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Introduction

This report outlines the design and implementation of a secure, scalable enterprise network across four sites: London, Leicester, Liverpool, and Leeds. The network incorporates OSPF routing with static fallback, VLAN segmentation, DHCP for dynamic IP allocation, and ACLs for internet access control. Additional security measures, such as password encryption, port security, and SSH access, were applied to all routers and switches. The objective was to build a reliable and efficient infrastructure that ensures traffic isolation, failover resilience, and compliance with modern network security practices. Configuration steps were tested and validated, with screenshots provided as evidence throughout the report.

Network Topology Overview

The network is designed to support a multi-site enterprise architecture across four locations: London, Leicester, Liverpool, and Leeds. Each site operates as a branch within the wider organizational structure and is inter-connected using serial links with dynamic and static routing for redundancy.

The design implements a hierarchical network topology with a focus on scalability, security, and efficient traffic segmentation. The topology integrates Layer 2 switching and Layer 3 routing, using technologies such as VLANs, Inter-VLAN routing (Router-on-aStick), DHCP, OSPF, and Access Control Lists (ACLs) to ensure both functionality and control.London serves as the central site and hosts the only internet connection in the network. All internet-bound traffic is routed through London via the GigabitEthernet0/0/1 interface. Access to the internet is restricted using ACLs to ensure that only devices within the London network have outbound internet access, in compliance with the organization's cybersecurity policies.

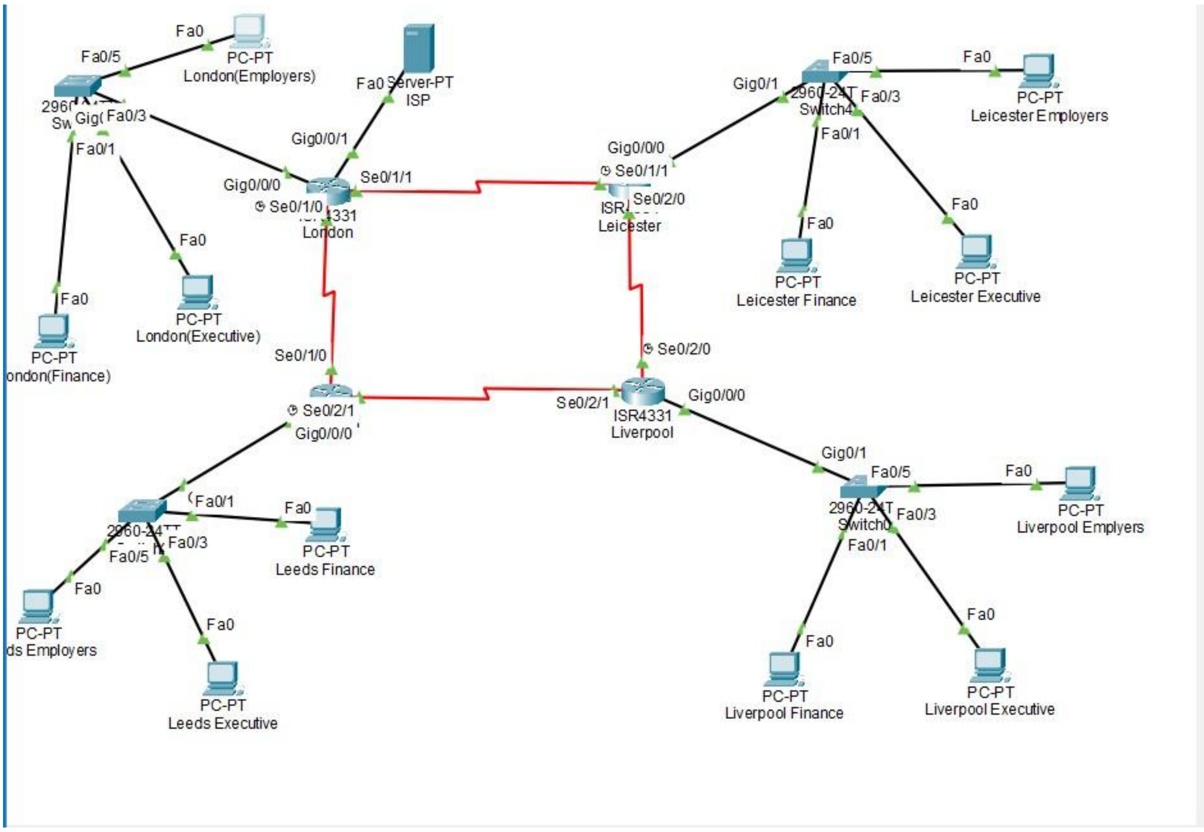


Figure 1 – Topology

Addressing table

The network design utilizes Variable Length Subnet Masking (VLSM) to allocate IP space based on actual host requirements across different sites. This method enhances address efficiency, minimizes waste, and supports structured routing by assigning distinct subnets to each location and VLAN. Such an approach aligns with best practices for scalable and organized network architectures (Serpanos and Wolf, 2011).

London

Device	Interface	IP Address	Subnet Mask
R1 – Router	G0/0/0	192.168.1.1	255.255.255.0
	S0/1/0	10.30.1.1	255.255.255.252
	S0/1/1	10.30.2.1	255.255.255.252
Switch-London	VLAN 30 (Finance)	192.168.10.2	255.255.255.0
	VLAN 40 (Exec)	192.168.20.2	255.255.255.0
	VLAN 50 (Employ)	192.168.30.2	255.255.255.0
PC1–London	NIC	DHCP	Assigned via VLAN 30

PC2–London	NIC	DHCP	Assigned via VLAN 40
PC3–London	NIC	DHCP	Assigned via VLAN 50

Leeds

Device	Interface	IP Address	Subnet Mask
R3 – Router	G0/0/0	192.168.4.1	255.255.255.0
	S0/2/1	10.30.4.2	255.255.255.252
	S0/1/0	10.30.1.2	255.255.255.252
Switch-Leeds	VLAN 30	192.168.130.2	255.255.255.0
	VLAN 40	192.168.140.2	255.255.255.0
	VLAN 50	192.168.150.2	255.255.255.0
PC1–Leeds	NIC	DHCP	Assigned via VLAN 30
PC2–Leeds	NIC	DHCP	Assigned via VLAN 40
PC3–Leeds	NIC	DHCP	Assigned via VLAN 50

Liverpool

Device	Interface	IP Address	Subnet Mask
R4 – Router	G0/0/0	192.168.3.1	255.255.255.0
	S0/2/1	10.30.4.1	255.255.255.252
	S0/2/0	10.30.3.2	255.255.255.252
Switch-Liverpool	VLAN 30	192.168.100.2	255.255.255.0
	VLAN 40	192.168.110.2	255.255.255.0
	VLAN 50	192.168.120.2	255.255.255.0
PC1–Liverpool	NIC	DHCP	Assigned via VLAN 30
PC2–Liverpool	NIC	DHCP	Assigned via VLAN 40
PC3–Liverpool	NIC	DHCP	Assigned via VLAN 50

Leicester

Device	Interface	IP Address	Subnet Mask
R2 – Router	G0/0/0	192.168.2.1	255.255.255.0
	S0/2/0	10.30.3.1	255.255.255.252

	S0/1/1	10.30.2.2	255.255.255.252
Switch-Leicester	VLAN 30	192.168.40.2	255.255.255.0
	VLAN 40	192.168.50.2	255.255.255.0
	VLAN 50	192.168.60.2	255.255.255.0
PC1–Leicester	NIC	DHCP	Assigned via VLAN 30
PC2–Leicester	NIC	DHCP	Assigned via VLAN 40
PC3–Leicester	NIC	DHCP	Assigned via VLAN 50

Routing

To establish resilient and adaptive inter-site communication, the network employs the Open Shortest Path First (OSPF) protocol in a single-area configuration (Area 0). OSPF was chosen for its rapid convergence, hierarchical design support, and efficient link-state operations, making it ideal for multi-branch enterprise networks (Lai et al., 2008). In addition to OSPF, static routes with higher administrative distances are configured as a fallback solution, ensuring uninterrupted connectivity in the event of dynamic route failure. This hybrid routing strategy improves both reliability and control (Medhi and Ramasamy, 2007).

OSPF-Routing Table:

Router	OSPF Process ID	Router ID	Networks Advertised	Passive Interfaces
R1 – London	1	1.1.1.1	192.168.1.0/24	R1 – London
			10.30.1.0/30	
			10.30.2.0/30	
R2 – Leicester	1	2.2.2.2	192.168.2.0/24	G0/0/0, Loopback0
			10.30.2.0/30	
			10.30.3.0/30	
R3 – Leeds	1	3.3.3.3	192.168.3.0/24	G0/0/0, Loopback0

			10.30.1.0/30	
			10.30.4.0/30	
			192.168.70.0/24	
			192.168.80.0/24	
			192.168.90.0/24	
R4 – Liverpool	1	4.4.4.4	192.168.4.0/24	G0/0/0, Loopback0
			10.30.3.0/30	
			10.30.4.0/30	
			192.168.100.0/24	
			192.168.110.0/24	
			192.168.120.0/24	

Verifying OSPF configuration:

R1-London

```
R1#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:37    10.30.1.2       Serial0/1/0
2.2.2.2           0   FULL/  -        00:00:30    10.30.2.2       Serial0/1/1
```

Figure 2

```
R1#show ip route ospf
     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O       10.30.3.0 [110/12952] via 10.30.2.2, 00:28:19, Serial0/1/1
O       10.30.4.0 [110/12952] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.2.0 [110/6486] via 10.30.2.2, 00:28:19, Serial0/1/1
O    192.168.40.0 [110/6576] via 10.30.2.2, 00:28:19, Serial0/1/1
O    192.168.50.0 [110/6576] via 10.30.2.2, 00:28:19, Serial0/1/1
O    192.168.60.0 [110/6576] via 10.30.2.2, 00:28:19, Serial0/1/1
O    192.168.70.0 [110/6576] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.80.0 [110/6576] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.90.0 [110/6576] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.100.0 [110/13052] via 10.30.2.2, 00:28:19, Serial0/1/1
                   [110/13052] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.110.0 [110/13052] via 10.30.2.2, 00:28:19, Serial0/1/1
                   [110/13052] via 10.30.1.2, 00:28:19, Serial0/1/0
O    192.168.120.0 [110/13052] via 10.30.2.2, 00:28:19, Serial0/1/1
                   [110/13052] via 10.30.1.2, 00:28:19, Serial0/1/0
```

Figure 3

Neighbour of R2:

```
R2#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/  -        00:00:36    10.30.2.1       Serial0/1/1
4.4.4.4           0   FULL/  -        00:00:30    10.30.3.2       Serial0/2/0
```

Figure 4

Neighbour of R3:

```
R3#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/  -        00:00:39    10.30.1.1       Serial0/1/0
4.4.4.4           0   FULL/  -        00:00:38    10.30.4.1       Serial0/2/1
```

