2025

Network Design for StocksUK.

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Contents

Abstract

This project presented the design and implementation of a secure, scalable, and cost-effective WAN for StocksUK, supporting multiple sites in Manchester and London with both wired and wireless connectivity.

A redundant mesh topology was implemented to improve fault tolerance, with OSPF providing efficient and dynamic routing.

LANs were segmented using VLANs to enhance security, reduce broadcast traffic, and improve performance.

Centralised on-premises services, including DHCP and DNS, were deployed to simplify management and reduce operational costs, while SSH secured administrative access.

Overall, the network met the organisation's requirements and fulfilled all project objectives.

Introduction

StocksUK is a trading company that analyses and stores market data and requires a *secure*, *cost-effective* network to support locations in **Manchester** and **London**. Each city has **two offices**, each containing **ten workspaces**. A factory in the Manchester region will also be used for crypto mining.

Each workspace provides both **wired** and **wireless** connectivity. The Manchester factory follows the same design for consistency, with *wired connections used by default for improved security*. Wireless connectivity can be enabled if required.

Aim and Objectives

Aim:

To design a functional WAN that enables communication between all locations and sites. A mesh topology is planned to provide core redundancy while remaining cost-effective. The design will use a maximum of four routers for the mesh WAN, with each office sharing VLAN connections from Layer 3 switches, limited to two of these switches in total.

Objectives:

1. Develop an IP addressing plan using CIDR.
2. Develop routing table for WAN.
3. Develop password plan for network devices.
4. Configure SSH for each core network device.
5. Create suitable VLAN connections.
6. Enable DNS for company site.
7. Configure OSPF routing.
8. Configure DHCP for each location.

Network Design

Network Plan

Network Equipment Plan:

	Count	Purpose	Why
2811 Router	4	Serves a redundant WAN Connection	If a connection breaks, packets will still have a route to travel. Very important for stock data. Additionally, accepts 4 serial connections and 2 Fast Ethernet connections; perfect amount for WAN design.
3650 Multilayer Switch	2	Trunks VLAN connections to each site	Easier to distribute VLAN; very scalable for additional VLAN connections.
DNS Server	1	Hosts a DNS connection for both locations	Any new offices added to network can easily be hosted same DNS; scalable. Used to provide StocksUK their web IP.
DHCP Server	2	Hosts DHCP IP for each individual end-device at each location	IP configuration is quicker and easier; time-effective in the case of company upsize.
2960 Swich	7	Distributes wired connections to all end-devices on each site	Office PCs and Servers can connect to a single switch, which saves cost on additional network devices. Additionally, accepts 24 Fast Ethernet connections; enough ports available for needed wired connections.
Access Point	5	Allows for end-devices to connect wirelessly on each site	Allows for employees to use devices wirelessly.

Figure 1: Network Equipment Plan

This network plan defines the entire WAN and all LANs.
Servers are hosted on-premises rather than through the cloud to avoid unnecessary recurring costs associated with cloud services. Since the servers only provide internal services such as DHCP and DNS, cloud or internet-based hosting is not required. Hosting these services locally is therefore the most efficient and cost-effective solution for this network design.

Please refer to Figure 8 to see network equipment.

Client Equipment Plan:

	Count	Use
PC	60	50 wired PCs for employees (10 per site). 10 wireless PCs (2 per site) for illustration with wireless connectivity.
Tablet	1	Tablet connection illustrates Access Point works with tablets wirelessly.
Smartphone	1	Smartphone connection illustrates Access Point works with smartphones wirelessly.
Laptop	1	Laptop connection illustrates Access Point works with laptops wirelessly.

Figure 2: Client Equipment Plan

Client equipment was kept consistent across all sites while meeting StocksUK's requirements. Multiple devices were shown connected to the access point to demonstrate correct functionality. Figure 3 illustrates a typical office layout, where each desk would realistically include at least one portable device capable of wireless connection.

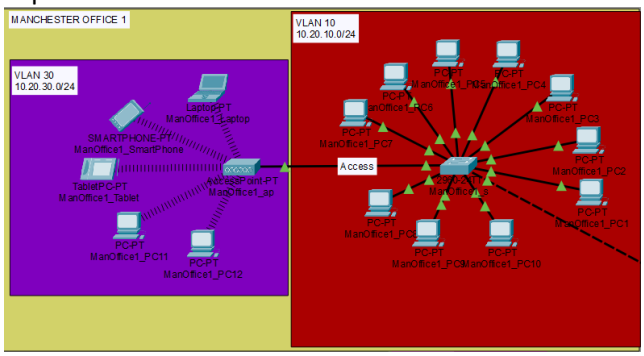

Figure 3:Client Design

IP Addressing plan:

Router	Interface	IP Address	Subnet Mask	Description
Manchester	Se0/1/0	10.0.0.9	255.255.255.252	Connect to London Router
Manchester	Se0/3/0	10.0.0.1	255.255.255.252	Connect to DNS Router
Manchester	Se0/0/0	10.0.0.5	255.255.255.252	Connect to Central Router
Manchester	Fa0/1	10.0.0.45	255.255.255.252	Connect to Manchester Switch
London	Se0/1/0	10.0.0.10	255.255.255.252	Connect to Manchester Router
London	Se0/2/0	10.0.0.25	255.255.255.252	Connect to Central Router
London	Se0/3/0	10.0.0.17	255.255.255.252	Connect to DNS Router
London	Fa0/1	10.0.0.57	255.255.255.252	Connect to London Switch
Central	Se0/0/0	10.0.0.6	255.255.255.252	Connect to Manchester Router
Central	Se0/2/0	10.0.0.26	255.255.255.252	Connect to London Router
Central	Se0/3/0	10.0.0.29	255.255.255.252	Connect to DNS Router
Central	Fa0/0	10.0.0.41	255.255.255.252	Connect to Manchester Switch
Central	Fa0/1	10.0.0.13	255.255.255.252	Connect to London Switch
DNS	Se0/0/0	10.0.0.2	255.255.255.252	Connect to Manchester Router
DNS	Se0/1/0	10.0.0.18	255.255.255.252	Connect to London Router
DNS	Se0/2/0	10.0.0.30	255.255.255.252	Connect to Central Router
DNS	Fa0/0	10.0.1.1	255.255.255.0	Connect to DNS Server

Figure 4: IP Addressing Plan for WAN Routers

L3 Switch	Interface	IP Address	Subnet Mask	Description
Manchester	Gig1/0/3	10.0.0.46	255.255.255.252	Connect to Manchester Router
Manchester	Gig1/0/4	10.0.0.42	255.255.255.252	Connect to Central Router
London	Gig1/0/3	10.0.0.58	255.255.252	Connect to London Router
London	Gig1/0/2	10.0.0.14	255.255.252	Connect to Central Router

Figure 5: IP Addressing Plan for WAN L3 Switches

CIDR /30 subnets were used for all point-to-point connections, as each link only required two host addresses. This improves WAN scalability by increasing available network bits and enhances efficiency and security by fully utilising all available host addresses.

VLAN addressing plan:

London Addressing Plan	VLAN	IP ADDRESS
London Office 1	10	10.10.10.0/24
London Office 1 AP	30	10.10.30.0/24
London Office 2	20	10.10.20.0/24
London Office 2 AP	40	10.10.40.0/24
London DHCP Server	50	10.10.50.0/24

Figure 6: London VLAN Addressing Plan

In the London network, five VLANs are configured within the **10.10.0.0** subnet. Each VLAN uses a /24 (Class C) CIDR subnet, which is more than required for the number of employees.

I considered using a /28 subnet to better match the user count and increase the number of available networks per location. However, I chose to keep the VLAN addressing scheme simple and instead used the DHCP server to limit each VLAN to 20 users. If StocksUK expands and requires network growth, transitioning to a /28 subnet would be a straightforward upgrade.

NOTE: I chose a limit of 20 for users on each VLAN to account for possible company upsize.

Manchester Addressing Plan	VLAN	IP ADDRESS
Manchester Office 1	10	10.20.10.0/24
Manchester Office 1 AP	30	10.20.30.0/24
Manchester Office 2	20	10.20.20.0/24
Manchester Office 2 AP	40	10.20.40.0/24
Manchester Factory	60	10.20.60.0/24
Manchester Factory AP	70	10.20.70.0/24
Manchester DHCP Server	50	10.20.50.0/24

Figure 7: Manchester VLAN Addressing Plan

I used the same approach for the Manchester sites as London, but on the **10.20.0.0** subnet. This also accounts for the factory, which adds two additional VLANs to the Manchester branch. As with London, each VLAN supports a maximum of 20 users.

DHCP was chosen to enable dynamic IP addressing and to limit the number of users per VLAN. Connecting the server to the Layer 3 switch allows it to be located independently from the sites while remaining accessible on the network and enables easy distribution of VLAN connections.

