

Networking & IT Infrastructure

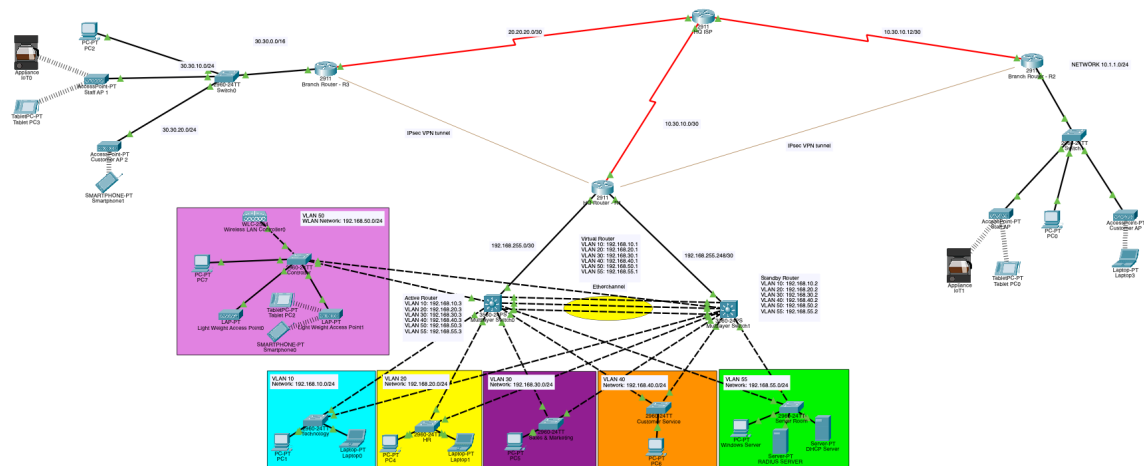
Overview

The network architecture adopts a best-in-class approach by implementing a 3-tier hierarchical design for the headquarters and a relatively simple design for the branches, widely acknowledged as an industrial best practice for creating reliable, scalable, and cost-effective networks (GeeksforGeeks, 2022). This design optimises network performance, facilitates seamless scalability to accommodate future growth, and ensures cost efficiency in network management and maintenance. The hierarchical structure provides a clear separation of functions, enhancing overall network reliability and robustness.

Distribution & Core Layer:

- The network infrastructure is designed with a robust and resilient architecture, featuring a single HQ-router complemented by two multilayer switches for efficient inter-VLAN routing and enhanced redundancy through HSRP configuration. An EtherChannel is implemented between the switches to optimise bandwidth and load balancing, significantly boosting overall network performance. The utilisation of subnets and VLANs in tandem forms a multilayer security approach, strategically addressing vulnerabilities in both Layers 2 and 3.
- To future-proof the network for business growth, subnet selection follows Cisco's addressing guide recommendations, employing VLSM while allowing space for growth /16 and /24 for the HQ and various departments, ensuring scalability. Layer 2 security is prioritised with measures like PortFast, BPDUguard, port security, and auto-trunking disabling to fortify against potential attacks.
- Routing is achieved through OSPF, chosen for its compatibility with heterogeneous networks, as opposed to EIGRP, which is limited to homogeneous networks. WLAN security is bolstered with RADIUS server authentication, providing users with unique username and password combinations for heightened access control. For secure site-to-site connections, IPSec VPNs are implemented.

Network Diagram & Specifications



Subnet Assignment

Location	VLAN	Subnet/Network	Department
Headquarters		192.168.0.0/16	
	10	192.168.10.0/24	Technology
	20	192.168.20.0/24	HR
	30	192.168.30.0/24	Sales & Marketing
	40	192.168.40.0/24	Customer Service
	50	192.168.50.0/24	WLAN
	55	192.168.55.0/24	Server
	99	192.168.99.0/24	Management
Branch 1		10.1.0.0/16	
	10	10.1.10.0/24	Staff
	20	10.1.20.0/24	Customers
Branch 2		30.30.0.0/16	
	10	30.30.10.0/24	Staff
	20	30.30.20.0/24	Customers

Table 2.1: Subnet address range.

MLS1-WAN	192.168.255.0/30
MLS2-WAN	192.168.255.248/30
HQ Router-ISP	10.30.10.0/30
ISP-BRANCH 1	20.20.20.0/30
ISP-BRANCH 2	10.30.10.12/30

Table 2.2: IP network addresses between the interfaces.

IP Addressing Scheme

The devices in the network are assigned the following IP Address range as defined in Table 2.3.

Device Type	Assignable IP Addresses
HQ	
Any wired device in Technology (VLAN 10)	192.168.10.4 to 192.168.10.243
Any wired device in HR (VLAN 20)	192.168.20.4 to 192.168.20.243
Any wired device in Sales(VLAN 30)	192.168.30.4 to 192.168.30.243
Any wired device in Customer Service (VLAN 40)	192.168.40.4 to 192.168.40.243
Any wirelessly connected device (VLAN 50)	192.168.50.4 to 192.168.50.243
Active Directory Windows Server (VLAN 55)	192.168.55.6
DHCP Server (VLAN 55)	192.168.55.4
RADIUS Server (VLAN 55)	192.168.55.5
JEWEL BRANCH	
Any wired or wireless device - Staff (VLAN 10)	10.1.10.2 to 10.1.10.254
Any wireless device - Customers (VLAN 20)	10.1.20.2 to 10.1.20.254
ORCHARD BRANCH	
Any wired or wireless device - Staff (VLAN 10)	30.30.10.2 to 30.30.10.254
Any wireless device - Customers (VLAN 20)	30.30.20.2 to 30.30.20.254

Table 2.3: Allotment of IPv4 addresses for different device types.

System Configurations

HQ - Switches & Routers

Basic Device Configuration (VLAN Creation for HQ switches).

```
Creating VLANs on switches

configure terminal
vlan 10
name Technology
exit
vlan 20
name HR
exit
vlan 30
name Sales
exit
vlan 40
name Cust
exit
vlan 50
name WLAN
exit
vlan 55
name Server
exit
vlan 99
name Management
exit

int range fa0/1-2
switchport mode trunk
exit

int range fa0/3-24
switchport mode access
switchport access vlan 10
exit |
```

Figure 2.1: Sample configuration for VLAN creation and setting up trunk ports on HQ switches.

```

SW-Tech(config)#exit
SW-Tech#
%SYS-5-CONFIG_I: Configured from console by console

SW-Tech#
SW-Tech#sh vlan brief

VLAN Name                Status    Ports
-----
1    default                active    Gig0/1, Gig0/2
10   Technology              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
20   HR                      active
30   Sales                   active
40   Cust                    active
50   WLAN                    active
55   Server                  active
99   Management              active
1002 fddi-default           active
1003 token-ring-default    active
1004 fddinet-default       active
1005 trnet-default         active

SW-Tech#sh ip int
SW-Tech#sh ip interface ?
Vlan      Catalyst Vlan
brief     Brief summary of IP status and configuration
|         Output Modifiers
<cr>

SW-Tech#sh ip interface brief

Interface      IP-Address  OK? Method Status          Protocol
FastEthernet0/1 unassigned  YES manual up              up
FastEthernet0/2 unassigned  YES manual up              up
FastEthernet0/3 unassigned  YES manual up              up
FastEthernet0/4 unassigned  YES manual up              up
FastEthernet0/5 unassigned  YES manual administratively down down
FastEthernet0/6 unassigned  YES manual administratively down down
FastEthernet0/7 unassigned  YES manual administratively down down
FastEthernet0/8 unassigned  YES manual administratively down down
FastEthernet0/9 unassigned  YES manual administratively down down
FastEthernet0/10 unassigned YES manual administratively down down
FastEthernet0/11 unassigned YES manual administratively down down
FastEthernet0/12 unassigned YES manual administratively down down
FastEthernet0/13 unassigned YES manual administratively down down
FastEthernet0/14 unassigned YES manual administratively down down
FastEthernet0/15 unassigned YES manual administratively down down
FastEthernet0/16 unassigned YES manual administratively down down
FastEthernet0/17 unassigned YES manual administratively down down
FastEthernet0/18 unassigned YES manual administratively down down
FastEthernet0/19 unassigned YES manual administratively down down
FastEthernet0/20 unassigned YES manual administratively down down
FastEthernet0/21 unassigned YES manual administratively down down

SW-Tech#