Figure 5

```
R3#sh ip ro ospf
     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O       10.30.2.0 [110/12952] via 10.30.1.1, 00:22:59, Serial0/1/0
O       10.30.3.0 [110/12952] via 10.30.4.1, 01:24:10, Serial0/2/1
O    192.168.1.0 [110/6486] via 10.30.1.1, 00:22:59, Serial0/1/0
O    192.168.2.0 [110/12962] via 10.30.4.1, 00:22:49, Serial0/2/1
                 [110/12962] via 10.30.1.1, 00:22:49, Serial0/1/0
O    192.168.10.0 [110/6576] via 10.30.1.1, 00:22:59, Serial0/1/0
O    192.168.20.0 [110/6576] via 10.30.1.1, 00:22:59, Serial0/1/0
O    192.168.30.0 [110/6576] via 10.30.1.1, 00:22:59, Serial0/1/0
O    192.168.40.0 [110/13052] via 10.30.4.1, 00:22:49, Serial0/2/1
                  [110/13052] via 10.30.1.1, 00:22:49, Serial0/1/0
O    192.168.50.0 [110/13052] via 10.30.4.1, 00:22:49, Serial0/2/1
                  [110/13052] via 10.30.1.1, 00:22:49, Serial0/1/0
O    192.168.60.0 [110/13052] via 10.30.4.1, 00:22:49, Serial0/2/1
                  [110/13052] via 10.30.1.1, 00:22:49, Serial0/1/0
O    192.168.100.0 [110/6576] via 10.30.4.1, 01:24:10, Serial0/2/1
O    192.168.110.0 [110/6576] via 10.30.4.1, 01:24:10, Serial0/2/1
O    192.168.120.0 [110/6576] via 10.30.4.1, 01:24:10, Serial0/2/1
O*E2 0.0.0.0/0 [110/1] via 10.30.1.1, 00:22:59, Serial0/1/0
```

Figure 6

Neighbour of R4:

```
R4#show ip ospf neighbor


Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -        00:00:31    10.30.3.1       Serial0/2/0
3.3.3.3           0   FULL/  -        00:00:38    10.30.4.2       Serial0/2/1
```

```
R4#show ip route ospf
     10.0.0.0/8 is variably subnetted, 6 subnets, 2 masks
O       10.30.1.0 [110/12952] via 10.30.4.2, 00:26:50, Serial0/2/1
O       10.30.2.0 [110/12952] via 10.30.3.1, 00:26:50, Serial0/2/0
O    192.168.2.0 [110/6486] via 10.30.3.1, 00:26:50, Serial0/2/0
O    192.168.10.0 [110/13052] via 10.30.4.2, 00:26:40, Serial0/2/1
                  [110/13052] via 10.30.3.1, 00:26:40, Serial0/2/0
O    192.168.20.0 [110/13052] via 10.30.4.2, 00:26:40, Serial0/2/1
                  [110/13052] via 10.30.3.1, 00:26:40, Serial0/2/0
O    192.168.30.0 [110/13052] via 10.30.4.2, 00:26:40, Serial0/2/1
                  [110/13052] via 10.30.3.1, 00:26:40, Serial0/2/0
O    192.168.40.0 [110/6576] via 10.30.3.1, 00:26:50, Serial0/2/0
O    192.168.50.0 [110/6576] via 10.30.3.1, 00:26:50, Serial0/2/0
O    192.168.60.0 [110/6576] via 10.30.3.1, 00:26:50, Serial0/2/0
O    192.168.70.0 [110/6576] via 10.30.4.2, 00:26:50, Serial0/2/1
O    192.168.80.0 [110/6576] via 10.30.4.2, 00:26:50, Serial0/2/1
O    192.168.90.0 [110/6576] via 10.30.4.2, 00:26:50, Serial0/2/1
O*E2 0.0.0.0/0 [110/1] via 10.30.4.2, 00:26:40, Serial0/2/1
O*E2 0.0.0.0/0 [110/1] via 10.30.3.1, 00:26:40, Serial0/2/0
```

Figure 7

Routing testing:

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	London(Employers)	London	ICMP		0.000	N	0	(edit)	
	Successful	London(Executive)	London	ICMP		0.000	N	1	(edit)	
	Successful	London(Finance)	London	ICMP		0.000	N	2	(edit)	

Figure 8:Successful ping between devices and router London

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Leicester Finance	Leicester	ICMP		0.000	N	0	(edit)	
	Successful	Leicester Executive	Leicester	ICMP		0.000	N	1	(edit)	
	Successful	Leicester Employers	Leicester	ICMP		0.000	N	2	(edit)	

Figure 9Successful ping between devices and router Leicester

	Successful	Liverpool Finance	Liverpool	ICMP		0.000	N	0	(edit)	(delete)
	Successful	Liverpool Executive	Liverpool	ICMP		0.000	N	1	(edit)	(delete)
	Successful	Liverpool Emplyers	Liverpool	ICMP		0.000	N	2	(edit)	(delete)
	Successful	Leeds Finance	Leeds	ICMP		0.000	N	3	(edit)	(delete)
	Successful	Leeds Executive	Leeds	ICMP		0.000	N	4	(edit)	(delete)
	Successful	Leeds Employers	Leeds	ICMP		0.000	N	5	(edit)	(delete)

Figure 10Successful ping between devices and router Liverpool ////<< Successful ping between devices and router Leeds>>

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	London	Leicester	ICMP		0.000	N	0	(edit)	(delete)
	Successful	London	Liverpool	ICMP		0.000	N	1	(edit)	(delete)
	Successful	London	Leeds	ICMP		0.000	N	2	(edit)	(delete)

Figure 11

Connectivity between the routers at Leeds (R3) and Leicester (R2) was verified using ICMP ping tests. As evidenced by the test results, the ping from Leeds to Leicester's gateway IP address (192.168.2.1) and vice versa (192.168.70.1) achieved a 100% success rate, confirming stable two-way communication. Although the simulation panel initially showed failed attempts, these were resolved after finalizing OSPF and interface configurations. This confirms that dynamic routing between the two sites is fully operational

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Leeds	London	ICMP		0.000	N	0	(edit)	
	Successful	Leeds	Liverpool	ICMP		0.000	N	1	(edit)	
	Successful	Leicester	London	ICMP		0.000	N	2	(edit)	
	Successful	Leicester	Liverpool	ICMP		0.000	N	3	(edit)	
	Failed	Leicester	Leeds	ICMP		0.000	N	4	(edit)	
	Failed	Leeds	Leicester	ICMP		0.000	N	5	(edit)	

Figure 12

Leeds – Liecester:

```
R3#ping 192.168.2.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.2.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/28/53 ms
```

Figure 13

Leicester-Leeds:

```
R2#ping 192.168.70.1

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.70.1, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 4/12/42 ms

R2#
```

Figure 14

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Liverpool	Leeds	ICMP		0.000	N	0	(edit)	(delete)
	Successful	Liverpool	Leicester	ICMP		0.000	N	1	(edit)	(delete)
	Successful	Liverpool	London	ICMP		0.000	N	2	(edit)	(delete)

Figure 15

	Successful	London(Employers)	Leicester Employ...	ICMP		0.000	N	0	(edit)
	Successful	London(Employers)	Leicester Executive	ICMP		0.000	N	1	(edit)
	Successful	London(Employers)	Leicester Finance	ICMP		0.000	N	2	(edit)
	Successful	London(Employers)	Liverpool Emplyers	ICMP		0.000	N	3	(edit)
	Successful	London(Employers)	Liverpool Executive	ICMP		0.000	N	4	(edit)
	Successful	London(Employers)	Liverpool Finance	ICMP		0.000	N	5	(edit)
	Successful	London(Employers)	Leeds Finance	ICMP		0.000	N	6	(edit)
	Successful	London(Employers)	Leeds Executive	ICMP		0.000	N	7	(edit)
	Successful	London(Employers)	Leeds Employers	ICMP		0.000	N	8	(edit)
	Successful	London(Executive)	Leicester Employ...	ICMP		0.000	N	9	(edit)
	Successful	London(Executive)	Leicester Executive	ICMP		0.000	N	10	(edit)
	Successful	London(Executive)	Leicester Finance	ICMP		0.000	N	11	(edit)
	Successful	London(Executive)	Liverpool Emplyers	ICMP		0.000	N	12	(edit)
	Successful	London(Executive)	Liverpool Executive	ICMP		0.000	N	13	(edit)
	Successful	London(Executive)	Liverpool Finance	ICMP		0.000	N	14	(edit)
	Successful	London(Executive)	Leeds Finance	ICMP		0.000	N	15	(edit)
	Successful	London(Executive)	Leeds Executive	ICMP		0.000	N	16	(edit)
	Successful	London(Executive)	Leeds Employers	ICMP		0.000	N	17	(edit)
	Successful	London(Finance)	Leicester Employ...	ICMP		0.000	N	18	(edit)
	Successful	London(Finance)	Leicester Executive	ICMP		0.000	N	19	(edit)
	Successful	London(Finance)	Leicester Finance	ICMP		0.000	N	20	(edit)
	Successful	London(Finance)	Liverpool Emplyers	ICMP		0.000	N	21	(edit)
	Successful	London(Finance)	Liverpool Executive	ICMP		0.000	N	22	(edit)
	Successful	London(Finance)	Liverpool Finance	ICMP		0.000	N	23	(edit)
	Successful	London(Finance)	Leeds Finance	ICMP		0.000	N	24	(edit)
	Successful	London(Finance)	Leeds Executive	ICMP		0.000	N	25	(edit)
	Successful	London(Finance)	Leeds Employers	ICMP		0.000	N	26	(edit)

Figure 16 Successful ping between London devices and other devices

	Successful	Leeds Finance	London(Employers)	ICMP		0.000	N	0	(edit)
	Successful	Leeds Finance	London(Executive)	ICMP		0.000	N	1	(edit)
	Successful	Leeds Finance	London(Finance)	ICMP		0.000	N	2	(edit)
	Successful	Leeds Finance	Leicester Employ...	ICMP		0.000	N	3	(edit)
	Successful	Leeds Finance	Leicester Executive	ICMP		0.000	N	4	(edit)
	Successful	Leeds Finance	Leicester Finance	ICMP		0.000	N	5	(edit)
	Successful	Leeds Finance	Liverpool Emplyers	ICMP		0.000	N	6	(edit)
	Successful	Leeds Finance	Liverpool Executive	ICMP		0.000	N	7	(edit)
	Successful	Leeds Finance	Liverpool Finance	ICMP		0.000	N	8	(edit)
	Successful	Leeds Executive	London(Finance)	ICMP		0.000	N	9	(edit)
	Successful	Leeds Executive	London(Executive)	ICMP		0.000	N	10	(edit)
	Successful	Leeds Executive	London(Employers)	ICMP		0.000	N	11	(edit)
	Successful	Leeds Executive	Leicester Finance	ICMP		0.000	N	12	(edit)
	Successful	Leeds Executive	Leicester Executive	ICMP		0.000	N	13	(edit)
	Successful	Leeds Executive	Leicester Employ...	ICMP		0.000	N	14	(edit)
	Successful	Leeds Executive	Liverpool Emplyers	ICMP		0.000	N	15	(edit)
	Successful	Leeds Executive	Liverpool Executive	ICMP		0.000	N	16	(edit)
	Successful	Leeds Executive	Liverpool Finance	ICMP		0.000	N	17	(edit)
	Successful	Leeds Employers	London(Executive)	ICMP		0.000	N	18	(edit)
	Successful	Leeds Employers	London(Finance)	ICMP		0.000	N	19	(edit)
	Successful	Leeds Employers	London(Employers)	ICMP		0.000	N	20	(edit)
	Successful	Leeds Employers	Leicester Employ...	ICMP		0.000	N	21	(edit)
	Successful	Leeds Employers	Leicester Executive	ICMP		0.000	N	22	(edit)
	Successful	Leeds Employers	Leicester Finance	ICMP		0.000	N	23	(edit)
	Successful	Leeds Employers	Liverpool Emplyers	ICMP		0.000	N	24	(edit)
	Successful	Leeds Employers	Liverpool Executive	ICMP		0.000	N	25	(edit)
	Successful	Leeds Employers	Liverpool Finance	ICMP		0.000	N	26	(edit)

