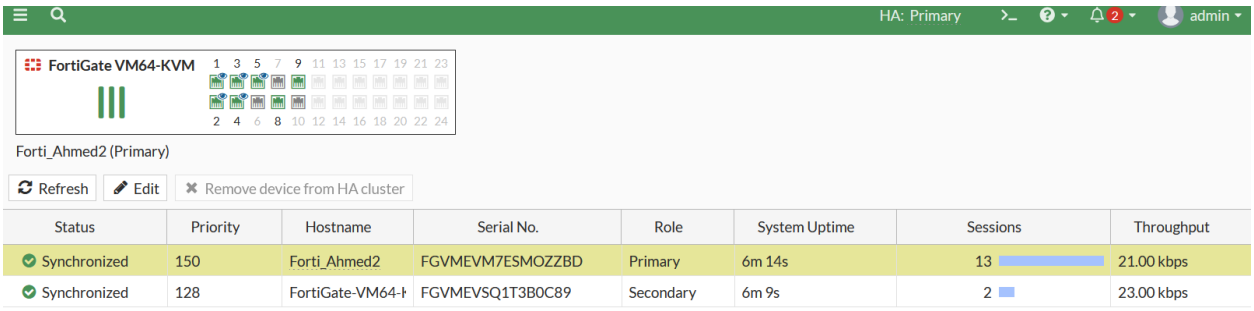

Figure 41:HA

5. SNMP Monitoring

6.1 SNMP Agent Settings

- SNMP agent: **Enabled**
- SNMP v1/v2c enabled

6.2 SNMP Community

- **Name:** SNMP
- Queries: v1 & v2 enabled
- Traps: v1 & v2 enabled
- Host: **10.20.20.5/32**
- Events monitored: 38

Server Infrastructure Configuration (Windows Server 2016)

The Windows Server 2016 implementation within the HQ environment hosts multiple critical infrastructure services essential for enterprise operations. These services support authentication, identity management, DHCP allocation, time synchronization, file sharing, logging, and application_delivery.

The server is fully integrated with the HQ and Branch networks.

Below is a detailed overview of all services installed and configured:

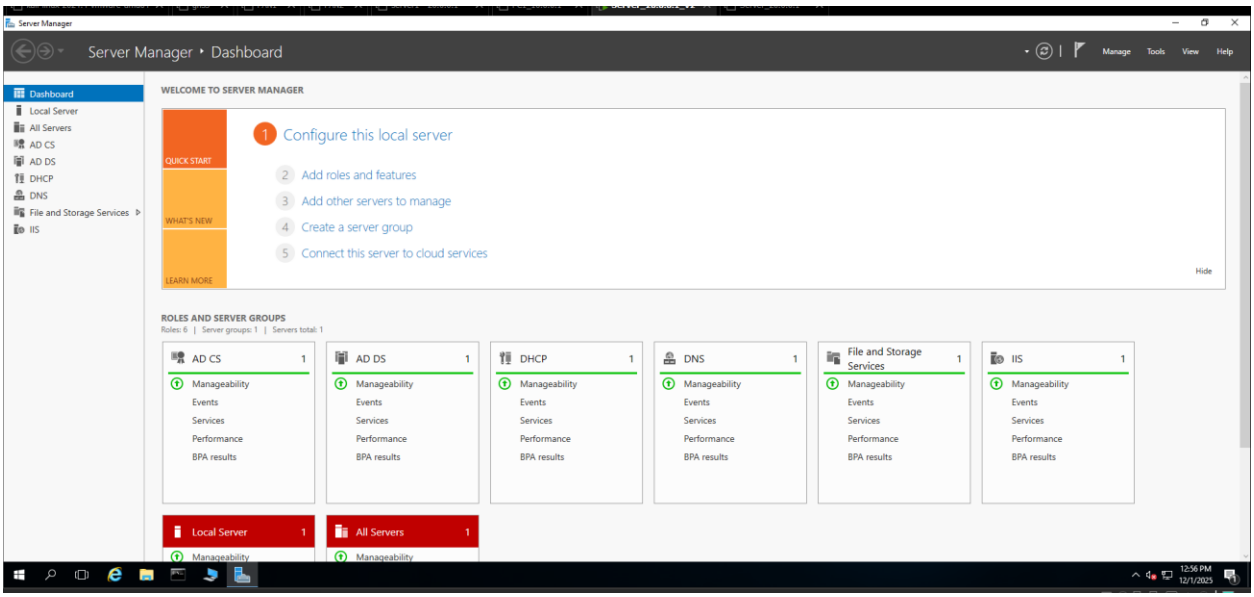

Figure 42:Server_Services

1. Active Directory Domain Services (AD DS) & Certificate Authority (CA)

The server functions as the primary domain controller and Certificate Authority for the enterprise.

Roles:

- **Active Directory Domain Services:** Provides centralized authentication, user/group management, and GPO enforcement.
- **Certificate Authority (CA):** Issues certificates for domain devices, servers, HTTPS, Wi-Fi authentication, VPN, and secure network communication.

Figure 43:Active_Directory

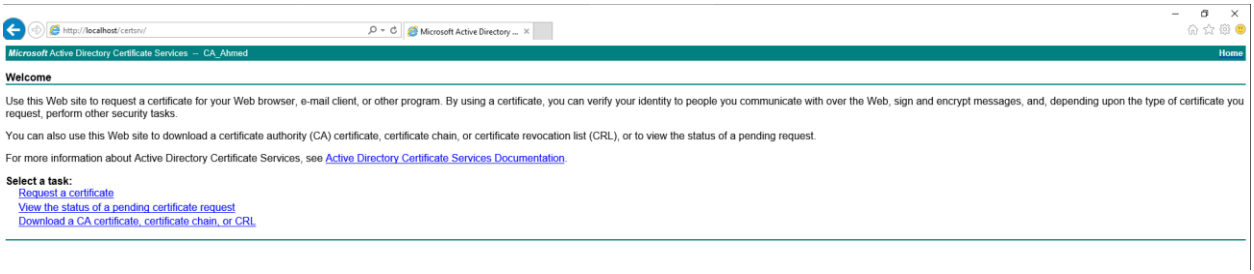

Figure 44:CA_server

2. DHCP Server

The server provides dynamic IP addressing for HQ and Branch subnets using DHCP scopes or DHCP relay (via FortiGate).