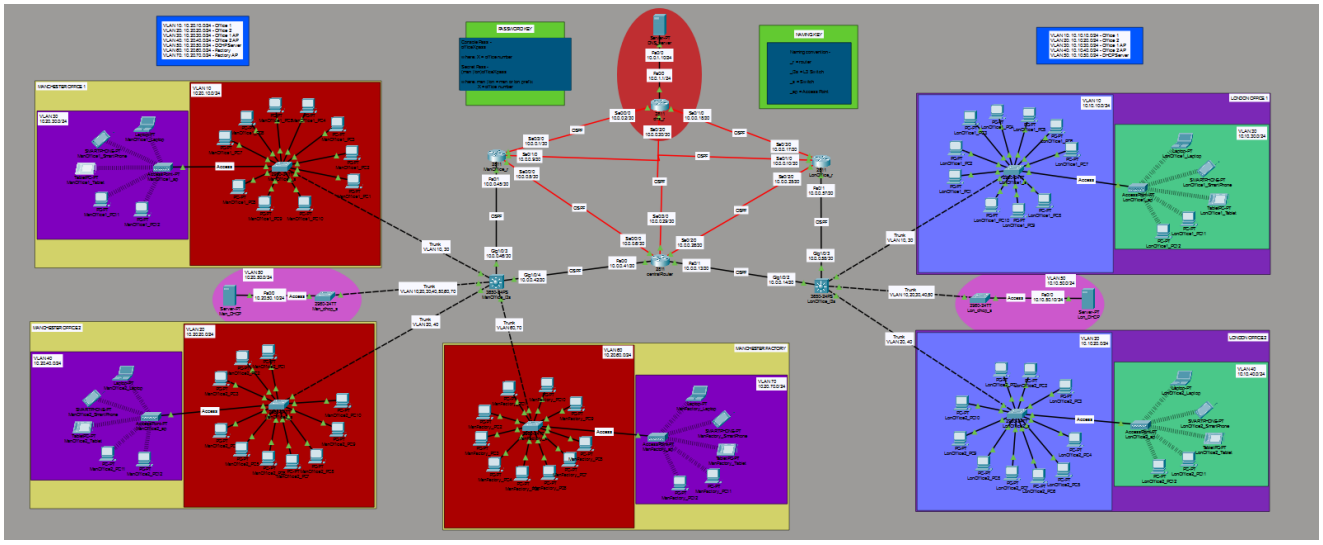

Figure 8: Complete Network Design

Figure 8 presents the complete network design for StocksUK, featuring a redundant WAN that allows packets to reroute if a router fails. This ensures reliable data delivery, which is critical for StocksUK. TCP is used to guarantee data integrity, as packets are reassembled using sequence numbers and retransmitted if lost, unlike UDP.

The design includes five sites; each divided into wired and wireless VLANs. Each site shares a DHCP server

that dynamically assigns IP addresses, with the third octet segmented by VLAN. A central DNS server serves all locations by broadcasting a web IP, enabling web access across the network. The router connected to the DHCP server uses a /24 CIDR interface to support high traffic volumes and many hosts.

Network Configuration

DHCP Configuration

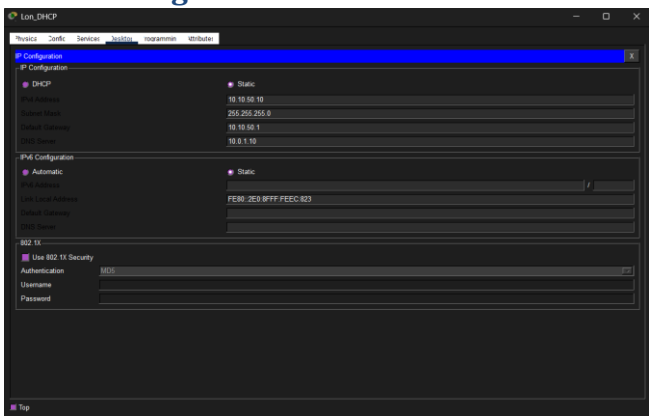

Figure 9: London DHCP IP Configuration

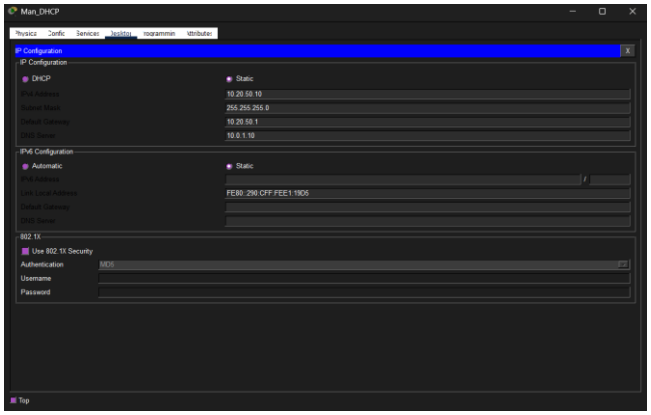

Figure 10: Manchester DHCP IP Configuration

Figure 9 shows the static IP configuration of **10.10.50.10** for London's DHCP server. The address is structured as follows:

- **First octet (10):** Identifies the WAN
- **Second octet (10):** Identifies the London sites
- **Third octet (50):** Identifies the DHCP server VLAN
- **Fourth octet (10):** Identifies the server host address

Also shown in Figure 9, London uses the DNS server, which it accesses by specifying the gateway to the DNS server: **10.0.1.10**.
Finally, end-devices in London access this DHCP server by accessing its default gateway, which I have specified to be: **10.10.50.1**.

Figure 10 shows the exact same configuration as done on the London DHCP server, however for the second octet in its IP it uses **20**, which specifies the Manchester area.

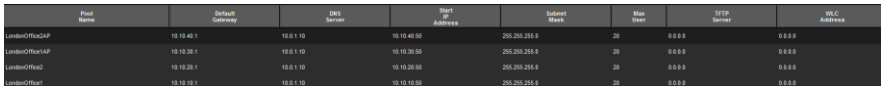

Figure 11: London DHCP Services

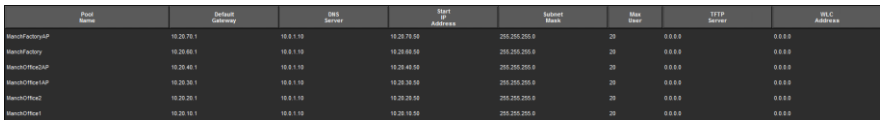

Figure 12: Manchester DHCP Services

Figure 11 and Figure 12 show how I created services in each DHCP server to dynamically host a different IP address based on the VLAN the area would be connected to. I did this by matching the third octet of the hosted IP to the VLAN number in the location.

E.g. Manchester Factory has VLAN of 60, DHCP hosts IP 10.20.60.1 to this service, and starts at the 50th address, because that's what I specified.

The above figures also show how I configured the max users to be 20 for each service.

DNS Configuration

Figure 13: DNS IP Configuration

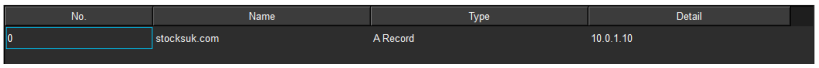

Figure 14: DNS Services

I configured a service in the DNS server which generates an A record DNS 'stocksuk.com', which uses the IP address 10.0.1.10 under-the-hood. See Figure 14. I referred to: *https://medium.com/@z6157881/configure-dns-server-on-cisco-packet tracer-e7c412b3b3dd*, to correctly implement DNS.

I also configured the gateway which accepts data from the connected routers interface **10.0.1.1**.

VLAN Configuration

```
Man_DHCP_Switch(config-if)#exit
Man_DHCP_Switch(config)#vlan 50
Man_DHCP_Switch(config-vlan)#name ManServer_DHCP
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#int fa0/1
Man_DHCP_Switch(config-if)#switchport mode access
Man_DHCP_Switch(config-if)#switchport access vlan 50
Man_DHCP_Switch(config-if)#no shut
Man_DHCP_Switch(config-if)#exit
Man_DHCP_Switch(config)#vlan 10
Man_DHCP_Switch(config-vlan)#name ManOffice1
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#vlan 20
Man_DHCP_Switch(config-vlan)#name ManOffice2
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#vlan 30
Man_DHCP_Switch(config-vlan)#name ManOffice1_AP
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#vlan 40
Man_DHCP_Switch(config-vlan)#name ManOffice2_AP
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#vlan 60
Man_DHCP_Switch(config-vlan)#name ManFactory
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#vlan 70
Man_DHCP_Switch(config-vlan)#name ManFactory_AP
Man_DHCP_Switch(config-vlan)#exit
Man_DHCP_Switch(config)#int gig0/1
Man_DHCP_Switch(config-if)#switchport mode trunk
Man_DHCP_Switch(config-if)#switchport trunk allowed vlan 10,20,30,40,50,60,70
Man_DHCP_Switch(config-if)#no shut
Man_DHCP_Switch(config-if)#exit
Man_DHCP_Switch(config)#
```

Figure 15: Configuring VLAN on Manchester DHCP switch

I had to transfer the DHCP VLAN from the DHCP server to the DHCP switch via access port and then use a trunk port to send all VLAN data to the Manchester L3 switch. This allowed the L3 switch to access all DHCP data from every VLAN.

```
Manchester_L3_Switch(config-if)#exit
Manchester_L3_Switch(config)#
Manchester_L3_Switch(config)#vlan 10
Manchester_L3_Switch(config-vlan)#name ManOffice1
Manchester_L3_Switch(config-vlan)#exit
Manchester_L3_Switch(config)#int vlan 10
Manchester_L3_Switch(config-if)#ip address 10.20.10.1 255.255.255.0
Manchester_L3_Switch(config-if)#ip helper-address 10.20.50.10
Manchester_L3_Switch(config-if)#desc VLAN for Manchester office 1
Manchester_L3_Switch(config-if)#no shut
Manchester_L3_Switch(config-if)#exit
Manchester_L3_Switch(config)#
```

Figure 16: Manchester VLAN 10 configuration

In Figure 16, VLAN 10 (ManOffice1) is created on the Manchester Layer 3 switch and stored in the VLAN database for trunking to other sites. The VLAN is configured with the IP address 10.20.10.1 and a /24 subnet mask, providing 255 host addresses including the network and broadcast addresses.