Figure 17 Successful ping between Leeds devices and other devices

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Liverpool Emplyers	Leicester Employ...	ICMP		0.000	N	0	(edit)	(delete)
	Successful	Liverpool Emplyers	Leicester Executive	ICMP		0.000	N	1	(edit)	(delete)
	Successful	Liverpool Emplyers	Leicester Finance	ICMP		0.000	N	2	(edit)	(delete)
	Successful	Liverpool Emplyers	London(Employers)	ICMP		0.000	N	3	(edit)	(delete)
	Successful	Liverpool Emplyers	London(Executive)	ICMP		0.000	N	4	(edit)	(delete)
	Successful	Liverpool Emplyers	London(Finance)	ICMP		0.000	N	5	(edit)	(delete)
	Successful	Liverpool Emplyers	Leeds Finance	ICMP		0.000	N	6	(edit)	(delete)
	Successful	Liverpool Emplyers	Leeds Employers	ICMP		0.000	N	7	(edit)	(delete)
	Successful	Liverpool Executive	Leicester Employ...	ICMP		0.000	N	8	(edit)	(delete)
	Successful	Liverpool Executive	Leicester Executive	ICMP		0.000	N	9	(edit)	(delete)
	Successful	Liverpool Executive	London(Employers)	ICMP		0.000	N	10	(edit)	(delete)
	Successful	Liverpool Executive	London(Executive)	ICMP		0.000	N	11	(edit)	(delete)
	Successful	Liverpool Executive	London(Finance)	ICMP		0.000	N	12	(edit)	(delete)
	Successful	Liverpool Executive	Leeds Finance	ICMP		0.000	N	13	(edit)	(delete)
	Successful	Liverpool Executive	Leeds Executive	ICMP		0.000	N	14	(edit)	(delete)
	Successful	Liverpool Executive	Leeds Employers	ICMP		0.000	N	15	(edit)	(delete)
	Successful	Liverpool Finance	Leicester Employ...	ICMP		0.000	N	16	(edit)	(delete)
	Successful	Liverpool Finance	Leicester Executive	ICMP		0.000	N	17	(edit)	(delete)
	Successful	Liverpool Finance	Leicester Finance	ICMP		0.000	N	18	(edit)	(delete)
	Successful	Liverpool Finance	London(Employers)	ICMP		0.000	N	19	(edit)	(delete)
	Successful	Liverpool Finance	London(Executive)	ICMP		0.000	N	20	(edit)	(delete)
	Successful	Liverpool Finance	Leeds Finance	ICMP		0.000	N	21	(edit)	(delete)
	Successful	Liverpool Finance	Leeds Executive	ICMP		0.000	N	22	(edit)	(delete)
	Successful	Liverpool Finance	Leeds Employers	ICMP		0.000	N	23	(edit)	(delete)

Figure 18 Successful ping between Liverpool devices and other devices

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Leicester Employers	London(Employers)	ICMP		0.000	N	0	(edit)	
	Successful	Leicester Employers	London(Executive)	ICMP		0.000	N	1	(edit)	
	Successful	Leicester Employers	London(Finance)	ICMP		0.000	N	2	(edit)	
	Successful	Leicester Employers	Liverpool Emplyers	ICMP		0.000	N	3	(edit)	
	Successful	Leicester Employers	Liverpool Executive	ICMP		0.000	N	4	(edit)	
	Successful	Leicester Employers	Liverpool Finance	ICMP		0.000	N	5	(edit)	
	Successful	Leicester Employers	Leeds Finance	ICMP		0.000	N	6	(edit)	
	Successful	Leicester Employers	Leeds Executive	ICMP		0.000	N	7	(edit)	
	Successful	Leicester Employers	Leeds Employers	ICMP		0.000	N	8	(edit)	
	Successful	Leicester Executive	London(Employers)	ICMP		0.000	N	9	(edit)	
	Successful	Leicester Executive	London(Executive)	ICMP		0.000	N	10	(edit)	
	Successful	Leicester Executive	London(Finance)	ICMP		0.000	N	11	(edit)	
	Successful	Leicester Executive	Liverpool Emplyers	ICMP		0.000	N	12	(edit)	
	Successful	Leicester Executive	Liverpool Executive	ICMP		0.000	N	13	(edit)	
	Successful	Leicester Executive	Liverpool Finance	ICMP		0.000	N	14	(edit)	
	Successful	Leicester Executive	Leeds Finance	ICMP		0.000	N	15	(edit)	
	Successful	Leicester Executive	Leeds Executive	ICMP		0.000	N	16	(edit)	
	Successful	Leicester Executive	Leeds Employers	ICMP		0.000	N	17	(edit)	
	Successful	Leicester Finance	London(Employers)	ICMP		0.000	N	18	(edit)	
	Successful	Leicester Finance	London(Executive)	ICMP		0.000	N	19	(edit)	
	Successful	Leicester Finance	London(Finance)	ICMP		0.000	N	20	(edit)	
	Successful	Leicester Finance	Liverpool Emplyers	ICMP		0.000	N	21	(edit)	
	Successful	Leicester Finance	Liverpool Executive	ICMP		0.000	N	22	(edit)	
	Successful	Leicester Finance	Liverpool Finance	ICMP		0.000	N	23	(edit)	
	Successful	Leicester Finance	Leeds Finance	ICMP		0.000	N	24	(edit)	
	Successful	Leicester Finance	Leeds Executive	ICMP		0.000	N	25	(edit)	
	Successful	Leicester Finance	Leeds Employers	ICMP		0.000	N	26	(edit)	

Figure 19 Successful ping between Leicester devices and other devices

To validate end-to-end connectivity across the network, PC-to-PC ping tests were conducted between sites. Each device successfully obtained an IP address via DHCP, and the ping responses confirmed that inter-VLAN routing and OSPF-based communication were functioning correctly. As explained by Gavin, ping serves as a fundamental diagnostic tool to test connectivity between devices and ensure network reachability. The successful test results demonstrate that all configured hosts are fully reachable across the WAN, confirming the reliability of the overall network design.

Setting up Static with AD 120 Failback mechanism

London

```
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#ip route 192.168.8.0 255.255.248.0 10.30.2.2 120
R1(config)#ip route 192.168.16.0 255.255.252.0 10.30.2.2 120
R1(config)#ip route 192.168.24.0 255.255.254.0 10.30.1.2 120
```

Figure 20

Leicester

```
R2(config)#ip route 192.168.0.0 255.255.248.0 10.30.2.1 120
R2(config)#ip route 192.168.16.0 255.255.252.0 10.30.3.2 120
R2(config)#
R2#
%SYS-5-CONFIG_I: Configured from console by console

R2#co
% Ambiguous command: "co"
R2#conf
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#ip route 192.168.24.0 255.255.254.0 10.30.3.2 120
```

Figure 21

Leeds

```
R3(config)#
R3(config)#ip route 192.168.0.0 255.255.248.0 10.30.1.1 120
R3(config)#ip route 192.168.8.0 255.255.248.0 10.30.4.1 120
R3(config)#ip route 192.168.16.0 255.255.252.0 10.30.4.1 120
```

Figure 22

Liverpool

```
R4(config)#ip route 192.168.0.0 255.255.248.0 10.30.3.1 120
R4(config)#ip route 192.168.8.0 255.255.248.0 10.30.3.1 120
R4(config)#ip route 192.168.24.0 255.255.254.0 10.30.4.2 120
```

Figure 23

Verifying failover mechanism

```
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#inter Se0/1/1
R1(config-if)#shutdown
```

Figure 24

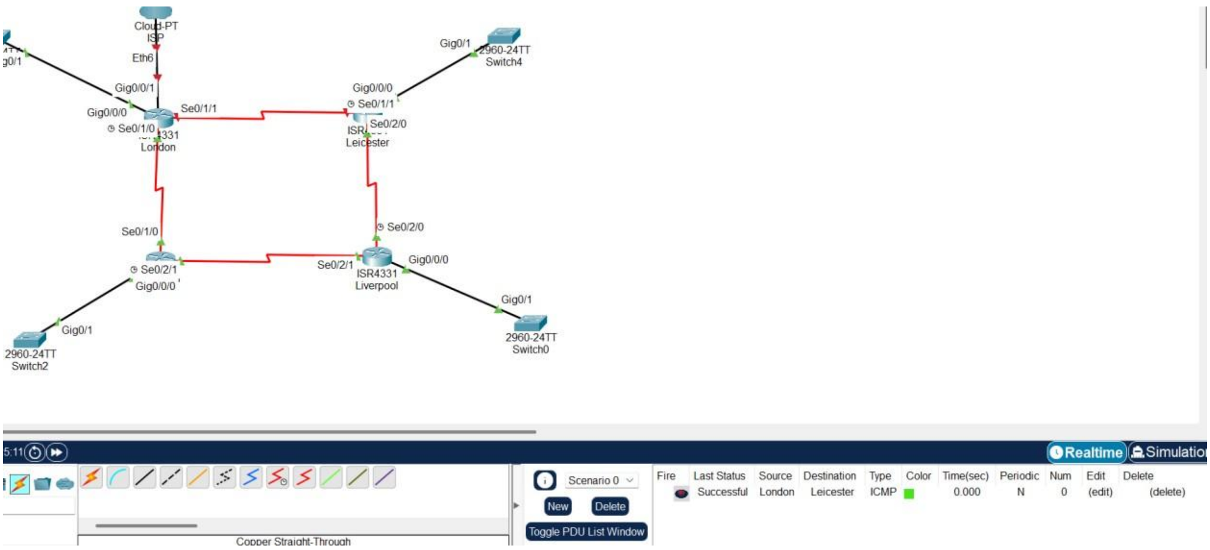


Figure 25

To validate the fallback routing mechanism, a primary link between London and Leicester was intentionally disabled using The shutdown command on interface Serial0/1/1 of the London router. Following this action, ICMP traffic was still successfully routed from London to Leicester, confirming that OSPF dynamically recalculated the best available path via the alternative route through Liverpool. This behavior confirms that the failover routing setup is functioning as intended, ensuring uninterrupted connectivity even during link failures.

