Designing Resilient Networks: A Lab in High Availability, Routing, and Wireless Integration

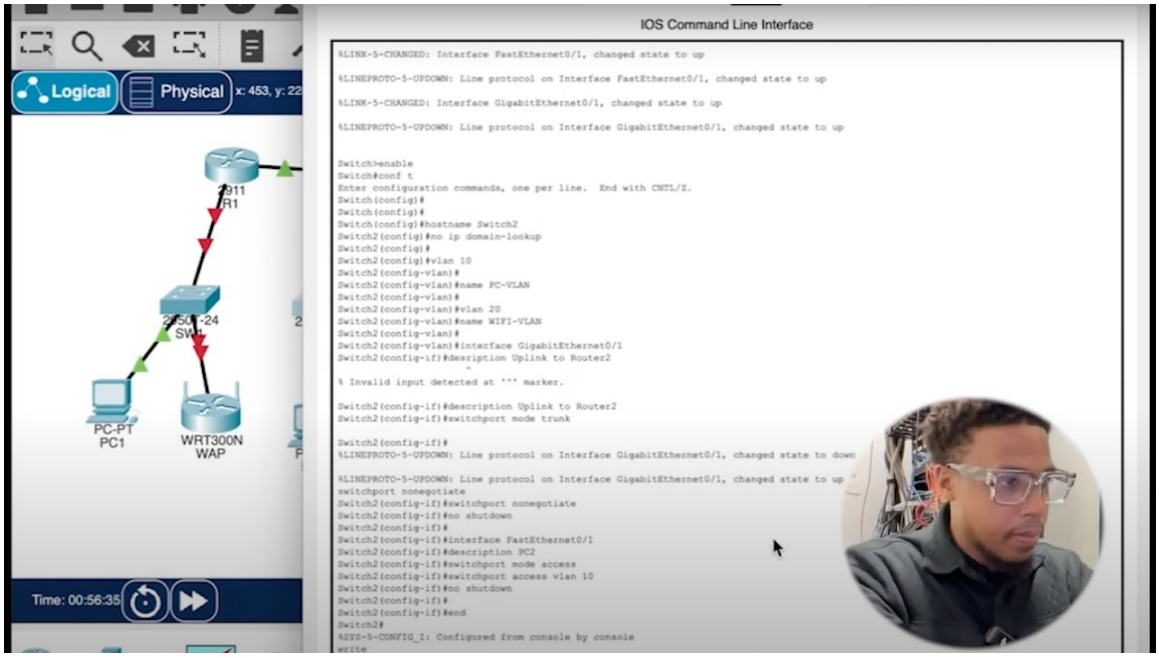
Executive Summary

This infrastructure was designed to simulate a realistic office network environment, with the goal to design and implement broadcast level network infrastructure. I built it from the ground up in Cisco Packet Tracer, configuring routers, switches, DHCP, routing protocols, VLAN segmentation, and wireless access. The topology includes redundancy, dynamic routing, IP address management, and logical traffic separation.

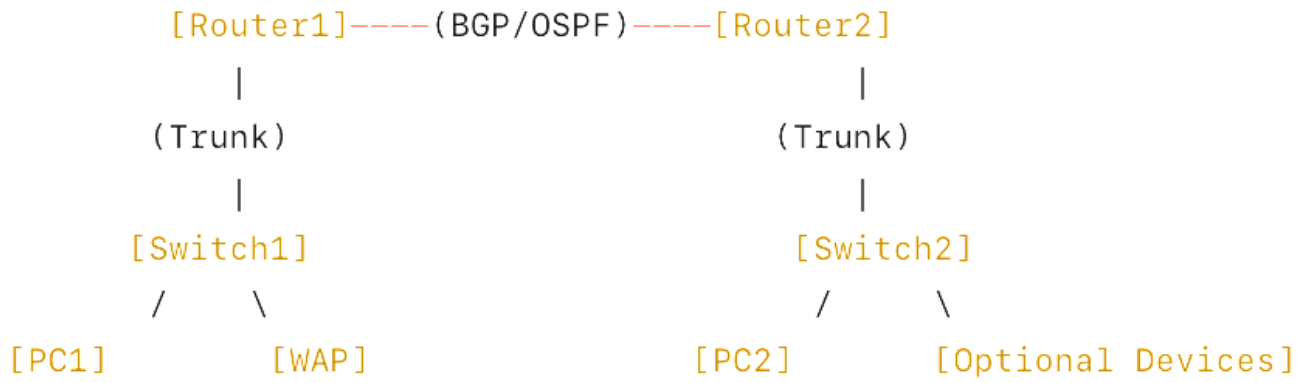
Engineer: Jeremi D. Wright

Tools Used: Cisco Packet Tracer 8.2, CLI, BGP, OSPF, HSRP, DHCP, VLANs, Wireless Security