A helper IP address is also configured, pointing to the Manchester DHCP server. This forwards DHCP requests from the Office 1 subnet to the DHCP server subnet, enabling centralized IP address management across multiple networks.

```
Manchester_L3_Switch#conf t
Enter configuration commands, one per line.  End with CNTL/Z.
Manchester_L3_Switch(config)#int gig1/0/5
Manchester_L3_Switch(config-if)#switchport mode trunk
Manchester_L3_Switch(config-if)#switchport trunk allowed vlan 10, 30
                                                                 ^
% Invalid input detected at '^' marker.

Manchester_L3_Switch(config-if)#switchport trunk allowed vlan 10,30
Manchester_L3_Switch(config-if)#no shut
Manchester_L3_Switch(config-if)#exit
Manchester_L3_Switch(config)#
```

Figure 17: Manchester Trunk configuration

Figure 17 shows how I configure the trunk to office 1 in Manchester. I allow VLAN's 10 and 30, since VLAN 10 is for office 1 devices, and VLAN 30 is for the access point in office 1.

```
ManOffice1_Switch(config-if)#exit
ManOffice1_Switch(config)#vlan 10
ManOffice1_Switch(config-vlan)#name ManOffice1
ManOffice1_Switch(config-vlan)#exit
ManOffice1_Switch(config)#int vlan 10
ManOffice1_Switch(config-if)#
%LINK-5-CHANGED: Interface Vlan10, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface Vlan10, changed state to up

ManOffice1_Switch(config-if)#exit
ManOffice1_Switch(config)#int range fa0/3 - 24
ManOffice1_Switch(config-if-range)#switchport mode access
ManOffice1_Switch(config-if-range)#switchport access vlan 10
ManOffice1_Switch(config-if-range)#no shut
ManOffice1_Switch(config-if-range)#exit
ManOffice1_Switch(config)#
```

Figure 18: Manchester Office 1 Switch VLAN 10 Configuration

Figure 18 shows I create the VLAN 10 to store in the switch's database, which is then used to distribute to all Fast Ethernet ports which would be occupied by PCs. These distributions are made across access ports.

For VLAN IP addressing and VLAN commands, I reference: https://diadenkov.medium.com/cisco-layer-3-switch-intervlan-routing-without-router-8e04f2315a56.

OSPF Configuration

OSPF (Open Shortest Path First) is a routing protocol that uses a link-state routing algorithm, specifically Dijkstra's algorithm, to calculate the shortest path based on path cost.

I chose OSPF for WAN routing instead of RIP because RIP has a 15-hop limit, while OSPF has no hop limit, making it more scalable for large networks. OSPF also uses bandwidth as a metric for more efficient path selection, whereas RIP relies only on hop count. Additionally, OSPF's use of Dijkstra's algorithm allows it to calculate optimal paths more efficiently than RIP's Bellman-Ford algorithm, resulting in faster convergence. Referenced from: https://www.auvik.com/franklyit/blog/ospf-protocol-explained/

```
DNS_Router(config)#router ospf 1
DNS_Router(config-router)#network 10.0.1.0 0.0.0.255 area 0
DNS_Router(config-router)#
```

Figure 19: OSPF Configuration to DNS server

```
Central_Router#show ip route ospf
     10.0.0.0/8 is variably subnetted, 28 subnets, 3 masks
O       10.0.0.0 [110/66] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.0.0.8 [110/66] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
                 [110/66] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.0.0.16 [110/66] via 10.0.0.14, 4294967281:4294967272:4294967285, FastEthernet0/1
O       10.0.0.44 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.0.0.56 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.0.1.0 [110/65] via 10.0.0.30, 4294967281:4294967272:4294967275, Serial0/3/0
O       10.10.10.0 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.10.20.0 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.10.30.0 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.10.40.0 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.10.50.0 [110/2] via 10.0.0.14, 4294967282:4294967251:4294967250, FastEthernet0/1
O       10.20.10.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.20.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.30.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.40.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.50.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.60.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0
O       10.20.70.0 [110/2] via 10.0.0.42, 4294967282:4294967251:4294967250, FastEthernet0/0

Central_Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.0.0.49         0   FULL/  -        00:00:37    10.0.0.5        Serial0/0/0
10.20.0.0         1   FULL/DR         00:00:39    10.0.0.42       FastEthernet0/0
10.10.0.0         1   FULL/DR         00:00:37    10.0.0.14       FastEthernet0/1
3.3.3.3           0   FULL/  -        00:00:30    10.0.0.25       Serial0/2/0
2.2.2.2           0   FULL/  -        00:00:37    10.0.0.30       Serial0/3/0
Central_Router#
```

Figure 20: OSPF Routing in Central Router

I suggest referring to Figure 8 when analysing Figure 20.
Figure 20 shows the IP addresses which pass through the Central Router, and which port they come from.

View Appendix A - Additional OSPF Configuration to see more OSPF configuration and routing.

SSH Configuration

```
Manchester_Router(config-if)#exit
Manchester_Router(config)#ip domain-name admin
Manchester_Router(config)#crypto key generate rsa
% You already have RSA keys defined named Manchester_Router.admin .
% Do you really want to replace them? [yes/no]: yes
The name for the keys will be: Manchester_Router.admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

Manchester_Router(config)#username admin password manchesteradmin
*Mar 5 8:6:48.907: %SSH-5-ENABLED: SSH 1.99 has been enabled
Manchester_Router(config)#line vty 0 15
Manchester_Router(config-line)#transport input ssh
Manchester_Router(config-line)#login local
Manchester_Router(config-line)#exit
Manchester_Router(config)#
```

Figure 21: Configure SSH on Manchester Router

SSH was configured on all network devices to enable secure administrative access to routers and Layer 3 switches. A 2048-bit RSA key encrypts authentication data, protecting management traffic from packet sniffing, which is critical for StocksUK due to the transmission of sensitive data such as cryptocurrency transactions.

SSH was chosen over Telnet because Telnet transmits data in plaintext, creating a significant security vulnerability that allows attackers to intercept sensitive information.

(Configuration and description both reference: https://moodle.mmu.ac.uk/pluginfile.php/8409946/mod_resource/content/1/Net_Wk9_Lab.pdf & https://computernetworking747640215.wordpress.com/2018/07/05/secure-shell-ssh-configuration-on-a-switch-and-router-in-packet-tracer/).

View Appendix A - Additional SSH Configuration to see more SSH configuration on different network devices.