Configuring ABSR that advertise a default route in to the OSPF domain

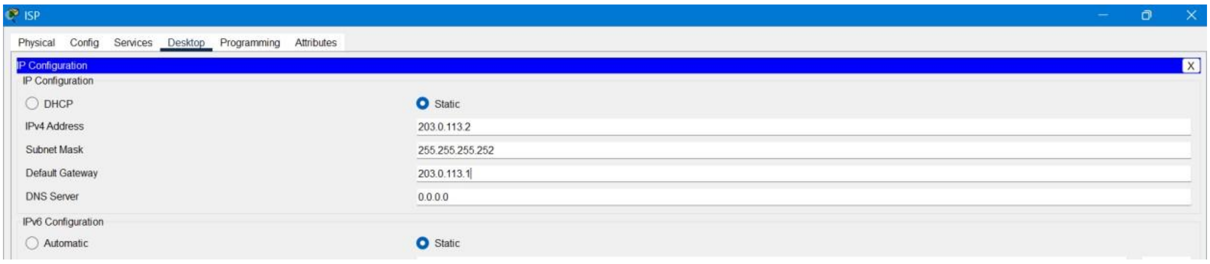


Figure 26Figure 27

```
R1(config-router)#default-information or
R1(config-router)#default-information originate
R1(config-router)#exit
R1(config)#ip route 0.0.0.0 0.0.0.0 203.0.113.2
R1(config)#exit
R1#
```

Figure 28

Figure 29

```
R1(config)#inter g0/0/1
R1(config-if)#ip address 203.0.113.1 255.255.255.252
R1(config-if)#no shutd
```

```
R1#show ip protocols

Routing Protocol is "ospf 1"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Router ID 1.1.1.1
  Number of areas in this router is 1. 1 normal 0 stub 0 nssa
  Maximum path: 4
  Routing for Networks:
    192.168.1.0 0.0.0.255 area 0
    10.30.2.0 0.0.0.3 area 0
    10.30.1.0 0.0.0.3 area 0
  Passive Interface(s):
    Loopback0
  Routing Information Sources:
    Gateway         Distance      Last Update
    1.1.1.1              110      00:03:07
    2.2.2.2              110      00:04:40
    3.3.3.3              110      00:04:13
    4.4.4.4              110      00:11:51
  Distance: (default is 110)
```

Figure 30

Implementing ABRSP helps protect the routers that connect different parts of the network or link it to the internet. These routers play a key role in sharing routing information, so securing them prevents fake or harmful routes from getting in. It's a smart way to keep the network stable and safe, especially when advertising default routes.

Switching

VLAN Design and Implementation

Virtual LANs (VLANs) were implemented to logically segment network traffic, improving both security and performance by isolating departments such as Finance, Executive, and Employers into VLANs 30, 40, and 50 respectively (Cisco, n.d.). At the London site, VLANs were assigned to specific FastEthernet ports—0/1-2 for Finance, 0/3-4 for Executive, and 0/5-6 for Employers—with each configured in access mode to prevent VLAN hopping. Router-on-a-Stick configuration was used to enable inter-VLAN communication and DHCP services via sub-interfaces. This standardized VLAN setup was consistently applied across Leicester, Liverpool, and Leeds to maintain scalability and centralized policy control.

Assigning Vlan on each site:

```
S1_London(config)#vlan 30
S1_London(config-vlan)#name Finance
S1_London(config-vlan)#exit
S1_London(config)#vlan 40
S1_London(config-vlan)#name Executive
S1_London(config-vlan)#exit
S1_London(config)#vlan 50
S1_London(config-vlan)#name Employers
S1_London(config-vlan)#exit
```

Figure 31

Assign Vlan to access port

```
S1_London(config)#interface ran
S1_London(config)#interface range fas
S1_London(config)#interface range fastEthernet 0/1 -2
S1_London(config-if-range)#switc mod acces
S1_London(config-if-range)#switc acce vlan 30
S1_London(config-if-range)#exit
S1_London(config)#inte rang fast 0/3 -4
S1_London(config-if-range)#switchpor mode acc
S1_London(config-if-range)#switchp access vlan 40
```

Figure 32

```
S1_London(config)#int range fast 0/5-6
S1_London(config-if-range)#swit mode acc
S1_London(config-if-range)#swit mode access
S1_London(config-if-range)#swit access vlan 50
```

Figure 33

Router-on-a-Stick Sub interface Setup per Router

London

```
R1(config)#interface g0/0/0.30
R1(config-subif)# encapsulation dot1Q 30
R1(config-subif)# ip address 192.168.10.1 255.255.255.0
```

Figure 34

```
R1(config-subif)#interface g0/0/0.40
R1(config-subif)# encapsulation dot1Q 40
R1(config-subif)# ip address 192.168.20.1 255.255.255.0
```

Figure 35s

```
R1(config-subif)#interface g0/0/0.50
R1(config-subif)# encapsulation dot1Q 50
R1(config-subif)# ip address 192.168.30.1 255.255.255.0
```

Figure 36

Leicester

```
R2(config)#interface g0/0/0.30
R2(config-subif)# encapsulation dot1Q 30
R2(config-subif)# ip address 192.168.40.1 255.255.255.0
R2(config-subif)#interface g0/0/0.40
R2(config-subif)# encapsulation dot1Q 40
R2(config-subif)# ip address 192.168.50.1 255.255.255.0
R2(config-subif)#interface g0/0/0.50
R2(config-subif)# encapsulation dot1Q 50
R2(config-subif)# ip address 192.168.60.1 255.255.255.0
%LINK-5-CHANGED: Interface GigabitEthernet0/0/0.30, changed state to up
```

Figure 37

Leeds

```
R3(config-if)#interface g0/0/0.30
R3(config-subif)# encapsulation dot1Q 30
R3(config-subif)# ip address 192.168.70.1 255.255.255.0
R3(config-subif)#interface g0/0/0.40
R3(config-subif)# encapsulation dot1Q 40
R3(config-subif)# ip address 192.168.80.1 255.255.255.0

R3(config-subif)#interface g0/0/0.50
R3(config-subif)# encapsulation dot1Q 50
R3(config-subif)# ip address 192.168.90.1 255.255.255.0
```

Figure 38

Liverpool

```
R4(config)#interface g0/0/0.30
R4(config-subif)# encapsulation dot1Q 30
R4(config-subif)# ip address 192.168.100.1 255.255.255.0
R4(config-subif)#interface g0/0/0.40
R4(config-subif)# encapsulation dot1Q 40
R4(config-subif)# ip address 192.168.110.1 255.255.255.0
R4(config-subif)#interface g0/0/0.50
R4(config-subif)# encapsulation dot1Q 50
R4(config-subif)# ip address 192.168.120.1 255.255.255.0
```

Figure 39

Figure 40

```
S3_leeds#sh vlan

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    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
30   Finance                          active    Fa0/1, Fa0/2
40   Executive                        active    Fa0/3, Fa0/4
50   Employers                        active    Fa0/5, Fa0/6
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        0      0
30   enet  100030     1500  -      -      -        -    -        0      0
40   enet  100040     1500  -      -      -        -    -        0      0
50   enet  100050     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        0      0
1003 tr    101003     1500  -      -      -        -    -        0      0
1004 fdnet 101004     1500  -      -      -        ieee -        0      0
1005 trnet 101005     1500  -      -      -        ibm  -        0      0

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------

Remote SPAN VLANs
------------------------------------------------------------------------------

Primary Secondary Type              Ports
------- --------- ----------------- ------------------------------------------
```

Figure 41

```
S4_Liverpool#sh vla

VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    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
30   Finance                          active    Fa0/1, Fa0/2
40   Executive                        active    Fa0/3, Fa0/4
50   Employers                        active    Fa0/5, Fa0/6
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        0      0
30   enet  100030     1500  -      -      -        -    -        0      0
40   enet  100040     1500  -      -      -        -    -        0      0
50   enet  100050     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        0      0
1003 tr    101003     1500  -      -      -        -    -        0      0
1004 fdnet 101004     1500  -      -      -        ieee -        0      0
1005 trnet 101005     1500  -      -      -        ibm  -        0      0

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------

Remote SPAN VLANs
------------------------------------------------------------------------------

Primary Secondary Type              Ports
------- --------- ----------------- ------------------------------------------
```

Figure 42

```
VLAN Name                             Status    Ports
---- -------------------------------- --------- -------------------------------
1    default                          active    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
30   Finance                          active    Fa0/1, Fa0/2
40   Executive                        active    Fa0/3, Fa0/4
50   Employers                        active    Fa0/5, Fa0/6
1002 fddi-default                     active
1003 token-ring-default               active
1004 fddinet-default                  active
1005 trnet-default                    active

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------
1    enet  100001     1500  -      -      -        -    -        0      0
30   enet  100030     1500  -      -      -        -    -        0      0
40   enet  100040     1500  -      -      -        -    -        0      0
50   enet  100050     1500  -      -      -        -    -        0      0
1002 fddi  101002     1500  -      -      -        -    -        0      0
1003 tr    101003     1500  -      -      -        -    -        0      0
1004 fdnet 101004     1500  -      -      -        ieee -        0      0
1005 trnet 101005     1500  -      -      -        ibm  -        0      0

VLAN Type  SAID       MTU   Parent RingNo BridgeNo Stp  BrdgMode Trans1 Trans2
---- ----- ---------- ----- ------ ------ -------- ---- -------- ------ ------

Remote SPAN VLANs
------------------------------------------------------------------------------

Primary Secondary Type              Ports
------- --------- ----------------- ------------------------------------------
```

Figure 43

The successful creation and port assignment of VLANs at each site were verified using the show vlan command on the switches. The output confirmed that VLANs 30, 40, and 50 were correctly created and associated with their designated access ports at London, Leicester, Liverpool, and Leeds. As highlighted by Sun et al. (2014), proper VLAN segmentation and verification help ensure isolated traffic domains and reduce broadcast congestion, contributing to more secure and efficient network operation.

Trunking

Trunking is essential on Layer 2 switches to enable communication between multiple VLANs over a single physical link. In a router-on-a-stick setup, trunk ports forward tagged traffic from all VLANs to the router's sub-interfaces for inter-VLAN routing. Without trunking, VLANs would remain isolated, preventing access to shared resources or centralized services (Aziz).

```
S1_London#sh int 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      1,30,40,50

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      1,30,40,50
```

Figure 44

```
S3_leeds#sh int 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      1,30,40,50

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      1,30,40,50
```

Figure 45

```
S4_Liverpool#sh int tru
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      1,30,40,50

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      1,30,40,50
```

Figure 46

```
S2_Leicester#sh int 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      1,30,40,50

Port        Vlans in spanning tree forwarding state and not pruned
Gig0/1      1,30,40,50
```

Figure 47Figure 48

To enable inter-VLAN communication, trunking was configured on the switch port connecting to the router using IEEE 802.1Q encapsulation. This allows multiple VLANs to traverse a single physical link by tagging traffic with VLAN identifiers. The "show interfaces trunk" command was used to verify trunk status. The output confirmed that Gig0/1 was actively trunking with

VLANs 30, 40, and 50 allowed and forwarding. This setup is crucial for supporting the router-on-a-stick design and ensuring seamless VLANbased segmentation across the network (Aziz).