Supplement to:
Walkthrough Video (https://www.youtube.com/watch?v=hxoq7zfcVPU)



Topology Diagram



Device & Interface Table

Device	Interface	IP Address / VLAN	Description
Router 1	Gi0/0.10	192.168.10.1 / VLAN 10	HSRP Active, PC subnet gateway
Router 1	Gi0/0.20	192.168.20.1 / VLAN 20	HSRP Active, WiFi subnet gateway
Router 1	Gi0/1	10.0.0.1 /30	OSPF/BGP to Router2
Router 2	Gi0/0.10	192.168.10.2 / VLAN 10	HSRP Standby
Router 2	Gi0/0.20	192.168.20.2 / VLAN 20	HSRP Standby
Router 2	Gi0/1	10.0.0.2 /30	OSPF/BGP to Router1
Switch 1	Fa0/1	VLAN 10	PC1
Switch 1	Fa0/2	VLAN 20	WAP
Switch 1	Gi0/1	Trunk	To Router1
Switch 2	Fa0/1	VLAN 10	PC2
Switch 2	Gi0/1	Trunk	To Router2
WAP	Ethernet 1	192.168.20.10	Static, WiFi clients

Protocols Used & Rationale

HSRP (Hot Standby Router Protocol)

- **Used For:** Gateway redundancy on VLANs 10 and 20
- **Why:** Ensures high availability — clients always have a default gateway

OSPF (Open Shortest Path First)

- **Used For:** Internal dynamic routing between routers
- **Why:** Fast convergence, supports scalable topologies, automatic route updates

BGP (Border Gateway Protocol)

- **Used For:** Simulating WAN peering between Router1 (AS 65001) and Router2 (AS 65002)
- **Why:** Demonstrates ability to configure external routing and inter-domain reachability

VLANs

- **Used For:** Traffic separation — VLAN 10 (wired PCs), VLAN 20 (wireless)
- **Why:** Enhances security, broadcast control, and logical segmentation

DHCP

- **Used For:** Dynamic IP assignment on both VLANs via Router1
- **Why:** Simulates centralized IPAM in real networks; reduces admin overhead

WPA2 WiFi

- **Used For:** Laptop connectivity to VLAN 20 via secure SSID (OfficeWiFi)
- **Why:** Completes the real-world hybrid network scenario with secure wireless access

CLI: Router1 & Router2 Configurations

```
hostname Router1
no ip domain-lookup

interface GigabitEthernet0/0
 no shutdown

interface GigabitEthernet0/0.10
 encapsulation dot1Q 10
 ip address 192.168.10.1 255.255.255.0
 standby 10 ip 192.168.10.254
 standby 10 priority 110
 standby 10 preempt
 no shutdown

interface GigabitEthernet0/0.20
 encapsulation dot1Q 20
 ip address 192.168.20.1 255.255.255.0
 standby 20 ip 192.168.20.254
 standby 20 priority 110
 standby 20 preempt
 no shutdown

interface GigabitEthernet0/1
 ip address 10.0.0.1 255.255.255.252
 no shutdown

router ospf 1
 router-id 1.1.1.1
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.20.0 0.0.0.255 area 0
 network 10.0.0.0 0.0.0.3 area 0

router bgp 65001
 neighbor 10.0.0.2 remote-as 65002

ip dhcp pool VLAN10-PCs
 network 192.168.10.0 255.255.255.0
 default-router 192.168.10.254
 dns-server 8.8.8.8

ip dhcp pool VLAN20-WiFi
 network 192.168.20.0 255.255.255.0
 default-router 192.168.20.254
 dns-server 8.8.8.8

end
write memory
```

```
hostname Router2
no ip domain-lookup

interface GigabitEthernet0/0
 no shutdown

interface GigabitEthernet0/0.10
 encapsulation dot1Q 10
 ip address 192.168.10.2 255.255.255.0
 standby 10 ip 192.168.10.254
 standby 10 priority 100
 standby 10 preempt
 no shutdown

interface GigabitEthernet0/0.20
 encapsulation dot1Q 20
 ip address 192.168.20.2 255.255.255.0
 standby 20 ip 192.168.20.254
 standby 20 priority 100
 standby 20 preempt
 no shutdown

interface GigabitEthernet0/1
 ip address 10.0.0.2 255.255.255.252
 no shutdown

router ospf 1
 router-id 2.2.2.2
 network 192.168.10.0 0.0.0.255 area 0
 network 192.168.20.0 0.0.0.255 area 0
 network 10.0.0.0 0.0.0.3 area 0

router bgp 65002
 neighbor 10.0.0.1 remote-as 65001

 end
 write memory
```