```

☐ Top

Figure 2.2: Verification of VLANs and port allocations and shutdown of unused ports for added security.

```
int vlan 55
ip add 192.168.55.2 255.255.255.0
no shut
standby 55 priority 90
standby 55 ip 192.168.55.1
exit

Config for OSPF
router ospf 25
router-id 1.3.1.3
network 192.168.255.248 0.0.0.3 area 0
network 192.168.10.0 0.0.0.255 area 0
network 192.168.20.0 0.0.0.255 area 0
network 192.168.30.0 0.0.0.255 area 0
network 192.168.40.0 0.0.0.255 area 0
network 192.168.50.0 0.0.0.255 area 0
network 192.168.55.0 0.0.0.255 area 0
```

Figure 2.3: Commands for configuration of MLSs of VLAN interfaces, HSRP & OSPF.

Similar commands execute the VLANs created on the MLSs to the switches i.e:

vlan 10

name Technology

Then, the VLAN interfaces are created, and an IP address is assigned. For HSRP, we put a priority number and then allocate a standby IP address of the virtual router. Following that, we can configure the OSPF routing protocol for the MLSs by advertising the adjacent networks.

MLS1-HQ#sh standby brief							
P indicates configured to preempt.							
Interface	Grp	Pri	P	State	Active	Standby	Virtual IP
Vl10	10	100		Active	local	192.168.10.2	192.168.10.1
Vl20	20	100		Active	local	192.168.20.2	192.168.20.1
Vl30	30	100		Active	local	192.168.30.2	192.168.30.1
Vl40	40	100		Active	local	192.168.40.2	192.168.40.1
Vl50	50	100		Active	local	192.168.50.2	192.168.50.1
Vl55	55	100		Active	local	192.168.55.2	192.168.55.1
MLS1-HQ#							

MLS-HQ2#sh standby brief							
P indicates configured to preempt.							
Interface	Grp	Pri	P	State	Active	Standby	Virtual IP
Vl10	10	90		Standby	192.168.10.3	local	192.168.10.1
Vl20	20	90		Standby	192.168.20.3	local	192.168.20.1
Vl30	30	90		Standby	192.168.30.3	local	192.168.30.1
Vl40	40	90		Standby	192.168.40.3	local	192.168.40.1
Vl50	50	90		Standby	192.168.50.3	local	192.168.50.1
Vl55	55	90		Standby	192.168.55.3	local	192.168.55.1
MLS-HQ2#							

Figure 2.4: MLS1 & MLS2 HSRP verification.

```

router ospf 25
  router-id 1.2.1.2
  log-adjacency-changes
  network 192.168.10.0 0.0.0.255 area 0
  network 192.168.20.0 0.0.0.255 area 0
  network 192.168.30.0 0.0.0.255 area 0
  network 192.168.40.0 0.0.0.255 area 0
  network 192.168.50.0 0.0.0.255 area 0
  network 192.168.55.0 0.0.0.255 area 0
  network 192.168.255.0 0.0.0.3 area 0
!
router rip
!
ip classless
!
MLS1-HQ#

```

```

router ospf 25
  router-id 1.3.1.3
  log-adjacency-changes
  network 10.30.10.8 0.0.0.3 area 0
  network 192.168.10.0 0.0.0.255 area 0
  network 192.168.20.0 0.0.0.255 area 0
  network 192.168.30.0 0.0.0.255 area 0
  network 192.168.40.0 0.0.0.255 area 0
  network 192.168.50.0 0.0.0.255 area 0
  network 192.168.55.0 0.0.0.255 area 0
  network 192.168.255.248 0.0.0.3 area 0
.

```

Figure 2.5: MLS1 & MLS2 ospf verification with 1.2.1.2 & 1.3.1.3 as their respective router-ids

EtherChannel Configuration & Verification

```

Etherchannel Configuration

en
configure terminal
int range fa0/22-24
channel-group 1 mode active

int port-channel 1
switchport mode trunk

```

Figure 2.6: Etherchannel configuration between the multilayer switches.

```

MLS1-HQ#sh etherchannel po
MLS1-HQ#sh etherchannel port-channel ?
<cr>
MLS1-HQ#sh etherchannel port-channel
Channel-group listing:
-----

Group: 1
-----
Port-channels in the group:
-----

Port-channel: Po1      (Primary Aggregator)
-----

Age of the Port-channel   = 00d:02h:57m:13s
Logical slot/port        = 2/1      Number of ports = 3
GC                        = 0x00000000    HotStandBy port = null
Port state                = Port-channel
Protocol                  = LACP
Port Security              = Disabled

Ports in the Port-channel:

Index  Load  Port    EC state    No of bits
-----+-----+-----+-----+-----
0      00    Fa0/22   Active      0
0      00    Fa0/24   Active      0
0      00    Fa0/23   Active      0
Time since last port bundled: 00d:02h:57m:13s  Fa0/23
Group: 2

```

```

MLS-HQ2>en
Password:
MLS-HQ2#sh ether
MLS-HQ2#sh etherchannel por
MLS-HQ2#sh etherchannel port-channel 1
^
% Invalid input detected at '^' marker.

MLS-HQ2#sh etherchannel port-channel
Channel-group listing:
-----

Group: 1
-----
Port-channels in the group:
-----

Port-channel: Po1      (Primary Aggregator)
-----

Age of the Port-channel   = 00d:02h:59m:00s
Logical slot/port        = 2/1      Number of ports = 3
GC                        = 0x00000000    HotStandBy port = null
Port state                = Port-channel
Protocol                  = LACP
Port Security              = Disabled

Ports in the Port-channel:

Index  Load  Port    EC state    No of bits
-----+-----+-----+-----+-----
0      00    Fa0/24   Active      0
0      00    Fa0/23   Active      0
0      00    Fa0/22   Active      0
Time since last port bundled: 00d:02h:59m:00s  Fa0/22
MLS-HQ2#

```

Figure 2.7: Verification of EtherChannel created between the two multilayer switches.