Network Configuration Tests

DHCP Tests

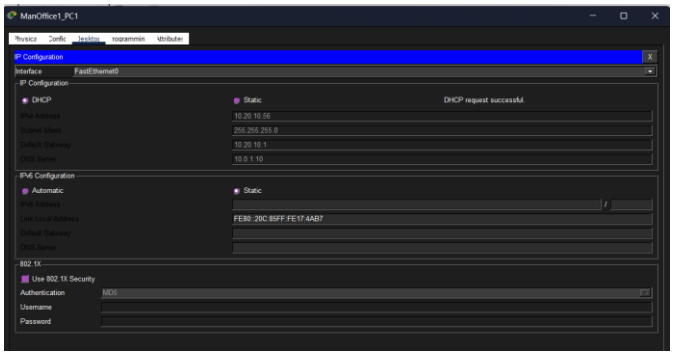

Figure 22: Manchester PC successful DHCP connection

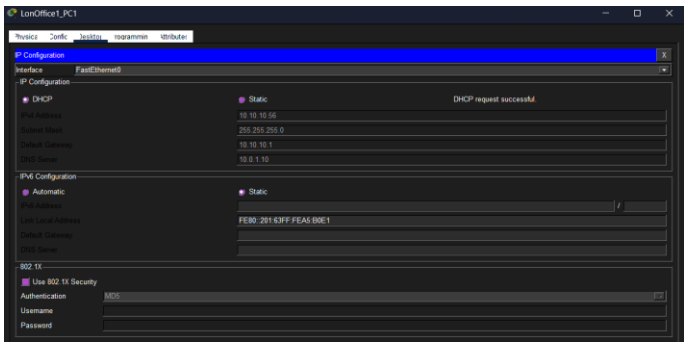

Figure 23: London PC successful DHCP connection

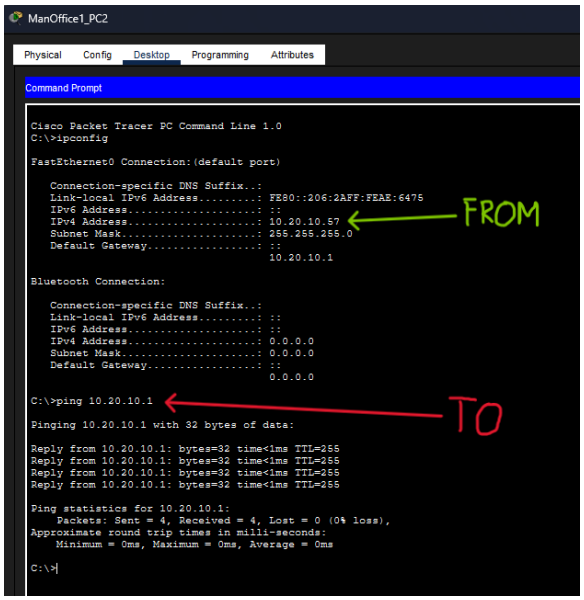

Figure 24: Manchester PC ping Manchester DHCP server

For Manchester's DHCP server, Figure 22 shows a successful DHCP connection to an office PC, and Figure 24 shows a successful ping to the Manchester DHCP server.

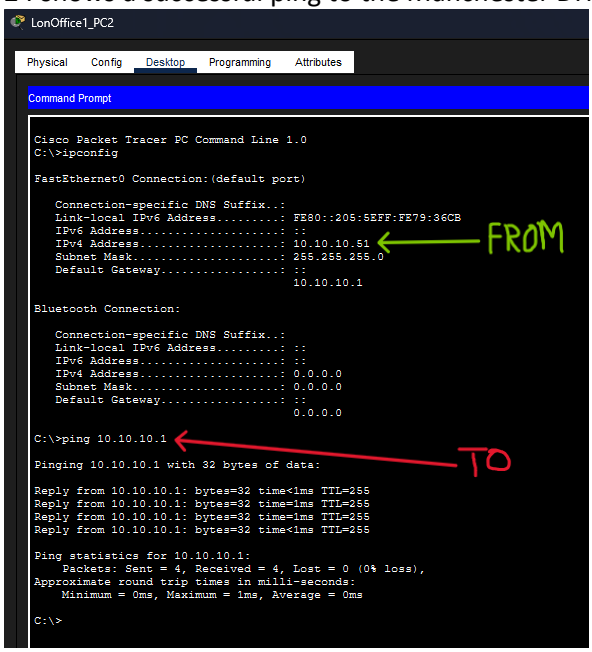

Figure 25: London PC ping London DHCP server

For London's DHCP server, Figure 23 shows a successful DHCP connection to an office PC, and Figure 25 shows a successful ping to the London DHCP server.

These tests complete objective 8.

DNS Tests

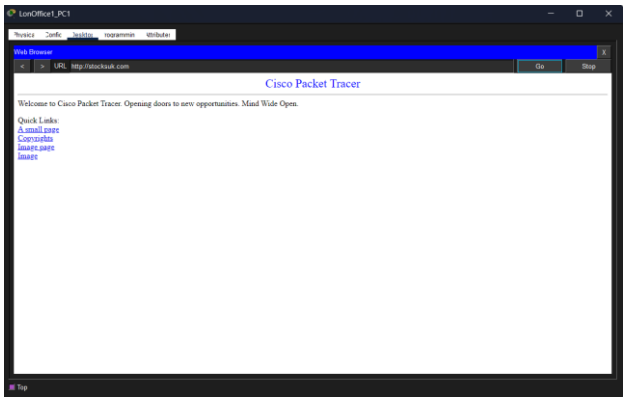

Figure 26: London PC connect to DNS webpage

Figure 27: London PC pinging DNS Server

Figure 27 demonstrates a ping request from a PC in London office 1 to the DNS and its underlying IP address. It shows packets being received and sent back from the DNS server, showing the DNS works.

Furthermore, Figure 26 shows the same office PC connecting to the DNS through a web browser. This confirms completion of objective 6.

VLAN Tests

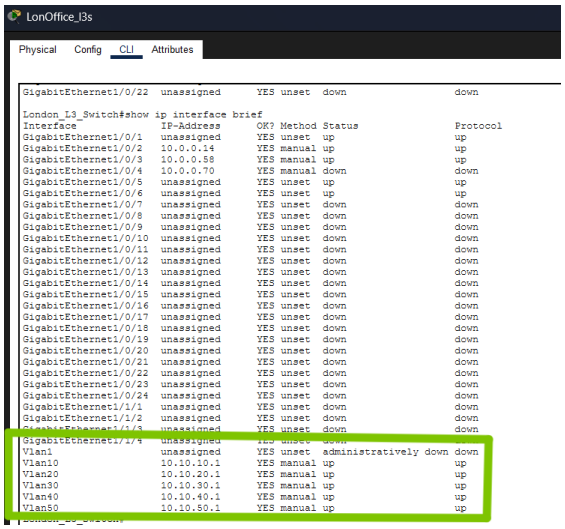

Figure 28: London VLAN IP proof

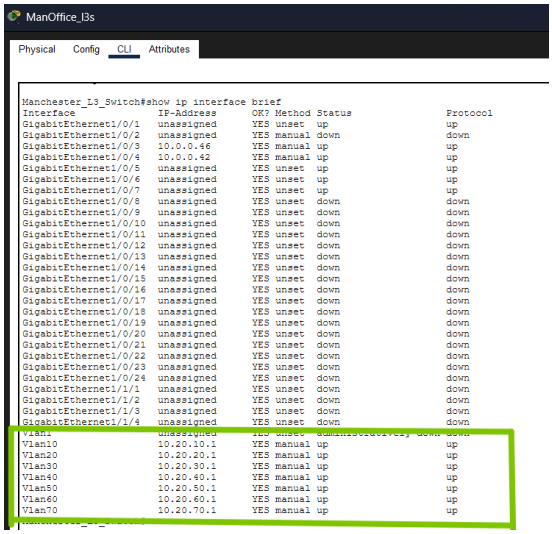

Figure 29: Manchester VLAN IP proof

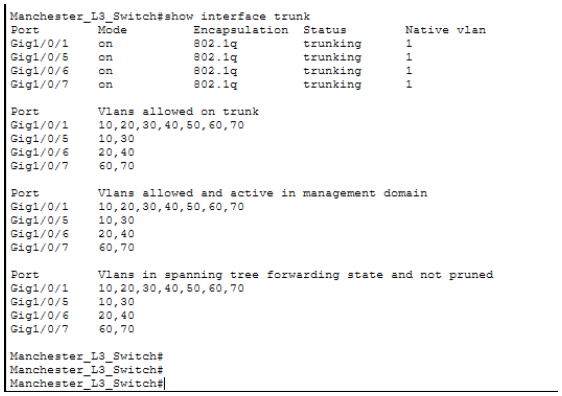

Figure 30: Manchester Trunk information

```
London_L3_Switch#show interface trunk
Port        Mode         Encapsulation  Status        Native vlan
Gig1/0/1    on           802.1q         trunking      1
Gig1/0/5    on           802.1q         trunking      1
Gig1/0/6    on           802.1q         trunking      1

Port        Vlans allowed on trunk
Gig1/0/1    10,20,30,40,50
Gig1/0/5    10,30
Gig1/0/6    20,40

Port        Vlans allowed and active in management domain
Gig1/0/1    10,20,30,40,50
Gig1/0/5    10,30
Gig1/0/6    20,40

Port        Vlans in spanning tree forwarding state and not pruned
Gig1/0/1    10,20,30,40,50
Gig1/0/5    10,30
Gig1/0/6    20,40

London_L3_Switch#
London_L3_Switch#
London_L3_Switch#
```

Figure 31: London Trunk information

Figure 28 and Figure 29 prove active VLAN's inside of Manchester and London's L3 switch.
Figure 30 and Figure 31 show the trunked interfaces on the L3 switches, and what VLAN's they carry.