CLI: Switch1, Switch2, & Wireless Router Configurations

```
hostname Switch1
no ip domain-lookup

vlan 10
 name PC-VLAN

vlan 20
 name WIFI-VLAN

interface GigabitEthernet0/1
 description Uplink to Router1
 switchport mode trunk
 switchport nonegotiate

interface FastEthernet0/1
 description PC1 Connection
 switchport mode access
 switchport access vlan 10

interface FastEthernet0/2
 description WAP Connection
 switchport mode access
 switchport access vlan 20

 end
 write memory
```

```
hostname Switch2
no ip domain-lookup

vlan 10
 name PC-VLAN

vlan 20
 name WIFI-VLAN

interface GigabitEthernet0/1
 description Uplink to Router2
 switchport mode trunk
 switchport nonegotiate

interface FastEthernet0/1
 description PC2 Connection
 switchport mode access
 switchport access vlan 10

end
write memory
```

On the **WRT300N** device (through the GUI):

- Connect **Ethernet1** to **Switch1 Fa0/2**.
- Set Static IP: `192.168.20.10`
- Subnet Mask: `255.255.255.0`
- Gateway: `192.168.20.254`
- DHCP Server: **Disable**
- Wireless Settings:
  - SSID: `OfficeWiFi`
  - WPA2-PSK
  - Passphrase: `office123`

CLI Output Screenshots: Router1 (show commands:ip ospf neighbor, interface brief, standby brief, ip bgp summary, ping)

```
Router1#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     unassigned      YES unset  up                    up
GigabitEthernet0/0.10  192.168.10.1    YES manual up                    up
GigabitEthernet0/0.20  192.168.20.1    YES manual up                    up
GigabitEthernet0/1     10.0.0.1        YES manual up                    up
GigabitEthernet0/2     unassigned      YES unset  administratively down down
Vlan1                  unassigned      YES unset  administratively down down
Router1#
Router1#show standby broef
                       ^
% Invalid input detected at '^' marker.

Router1#show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
Gig         10   110 P Active   local           unknown         192.168.10.254
Gig         20   110 P Active   local           unknown         192.168.20.254
Router1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   FULL/BDR        00:00:31    10.0.0.2        GigabitEthernet0/1
Router1#show ip bgp summary
BGP router identifier 192.168.20.1, local AS number 65001
BGP table version is 1, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.0.2        4 65002      35      37        1    0    0 00:11:13        4

Router1#ping 192.168.10.254

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.254, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/4/10 ms

Router1#
```

CLI Output Screenshots: Router2 (show commands:ip ospf neighbor, interface brief, standby brief, ip bgp summary, ping)

```
ROUTER2>
ROUTER2>show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0     unassigned      YES unset  up                    up
GigabitEthernet0/0.10  unassigned      YES unset  up                    up
GigabitEthernet0/0.20  unassigned      YES unset  up                    up
GigabitEthernet0/1     10.0.0.2        YES manual up                    up
GigabitEthernet0/2     unassigned      YES unset  administratively down down
Vlan1                  unassigned      YES unset  administratively down down
ROUTER2>show standby brief
              ^
% Invalid input detected at '^' marker.

ROUTER2>show standby brief
              ^
% Invalid input detected at '^' marker.

ROUTER2>enable
ROUTER2#show standby brief
                     P indicates configured to preempt.
                     |
Interface   Grp  Pri P State    Active          Standby         Virtual IP
Gig         10   100   Active   local           unknown         192.168.10.254
Gig         20   100 P Active   local           unknown         192.168.20.254
ROUTER2#
ROUTER2#show ip bgp summary
BGP router identifier 10.0.0.2, local AS number 65002
BGP table version is 2, main routing table version 6
0 network entries using 0 bytes of memory
0 path entries using 0 bytes of memory
0/0 BGP path/bestpath attribute entries using 0 bytes of memory
0 BGP AS-PATH entries using 0 bytes of memory
0 BGP route-map cache entries using 0 bytes of memory
0 BGP filter-list cache entries using 0 bytes of memory
Bitfield cache entries: current 1 (at peak 1) using 32 bytes of memory
BGP using 32 total bytes of memory
BGP activity 0/0 prefixes, 0/0 paths, scan interval 60 secs

Neighbor        V    AS MsgRcvd MsgSent   TblVer  InQ OutQ Up/Down  State/PfxRcd
10.0.0.1        4 65001      39      40        2    0    0 00:14:48        4

ROUTER2#ping 192.168.10.254

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.254, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

ROUTER2#
```