Features:

- Multiple scopes for HR, Sales, Finance, Media, IT
- DHCP Options configured (DNS, gateway, domain name)
- Supports Branch DHCP relay from FortiGate

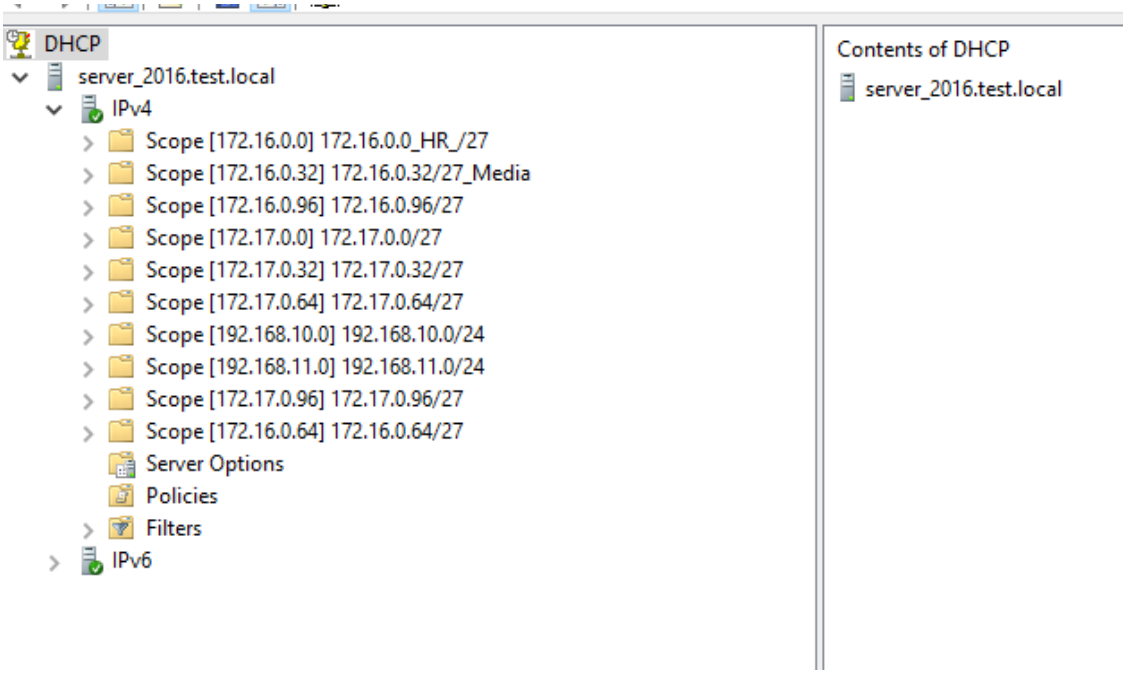

Figure 45:DHCP

3. DNS Server

The local DNS server hosts internal DNS zones to support Active Directory and internal name resolution.

Capabilities:

- Forward lookup zones
- Reverse lookup zones
- Conditional forwarders for external domains
- Integrated with AD for secure dynamic updates

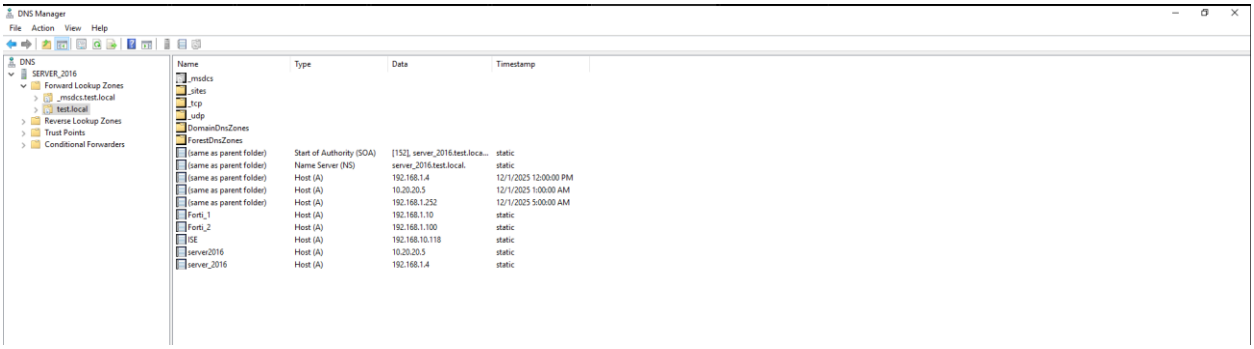

Figure 46:DNS

4. Web Server (IIS)

The machine hosts an internal **Web Server (HTTP/HTTPS)** used for testing, internal apps, and DMZ publishing.

Services:

- HTTP hosting
- HTTPS hosting using CA-issued certificate
- Published externally through FortiGate VIP rules