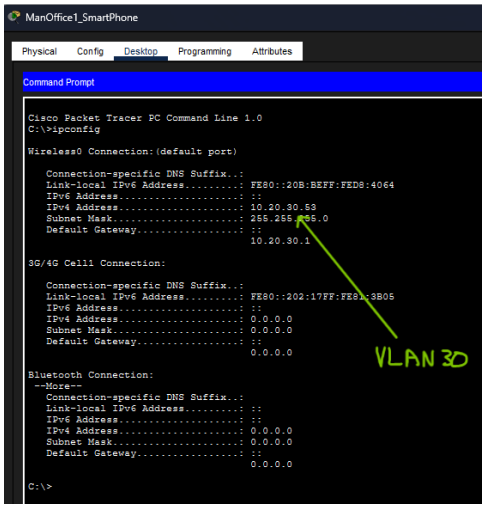

Figure 32: Manchester Phone on VLAN 30

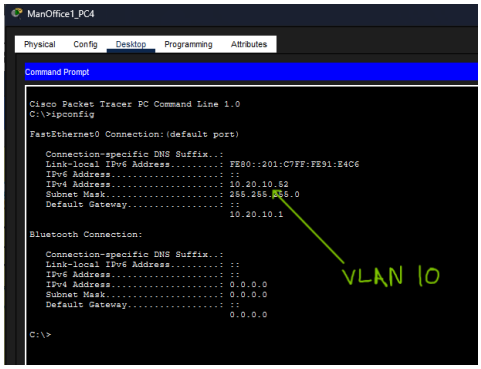

Figure 33: Manchester PC on VLAN 10

Figure 32 shows how the VLAN has made the third octet in the IP to 30 on a smartphone on the access point of office 1 in Manchester.
Figure 33 shows how the VLAN has made the third octet in the IP to 10 on a PC in office 1 in Manchester.
This marks objective 5 complete.

Routing Tests

These tests will be held in office 1 in London, more tests from Manchester office 1 will be displayed in Appendix A - Manchester Office 1 Ping Tests.

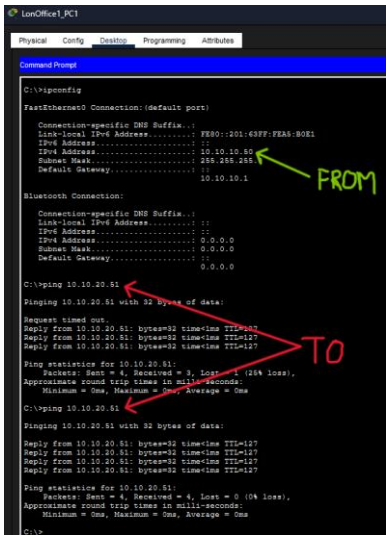

Figure 34: Ping from London office 1 to London office 2

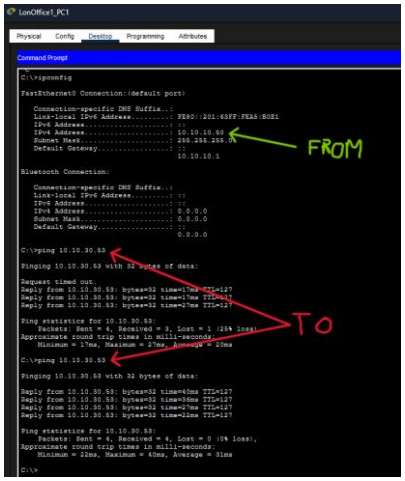

Figure 35: Ping from London Office 1 to London Office 1 Access Point

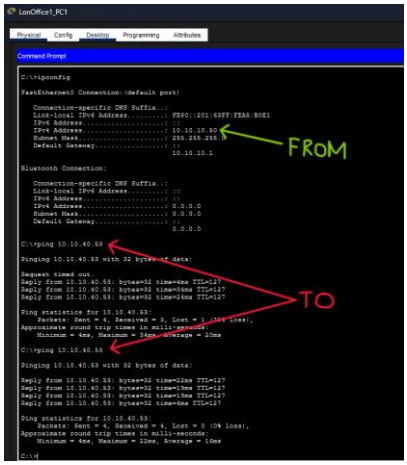

Figure 36: Ping from London Office 1 to London Office 2 Access Point

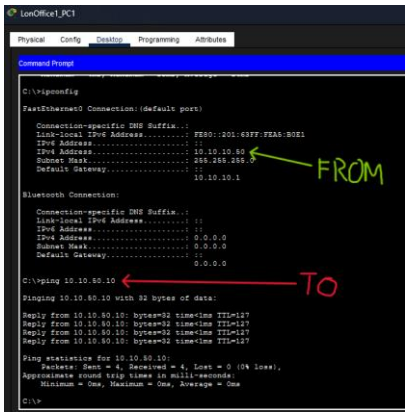

Figure 37: Ping from London Office 1 to London DHCP server

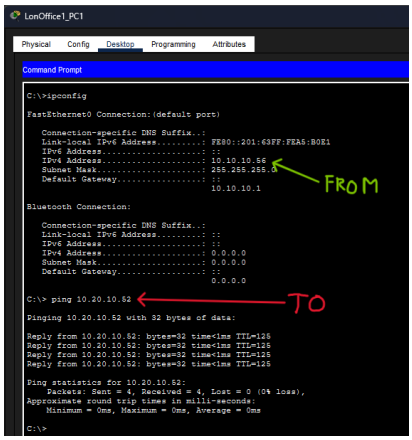

Figure 38: Ping from London Office 1 to Manchester Office 1

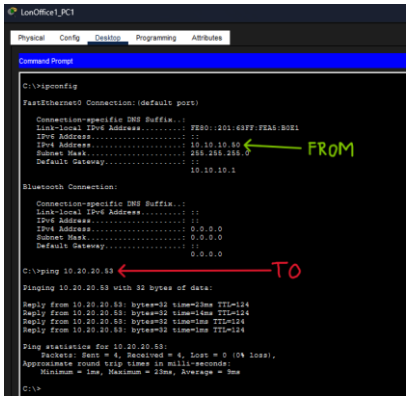

Figure 39: Ping from London Office 1 to Manchester Office 2

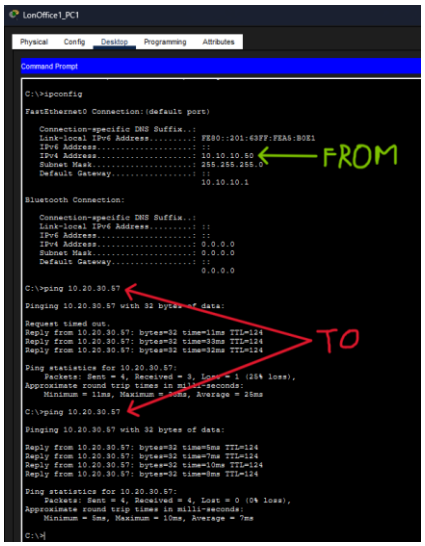

Figure 40: Ping from London Office 1 to Manchester Office 1 Access Point

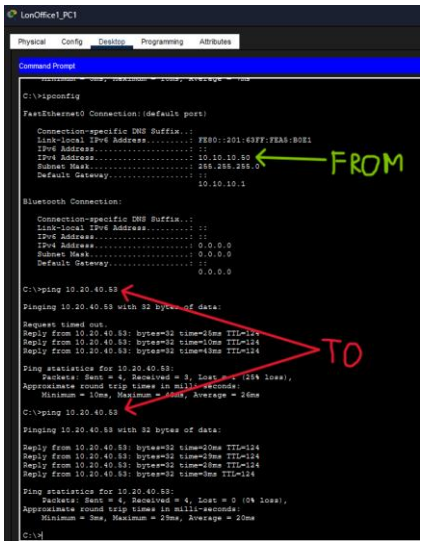

Figure 41: Ping from London Office 1 to Manchester Office 2 Access Point

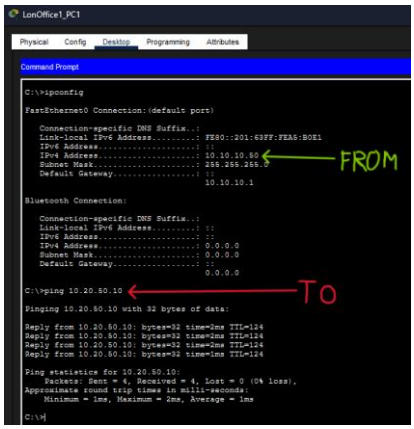

Figure 42: Ping from London Office 1 to Manchester DHCP server

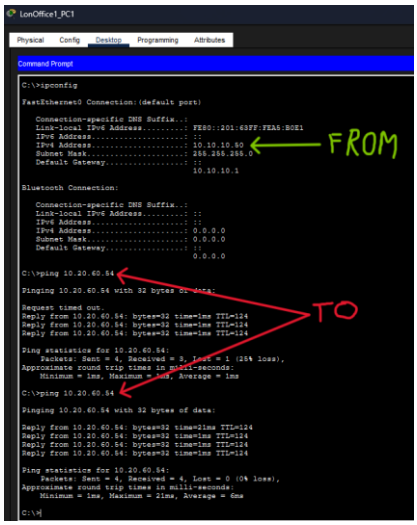

Figure 43: Ping from London Office 1 to Manchester Factory

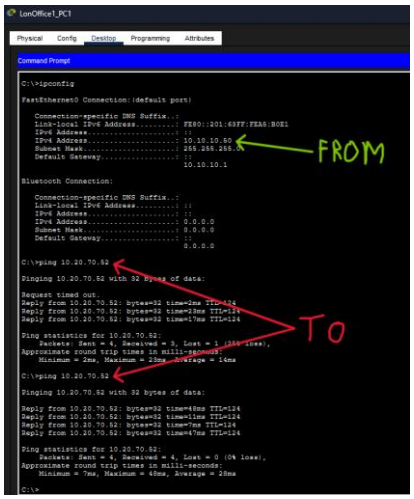

Figure 44: Ping from London Office 1 to Manchester Factory Access Point

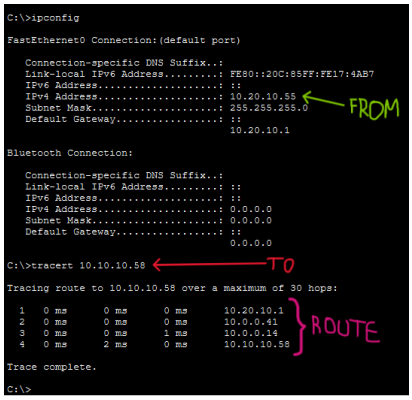

Figure 45: Tracert command from Manchester Office 1 to London Office 1

These figures above prove that each route to every location/VLAN works as expected.
Figure 45 directly shows the route taken from the VLAN in Manchester office 1 to the PC in London's office. References from: https://medium.com/@minwork/tracert-or-traceroute-command-54d5f031ee9b

See Figure 27 to see successful DNS server ping.
This completes objective 7.