Router OSPF and NAT configuration

```

WAN#sh ip ospf
Routing Process "ospf 25" with ID 1.4.1.4
Supports only single TOS(TOS0) routes
Supports opaque LSA
It is an area border router
SPF schedule delay 5 secs, Hold time between two SPFs 10 secs
Minimum LSA interval 5 secs. Minimum LSA arrival 1 secs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of DCbitless external and opaque AS LSA 0
Number of DoNotAge external and opaque AS LSA 0
Number of areas in this router is 2. 2 normal 0 stub 0 nssa
External flood list length 0
  Area BACKBONE(0)
    Number of interfaces in this area is 3
    Area has no authentication
    SPF algorithm executed 20 times
    Area ranges are
    Number of LSA 14. Checksum Sum 0x07782b
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0
  Area 3
    Number of interfaces in this area is 0
    Area has no authentication
    SPF algorithm executed 3 times
    Area ranges are
    Number of LSA 15. Checksum Sum 0x06b0c4
    Number of opaque link LSA 0. Checksum Sum 0x000000
    Number of DCbitless LSA 0
    Number of indication LSA 0
    Number of DoNotAge LSA 0
    Flood list length 0

WAN#
WAN#
WAN#
WAN#sh ip ospf ne
WAN#sh ip ospf neighbor

Neighbor ID      Pri   State           Dead Time   Address        Interface
1.2.1.2          1     FULL/BDR        00:00:36    192.168.255.2  GigabitEthernet0/0
1.3.1.3          1     FULL/BDR        00:00:37    192.168.255.250 GigabitEthernet0/2
10.30.10.1       0     FULL/-          00:00:33    10.30.10.1     Serial0/0/0
WAN#

```

Figure 2.8: HQ WAN router OSPF verification.

DHCP Pools & Verification

Pool Name	Default Gateway	DNS Server	Start IP Address	Subnet Mask	Max User	TFTP Server	WLC Address
vlan20serverpool	192.168.20.1	0.0.0.0	192.168.20.4	255.255.255.0	240	0.0.0.0	0.0.0.0
vlan50serverpool	192.168.50.1	0.0.0.0	192.168.50.4	255.255.255.0	240	0.0.0.0	0.0.0.0
vlan40serverpool	192.168.40.1	0.0.0.0	192.168.40.4	255.255.255.0	240	0.0.0.0	0.0.0.0
vlan30serverpool	192.168.30.1	0.0.0.0	192.168.30.4	255.255.255.0	240	0.0.0.0	0.0.0.0
vlan10serverpool	192.168.10.1	0.0.0.0	192.168.10.4	255.255.255.0	240	0.0.0.0	0.0.0.0
serverPool	0.0.0.0	0.0.0.0	192.168.55.0	255.255.255.0	512	0.0.0.0	0.0.0.0

Figure 2.9: DHCP pool of IP addresses for leasing for each subnet.

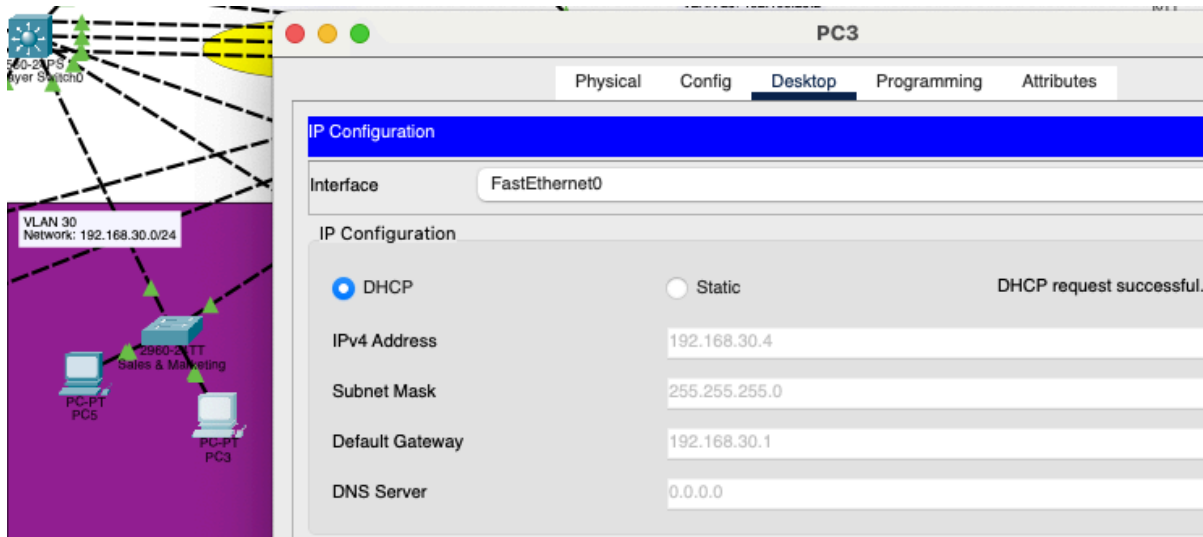
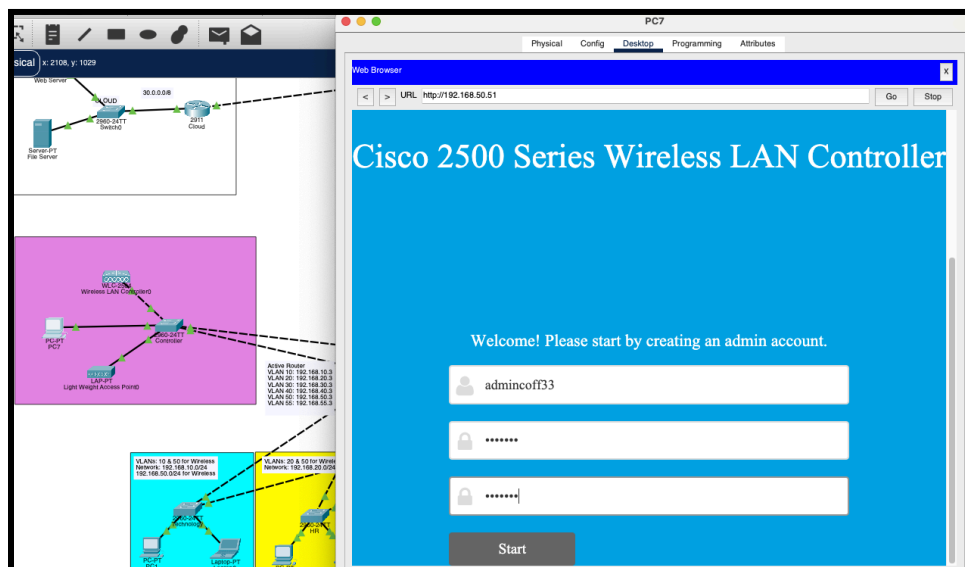
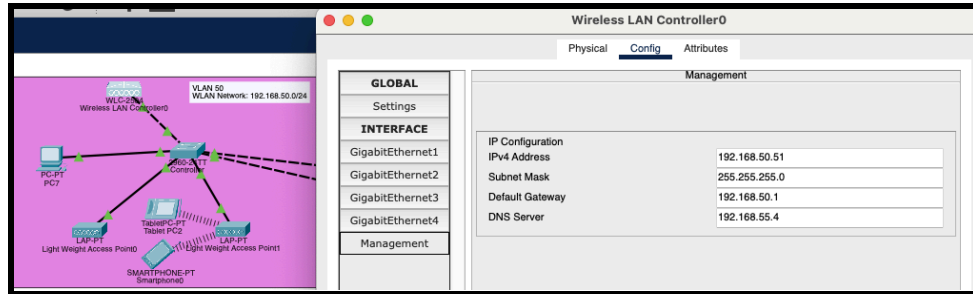


Figure 2.10: Verification and successful assignment of IP address by DHCP server.

WLC Configuration & RADIUS Server Authentication

We have set up a WLC to manage our WLAN, which is also scalable, should additional networks be added. As seen from the screenshots below, there are two access points on the configuration web page and our leading network, 4guyscoffeeOfficeNetwork. WLCs provide an added layer of security to APs by providing authentication at a higher level, detecting rogue devices, and protecting the network behind a firewall. WLCs allow for centralised AP deployment. They simplify network maintenance operations. Also, we included a RADIUS server for authentication, requiring login credentials for staff users in the office HQ to access the wifi network instead of a wired connection.