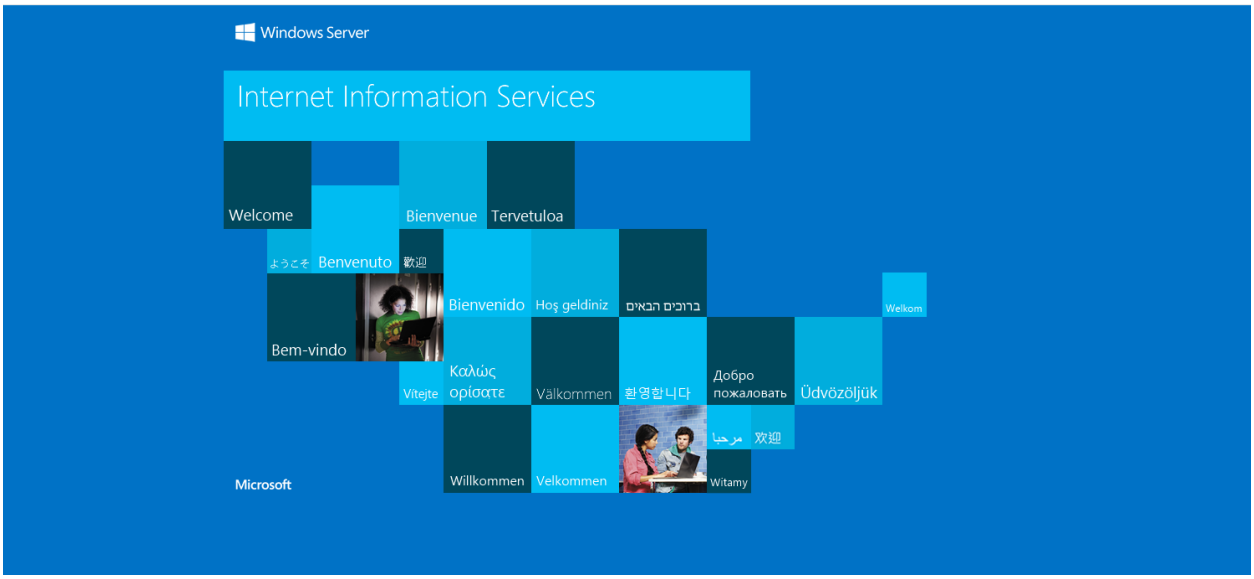

Figure 47:IIS

5. SMTP Server

The server includes SMTP service used for internal mail routing or for application-level email notifications.

Use Cases:

- Alerting systems
- Syslog email notifications
- Application testing

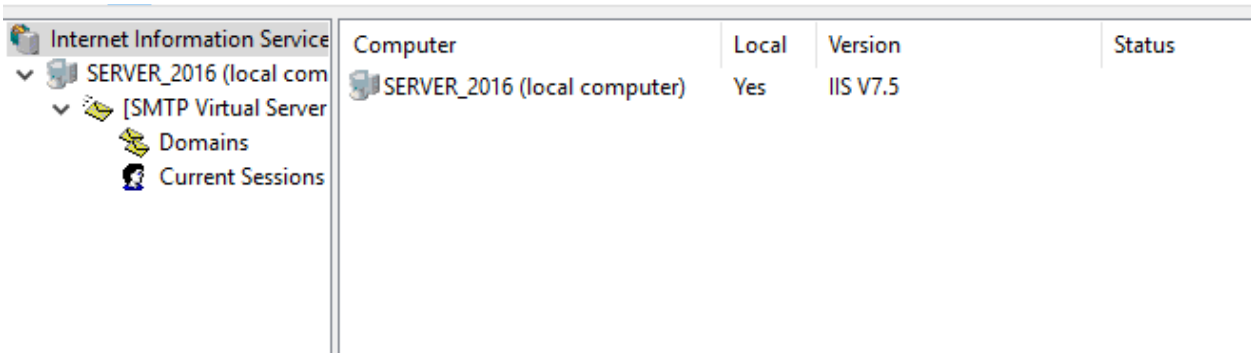

Figure 48:SMTP

6. FTP Server

The server hosts an internal **FTP/FTPS** service for secure file transfer between departments.

Security:

- NTFS permission-based access
- Only allowed via controlled policies through FortiGate

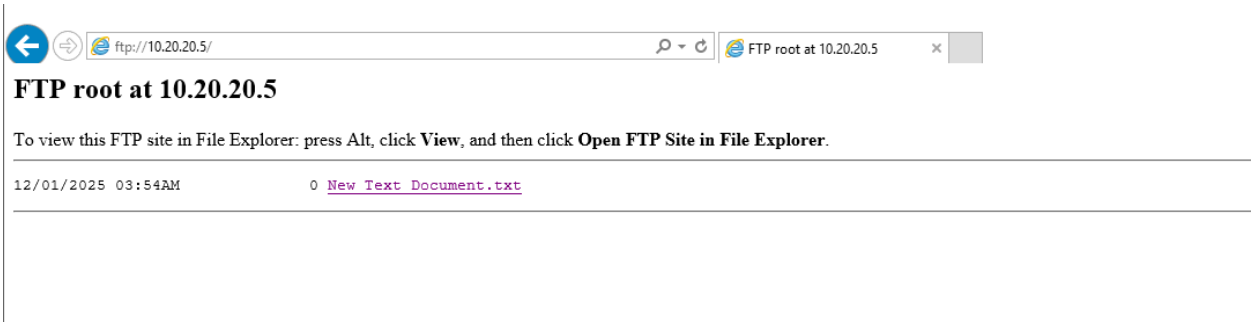

Figure 49:FTP

8. NTP Server

The server operates as the internal **Network Time Protocol (NTP) server**.

Purpose:

- Time synchronization for all domain devices
- Required for Kerberos authentication
- FortiGate, switches, servers, and clients use it as the primary time source

9. SNMP Server

SNMP service is enabled to allow network monitoring tools to query system status.

Purpose:

- Integration with network monitoring systems
- Performance and availability metrics collection
- Works with FortiGate SNMP configuration