SSH Tests

```
Manchester_Router#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
Manchester_Router#
```

Figure 46: Testing SSH on Manchester Router

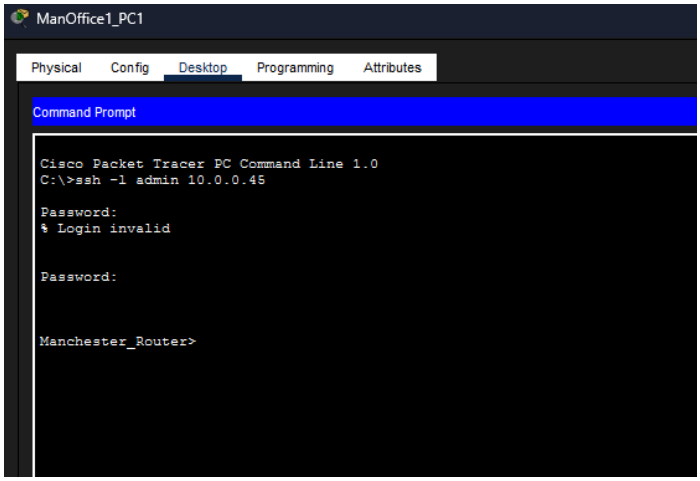

Figure 47: Entering SSH on Manchester office 1 PC

Figure 46 shows SSH correctly configured on the Manchester router. Figure 47 further shows a PC in Manchester office 1 entering the SSH of the Manchester router.

SSH checks for all network devices can be found in Appendix A - Additional SSH Tests, which completes objective 4.

Network Evaluation and Discussion

Referring to Figure 8 , the WAN consists of four core routers connected to Layer 3 switches, each representing a location. The design is scalable, as an additional router and L3 switch can be introduced to distribute VLANs. DNS is already integrated into the WAN and would only require configuration on a new DHCP server, while subnet isolation further supports scalability.

The WAN is also redundant, reducing downtime by allowing traffic to reroute during router failures. However, this redundancy increases cost and network complexity.

Despite this, routing efficiency remains high due to the use of OSPF, which applies Dijkstra's algorithm to ensure optimal path selection. The design could be simplified by removing the dedicated DNS router to reduce costs, as future expansion would naturally increase redundancy. Overall, the network effectively meets the project requirements.

Conclusion

StocksUK now operates a secure, reliable, and scalable network supporting employees across four distributed sites. Each site provides wired and wireless connectivity within isolated VLANs, improving security, reducing broadcast traffic, and enhancing performance.

OSPF enables efficient WAN routing, ensuring optimal path selection and high availability through redundancy. Centralised services such as DHCP and DNS simplify network management, while SSH secures administrative access to WAN devices.

Although the redundant WAN design increases cost and complexity, this trade-off is justified by improved fault tolerance, reduced downtime, and support for business-critical data. The modular architecture also allows future expansion with minimal reconfiguration.

Overall, the network design meets StocksUK's requirements and provides a robust solution for current operations and future growth.

References

- *Banks, E. (2014). Open Shortest Path First OSPF Protocol Explained. [online] Auvik Networks Inc. Available at: https://www.auvik.com/franklyit/blog/ospf-protocol-explained/.*
- Kimanzi, S. (2018). *Secure Shell (SSH) configuration on a switch and router in Packet Tracer*. [online] Computer Networking Highlights. Available at: https://computernetworking747640215.wordpress.com/2018/07/05/secure-shell-ssh-configuration-on-a-switch-and-router-in-packet-tracer/.
- *Anshika (2024). Configure DNS Server On Cisco Packet Tracer. [online] Medium. Available at: https://medium.com/@z6157881/configure-dns-server-on-cisco-packet tracer-e7c412b3b3dd.*
- *Jones, M. (2025). DHCP, Redundancy, SSH [online] Mmu.ac.uk. Available at: https://moodle.mmu.ac.uk/pluginfile.php/8409946/mod_resource/content/1/Net_Wk9_Lab.pdf.*
- Vladyslav Diadenko (2021). *Cisco Layer 3 Switch Inter-VLAN Routing*. [online] Medium. Available at: https://diadenkov.medium.com/cisco-layer-3-switch-intervlan-routing-without-router-8e04f2315a56.
- Adhikari, M. (2024). *traceroute command*. [online] Medium. Available at: https://medium.com/@minwork/tracert-or-traceroute-command-54d5f031ee9b.