DHCP settings

“Dynamic Host Configuration Protocol (DHCP) plays a critical role in simplifying IP address management, particularly in networks with a large number of devices. Rather than manually assigning IP addresses to each device, DHCP automates this process, ensuring efficient and error-free address allocation. For example, when a new desktop joins the network, it broadcasts a discovery message to locate available DHCP servers. A server, such as dhcpserve, responds with an appropriate IP address, subnet mask, default gateway, and DNS information. The desktop then confirms the offer, and the server finalizes the lease, preventing IP conflicts and ensuring reliability. This structured four-step exchange not only streamlines connectivity but also supports redundancy by allowing clients to select among multiple DHCP servers (Droms)

```
R1(config)#ip dhcp excluded-address 192.168.10.1 192.168.10.10
R1(config)#ip dhcp excluded-address 192.168.20.1 192.168.20.10
R1(config)#ip dhcp excluded-address 192.168.30.1 192.168.30.10
R1(config)#ip dhcp pool Finance_London
R1(dhcp-config)#network 192.168.10.0 255.255.255.0
R1(dhcp-config)#default-router 192.168.10.1
R1(dhcp-config)#dns-server 8.8.8.8
R1(dhcp-config)#exit
R1(config)#ip dhcp pool Executive_London
R1(dhcp-config)# network 192.168.20.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.20.1
R1(dhcp-config)# dns-server 8.8.8.8
R1(dhcp-config)#exit
R1(config)#ip dhcp pool Employers_London
R1(dhcp-config)# network 192.168.30.0 255.255.255.0
R1(dhcp-config)# default-router 192.168.30.1
R1(dhcp-config)# dns-server 8.8.8.8
R1(dhcp-config)#exit
```

Figure 49

```
R3(config)#ip dhcp excluded-address 192.168.70.1 192.168.70.10
R3(config)#ip dhcp excluded-address 192.168.80.1 192.168.80.10
R3(config)#ip dhcp excluded-address 192.168.90.1 192.168.90.10
R3(dhcp-config)# network 192.168.70.0 255.255.255.0
R3(dhcp-config)# default-router 192.168.70.1
R3(dhcp-config)# dns-server 8.8.8.8
R3(dhcp-config)#ip dhcp pool Executive_Leeds
R3(dhcp-config)# network 192.168.80.0 255.255.255.0
R3(dhcp-config)# default-router 192.168.80.1
R3(dhcp-config)# dns-server 8.8.8.8
R3(dhcp-config)#ip dhcp pool Employers_Leeds
R3(dhcp-config)# network 192.168.90.0 255.255.255.0
R3(dhcp-config)# default-router 192.168.90.1
R3(dhcp-config)# dns-server 8.8.8.8
```

Figure 50

```
R4(config)#ip dhcp excluded-address 192.168.100.1 192.168.100.10
R4(config)#ip dhcp excluded-address 192.168.110.1 192.168.110.10
R4(config)#ip dhcp excluded-address 192.168.120.1 192.168.120.10
R4(config)#ip dhcp pool Finance_Liverpool
R4(dhcp-config)# network 192.168.100.0 255.255.255.0
R4(dhcp-config)# default-router 192.168.100.1
R4(dhcp-config)# dns-server 8.8.8.8
R4(dhcp-config)#ip dhcp pool Executive_Liverpool
R4(dhcp-config)# network 192.168.110.0 255.255.255.0
R4(dhcp-config)# default-router 192.168.110.1
R4(dhcp-config)# dns-server 8.8.8.8
R4(dhcp-config)#ip dhcp pool Employers_Liverpool
R4(dhcp-config)# network 192.168.120.0 255.255.255.0
R4(dhcp-config)# default-router 192.168.120.1
R4(dhcp-config)# dns-server 8.8.8.8
```

Figure 51

```
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#ip dhcp excluded-address 192.168.40.1 192.168.40.10
R2(config)#ip dhcp excluded-address 192.168.50.1 192.168.50.10
R2(config)#ip dhcp excluded-address 192.168.60.1 192.168.60.10
R2(config)#ip dhcp pool Finance_Leicester
R2(dhcp-config)# network 192.168.40.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.40.1
R2(dhcp-config)# dns-server 8.8.8.8
R2(dhcp-config)#ip dhcp pool Executive_Leicester
R2(dhcp-config)# network 192.168.50.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.50.1
R2(dhcp-config)#dns-server 8.8.8.8
R2(dhcp-config)#ip dhcp pool Employers_Leicester
R2(dhcp-config)# network 192.168.60.0 255.255.255.0
R2(dhcp-config)# default-router 192.168.60.1
R2(dhcp-config)# dns-server 8.8.8.8
R2(dhcp-config)#
```

Figure 52

DHCP Testing

London Area

PC -Employers

Figure 53

PC-Finance

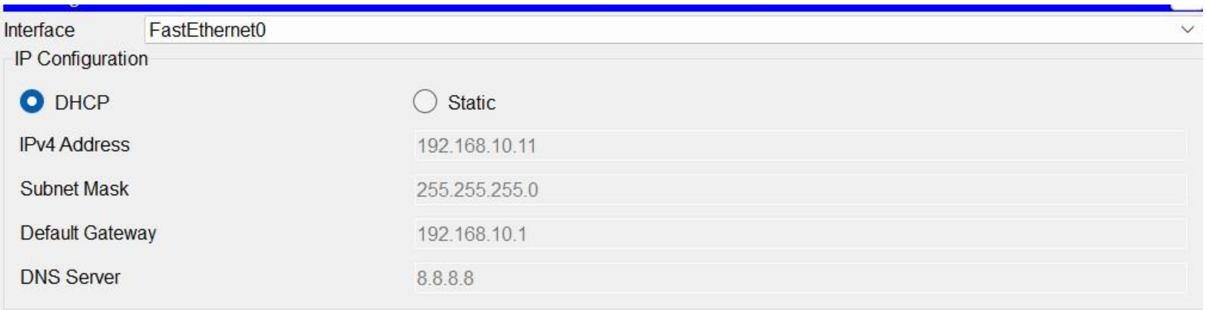


Figure 54

PC-Executive

Figure 55

Leicester Area

PC-Finance

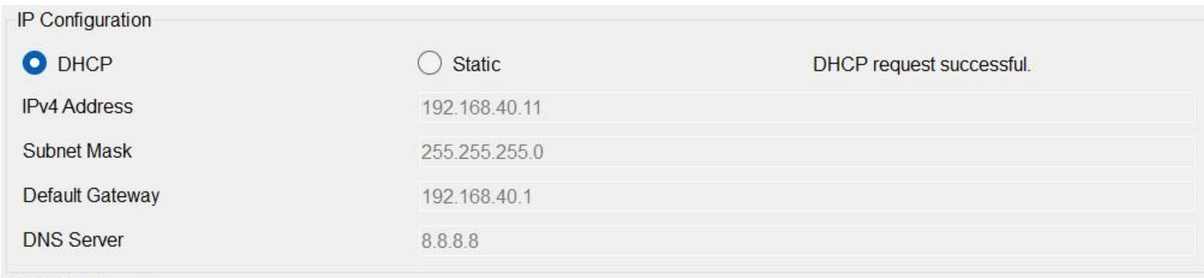


Figure 56

PC-Executive

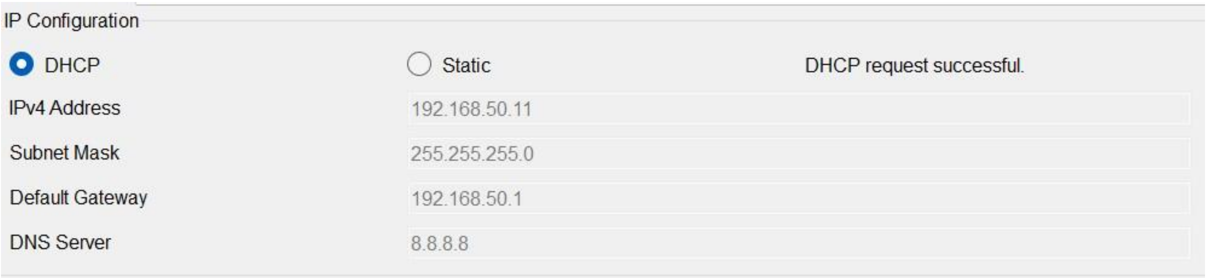


Figure 57

PC-Employers

Figure 58

Liverpool Area

PC-Finance

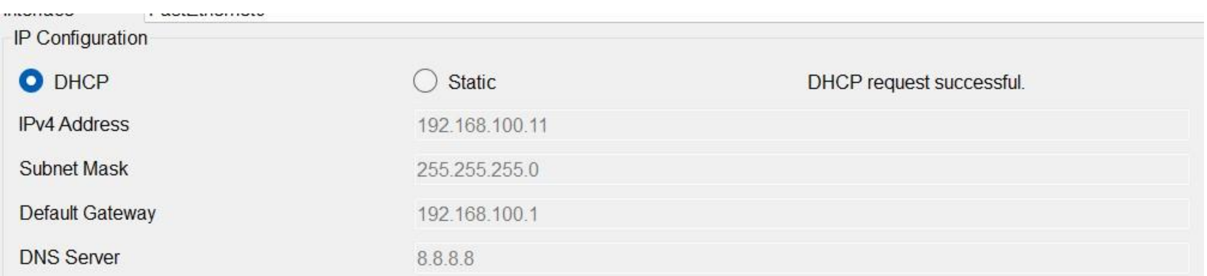


Figure 59s

PC-Executive

Figure 60

PC-Employers

Figure 61

Leeds Area

PC-Finance

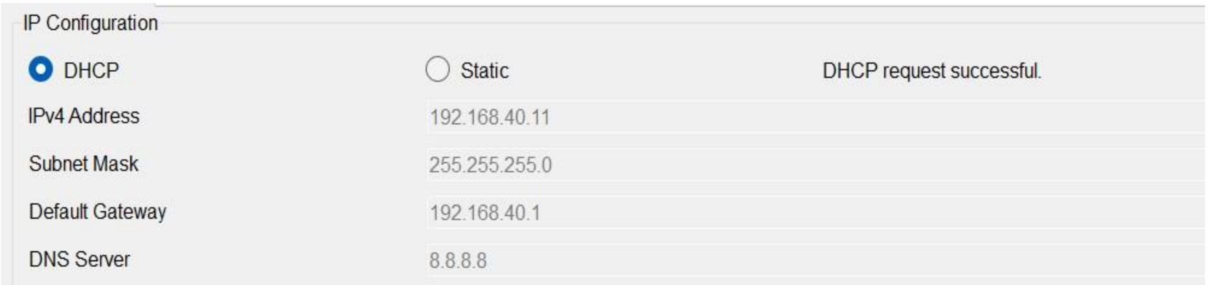


Figure 62

PC-Executive

Figure 63

PC-Employers

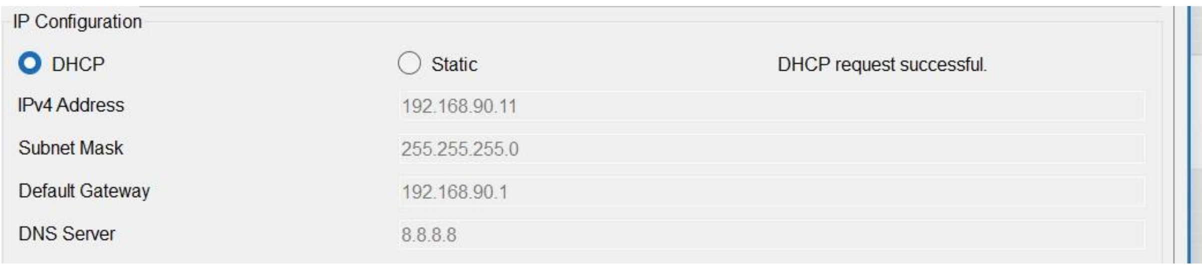


Figure 64

DHCP Verification

R1 London

```
R1#sh ip dhc bind
IP address       Client-ID/               Lease expiration        Type
                 Hardware address
192.168.10.11    0001.64CD.9743            --                     Automatic
192.168.20.11    0005.5E18.B7D9            --                     Automatic
192.168.30.11    00D0.FF72.23E9            --                     Automatic
```