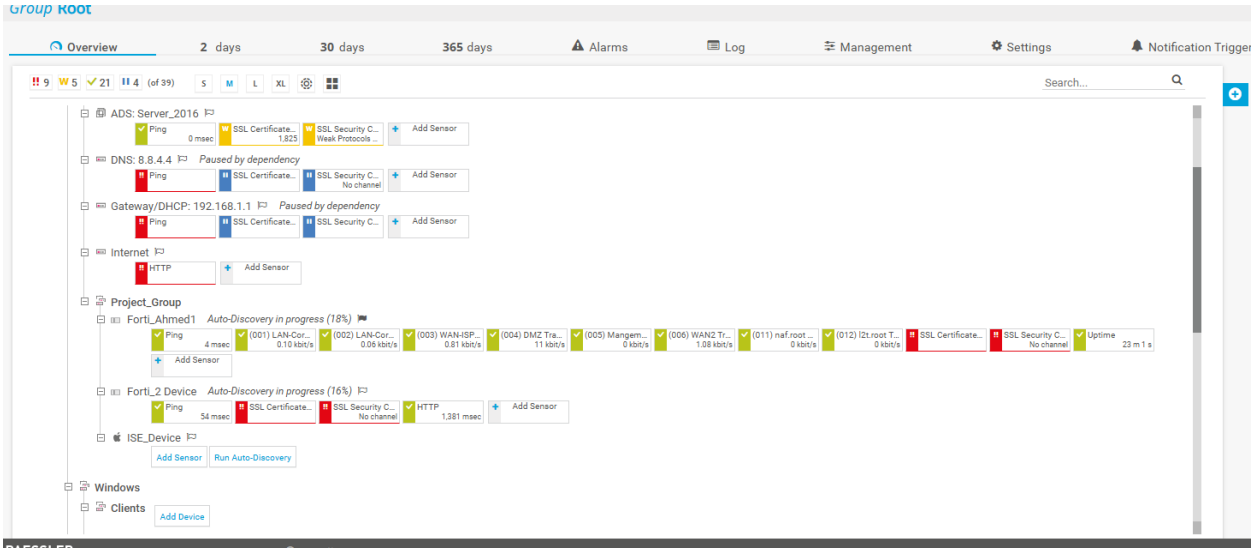

Figure 50:PRTG_SNMP

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10. Syslog Server

A syslog service is installed to collect logs from network devices and security appliances.

Capabilities:

- Receives logs from FortiGate and other devices
- Stores event, system, and security logs
- Supports auditing and troubleshooting operations

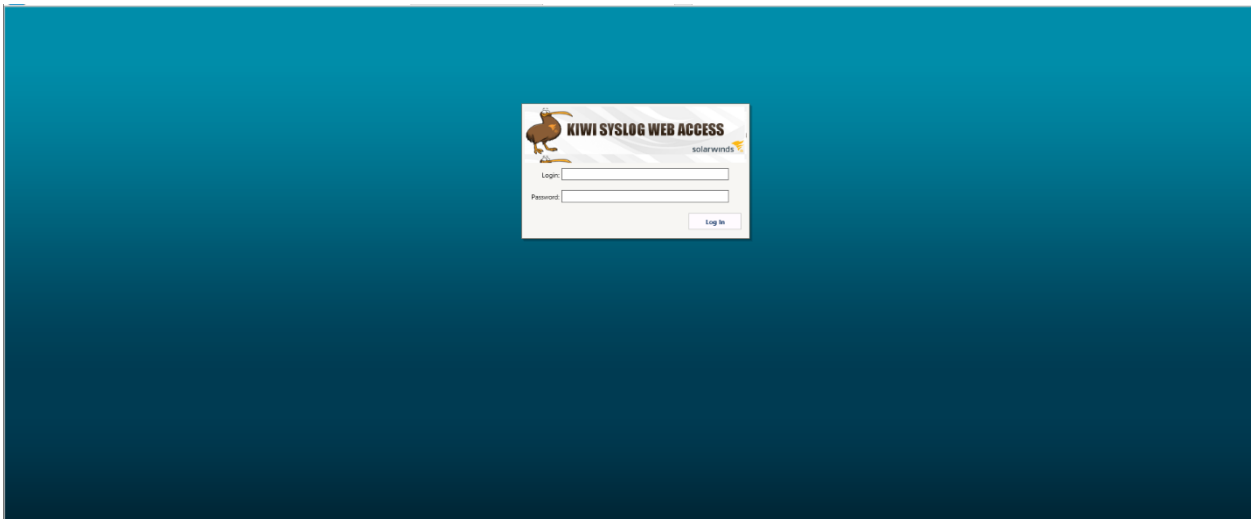

Figure 51:KIWI_Syslog

Cisco ISE Configuration Overview

Cisco Identity Services Engine (ISE) is deployed as the central identity, authentication, and policy enforcement platform for the enterprise network. The solution provides secure access control for both wired and wireless users, centralized device administration, and full integration with FortiGate and Active Directory.

The following ISE services and features are enabled and actively used in the environment

1. RADIUS Services

The Cisco ISE server is configured as a **RADIUS Authentication and Authorization Server** for both HQ and Branch networks.
RADIUS is used to authenticate end users, endpoints, and devices connecting to switches or network access points.

Key Capabilities Enabled

- **AAA Authentication** for network users
- **Authorization policy enforcement**
- **RADIUS Accounting** for FortiGate and switches
- **Integration with Active Directory domain for user-based authentication**

ISE acts as the main identity authority for:

- 802.1X authenticated users
- MAB endpoints
- WebAuth guest users
- Network devices authenticating via RADIUS