Appendix A

Manchester Office 1 Ping Tests

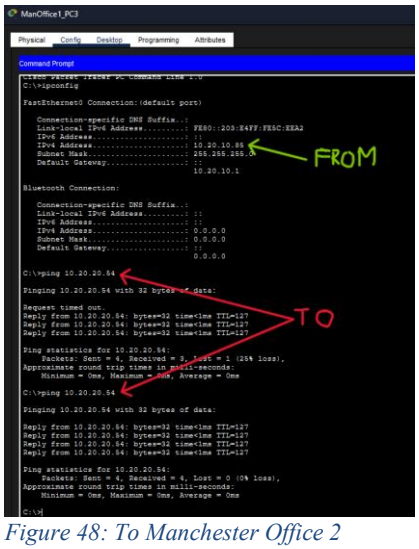

Figure 48: To Manchester Office 2

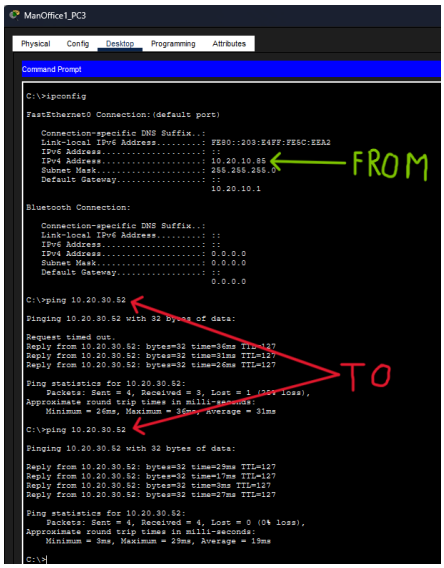

Figure 49: To Manchester Office 1 AP

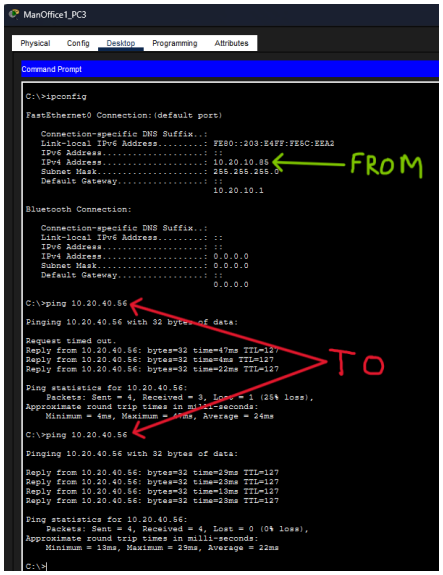

Figure 50: To Manchester Office 2 AP

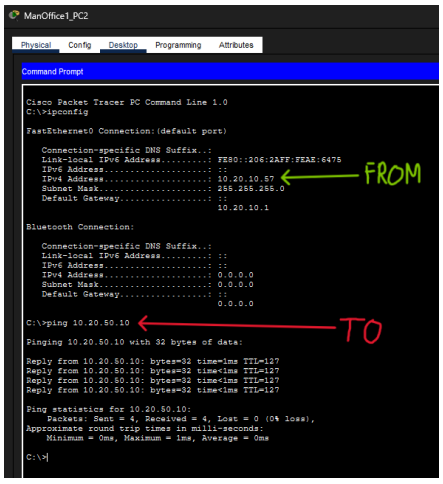

Figure 51: To Manchester DNS

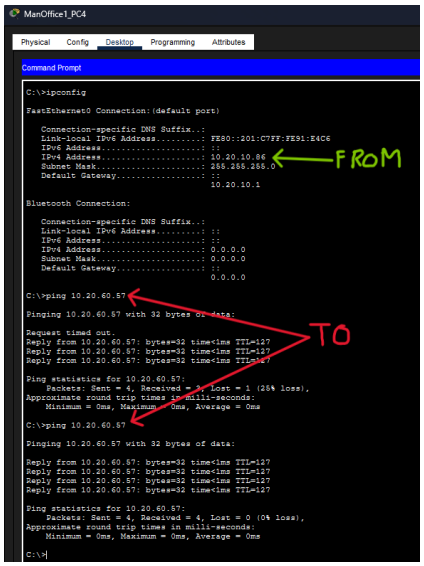

Figure 52: To Manchester Factory

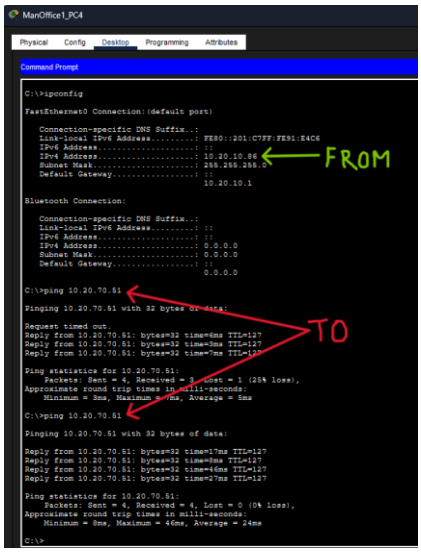

Figure 53: To Manchester Factory AP

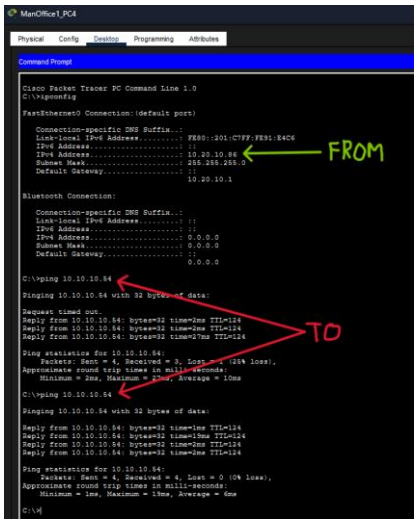

Figure 54: To London Office 1

Figure 55: To London Office 1

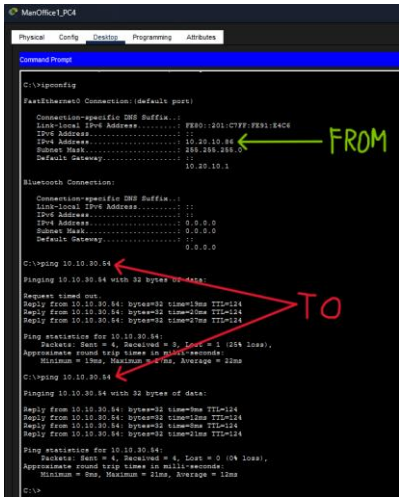

Figure 56: To London Office 1 AP

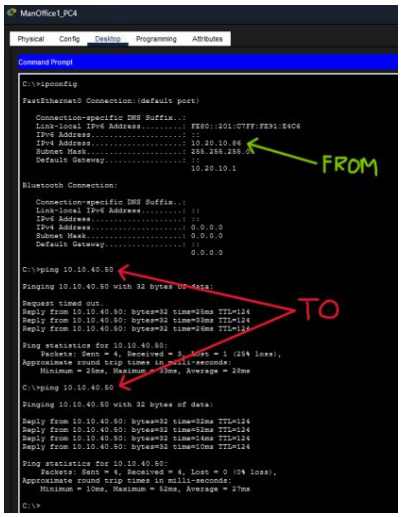

Figure 57: To London Office 2 AP

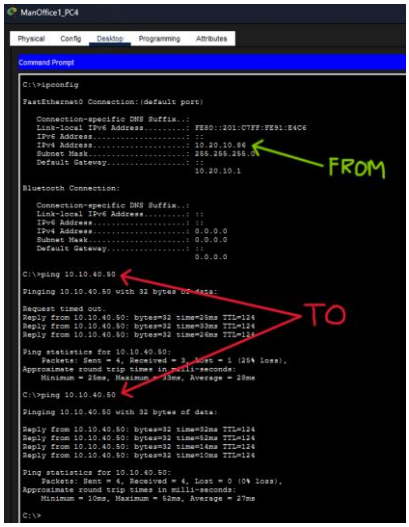

Figure 58: To London DNS

Additional OSPF Configuration

```
DNS_Router#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
10.0.0.49         0   FULL/  -        00:00:34    10.0.0.1        Serial0/0/0
4.4.4.4           0   FULL/  -        00:00:37    10.0.0.29       Serial0/2/0
3.3.3.3           0   FULL/  -        00:00:35    10.0.0.17       Serial0/1/0
DNS_Router#show ip route ospf
     10.0.0.0/8 is variably subnetted, 15 subnets, 2 masks
O       10.0.0.4 [110/845] via 10.0.0.1, 00:06:24, Serial0/0/0
                 [110/845] via 10.0.0.29, 00:06:24, Serial0/2/0
O       10.0.0.8 [110/845] via 10.0.0.1, 00:09:34, Serial0/0/0
                 [110/845] via 10.0.0.17, 00:09:34, Serial0/1/0
O       10.0.0.12 [110/782] via 10.0.0.29, 00:06:24, Serial0/2/0
O       10.0.0.24 [110/845] via 10.0.0.17, 00:06:24, Serial0/1/0
                  [110/845] via 10.0.0.29, 00:06:24, Serial0/2/0
O       10.0.0.40 [110/782] via 10.0.0.29, 00:06:24, Serial0/2/0
O       10.0.0.44 [110/782] via 10.0.0.1, 00:11:04, Serial0/0/0
O       10.0.0.56 [110/782] via 10.0.0.17, 00:09:34, Serial0/1/0

DNS_Router#show ip ospf interface brief
Interface     PID   Area                    IP Address/Mask          Cost  State  Nbrs F/C
Se0/0/0         1   0                     10.0.0.2/255.255.255.252   781  POINT  0/0
Se0/1/0         1   0                     10.0.0.18/255.255.255.252  781  POINT  0/0
Se0/2/0         1   0                     10.0.0.30/255.255.255.252  781  POINT  0/0
Fa0/0           1   0                       10.0.1.1/255.255.255.252   1      DR  0/0

DNS_Router#
```

Figure 59: DNS Router

```
London_L3_Switch#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
4.4.4.4           1   FULL/DR         00:00:30    10.0.0.13       GigabitEthernet1/0/2
3.3.3.3           1   FULL/DR         00:00:37    10.0.0.57       GigabitEthernet1/0/3
London_L3_Switch#show ip route ospf
     10.0.0.0/8 is variably subnetted, 30 subnets, 3 masks
O       10.0.0.0 [110/129] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.4 [110/129] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.8 [110/65] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.16 [110/65] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.24 [110/65] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.28 [110/129] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.40 [110/66] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.0.44 [110/66] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.0.1.0 [110/66] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.10.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.20.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.30.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.40.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.50.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.60.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3
O       10.20.70.0 [110/67] via 10.0.0.57, 00:03:05, GigabitEthernet1/0/3

London_L3_Switch#show ip ospf interface brief
Interface     PID   Area                IP Address/Mask          Cost  State  Nbrs F/C
Vlan            1   0                   10.10.10.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.10.20.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.10.30.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.10.40.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.10.50.1/255.255.255.0   1       DR  0/0
Gig1/0/2        1   0                   10.0.0.14/255.255.255.252  1      BDR  0/0
Gig1/0/3        1   0                   10.0.0.58/255.255.255.252  1      BDR  0/0

London L3 Switch#
```

Figure 60: London L3 Switch

```
London_Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
4.4.4.4           0   FULL/  -        00:00:33    10.0.0.26       Serial0/2/0
10.0.0.49         0   FULL/  -        00:00:30    10.0.0.9        Serial0/1/0
10.0.1.1          0   FULL/  -        00:00:32    10.0.0.18       Serial0/3/0
London_Router#show ip route ospf
     10.0.0.0/8 is variably subnetted, 15 subnets, 2 masks
O       10.0.0.0 [110/128] via 10.0.0.9, 00:07:58, Serial0/1/0
O       10.0.0.4 [110/128] via 10.0.0.9, 00:04:58, Serial0/1/0
                 [110/128] via 10.0.0.26, 00:04:58, Serial0/2/0
O       10.0.0.12 [110/65] via 10.0.0.26, 00:04:58, Serial0/2/0
O       10.0.0.28 [110/128] via 10.0.0.26, 00:04:58, Serial0/2/0
O       10.0.0.40 [110/65] via 10.0.0.26, 00:04:58, Serial0/2/0
O       10.0.0.44 [110/65] via 10.0.0.9, 00:07:58, Serial0/1/0
O       10.0.1.0 [110/65] via 10.0.0.18, 00:08:08, Serial0/3/0

London_Router#show ip ospf interface brief
Interface     PID   Area                IP Address/Mask          Cost  State  Nbrs F/C
Fa0/1           1   0                   10.0.0.57/255.255.255.252  1       DR  0/0
Se0/1/0         1   0                   10.0.0.10/255.255.255.252  64    POINT  0/0
Se0/2/0         1   0                   10.0.0.25/255.255.255.252  64    POINT  0/0
Se0/3/0         1   0                   10.0.0.17/255.255.255.252  64    POINT  0/0

London_Router#
```