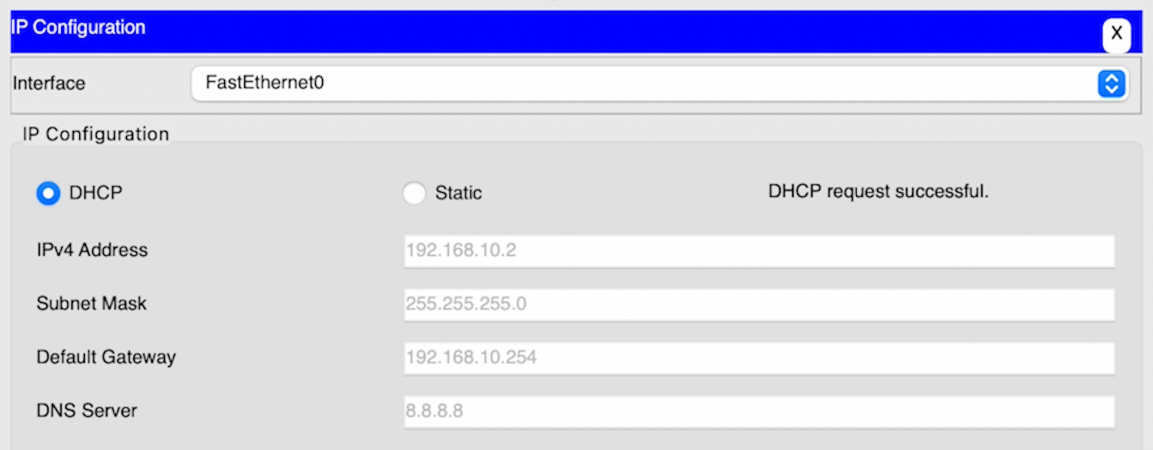
CLI Output Screenshots: Switch1 (show commands: vlan brief, interfaces trunk)