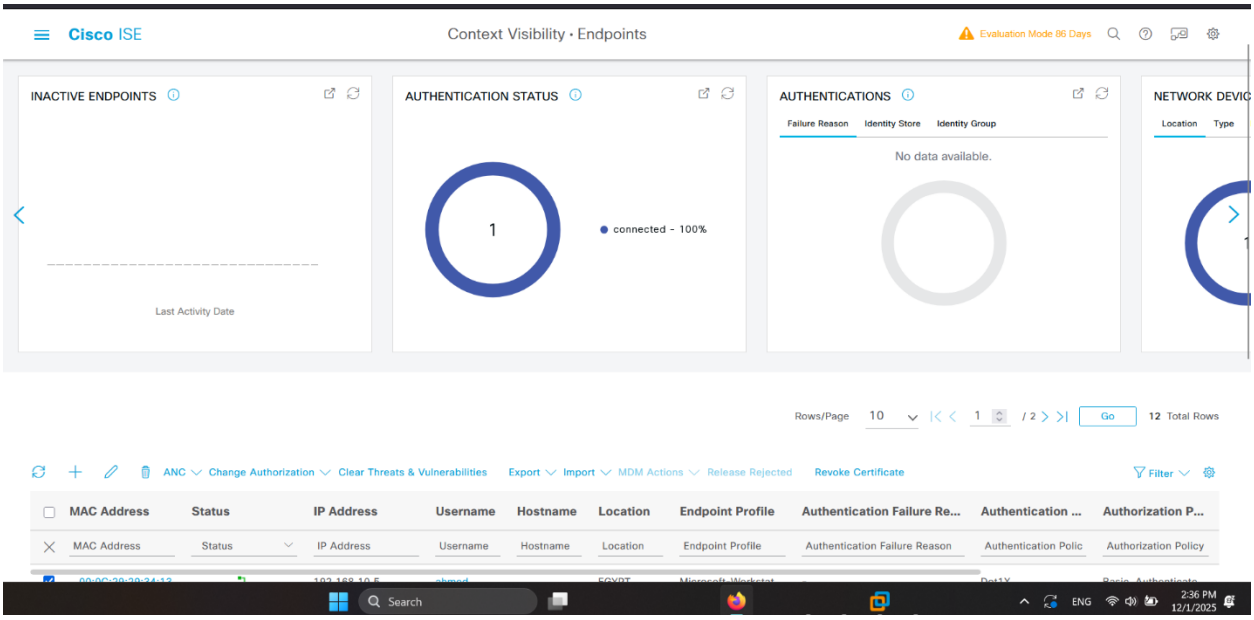

Figure 52:Ise

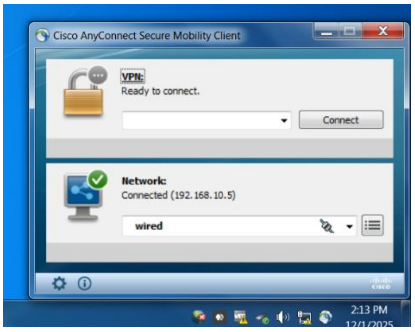

Figure 53:Anycconnect

```
Interface    Identifier     Method  Domain  Status Fg Session ID
-----------------------------------------------------------------------------
Et0/3        000c.2929.3413 mab     DATA    Auth      C0A80A230000000B000107B8


Key to Session Events Blocked Status Flags:

  A - Applying Policy (multi-line status for details)
  D - Awaiting Deletion
  F - Final Removal in progress
  I - Awaiting IIF ID allocation
  N - Waiting for AAA to come up
  P - Pushed Session
  R - Removing User Profile (multi-line status for details)
  U - Applying User Profile (multi-line status for details)
  X - Unknown Blocker

Runnable methods list:
  Handle  Priority  Name
    7        0      dot1xSupp
    6        5      dot1x
    11       10     mab
    9        15     webauth

IT-SW#
IT-SW#
```

Figure 54:MAB_Auth

```
IT-SW#show authentication sessions interface e0/3

Interface    Identifier     Method  Domain  Status Fg Session ID
-----------------------------------------------------------------------------
Et0/3        000c.2929.3413 dot1x   DATA    Auth      C0A80A230000000C0005BB0B


Key to Session Events Blocked Status Flags:

  A - Applying Policy (multi-line status for details)
  D - Awaiting Deletion
  F - Final Removal in progress
  I - Awaiting IIF ID allocation
  N - Waiting for AAA to come up
  P - Pushed Session
  R - Removing User Profile (multi-line status for details)
  U - Applying User Profile (multi-line status for details)
  X - Unknown Blocker

Runnable methods list:
  Handle  Priority  Name
    7        0      dot1xSupp
    6        5      dot1x
    11       10     mab
    9        15     webauth

IT-SW#
```

Figure 55:RADUIS(Dot1x)

2. TACACS+ Services (Device Administration)

Cisco ISE is also configured as a **TACACS+ server** to control administrative access to network devices (FortiGate, switches, routers).

TACACS+ Functionalities Enabled

- Centralized admin login for all network devices
- Role-based access control (RBAC)
- Command authorization restrictions
- Full accounting and logging of admin activities

Use Case

TACACS+ ensures that:

- Only authorized engineers can log in to devices
- Each user gets a specific privilege level
- Sensitive commands are restricted or blocked
- All admin actions are logged for compliance/auditing

3. Integration with FortiGate Firewall

The Cisco ISE server integrates with HQ FortiGate via:

- **RADIUS** authentication
- **RADIUS** accounting
- **TACACS+** device admin control

FortiGate uses ISE for:

- Admin authentication
- Identity-based firewall policies
- Centralized **AAA** for all administrative sessions

Penetration Testing & Hardening Summary (Server 10.20.20.5)

As part of the security validation process, a full internal penetration test was performed on the Windows Server 2016 machine located at **10.20.20.5**. The objective was to identify potential vulnerabilities, validate real exploitation paths, and then apply effective hardening measures.

The penetration test included service enumeration, SMB/LDAP security assessment, MS17-010 exploitation testing, RDP security analysis, IIS review, and configuration validation. All results, logs, and exploitation attempts were documented and cross-validated using Nmap, enum4linux, Metasploit, and Impacket tools