The bottom image shows the Cisco 2500 Series Wireless LAN Controller setup wizard in a web browser. The URL is <http://192.168.50.51>.

Cisco 2500 Series Wireless LAN Controller

Set Up Your Controller

System Name: WLC

Country: China (CN)

Date & Time: 02/01/2024 19:17:51

Timezone: Tokyo, Osaka, Sapporo

NTP Server: (optional)

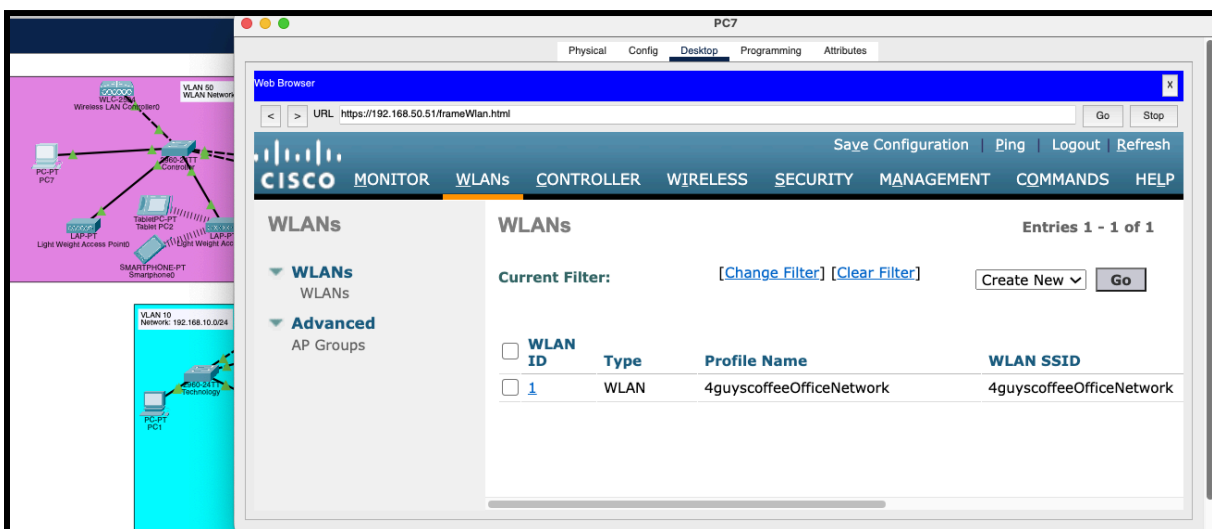
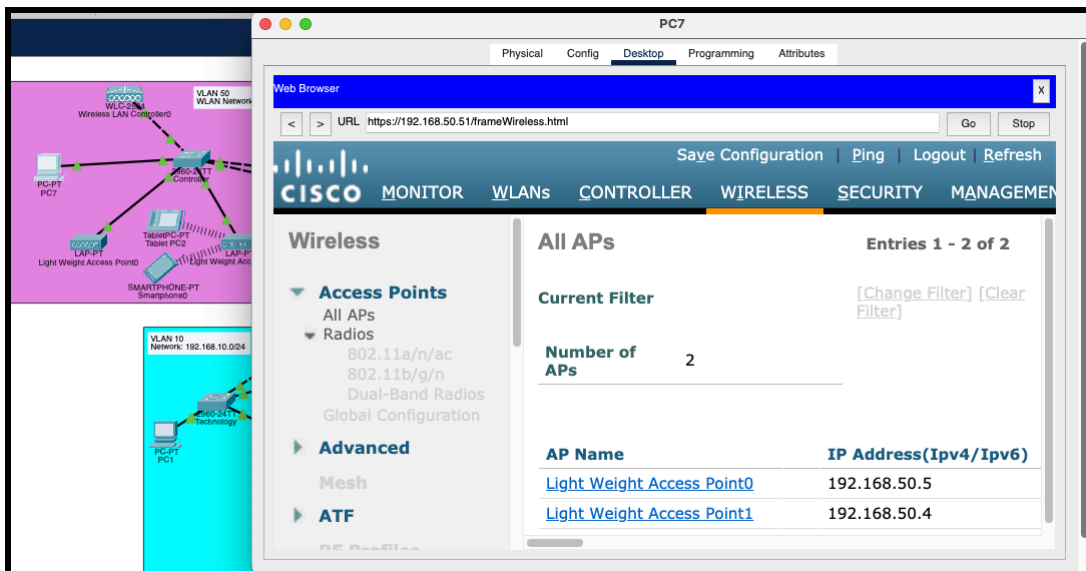
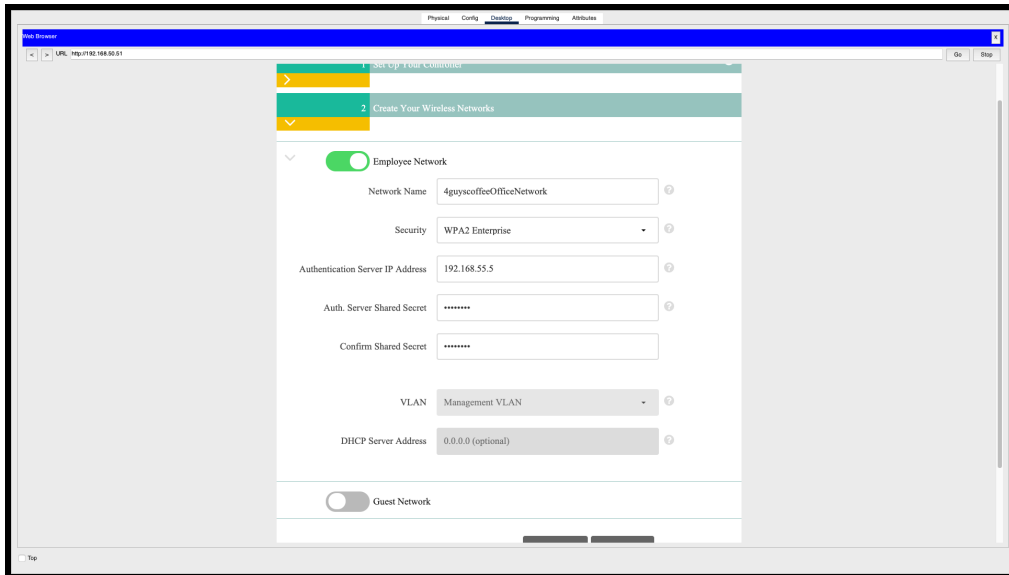
Management IP Address: 192.168.50.51