Figure 61: London Router

```
Manchester_L3_Switch#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
10.0.0.49         1   FULL/DR         00:00:30    10.0.0.45       GigabitEthernet1/0/3
4.4.4.4           1   FULL/DR         00:00:33    10.0.0.41       GigabitEthernet1/0/4
Manchester_L3_Switch#show ip route ospf
     10.0.0.0/8 is variably subnetted, 31 subnets, 3 masks
O       10.0.0.0 [110/65] via 10.0.0.45, 00:03:49, GigabitEthernet1/0/3
O       10.0.0.4 [110/65] via 10.0.0.45, 00:03:49, GigabitEthernet1/0/3
                 [110/65] via 10.0.0.41, 00:03:49, GigabitEthernet1/0/4
O       10.0.0.8 [110/65] via 10.0.0.45, 00:03:49, GigabitEthernet1/0/3
O       10.0.0.16 [110/129] via 10.0.0.45, 00:03:49, GigabitEthernet1/0/3
                  [110/129] via 10.0.0.41, 00:03:49, GigabitEthernet1/0/4
O       10.0.0.24 [110/65] via 10.0.0.41, 00:03:49, GigabitEthernet1/0/4
O       10.0.0.28 [110/65] via 10.0.0.41, 00:03:49, GigabitEthernet1/0/4
O       10.0.0.56 [110/66] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3
                  [110/66] via 10.0.0.41, 00:02:22, GigabitEthernet1/0/4
O       10.0.1.0 [110/66] via 10.0.0.45, 00:03:49, GigabitEthernet1/0/3
                 [110/66] via 10.0.0.41, 00:03:49, GigabitEthernet1/0/4
O       10.10.10.0 [110/67] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3
                   [110/67] via 10.0.0.41, 00:02:22, GigabitEthernet1/0/4
O       10.10.20.0 [110/67] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3
                   [110/67] via 10.0.0.41, 00:02:22, GigabitEthernet1/0/4
O       10.10.30.0 [110/67] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3
                   [110/67] via 10.0.0.41, 00:02:22, GigabitEthernet1/0/4
O       10.10.40.0 [110/67] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3
                   [110/67] via 10.0.0.41, 00:02:22, GigabitEthernet1/0/4
O       10.10.50.0 [110/67] via 10.0.0.45, 00:02:22, GigabitEthernet1/0/3

Manchester_L3_Switch#show ip ospf interface brief
Interface     PID   Area                IP Address/Mask          Cost  State  Nbrs F/C
Vlan            1   0                   10.20.10.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.20.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.30.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.40.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.50.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.60.1/255.255.255.0   1       DR  0/0
Vlan            1   0                   10.20.70.1/255.255.255.0   1       DR  0/0
Gig1/0/3        1   0                   10.0.0.46/255.255.255.252  1      BDR  0/0
Gig1/0/4        1   0                   10.0.0.42/255.255.255.252  1      BDR  0/0

Manchester_L3_Switch#
```

Figure 62: Manchester L3 Switch

```
Manchester_Router#show ip ospf neighbor

Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:38    10.0.0.10       Serial0/1/0
4.4.4.4           0   FULL/  -        00:00:30    10.0.0.6        Serial0/0/0
10.0.1.1          0   FULL/  -        00:00:39    10.0.0.2        Serial0/3/0
Manchester_Router#show ip route ospf
     10.0.0.0/8 is variably subnetted, 15 subnets, 2 masks
O       10.0.0.12 [110/65] via 10.0.0.6, 00:03:17, Serial0/0/0
O       10.0.0.16 [110/128] via 10.0.0.10, 00:06:17, Serial0/1/0
O       10.0.0.24 [110/128] via 10.0.0.6, 00:03:17, Serial0/0/0
                  [110/128] via 10.0.0.10, 00:03:17, Serial0/1/0
O       10.0.0.28 [110/128] via 10.0.0.6, 00:03:17, Serial0/0/0
O       10.0.0.40 [110/65] via 10.0.0.6, 00:03:17, Serial0/0/0
O       10.0.0.56 [110/65] via 10.0.0.10, 00:06:17, Serial0/1/0
O       10.0.1.0 [110/65] via 10.0.0.2, 00:07:49, Serial0/3/0

Manchester_Router#show ip ospf interface brief
Interface     PID   Area                  IP Address/Mask          Cost  State  Nbrs F/C
Fa0/1           1   0                   10.0.0.45/255.255.255.252   1       DR  0/0
Se0/0/0         1   0                     10.0.0.5/255.255.255.252   64   POINT  0/0
Se0/1/0         1   0                     10.0.0.9/255.255.255.252   64   POINT  0/0
Se0/3/0         1   0                     10.0.0.1/255.255.255.252   64   POINT  0/0

Manchester_Router#
```

Figure 63: Manchester Router

Additional SSH Configuration

```
London_Router(config-if)#exit
London_Router(config)#ip domain-name admin
London_Router(config)#crypto key generate rsa
The name for the keys will be: London_Router.admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

London_Router(config)#username admin password londonadmin
*Mar 3 5:55:22.172: %SSH-5-ENABLED: SSH 1.99 has been enabled
London_Router(config)#line vty 0 15
London_Router(config-line)#transport input ssh
London_Router(config-line)#login local
London_Router(config-line)#exit
London_Router(config)#
```

Figure 64: London Router

```
Central_Router#config t
Enter configuration commands, one per line.  End with CNTL/Z.
Central_Router(config)#ip domain-name central-admin
Central_Router(config)#crypto key generate rsa
The name for the keys will be: Central_Router.central-admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

Central_Router(config)#username admin password centraladmin
*Mar 3 5:56:53.790: %SSH-5-ENABLED: SSH 1.99 has been enabled
Central_Router(config)#line vty 0 15
Central_Router(config-line)#transport
% Incomplete command.
Central_Router(config-line)#transport input ssh
Central_Router(config-line)#login local
Central_Router(config-line)#exit
Central_Router(config)#
```

Figure 65: Central Router

```
DNS_Router(config-if)#exit
DNS_Router(config)#ip domain-name dns-admin
DNS_Router(config)#crypto key generate rsa
The name for the keys will be: DNS_Router.dns-admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

DNS_Router(config)#username admin password dnsadmin
*Mar 3 3:33:36.303: %SSH-5-ENABLED: SSH 1.99 has been enabled
DNS_Router(config)#line vty 0 15
DNS_Router(config-line)#transport input ssh
DNS_Router(config-line)#login local
DNS_Router(config-line)#exit
DNS_Router(config)#
```

Figure 66: DNS Router

```
London_L3_Switch(config-if)#exit
London_L3_Switch(config)#ip domain-name L3admin
London_L3_Switch(config)#crypto key generate rsa
The name for the keys will be: London_L3_Switch.L3admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

London_L3_Switch(config)#username admin password londonL3admin
*Mar 3 1:37:44.390: %SSH-5-ENABLED: SSH 1.99 has been enabled
London_L3_Switch(config)#line vty 0 15
London_L3_Switch(config-line)#transport input ssh
London_L3_Switch(config-line)#login local
London_L3_Switch(config-line)#exit
London_L3_Switch(config)#
```

Figure 67: London L3 Switch

```
Manchester_L3_Switch(config-if)#exit
Manchester_L3_Switch(config)#ip domain-name L3admin
Manchester_L3_Switch(config)#crypto key generate rsa
The name for the keys will be: Manchester_L3_Switch.L3admin
Choose the size of the key modulus in the range of 360 to 4096 for your
  General Purpose Keys. Choosing a key modulus greater than 512 may take
  a few minutes.

How many bits in the modulus [512]: 2048
% Generating 2048 bit RSA keys, keys will be non-exportable...[OK]

Manchester_L3_Switch(config)#username admin password manchesterL3admin
*Mar 3 2:34:5.281: %SSH-5-ENABLED: SSH 1.99 has been enabled
Manchester_L3_Switch(config)#line vty 0 15
Manchester_L3_Switch(config-line)#transport input ssh
Manchester_L3_Switch(config-line)#login local
Manchester_L3_Switch(config-line)#exit
Manchester_L3_Switch(config)#
```

Figure 68: Manchester L3 Switch

Additional SSH Tests

```
London_Router#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
London_Router#
```

Figure 69: London Router

```
Central_Router#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
Central_Router#
```

Figure 70: Central Router

```
DNS_Router#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
DNS_Router#
```

Figure 71: DNS Router

```
London_L3_Switch#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
London_L3_Switch#
```

Figure 72: London L3 Switch

```
Manchester_L3_Switch#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
Manchester_L3_Switch#
```

Figure 73: Manchester L3 Switch