Figure 65

R2 Leicester

```
R2#sh ip dhcp bind
IP address       Client-ID/               Lease expiration        Type
                 Hardware address
192.168.40.11    00D0.FF4D.1875            --                     Automatic
192.168.50.11    000C.853D.2B26            --                     Automatic
192.168.60.11    0060.3E46.7922            --                     Automatic
```

Figure 66

R3 Leeds

```
R3#sh ip dhcp bin
IP address       Client-ID/               Lease expiration        Type
                 Hardware address
192.168.70.11    00D0.BAC7.BC91            --                     Automatic
192.168.80.11    000D.BD3A.3D1C            --                     Automatic
192.168.90.11    0090.21B0.06E0            --                     Automatic
```

Figure 67

R4 Liverpool

```
R4#sho ip dhcp bi
IP address       Client-ID/               Lease expiration        Type
                 Hardware address
192.168.100.11   0010.116B.92B7            --                     Automatic
192.168.110.11   00E0.F753.8A3C            --                     Automatic
192.168.120.11   00E0.A373.B574            --                     Automatic
R4#
```

Figure 68

To confirm the successful allocation of IP addresses via DHCP, the show ip dhcp binding command was used on the router. This command displays a list of dynamically assigned IP addresses along with the corresponding MAC addresses of the client devices. By matching these bindings with the expected VLAN ranges and devices, it provides concrete evidence that the DHCP server is functioning correctly and assigning IPs as per the defined pools. This step ensures transparency and traceability in IP address management, reinforcing the reliability of the automated configuration process (Droms).

Ping Testing

London area

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	London(Employers)	London(Executive)	ICMP		0.000	N	0	(edit)	
	Successful	London(Employers)	London(Finance)	ICMP		0.000	N	1	(edit)	
	Successful	London(Executive)	London(Employers)	ICMP		0.000	N	2	(edit)	
	Successful	London(Executive)	London(Finance)	ICMP		0.000	N	3	(edit)	
	Successful	London(Finance)	London(Executive)	ICMP		0.000	N	4	(edit)	
	Successful	London(Finance)	London(Employers)	ICMP		0.000	N	5	(edit)	

Figure 69

Leeds area

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Leeds Finance	Leeds Executive	ICMP		0.000	N	0	(edit)	
	Successful	Leeds Executive	Leeds Finance	ICMP		0.000	N	1	(edit)	
	Successful	Leeds Executive	Leeds Employers	ICMP		0.000	N	2	(edit)	
	Successful	Leeds Employers	Leeds Executive	ICMP		0.000	N	3	(edit)	
	Successful	Leeds Employers	Leeds Finance	ICMP		0.000	N	4	(edit)	
	Successful	Leeds Finance	Leeds Employers	ICMP		0.000	N	5	(edit)	

Figure 70

Liverpool area

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Liverpool Emplyers	Liverpool Executive	ICMP		0.000	N	0	(edit)	
	Successful	Liverpool Emplyers	Liverpool Finance	ICMP		0.000	N	1	(edit)	
	Successful	Liverpool Executive	Liverpool Emplyers	ICMP		0.000	N	2	(edit)	
	Successful	Liverpool Executive	Liverpool Finance	ICMP		0.000	N	3	(edit)	
	Successful	Liverpool Finance	Liverpool Executive	ICMP		0.000	N	4	(edit)	
	Successful	Liverpool Finance	Liverpool Emplyers	ICMP		0.000	N	5	(edit)	

Figure 71

Leicester area

Fire	Last Status	Source	Destination	Type	Color	Time(sec	Periodic	Num	Edit	Delete
	Successful	Leicester Executive	Leicester Finance	ICMP		0.000	N	0	(edit)	
	Successful	Leicester Finance	Leicester Executive	ICMP		0.000	N	1	(edit)	
	Successful	Leicester Finance	Leicester Employers	ICMP		0.000	N	2	(edit)	
	Successful	Leicester Employers	Leicester Executive	ICMP		0.000	N	3	(edit)	
	Successful	Leicester Employers	Leicester Finance	ICMP		0.000	N	4	(edit)	
	Successful	Leicester Executive	Leicester Employers	ICMP		0.000	N	5	(edit)	

Figure 72

Successful ping tests were performed between devices within each region to confirm proper IP assignment and local connectivity. The 100% success rate across all sites verifies that DHCP is functioning correctly and that VLAN configurations are supporting effective intra-site communication

Security

To secure the network infrastructure, essential configurations were applied to all routers and switches. Console and VTY lines were protected with passwords, and the service password-encryption command was used to prevent plain-text exposure of credentials. Insecure protocols like Telnet were disabled and replaced with SSH to ensure encrypted remote access. A login banner was also set to provide a legal warning and deter unauthorized users.

These measures align with best practices and significantly reduce risks such as unauthorized access and credential leakage. As noted by G. Mason and J. Newcomb, securing access points on network devices is crucial for maintaining overall network integrity.

London,Router

```
R1(config)#service password-encryption
R1(config)#ip domain-name mynetwork.local
R1(config)#crypto key generate rsa
The name for the keys will be: R1.mynetwork.local
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]

R1(config)#username admin secret cisco
*Mar 1 3:37:29.247: %SSH-5-ENABLED: SSH 1.99 has been enabled
R1(config)#line vty 0 4
R1(config-line)#login local
R1(config-line)#transport input ssh
R1(config-line)#exit
R1(config)#
```

Figure 73

Switch

```
S1_London(config)#
S1_London(config)#enable secret class
S1_London(config)#service password-encryption
S1_London(config)#banner motd # Unauthorized access is prohibited. #
S1_London(config)#
S1_London(config)#line console 0
S1_London(config-line)# password cisco
S1_London(config-line)# login
S1_London(config-line)# logging synchronous
S1_London(config-line)#exit
S1_London(config)#
S1_London(config)#line vty 0 4
S1_London(config-line)# password cisco
S1_London(config-line)# login
S1_London(config-line)# transport input ssh
S1_London(config-line)#exit
S1_London(config)#ip domain-name mynetwork.local
S1_London(config)#crypto key generate rsa
The name for the keys will be: S1_London.mynetwork.local
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]

S1_London(config)#
*Mar 1 3:58:57.26: %SSH-5-ENABLED: SSH 1.99 has been enabled
S1_London(config)#username admin secret cisco
S1_London(config)#line vty 0 4
S1_London(config-line)# login local
S1_London(config-line)# transport input ssh
S1_London(config-line)#exit
```

Figure 74

Leicester

```
R2#conf
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#service password-encryption
R2(config)#ip domain-name mynetwork.local
R2(config)#crypto key generate rsa
The name for the keys will be: R2.mynetwork.local
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]

R2(config)#
*Mar 1 3:45:4.435: %SSH-5-ENABLED: SSH 1.99 has been enabled
R2(config)#username admin secret cisco
R2(config)#
R2(config)#line vty 0 4
R2(config-line)# login local
R2(config-line)# transport input ssh
R2(config-line)#exit
```

Figure 75

Switch

```
S2_Leicester(config)#enable secret class
S2_Leicester(config)#service password-encryption
S2_Leicester(config)#banner motd # Unauthorized access is prohibited. #
S2_Leicester(config)#
S2_Leicester(config)#line console 0
S2_Leicester(config-line)# password cisco
S2_Leicester(config-line)# login
S2_Leicester(config-line)# logging synchronous
S2_Leicester(config-line)#exit
S2_Leicester(config)#
S2_Leicester(config)#line vty 0 4
S2_Leicester(config-line)# password cisco
S2_Leicester(config-line)# login
S2_Leicester(config-line)# transport input ssh
S2_Leicester(config-line)#exit
S2_Leicester(config)#ip domain-name mynetwork.local
S2_Leicester(config)#crypto key generate rsa
The name for the keys will be: S2_Leicester.mynetwork.local
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]

S2_Leicester(config)#
*Mar 1 4:0:38.706: %SSH-5-ENABLED: SSH 1.99 has been enabled
S2_Leicester(config)#username admin secret cisco
S2_Leicester(config)#line vty 0 4
S2_Leicester(config-line)# login local
S2_Leicester(config-line)# transport input ssh
S2_Leicester(config-line)#exit
```

Figure 76

Leeds

```
R3#conf
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R3(config)#service password-encryption
R3(config)#ip domain-name mynetwork.local
R3(config)#crypto key generate rsa
The name for the keys will be: R3.mynetwork.local
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]

R3(config)#
*Mar 1 3:47:3.122: %SSH-5-ENABLED: SSH 1.99 has been enabled
R3(config)#username admin secret cisco
R3(config)#
R3(config)#line vty 0 4
R3(config-line)# login local
R3(config-line)# transport input ssh
R3(config-line)#exit
```

Figure 77

Switch

```
S3_leeds(config)#enable secret class
S3_leeds(config)#service password-encryption
S3_leeds(config)#banner motd # Unauthorized access is prohibited. #
S3_leeds(config)#
S3_leeds(config)#line console 0
S3_leeds(config-line)# password cisco
S3_leeds(config-line)# login
S3_leeds(config-line)# logging synchronous
S3_leeds(config-line)#exit
S3_leeds(config)#
S3_leeds(config)#line vty 0 4
S3_leeds(config-line)# password cisco
S3_leeds(config-line)# login
S3_leeds(config-line)# transport input ssh
S3_leeds(config-line)#exit
S3_leeds(config)#ip domain-name mynetwork.local
S3_leeds(config)#crypto key generate rsa
The name for the keys will be: S3_leeds.mynetwork.local
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]

S3_leeds(config)#
*Mar 1 4:1:26.963: %SSH-5-ENABLED: SSH 1.99 has been enabled
S3_leeds(config)#username admin secret cisco
S3_leeds(config)#line vty 0 4
S3_leeds(config-line)# login local
S3_leeds(config-line)# transport input ssh
S3_leeds(config-line)#exit
```

Figure 78

Liverpool

```
R4#conf
Configuring from terminal, memory, or network [terminal]?
Enter configuration commands, one per line.  End with CNTL/Z.
R4(config)#service password-encryption
R4(config)#ip domain-name mynetwork.local
R4(config)#crypto key generate rsa
The name for the keys will be: R4.mynetwork.local
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]

R4(config)#
*Mar 1 3:46:9.571: %SSH-5-ENABLED: SSH 1.99 has been enabled
R4(config)#username admin secret cisco
R4(config)#
R4(config)#line vty 0 4
R4(config-line)# login local
R4(config-line)# transport input ssh
R4(config-line)#exit
```