3. Reconnaissance & Service Enumeration

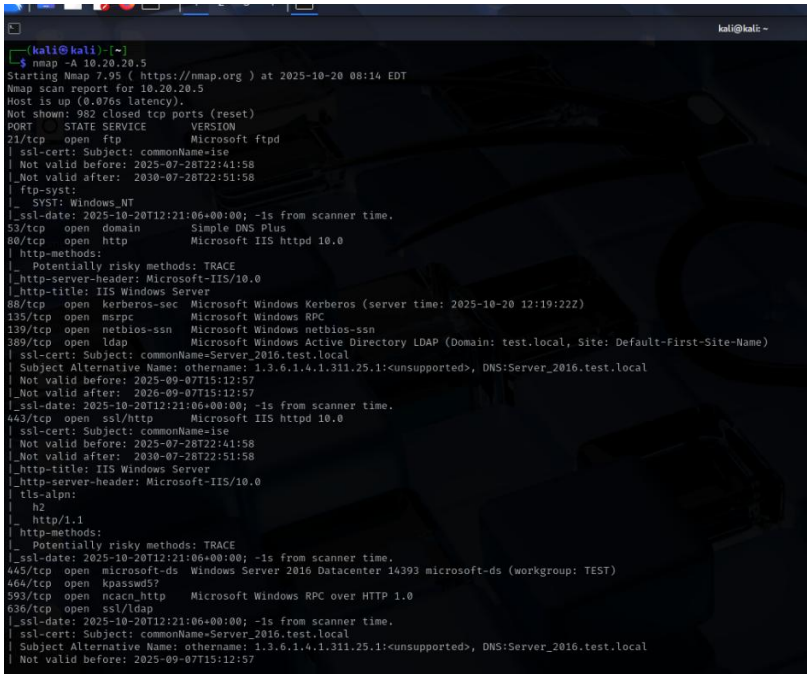

Figure 56:NMAP

4. SMB Vulnerability Assessment (MS17-010)

Finding: Vulnerable to MS17-010 (EternalBlue)

Nmap positively identified the machine as **vulnerable**, matching CVE-2017-0143 with **High Risk**.

Action Taken (Hardening)

- SMBv1 completely disabled
- SMBv2/3 enforced
- Share encryption enabled for sensitive folders (e.g., Finance)
- Server rebooted to apply kernel SMB patches

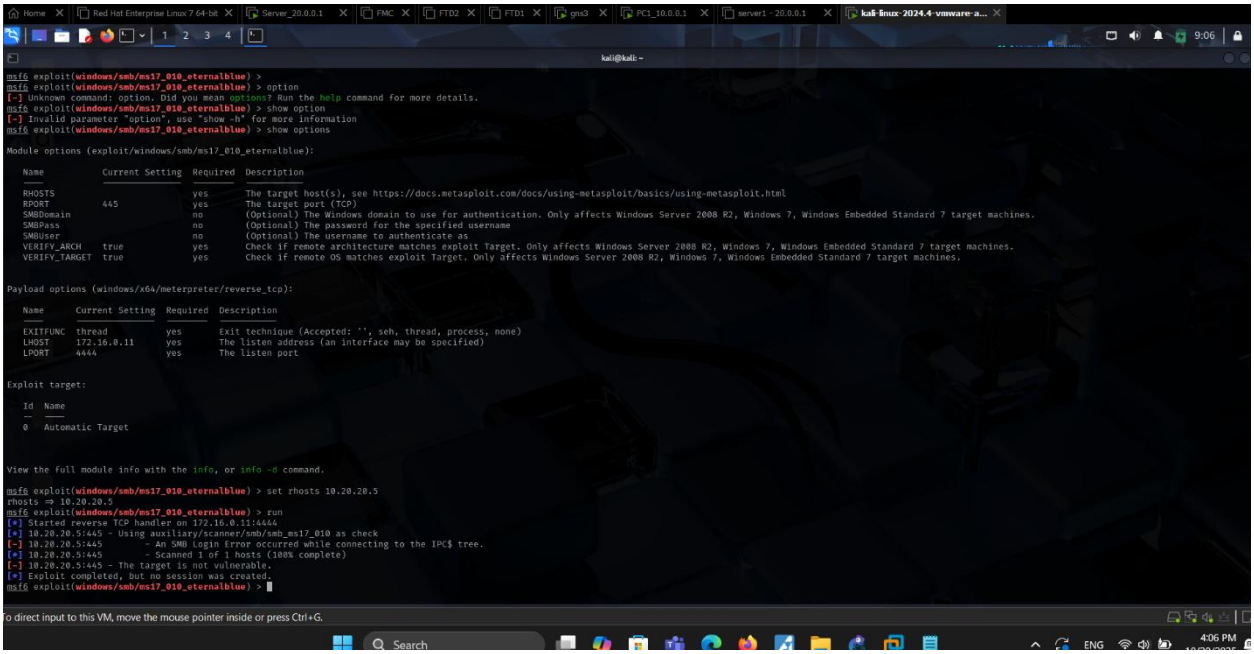

Figure 57:Attack_SMB

3. RDP Sec Findings

- RDP port **3389** was exposed
- Initial brute-force tests showed the server allowed authentication attempts but responded with NLA restrictions

Actions Taken

- Enforced **Network Level Authentication (NLA)**
- Enabled **Account Lockout Policy** after 5 failed attempts
- Restricted RDP access to internal IP ranges only
- Verified via RDP & xfreerdp logs that brute-force attempts were blocked

---

Project Challenges & Limitations

During the implementation of this enterprise-level network project, several technical challenges and platform limitations were encountered. These issues were mainly related to licensing constraints, device capabilities within the virtual lab environment, and the hardware resources required to simulate a real production network. The following points summarize the major challenges faced:

1. Licensing Limitations (FortiGate, FortiManager, Cisco ISE)

A significant challenge was the absence of full licenses for critical security and management platforms. Many enterprise-grade features are license-restricted, especially in GNS3 virtual images:

FortiGate & FortiManager

- FortiManager refused to register the FortiGate due to missing **FMG-VM license**, which prevents:
    - Centralized policy management
    - Global objects
    - Enterprise certificate automation