Subnet Mask: 255.255.255.0

Default Gateway: 192.168.50.1

Management VLAN ID: 0

Back Next



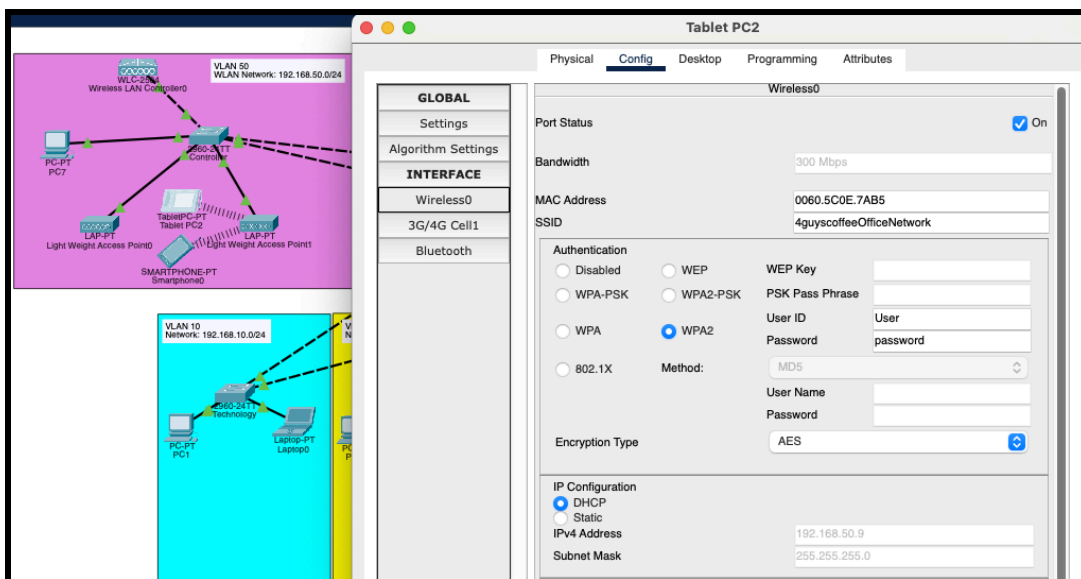
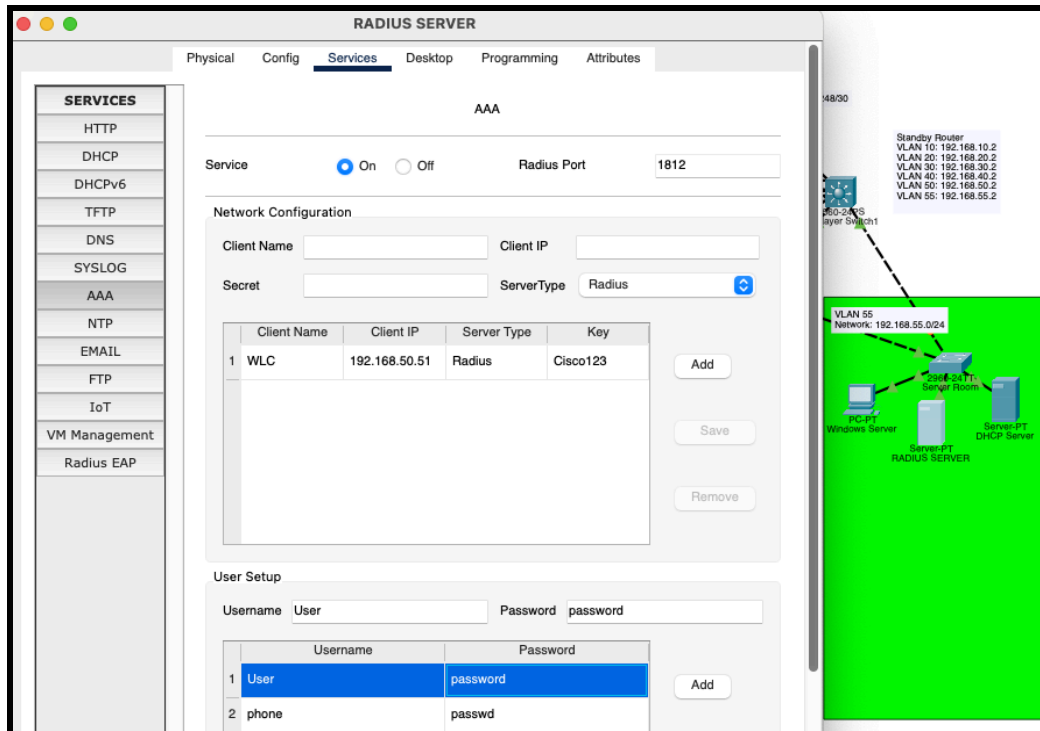


Figure 2.11-2.18: Series of screenshots for WLC and RADIUS server configuration.

Branch - Switches & Routers

Our cafe branches are dine-in cafes with wifi access for customers to use. We have set up the cafe with separate access points, different VLANs, and networks for multilayered security. We used a simple router-on-a-stick topology to facilitate inter-vlan connectivity as it is simple to set up and use SVIs. Both network topology and configurations of the branches are similar.

Switch VLANs

Table 4: VLAN table for the switches in each branch.

VLAN	Name
10	Staff
20	Customers

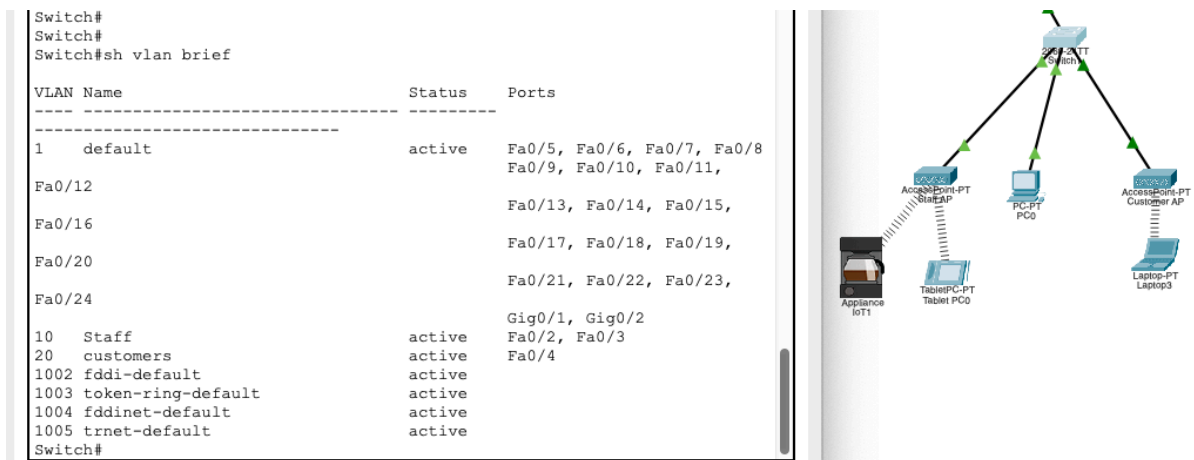


Figure 2.19: Verification of the VLANs on the switches in the branches.

Router

SVIs on Router for Inter-VLAN routing

```
Commands for configuration of SVIs
int gig0/2.10
encapsulation dot1q 10
ip add 10.1.10.1 255.255.255.0
exit
```

Figure 2.20: Configuration commands for SVIs on Router.

Branch Router - R2				
R2Branch#sh ip interface brief				
Interface	IP-Address	OK?	Method	Status
GigabitEthernet0/0	unassigned	YES	NVRAM	administratively down
GigabitEthernet0/1	unassigned	YES	manual	administratively down
GigabitEthernet0/2	unassigned	YES	NVRAM	up
GigabitEthernet0/2.10	10.1.10.1	YES	manual	up
GigabitEthernet0/2.20	10.1.20.1	YES	manual	up
Serial0/0/0	10.30.10.14	YES	NVRAM	up
Serial0/0/1	unassigned	YES	NVRAM	down
Vlan1	unassigned	YES	unset	administratively down
R2Branch#				

Figure 2.21: SVIs verification for branch router.