Figure 79

Switch

```
S4_Liverpool(config)#enable secret class
S4_Liverpool(config)#service password-encryption
S4_Liverpool(config)#banner motd # Unauthorized access is prohibited. #
S4_Liverpool(config)#
S4_Liverpool(config)#line console 0
S4_Liverpool(config-line)# password cisco
S4_Liverpool(config-line)# login
S4_Liverpool(config-line)# logging synchronous
S4_Liverpool(config-line)#exit
S4_Liverpool(config)#
S4_Liverpool(config)#line vty 0 4
S4_Liverpool(config-line)# password cisco
S4_Liverpool(config-line)# login
S4_Liverpool(config-line)# transport input ssh
S4_Liverpool(config-line)#exit
S4_Liverpool(config)#ip domain-name mynetwork.local
S4_Liverpool(config)#crypto key generate rsa
The name for the keys will be: S4_Liverpool.mynetwork.local
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]

S4_Liverpool(config)#
*Mar 1 4:2:8.92: %SSH-5-ENABLED: SSH 1.99 has been enabled
S4_Liverpool(config)#username admin secret cisco
S4_Liverpool(config)#line vty 0 4
S4_Liverpool(config-line)# login local
S4_Liverpool(config-line)# transport input ssh
S4_Liverpool(config-line)#exit
S4_Liverpool(config)#
```

Figure 80

Security Verification:

London

Router

```
R1#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
R1#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
R1#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
R1#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00
   4 vty 0     admin      idle                 00:08:55
   5 vty 1     admin      idle                 00:05:22
   7 vty 3     admin      idle                 00:06:18

  Interface    User               Mode         Idle     Peer Address
R1#
```

Figure 81

Switch

Switch

```
 Unauthorized access is prohibited.

User Access Verification

Password:

S1_London>en
Password:
S1_London#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
S1_London#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
line vty 5 15
 login
S1_London#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
S1_London#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
S1_London#
```

Figure 82

Leeds

Router

```
User Access Verification

Password:
Password:
Password:

R3>en
Password:
Password:
Password:
% Bad secrets

R3>en
Password:
R3#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
R3#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
R3#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
R3#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
R3#
```

Figure 83

Switch

```
User Access Verification

Password:
Password:
Password:

S3_leeds>en
Password:
S3_leeds#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
S3_leeds#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
line vty 5 15
 login
S3_leeds#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
S3_leeds#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
S3 leeds#
```

Figure 84

Liverpool

Router

```
R4>en
Password:
R4#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
R4#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
R4#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
R4#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
R4#
```

Figure 85

Switch

```
User Access Verification

Password:
Password:
Password:

S4_Liverpool>en
Password:
S4_Liverpool#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
S4_Liverpool#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
line vty 5 15
 login
S4_Liverpool#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
S4_Liverpool#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
S4_Liverpool#
```

Figure 86

Leicester

Router

```
User Access Verification

Password:
Password:
Password:

R2>en
Password:
R2#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
R2#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
R2#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
R2#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
R2#
```

Figure 87

Switch

```
User Access Verification

Password:
Password:
Password:

S2_Leicester>en
Password:
S2_Leicester#show run | include username
username admin secret 5 $1$mERr$hx5rVt7rPNoS4wqbXKX7m0
S2_Leicester#show run | section line vty
line vty 0 4
 password 7 0822455D0A16
 login local
 transport input ssh
line vty 5 15
 login
S2_Leicester#show ip ssh
SSH Enabled - version 1.99
Authentication timeout: 120 secs; Authentication retries: 3
S2_Leicester#show users
    Line       User       Host(s)              Idle       Location
*  0 con 0                idle                 00:00:00

  Interface    User               Mode         Idle     Peer Address
S2 Leicester#
```

Figure 88

Security measures were implemented on all routers and switches to restrict unauthorized access. This included setting encrypted passwords, securing console and VTY access, enabling SSH, and disabling Telnet. A legal banner was configured, and service password-encryption was applied to protect plaintext passwords. All settings were verified using appropriate show commands and saved to the startup configuration.

Verifying Security of Open Ports

London

Router

```
R1#
%SYS-5-CONFIG_I: Configured from console by console

R1#show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0/0   192.168.1.1     YES manual up                    up
GigabitEthernet0/0/0.30192.168.10.1    YES manual up                    up
GigabitEthernet0/0/0.40192.168.20.1    YES manual up                    up
GigabitEthernet0/0/0.50192.168.30.1    YES manual up                    up
GigabitEthernet0/0/1   203.0.113.1     YES manual up                    up
GigabitEthernet0/0/2   unassigned      YES unset  administratively down down
Serial0/1/0            10.30.1.1       YES manual up                    up
Serial0/1/1            10.30.2.1       YES manual up                    up
Serial0/2/0            unassigned      YES unset  administratively down down
Serial0/2/1            unassigned      YES unset  administratively down down
```

Figure 89

Switch

```
S1_London>en
Password:
S1_London#show ip int brie
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/1        unassigned      YES manual up                    up
FastEthernet0/2        unassigned      YES manual down                  down
FastEthernet0/3        unassigned      YES manual up                    up
FastEthernet0/4        unassigned      YES manual down                  down
FastEthernet0/5        unassigned      YES manual up                    up
FastEthernet0/6        unassigned      YES manual down                  down
FastEthernet0/7        unassigned      YES manual down                  down
FastEthernet0/8        unassigned      YES manual down                  down
FastEthernet0/9        unassigned      YES manual down                  down
FastEthernet0/10       unassigned      YES manual down                  down
FastEthernet0/11       unassigned      YES manual down                  down
FastEthernet0/12       unassigned      YES manual down                  down
FastEthernet0/13       unassigned      YES manual down                  down
FastEthernet0/14       unassigned      YES manual down                  down
FastEthernet0/15       unassigned      YES manual down                  down
FastEthernet0/16       unassigned      YES manual down                  down
FastEthernet0/17       unassigned      YES manual down                  down
FastEthernet0/18       unassigned      YES manual down                  down
FastEthernet0/19       unassigned      YES manual down                  down
FastEthernet0/20       unassigned      YES manual down                  down
FastEthernet0/21       unassigned      YES manual down                  down
FastEthernet0/22       unassigned      YES manual down                  down
FastEthernet0/23       unassigned      YES manual down                  down
FastEthernet0/24       unassigned      YES manual down                  down
GigabitEthernet0/1     unassigned      YES manual up                    up
GigabitEthernet0/2     unassigned      YES manual down                  down
Vlan1                  unassigned      YES manual administratively down down
S1_London#
```

Figure 90

Leeds

Router

Figure 91

```
R3#sh ip int bri
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0/0   unassigned      YES manual up                    up
GigabitEthernet0/0/0.30192.168.70.1    YES manual up                    up
GigabitEthernet0/0/0.40192.168.80.1    YES manual up                    up
GigabitEthernet0/0/0.50192.168.90.1    YES manual up                    up
GigabitEthernet0/0/1   unassigned      YES unset  administratively down down
GigabitEthernet0/0/2   unassigned      YES unset  administratively down down
Serial0/1/0            10.30.1.2       YES manual up                    up
Serial0/1/1            unassigned      YES unset  administratively down down
Serial0/2/0            unassigned      YES manual administratively down down
Serial0/2/1            10.30.4.2       YES manual up                    up
Loopback0              3.3.3.3         YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
R3#
```

Figure 91

Switch

```
S3_leeds>en
Password:
S3_leeds#sh ip in bri
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/1        unassigned      YES manual up                    up
FastEthernet0/2        unassigned      YES manual down                  down
FastEthernet0/3        unassigned      YES manual up                    up
FastEthernet0/4        unassigned      YES manual down                  down
FastEthernet0/5        unassigned      YES manual up                    up
FastEthernet0/6        unassigned      YES manual down                  down
FastEthernet0/7        unassigned      YES manual down                  down
FastEthernet0/8        unassigned      YES manual down                  down
FastEthernet0/9        unassigned      YES manual down                  down
FastEthernet0/10       unassigned      YES manual down                  down
FastEthernet0/11       unassigned      YES manual down                  down
FastEthernet0/12       unassigned      YES manual down                  down
FastEthernet0/13       unassigned      YES manual down                  down
FastEthernet0/14       unassigned      YES manual down                  down
FastEthernet0/15       unassigned      YES manual down                  down
FastEthernet0/16       unassigned      YES manual down                  down
FastEthernet0/17       unassigned      YES manual down                  down
FastEthernet0/18       unassigned      YES manual down                  down
FastEthernet0/19       unassigned      YES manual down                  down
FastEthernet0/20       unassigned      YES manual down                  down
FastEthernet0/21       unassigned      YES manual down                  down
FastEthernet0/22       unassigned      YES manual down                  down
FastEthernet0/23       unassigned      YES manual down                  down
FastEthernet0/24       unassigned      YES manual down                  down
GigabitEthernet0/1     unassigned      YES manual up                    up
GigabitEthernet0/2     unassigned      YES manual down                  down
Vlan1                  unassigned      YES manual administratively down down
S3_leeds#
```

Figure 92

Liverpool

Router

```
R4>en
Password:
R4#sh ip int br
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0/0   192.168.1.1     YES manual up                    up
GigabitEthernet0/0/0.30192.168.100.1   YES manual up                    up
GigabitEthernet0/0/0.40192.168.110.1   YES manual up                    up
GigabitEthernet0/0/0.50192.168.120.1   YES manual up                    up
GigabitEthernet0/0/1   unassigned      YES unset  administratively down down
GigabitEthernet0/0/2   unassigned      YES unset  administratively down down
Serial0/1/0            unassigned      YES unset  administratively down down
Serial0/1/1            unassigned      YES unset  administratively down down
Serial0/2/0            10.30.3.2       YES manual up                    up
Serial0/2/1            10.30.4.1       YES manual up                    up
Loopback0              4.4.4.4         YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
R4#
```

Figure 93

Switch

```
S4_Liverpool#sh ip int bri
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/1        unassigned      YES manual up                    up
FastEthernet0/2        unassigned      YES manual down                  down
FastEthernet0/3        unassigned      YES manual up                    up
FastEthernet0/4        unassigned      YES manual down                  down
FastEthernet0/5        unassigned      YES manual up                    up
FastEthernet0/6        unassigned      YES manual down                  down
FastEthernet0/7        unassigned      YES manual down                  down
FastEthernet0/8        unassigned      YES manual down                  down
FastEthernet0/9        unassigned      YES manual down                  down
FastEthernet0/10       unassigned      YES manual down                  down
FastEthernet0/11       unassigned      YES manual down                  down
FastEthernet0/12       unassigned      YES manual down                  down
FastEthernet0/13       unassigned      YES manual down                  down
FastEthernet0/14       unassigned      YES manual down                  down
FastEthernet0/15       unassigned      YES manual down                  down
FastEthernet0/16       unassigned      YES manual down                  down
FastEthernet0/17       unassigned      YES manual down                  down
FastEthernet0/18       unassigned      YES manual down                  down
FastEthernet0/19       unassigned      YES manual down                  down
FastEthernet0/20       unassigned      YES manual down                  down
FastEthernet0/21       unassigned      YES manual down                  down
FastEthernet0/22       unassigned      YES manual down                  down
FastEthernet0/23       unassigned      YES manual down                  down
FastEthernet0/24       unassigned      YES manual down                  down
GigabitEthernet0/1     unassigned      YES manual up                    up
GigabitEthernet0/2     unassigned      YES manual down                  down
Vlan1                  unassigned      YES manual administratively down down
```