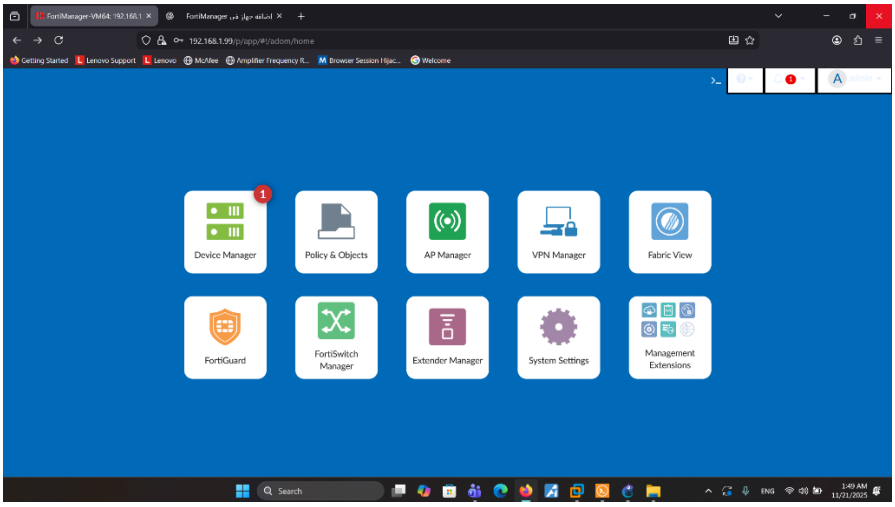

Figure 58:FortiManager

- Many FortiGate services require valid subscriptions (**UTM, IPS, Web Filtering, Application Control, VPN, and Certificates**).
- The firewall supported only limited VPN functionalities, so part of the VPN testing had to be validated using another vendor (**Palo Alto**) to ensure design functionality.