Router as DHCP

As it would be expensive to have a dedicated DHCP server for every branch, we have also configured the router branch to be a DHCP server.

```
Router DHCP configuration
ip dhcp pool 1
network 10.1.10.0 255.255.255.0
default-router 10.1.10.1
exit
ip dhcp excluded-address 10.1.10.1
ip dhcp pool 2
network 10.1.20.0 255.255.255.0
default-router 10.1.20.1
exit
ip dhcp excluded-address 10.1.20.1
```

Figure 2.22: Configuring branch router as DHCP server.

```
Branch Router - R2
Physical Config CLI Attributes
IOS Command Line Interface

more      Display the contents of a file
no        Disable debugging informations
ping      Send echo messages
reload    Halt and perform a cold restart

R2Branch#sh ip dhcp pool

Pool AA :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses : 511
Leased addresses : 0
Excluded addresses : 3
Pending event : none

0 subnet is currently in the pool

Pool BRANCH :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses : 254
Leased addresses : 0
Excluded addresses : 3
Pending event : none

1 subnet is currently in the pool
Current index IP address range Leased/Excluded/Total
10.1.1.1 10.1.1.1 - 10.1.1.254 0 / 3 / 254

Pool 1 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses : 254
Leased addresses : 3
Excluded addresses : 3
Pending event : none

1 subnet is currently in the pool
Current index IP address range Leased/Excluded/Total
10.1.10.1 10.1.10.1 - 10.1.10.254 3 / 3 / 254

Pool 2 :
Utilization mark (high/low) : 100 / 0
Subnet size (first/next) : 0 / 0
Total addresses : 254
Leased addresses : 1
Excluded addresses : 3
Pending event : none

1 subnet is currently in the pool
Current index IP address range Leased/Excluded/Total
10.1.20.1 10.1.20.1 - 10.1.20.254 1 / 3 / 254
R2Branch#
```

Figure 2.23: Router DHCP verification.

Router OSPF verification

```
R2Branch#sh ip ospf database
OSPF Router with ID (10.30.10.12) (Process ID 25)

Router Link States (Area 0)

Link ID      ADV Router   Age         Seq#         Checksum Link count
10.30.10.12  10.30.10.12  382        0x8000000d  0x00bb7d  4
10.30.10.1   10.30.10.1   385        0x8000000f  0x006bcf  6
20.20.20.1   20.20.20.1   384        0x8000000d  0x00e5f7  4
1.4.1.4      1.4.1.4      353        0x80000010  0x00bb94  4
1.3.1.3      1.3.1.3      344        0x80000017  0x00560b  7
1.2.1.2      1.2.1.2      341        0x80000017  0x002031  7

Net Link States (Area 0)

Link ID      ADV Router   Age         Seq#         Checksum
192.168.55.2 1.3.1.3     354        0x80000029  0x005229
192.168.255.1 1.4.1.4     353        0x80000011  0x00efd7
192.168.255.249 1.4.1.4    353        0x80000012  0x003e8d
192.168.50.2  1.3.1.3     349        0x8000002a  0x0087f7
192.168.20.2  1.3.1.3     349        0x8000002b  0x00d0cb
192.168.10.2  1.3.1.3     349        0x8000002c  0x003d68
192.168.40.3  1.2.1.2     346        0x80000009  0x003477
192.168.30.2  1.3.1.3     344        0x8000002d  0x005e32
R2Branch#
```

Figure 2.24: OSPF database of branch router.

Access Points Configuration

We made use of WPA2-PSK for security encryption for both staff and customer use at each access point.

The figure displays two screenshots of access point configuration interfaces, one for a 'Staff AP' and one for a 'Customer AP'. Both interfaces show the 'Config' tab for 'Port 1'.

Staff AP Configuration:

- Port Status:** On (checked)
- SSID:** 4guyscoffeeCafe
- 2.4 GHz Channel:** 6
- Coverage Range (meters):** 140.00
- Authentication:** WPA2-PSK (selected)
- WEP Key:** (empty)
- PSK Pass Phrase:** 4gcoffee
- User ID:** (empty)
- Password:** (empty)
- Encryption Type:** AES

Customer AP Configuration:

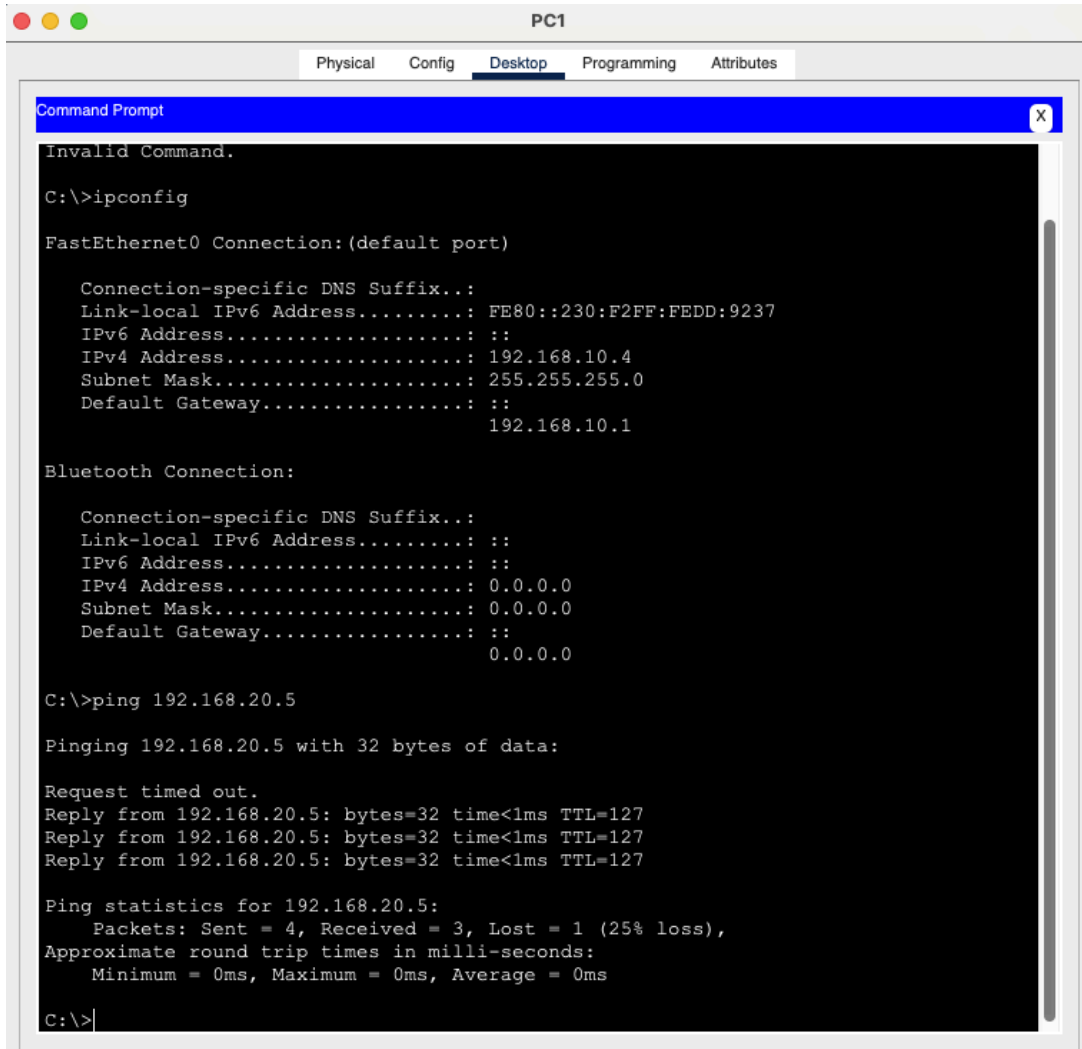
- Port Status:** On (checked)
- SSID:** 4GUYSOFFEEGUEST
- 2.4 GHz Channel:** 6
- Coverage Range (meters):** 140.00
- Authentication:** WPA2-PSK (selected)
- WEP Key:** (empty)
- PSK Pass Phrase:** guest123
- User ID:** (empty)
- Password:** (empty)
- Encryption Type:** AES

Figure 2.25-2.26: APs configuration for branch cafes with WPA2-passkey.