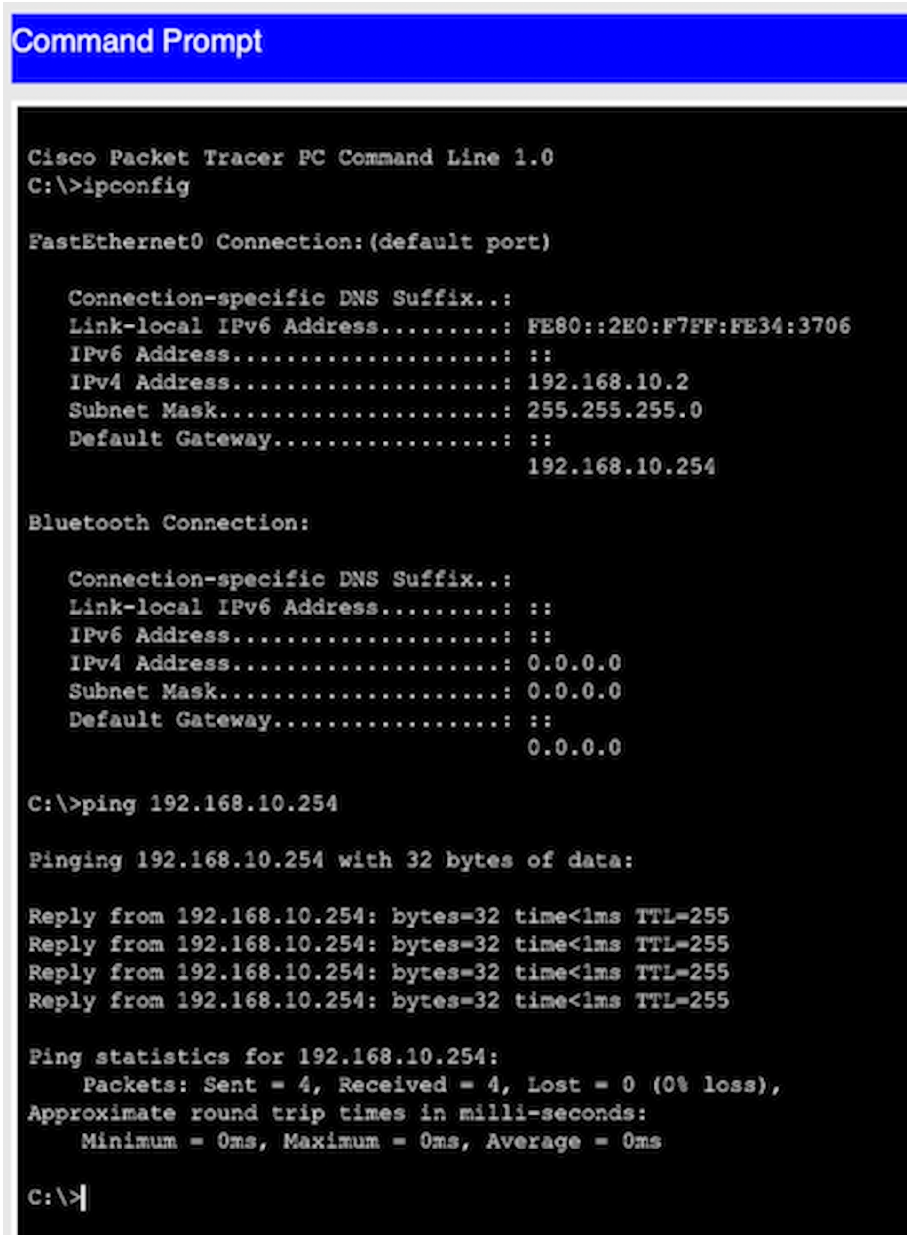
```
Switch1>enable
Switch1#show vlan brief

VLAN Name                                Status    Ports
---- ----------------------------------- --------- -------------------------------
1    default                             active    Fa0/3, Fa0/4, Fa0/5, Fa0/6
                                                   Fa0/7, Fa0/8, Fa0/9, Fa0/10
                                                   Fa0/11, Fa0/12, Fa0/13, Fa0/14
                                                   Fa0/15, Fa0/16, Fa0/17, Fa0/18
                                                   Fa0/19, Fa0/20, Fa0/21, Fa0/22
                                                   Fa0/23, Fa0/24, Gig0/2
10   PC-VLAN                             active    Fa0/1
20   WIFI-VLAN                           active    Fa0/2
1002 fddi-default                        active
1003 token-ring-default                  active
1004 fddinet-default                     active
1005 trnet-default                       active
Switch1#show inerfaces trunk
               ^
% Invalid input detected at '^' marker.

Switch1#show interfaces trunk
Port        Mode         Encapsulation  Status        Native vlan
Gig0/1      on           802.1q         trunking      1

Port        Vlans allowed on trunk
Gig0/1      1-1005

Port        Vlans allowed and active in management domain
Gig0/1      1,10,20

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      1,10,20

Switch1#
```