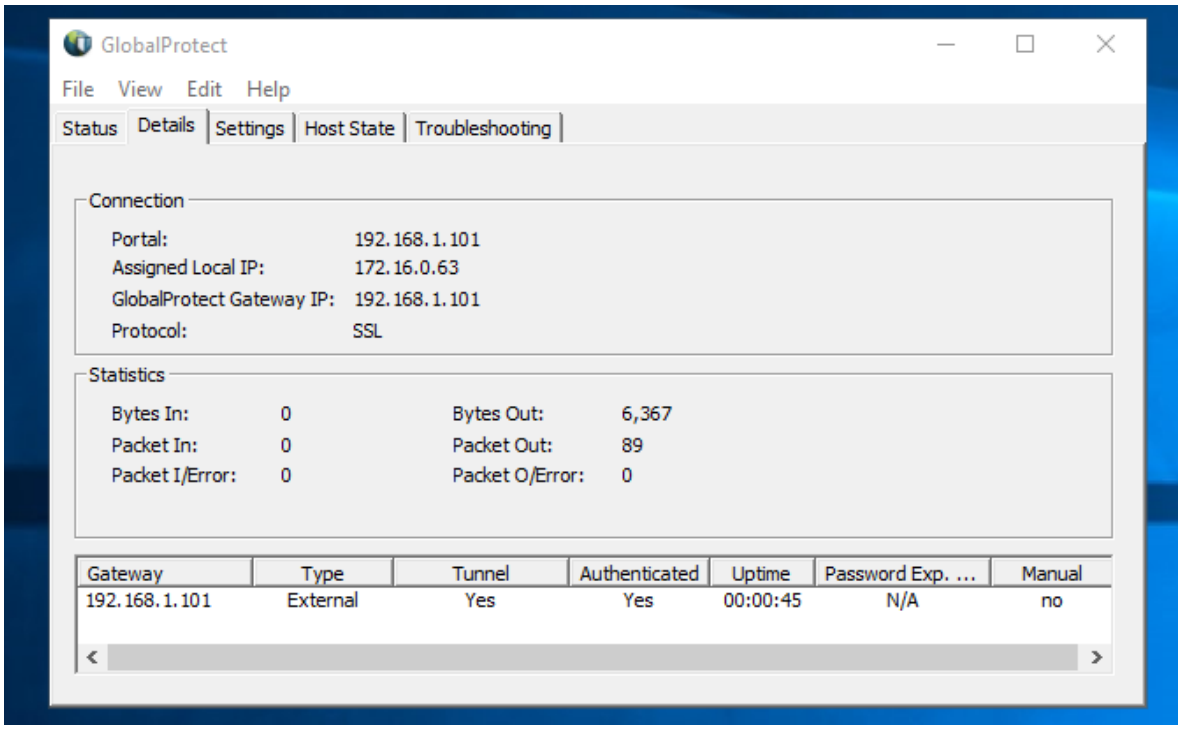

Figure 59:PALOALTO_RMVPN

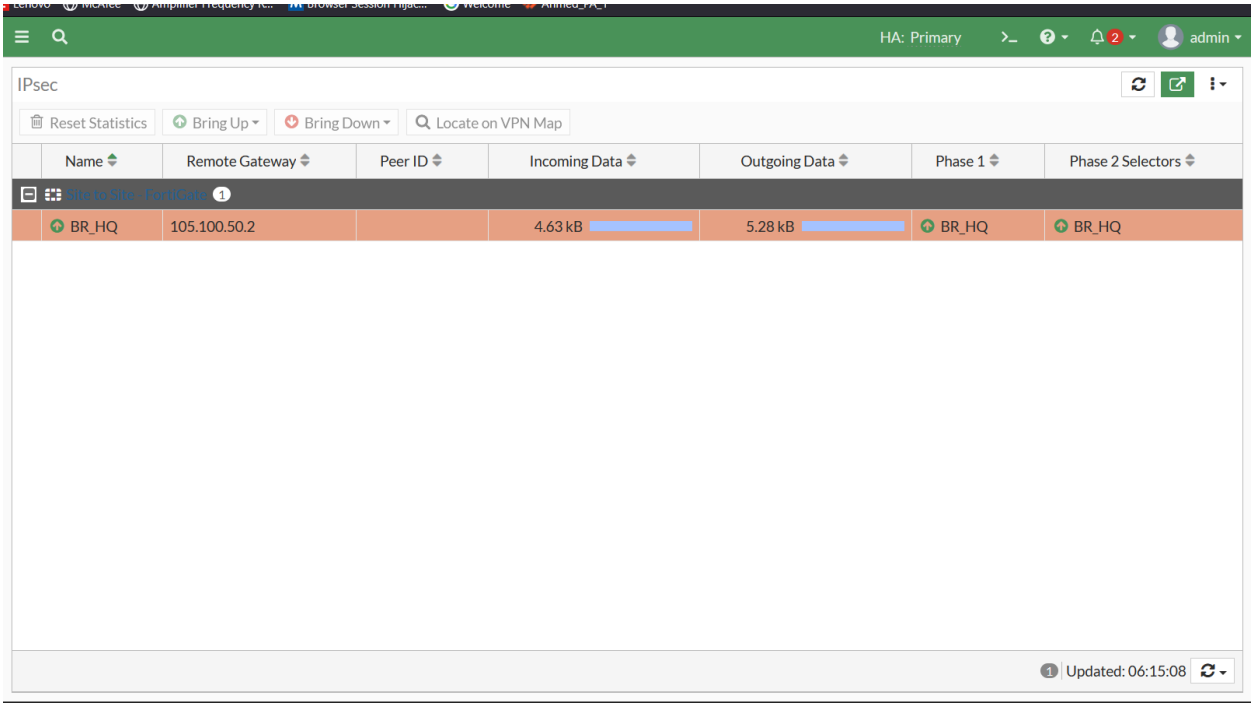

Figure 60:Forti_IPsec

Cisco ISE

Without a full Cisco ISE license, advanced NAC features could not be enabled, such as:

- **pxGrid**
- **Posture Assessment**
- **SGT (Scalable Group Tags)**
- **Profiling**
- **BYOD workflows**

These features are essential for Zero-Trust Network Access, but ISE in GNS3 runs with restricted capabilities.

2. GNS3 Switching Limitations

The virtual Layer 2 switches in GNS3 are extremely limited compared to real enterprise switches.

Limitations include:

- No full support for **MST**, **PVST+**, or **RSTP** behaviors

- Limited **EtherChannel** functionality
- No hardware-level forwarding or ASIC simulation
- Many advanced features (like DHCP Snooping, Dynamic ARP Inspection, IP Source Guard) are unavailable or only partially functional

These restrictions required adjusting the design to “lab-supported” capabilities rather than complete enterprise-grade L2 security.

3. Resource Requirements for a Full Enterprise Simulation (Summary)

The project required running a full multi-site enterprise environment in GNS3, including HQ, branches, FortiGate HA, Cisco ISE, Windows Server roles, DMZ services, SD-WAN, VPN, and multiple switches/routers. Such a large topology required high hardware specifications (powerful CPU, large RAM, fast SSD, and stable virtualization support).

Running all components simultaneously caused performance and stability challenges, especially with resource-intensive systems like ISE, FortiGate HA, and Windows Server.

Future Work

The current implementation successfully delivers a secure, scalable, and fully functional enterprise network connecting the Headquarters, Branch environment, DMZ servers, and IT Management systems. Although the architecture achieves all required objectives, several enhancements can further strengthen performance, scalability, and security posture in future iterations:

1. Full Integration with FortiManager and FortiAnalyzer

Due to licensing limitations in the current lab environment, centralized management was partially restricted. Future work should include:

- Enabling global policy deployment and bulk configuration management.
- Implementing automated backups, change tracking, and workflow-controlled updates.
- Integrating FortiAnalyzer for advanced logging, analytics, event correlation, and threat-intelligence reporting.

2. Expansion into Zero-Trust Network Access (ZTNA)

To evolve beyond traditional perimeter-based models, the network can be extended with:

- Identity-centric micro-segmentation.
- Device posture evaluation using Cisco ISE Posture module.
- Continuous trust verification and adaptive access controls.

3. Advanced SD-WAN Optimization

- Application-aware routing for latency-sensitive services.
- Performance-based steering across multiple ISPs.
- WAN optimization techniques for increased throughput and reduced packet loss.

4. Full VPN Portfolio Implementation

- Full IPsec site-to-site tunnels with certificate-based authentication.

- SSL-VPN for remote employees with granular access control.
- MFA authentication via FortiToken or third-party identity providers.

5. Enhanced Network Automation & Orchestration

- Using Python, Ansible, or Terraform for automated provisioning.
- Implementing API-driven configuration of FortiGate and Cisco ISE.
- Developing automated compliance checks and configuration audits.

6. Advanced Monitoring & Telemetry

- SNMPv3 secure monitoring for all devices.
- NetFlow/sFlow for detailed traffic analytics.
- Integration with SIEM platforms (Splunk, Elastic, QRadar, FortiSIEM) for real-time threat detection and unified event correlation.

7. Redundant Cisco ISE Deployment

- Multi-node ISE architecture (PAN, MnT, PSN).
- High availability for authentication and authorization services.
- Improved scalability for larger enterprise deployments.

8. Wireless Network Integration

- Enterprise-grade WLAN controllers (Cisco WLC or Fortinet Wireless).
- Secure 802.1X authentication using Cisco ISE.
- Role-based SSID segmentation for corporate, guest, and IoT devices.

9. Cloud Integration

- Hybrid-cloud connectivity (Azure VPN Gateway, AWS Transit Gateway).
- Integration with cloud identity platforms (Azure AD / Entra ID).
- Extending firewall and security policies to protect cloud-based workloads.

10. Deployment of SIEM & EDR for Enterprise-Grade Threat Detection (Added)

To elevate security maturity and enable true real-time incident detection and automated response, future work should include:

SIEM (Security Information and Event Management):

- Deploying a full SIEM platform such as **Splunk, QRadar, Elastic SIEM, Microsoft Sentinel, or FortiSIEM**.
- Centralizing logs from firewalls, servers, switches, ISE, endpoints, and DMZ services.
- Implementing advanced correlation rules, behavioral analytics, and automated alerts.
- Enabling long-term log retention for forensic investigations and compliance.

EDR (Endpoint Detection & Response):

- Deploying an enterprise EDR solution such as **CrowdStrike, SentinelOne, Microsoft Defender for Endpoint, Trellix, or FortiEDR**.
- Enforcing real-time endpoint visibility, threat hunting, malware prevention, and exploit detection.
- Integrating EDR with SIEM/SOAR platforms for automated response workflows.
- Enforcing continuous monitoring across all Windows, Linux, and DMZ servers.

EDR + SIEM integration provides full visibility across endpoints and networks, enhancing the organization's ability to detect, contain, and respond to advanced threats.