Connectivity

Connectivity between different VLANs

HQ LAN



The screenshot shows a PC1 window with tabs for Physical, Config, Desktop, Programming, and Attributes. The Desktop tab is active, displaying a Command Prompt window. The Command Prompt shows the output of the 'ipconfig' command for FastEthernet0 and Bluetooth connections. The FastEthernet0 connection shows an IPv4 address of 192.168.10.4 and a default gateway of 192.168.10.1. The Bluetooth connection shows an IPv4 address of 0.0.0.0. The Command Prompt also shows the output of the 'ping 192.168.20.5' command, which results in a 25% loss of packets (1 out of 4 sent).

```
PC1
Physical Config Desktop Programming Attributes
Command Prompt
Invalid Command.
C:\>ipconfig

FastEthernet0 Connection: (default port)

    Connection-specific DNS Suffix...:
    Link-local IPv6 Address . . . . .: FE80::230:F2FF:FEDD:9237
    IPv6 Address . . . . .: ::
    IPv4 Address . . . . .: 192.168.10.4
    Subnet Mask . . . . .: 255.255.255.0
    Default Gateway . . . . .: ::
                                   192.168.10.1

Bluetooth Connection:

    Connection-specific DNS Suffix...:
    Link-local IPv6 Address . . . . .: ::
    IPv6 Address . . . . .: ::
    IPv4 Address . . . . .: 0.0.0.0
    Subnet Mask . . . . .: 0.0.0.0
    Default Gateway . . . . .: ::
                                   0.0.0.0

C:\>ping 192.168.20.5

Pinging 192.168.20.5 with 32 bytes of data:

Request timed out.
Reply from 192.168.20.5: bytes=32 time<1ms TTL=127
Reply from 192.168.20.5: bytes=32 time<1ms TTL=127
Reply from 192.168.20.5: bytes=32 time<1ms TTL=127

Ping statistics for 192.168.20.5:
    Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>
```

Figure 2.27: Pinging from a PC in Technology, VLAN 10 to a PC in HR, VLAN 20.

Branch LAN

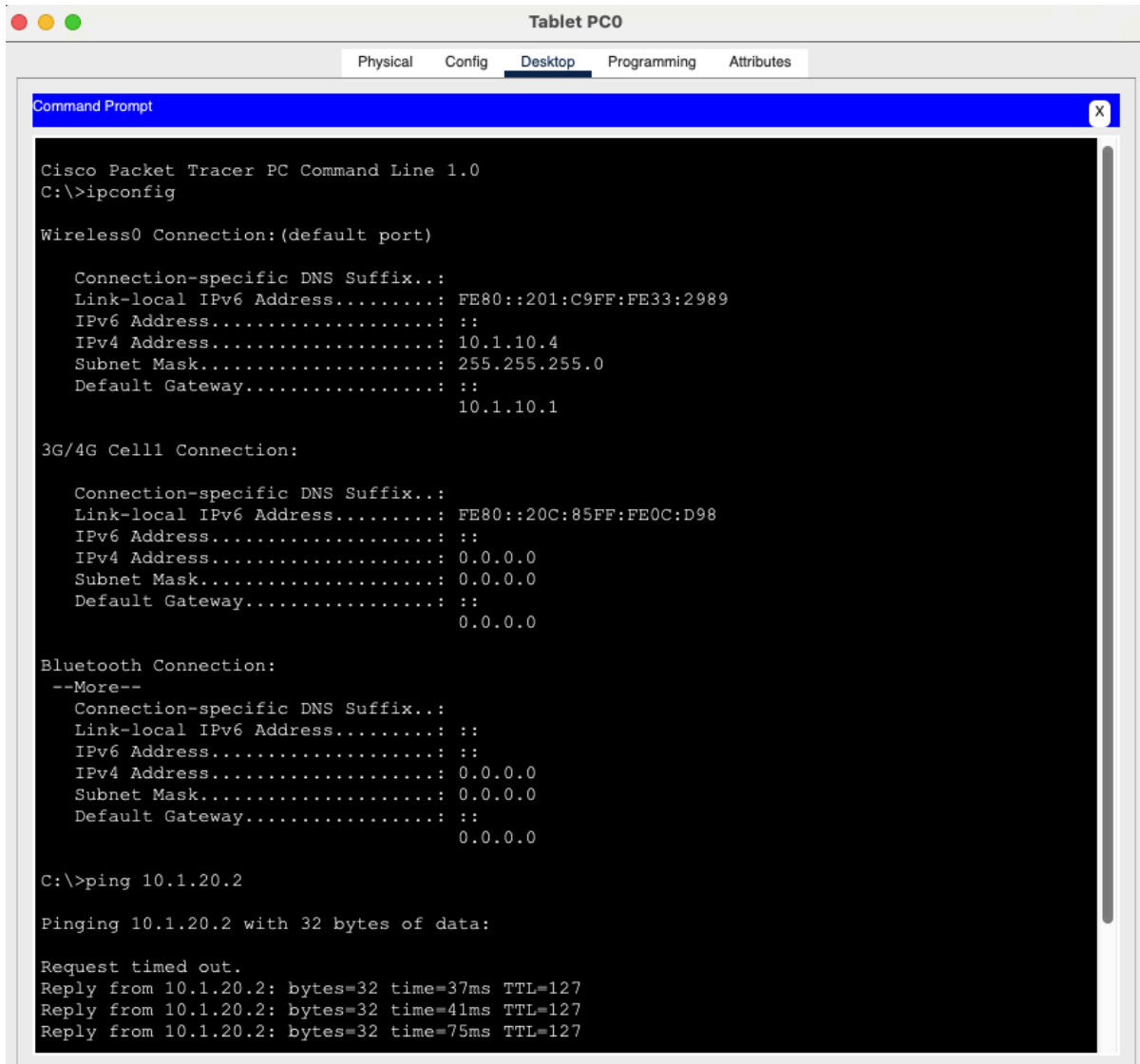


Figure 2.28: Pinging from a tablet connected to the staff AP, VLAN 10, to a customer laptop connected to the customer AP, VLAN 20.