Figure 94

Leicester

Router

```
R2#sh ip int bri
Interface              IP-Address      OK? Method Status                Protocol
GigabitEthernet0/0/0   192.168.2.1     YES manual up                    up
GigabitEthernet0/0/0.30192.168.40.1    YES manual up                    up
GigabitEthernet0/0/0.40192.168.50.1    YES manual up                    up
GigabitEthernet0/0/0.50192.168.60.1    YES manual up                    up
GigabitEthernet0/0/1   unassigned      YES unset  administratively down down
GigabitEthernet0/0/2   unassigned      YES unset  administratively down down
Serial0/1/0            unassigned      YES unset  administratively down down
Serial0/1/1            10.30.2.2       YES manual up                    up
Serial0/2/0            10.30.3.1       YES manual up                    up
Serial0/2/1            unassigned      YES unset  administratively down down
Loopback0              2.2.2.2         YES manual up                    up
Vlan1                  unassigned      YES unset  administratively down down
```

Figure 95

Switch

```
S2_Leicester>en
Password:
S2_Leicester#sh ip int br
Interface              IP-Address      OK? Method Status                Protocol
FastEthernet0/1        unassigned      YES manual up                    up
FastEthernet0/2        unassigned      YES manual down                  down
FastEthernet0/3        unassigned      YES manual up                    up
FastEthernet0/4        unassigned      YES manual down                  down
FastEthernet0/5        unassigned      YES manual up                    up
FastEthernet0/6        unassigned      YES manual down                  down
FastEthernet0/7        unassigned      YES manual down                  down
FastEthernet0/8        unassigned      YES manual down                  down
FastEthernet0/9        unassigned      YES manual down                  down
FastEthernet0/10       unassigned      YES manual down                  down
FastEthernet0/11       unassigned      YES manual down                  down
FastEthernet0/12       unassigned      YES manual down                  down
FastEthernet0/13       unassigned      YES manual down                  down
FastEthernet0/14       unassigned      YES manual down                  down
FastEthernet0/15       unassigned      YES manual down                  down
FastEthernet0/16       unassigned      YES manual down                  down
FastEthernet0/17       unassigned      YES manual down                  down
FastEthernet0/18       unassigned      YES manual down                  down
FastEthernet0/19       unassigned      YES manual down                  down
FastEthernet0/20       unassigned      YES manual down                  down
FastEthernet0/21       unassigned      YES manual down                  down
FastEthernet0/22       unassigned      YES manual down                  down
FastEthernet0/23       unassigned      YES manual down                  down
FastEthernet0/24       unassigned      YES manual down                  down
GigabitEthernet0/1     unassigned      YES manual up                    up
GigabitEthernet0/2     unassigned      YES manual down                  down
Vlan1                  unassigned      YES manual administratively down down
S2_Leicester#
```

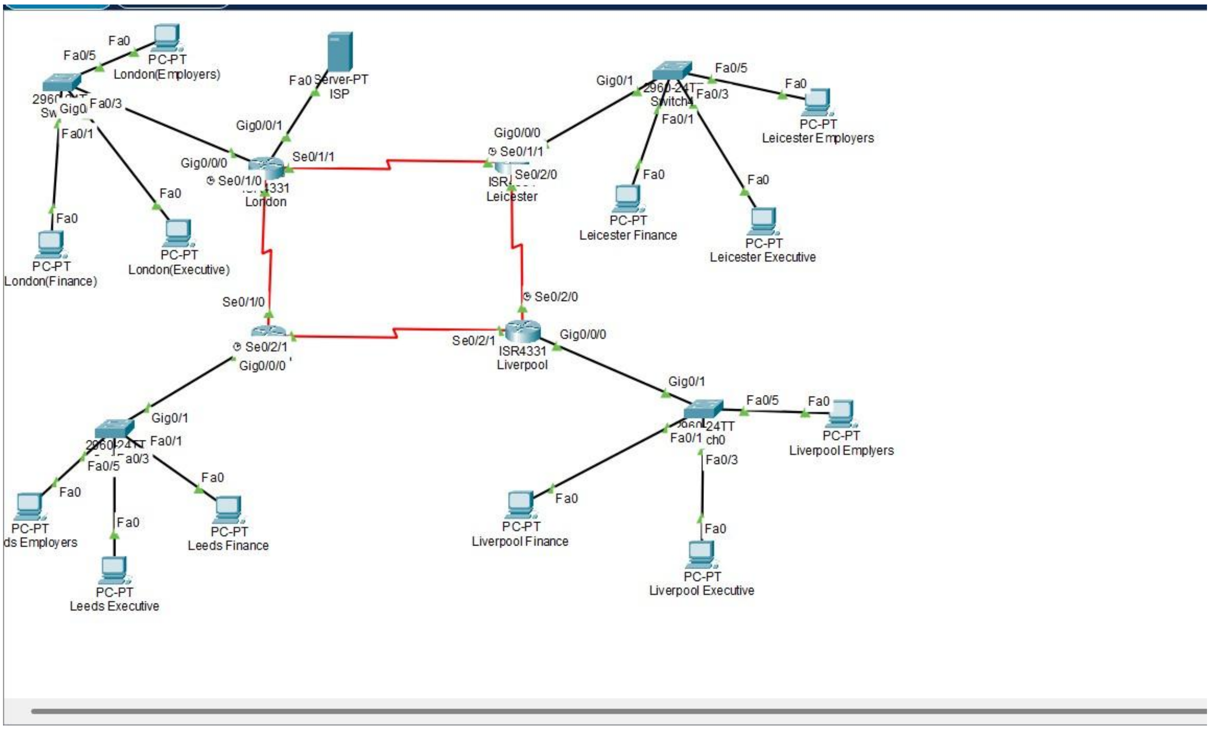
Figure 96Figure 97

To strengthen network security, all unused interfaces on routers and switches were administratively shut down. Leaving ports open poses a potential risk, as attackers may exploit them using techniques such as port scanning, TCP replay, or denial-of-service (DoS) attacks. As demonstrated by Al-Bahadili and Hadi (2010), proactive port control mechanisms like Hybrid Port Knocking emphasize the importance of closing unused ports to minimize attack surfaces. Even though HPK applies to advanced security setups, the principle of closing idle ports remains essential in any secure network design.

ACL

Access Control Lists (ACLs) offer a powerful mechanism to manage and secure network traffic. In this design, ACLs were used to restrict internet access for all sites except London, enhancing security and traffic control. ACLs help network administrators regulate access by filtering packets based on IP address and protocol, restrict unauthorized communication, and improve performance by reducing unnecessary traffic. Additionally, they assist in controlling the types of traffic allowed into or out of router interfaces. However, it is important to design ACLs efficiently, as poorly constructed lists can introduce latency and impact performance across the network (Tomar & Tyagi, 2014).

Final Testing for server connection with PC before implementing ACL:



London – ISP

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit
	Successful	London(Employers)	ISP	ICMP		0.000	N	0	(edit)
	Successful	London(Executive)	ISP	ICMP		0.000	N	1	(edit)
	Successful	London(Finance)	ISP	ICMP		0.000	N	2	(edit)

Figure 98

Leicester-ISP:

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	Delete
	Successful	Leicester Finance	ISP	ICMP		0.000	N	0	(edit)	(delete)
	Successful	Leicester Exec...	ISP	ICMP		0.000	N	1	(edit)	(delete)
	Successful	Leicester Empl...	ISP	ICMP		0.000	N	2	(edit)	(delete)

Figure 99

Liverpool-ISP:

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	D
	Successful	Liverpool Emplyers	ISP	ICMP		0.000	N	0	(edit)	(d
	Successful	Liverpool Executive	ISP	ICMP		0.000	N	1	(edit)	(d
	Successful	Liverpool Finance	ISP	ICMP		0.000	N	2	(edit)	(d

Figure 100

Leeds-ISP:

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Periodic	Num	Edit	D
	Successful	Leeds Finance	ISP	ICMP		0.000	N	0	(edit)	(d
	Successful	Leeds Executive	ISP	ICMP		0.000	N	1	(edit)	(d
	Successful	Leeds Employers	ISP	ICMP		0.000	N	2	(edit)	(d

Figure 101

ACL implementation:

```
R1(config)#no ip access-list extended BLOCK_INTERNET
R1(config)#ip access-list extended BLOCK_INTERNET
R1(config-ext-nacl)# deny ip 192.168.2.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.4.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.40.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.50.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.60.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.70.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.80.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.90.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.100.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.110.0 0.0.0.255 any
R1(config-ext-nacl)# deny ip 192.168.120.0 0.0.0.255 any
R1(config-ext-nacl)# permit ip any any
R1(config)#int g0/0/1
R1(config-if)#no ip access-group BLOCK_INTERNET in
R1(config-if)#ip access-group BLOCK_INTERNET out
R1(config-if)#
```

Figure 102

ACL Testing

London-ISP

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Perio
	Successful	London(Employers)	ISP	ICMP		0.000	N
	Successful	London(Executive)	ISP	ICMP		0.000	N
	Successful	London(Finance)	ISP	ICMP		0.000	N

Figure 103

Leicester-ISP

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Perio
	Failed	Leicester Finance	ISP	ICMP		0.000	N
	Failed	Leicester Executive	ISP	ICMP		0.000	N
	Failed	Leicester Employers	ISP	ICMP		0.000	N

Figure 104

Leeds-ISP

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Perio
	Failed	Leeds Finance	ISP	ICMP		0.000	N
	Failed	Leeds Executive	ISP	ICMP		0.000	N
	Failed	Leeds Employers	ISP	ICMP		0.000	N

Figure 105

Liverpool-ISP

Fire	Last Status	Source	Destination	Type	Color	Time(sec)	Perio
	Failed	Liverpool Finance	ISP	ICMP		0.000	N
	Failed	Liverpool Executive	ISP	ICMP		0.000	N
	Failed	Liverpool Emplyers	ISP	ICMP		0.000	N

Figure 106

The implementation of ACLs across the network successfully enforced access restrictions, particularly preventing users in specified VLANs from reaching the ISP. Final ping tests confirmed that only permitted traffic was allowed, while unauthorized requests were blocked as intended. This configuration enhances network security, controls resource access, and ensures compliance with organizational policies

Final view

Figure 107

Summary

This report detailed the end-to-end design and implementation of a secure, scalable, and resilient enterprise network interconnecting four regional sites: London, Leicester, Liverpool, and Leeds. The core of the routing architecture leveraged OSPF for dynamic path selection, with static routes serving as a reliable fallback mechanism to maintain connectivity during link failures.

The network was logically segmented using VLANs (Finance, Executive, and Employers) to enhance security and manageability, with inter-VLAN routing implemented via the router-on-a-stick method. DHCP services were configured to automate IP address assignment, ensuring operational efficiency and ease of scalability.

Access to external resources was tightly controlled using Access Control Lists (ACLs), restricting internet connectivity to the London site, while enforcing segmentation and security across all other locations. Additionally, best practices in router and switch hardening were applied, including encrypted credentials, disabled Telnet access, and shutdown of unused interfaces.

All configurations were rigorously tested through IP binding verification, inter-site and intra-VLAN connectivity tests, fallback simulations, and secure access validations. The resulting network infrastructure delivers high availability, robust security, and compliance with organizational requirements, positioning it for future growth and operational excellence.

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