CLI Output Screenshots: Switch2(show commands: vlan brief, interfaces trunk)

```
Switch2>
Switch2>enable
Switch2#show vlan brief

VLAN Name                                Status    Ports
---- ----------------------------------- --------- -------------------------------
1    default                             active    Fa0/2, Fa0/3, Fa0/4, Fa0/5
                                                   Fa0/6, Fa0/7, Fa0/8, Fa0/9
                                                   Fa0/10, Fa0/11, Fa0/12, Fa0/13
                                                   Fa0/14, Fa0/15, Fa0/16, Fa0/17
                                                   Fa0/18, Fa0/19, Fa0/20, Fa0/21
                                                   Fa0/22, Fa0/23, Fa0/24, Gig0/2
10   PC-VLAN                             active    Fa0/1
20   WIFI-VLAN                           active
1002 fddi-default                        active
1003 token-ring-default                  active
1004 fddinet-default                     active
1005 trnet-default                       active
Switch2#show interfaces brief
                       ^
% Invalid input detected at '^' marker.

Switch2#show interfaces brief
                       ^
% Invalid input detected at '^' marker.

Switch2#show interfaces status
Port      Name               Status       Vlan       Duplex  Speed Type
Fa0/1     PC2                connected    10         auto    auto  10/100BaseTX
Fa0/2                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/3                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/4                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/5                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/6                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/7                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/8                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/9                        notconnect   trunk      auto    auto  10/100BaseTX
Fa0/10                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/11                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/12                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/13                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/14                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/15                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/16                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/17                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/18                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/19                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/20                       notconnect   trunk      auto    auto  10/100BaseTX
Fa0/21                       notconnect   trunk      auto    auto  10/100BaseTX
 --More-- |
```

CLI Output Screenshots: PCs (IP Config & Ping)





Testing & Validation Summary

- ☑ All clients received DHCP addresses correctly
- ☑ HSRP failover was tested — Router2 takes over gateway role
- ☑ OSPF neighbors fully adjacent on Gi0/1 (FULL state)
- ☑ BGP session established between AS 65001 and 65002
- ☑ Inter-VLAN routing between VLAN 10 and VLAN 20, confirmed via ping tests
- ☑ Wireless client authenticated and pinged default gateway

My Approach to Redundancy at Every Layer

In critical network environments, even small outages can cause major operational disruption. I approach redundancy holistically ensuring that links, power, devices, and network paths are all designed to withstand individual failures without service interruption. True infrastructure reliability starts by expecting failure and engineering seamless recovery.

Link Redundancy

- **Multiple Physical Links:** Use of multiple cables between devices
- **EtherChannel / LAG (Link Aggregation Group):** Aggregates multiple physical links into a single logical link for redundancy and increased bandwidth.
- **STP (Spanning Tree Protocol):** Prevents loops in redundant Layer 2 networks by blocking redundant paths unless needed.

Device Redundancy

- **Dual-Homed Devices:** Devices connected to two different upstream switches or routers.
- **Redundant Switches/Routers:** Running parallel hardware for failover (e.g., core switch A and B).

Path Redundancy

- **Multiple Routing Paths:** Dynamic routing protocols (OSPF, EIGRP, BGP) automatically reroute traffic if a link or path goes down. Redundancy between different autonomous systems or ISPs. Ensures reachability through multiple upstream providers

- **MPLS Fast Reroute (FRR):** Rapid reroute of traffic in MPLS networks**.**

    Example from Project: I used OSPF between Router1 and Router2 so that dynamic routes are always up to date. If the peering link or an interface fails, the routing table adjusts automatical**ly.**

    Example from Project: I implemented eBGP between AS 65001 and AS 65002 to simulate external failover, similar to how a production network might maintain multi-provider connectivity.

Protocol and System Redundancy

- **First-Hop Redundancy Protocols (FHRP) – HSRP / VRRP / GLBP:** Default gateway redundancy. Prevents host downtime if the primary router fails.

    Example from Project: In my lab, I used HSRP to provide a shared virtual IP between Router1 and Router2 for both VLAN 10 and VLAN 20. If Router1 fails, Router2 immediately takes over as the active gateway without requiring any changes on client devices.

- **High Availability (HA) Clustering:** Firewall HA (e.g., Active/Standby or Active/Active).

- **Load Balancers:** Redundant pairs to keep web/application traffic flowing.

Power and Hardware Redundancy

- **Redundant Power Supplies (RPS):** For switches, routers, firewalls.

- **UPS and Generators:** For continued power during outages.

- **Dual Power Feeds:** Power from separate circuits.

Site-Level Redundancy

- **Data Center Redundancy:** Active/Active or Active/Standby setups across geographic locations.

- **Cloud Redundancy:** Leveraging multiple regions or availability zones (e.g., AWS Multi-AZ, Zone Redundancy).

WAN and ISP Redundancy

- **Dual ISP Links:** Failover between ISPs using policy-based routing or dynamic protocols.

- **SD-WAN:** Intelligent path selection with automatic failover and performance-based routing.

Server & Application Redundancy

- **Load Balancers:** Distribute traffic across redundant backend servers.

- **Virtualization Redundancy:** VMware HA, Hyper-V clustering.

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