Connectivity across LANs

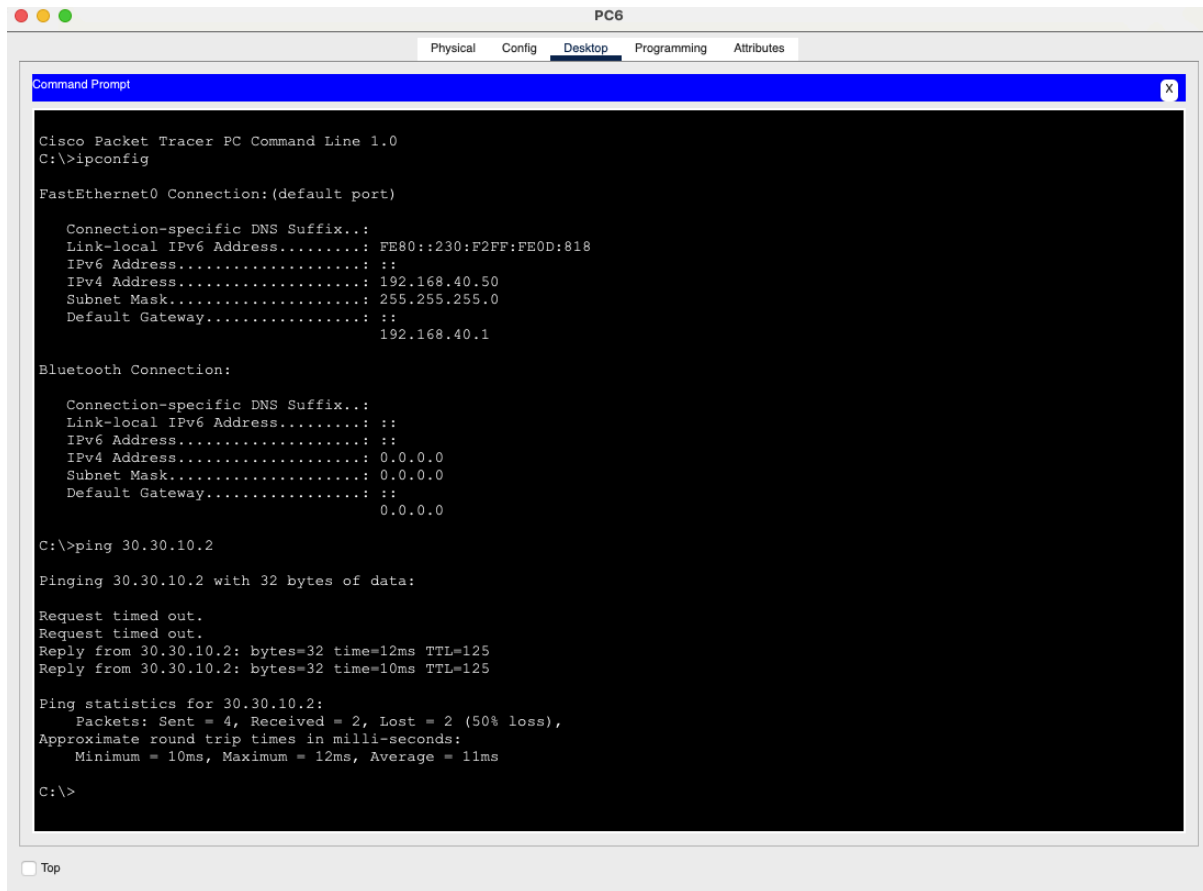


Figure 2.29: Pinging from HQ to Orchard Branch's PC.

Site-to-site VPN

Configuration of VPN

VPN Configuration

Step 1: Check if they have the security package installed in one of the geographical routers:
show version

Step 2: Install the package if it shows disabled
license boot module c2900 technology-package securityk9

Step 3: Create an extended access list to permit traffic to the specific interface of the branch.
access-list 100 permit ip 192.168.0.0 0.0.255.255 10.1.0.0 0.0.255.255

Step 4: Create the IPsec tunnel and bind to interface
crypto isakmp policy 10
encryption aes 256
authentication pre-share
group 5
exit
crypto isakmp key vpn address 10.30.10.14
crypto ipsec transform-set VPN-P2 esp-aes esp-sha-hmac
crypto map VPN-MAP 10 ipsec-isakmp
description VPN connection to R3
set peer 10.30.10.14
set transform-set VPN-P2
match address 100
exit
interface se0/0/0
crypto map VPN-MAP

Step 5: Repeat for the other branch router.

Figure 2.30: VPN tunnel configuration between 2 sites.

Technology Package License Information for Module:'c2900'

Technology	Technology-package Current	Type	Technology-package Next reboot
ipbase	ipbasek9	Permanent	ipbasek9
security	securityk9	Evaluation	securityk9
uc	disable	None	None
data	disable	None	None

Configuration register is 0x2102

WAN#

Figure 2.31: Security package installed - 'Evaluation'.

```
WAN#show ac
WAN#show access-lists
Extended IP access list 100
  10 permit ip 192.168.0.0 0.0.255.255 10.1.0.0 0.0.255.255
Extended IP access list 150
  10 permit ip 192.168.0.0 0.0.255.255 30.30.0.0 0.0.255.255 (1 match(es))
WAN#
```

Figure 2.32: Access List verification for VPN.

VPN verification

```
WAN#
WAN#
WAN#
WAN#sh cry
WAN#sh crypto ipsec sa

interface: Serial0/0/0
  Crypto map tag: VPN-MAP2, local addr 10.30.10.2

protected vrf: (none)
local  ident (addr/mask/prot/port): (192.168.0.0/255.255.0.0/0/0)
remote  ident (addr/mask/prot/port): (30.30.0.0/255.255.0.0/0/0)
current_peer 20.20.20.1 port 500
  PERMIT, flags={origin_is_acl,}
#pkts encaps: 11, #pkts encrypt: 11, #pkts digest: 0
#pkts decaps: 9, #pkts decrypt: 9, #pkts verify: 0
#pkts compressed: 0, #pkts decompressed: 0
#pkts not compressed: 0, #pkts compr. failed: 0
#pkts not decompressed: 0, #pkts decompress failed: 0
#send errors 1, #recv errors 0

local crypto endpt.: 10.30.10.2, remote crypto endpt.:20.20.20.1
path mtu 1500, ip mtu 1500, ip mtu idb Serial0/0/0
current outbound spi: 0xEE5B9B9C(3998981020)

inbound esp sas:
  spi: 0xBE16AC84(3189156996)
  transform: esp-aes esp-sha-hmac ,
  in use settings ={Tunnel, }
  conn id: 2000, flow_id: FPGA:1, crypto map: VPN-MAP2
  sa timing: remaining key lifetime (k/sec): (4525504/2619)
  IV size: 16 bytes
  replay detection support: N
  Status: ACTIVE

inbound ah sas:

inbound pcp sas:

outbound esp sas:
  spi: 0xEE5B9B9C(3998981020)
  transform: esp-aes esp-sha-hmac ,
  in use settings ={Tunnel, }
  conn id: 2001, flow_id: FPGA:1, crypto map: VPN-MAP2
  sa timing: remaining key lifetime (k/sec): (4525504/2619)
  IV size: 16 bytes
  replay detection support: N
  Status: ACTIVE

outbound ah sas:

outbound pcp sas:
```

Figure 2.33: Verification that a tunnel has been formed between the two sites and packets are encrypted after a successful ping.

Summary

Our network infrastructure utilises a 3-tier hierarchical design for the headquarters and a simpler design for our branch cafes. This tiered approach ensures reliability, scalability, and cost-effectiveness. The core network features a single HQ router, two multilayer switches for VLAN routing and redundancy, and an EtherChannel for optimised bandwidth. We leverage subnets and VLANs to create a multilayered security approach and have implemented OSPF routing for increased network flexibility. To accommodate future growth, we have adopted VLSM with /16 and /24 subnetting for the headquarters and departments. Additionally, we prioritise Layer 2 security with PortFast, BPDUguard, port security, and auto-trunking disabled.

For our WLAN, we utilise a WLC for centralised management, scalability, and enhanced security. The WLC authenticates users with a RADIUS server, requiring login credentials for staff accessing our 4guyscoffeeOfficeNetwork. Secure site-to-site communication is facilitated through IPSec VPNs. Our branch cafes each have a separate router-on-a-stick topology for inter-VLAN connectivity and utilise separate VLANs and networks to provide secure customer Wi-Fi access.