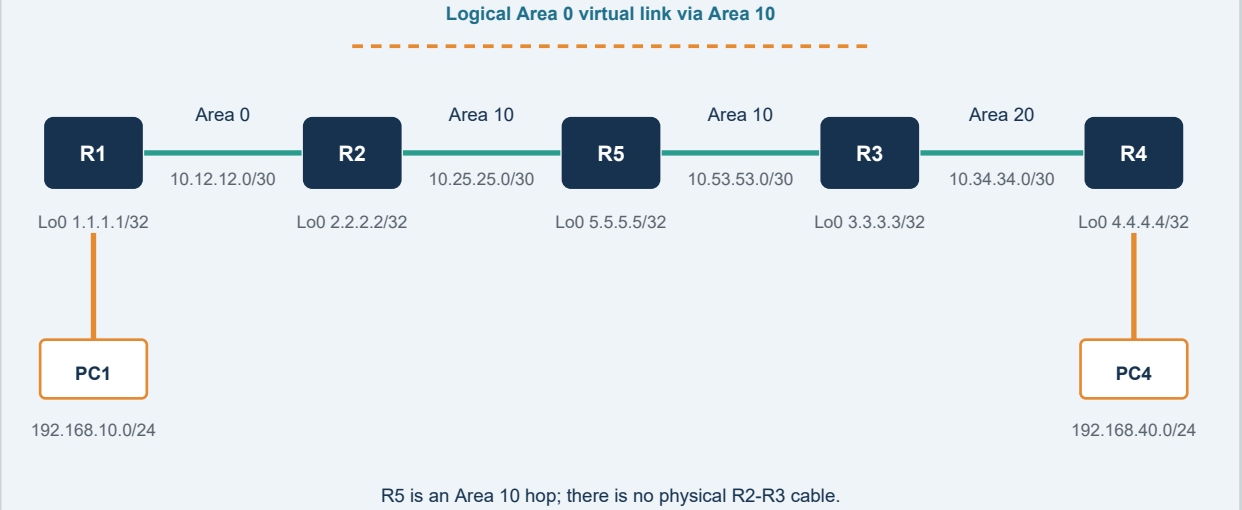
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Lab 05

OSPF Virtual Links & Backbone Connectivity



Guided workbook | 5 IOL L3 routers + 2 VPCS

Restore Area 0 connectivity through Area 10; verify both control plane and client forwarding.

Blueprint	Level	Estimated time	Validated platform
1.10.c(ii)-(iv)	Intermediate	150-190 min	EVE-NG / approved IOL L3

CLI annotations: GREEN - expected healthy result; YELLOW - warning or interpretation required; RED - fault or failed requirement. Colors are workbook annotations, not native CLI colors. Variable timers and ages may differ. Yellow/red items include a one-line reason.

1. Overview and production objective

A remote Area 20 site was connected through Area 10 before a physical Area 0 extension was available. Build a non-stub transit area, observe the missing backbone relationship, then establish a virtual link between the two ABRs. Verify control plane and real client forwarding. This is a transitional repair technique; a contiguous physical backbone is the long-term design. Blueprint 1.10.c(ii)-(iv); estimated 150-190 minutes.

2. Observable outcomes

Identify R2 and R3 as virtual-link endpoints by router ID, R5 as an internal transit router, and R1/R4 as client gateways. Prove Area 10 stays normal, R2-R3 virtual adjacency becomes FULL, Area 20 summaries reach the core, PC1-PC4 traffic works both ways, and a wrong peer ID has a scoped effect that can be repaired.

3. Enterprise scenario and interview value

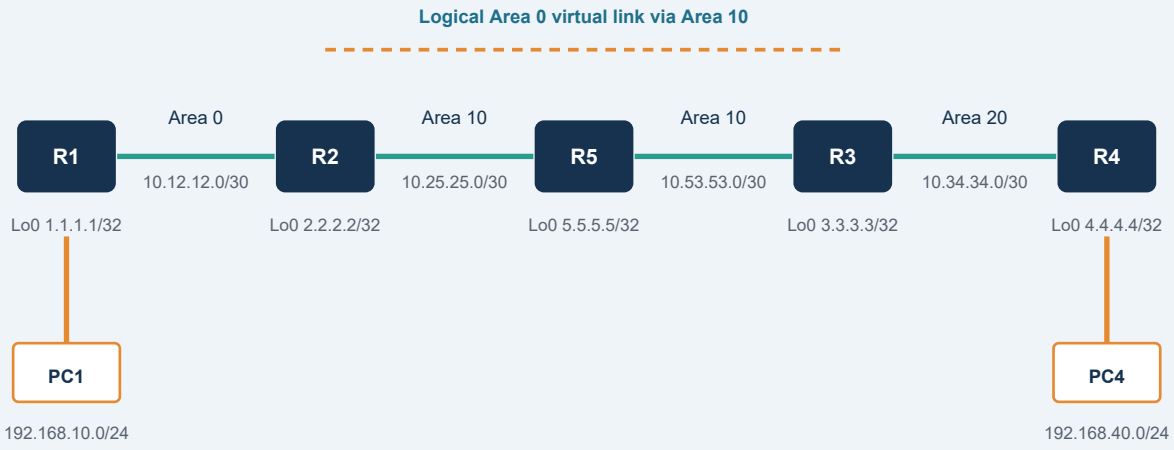
An acquired branch behind R3 uses Area 20; Area 10 separates it from the existing backbone at R2. R5 is a real hop in Area 10, demonstrating that the virtual link is a logical OSPF adjacency rather than an Ethernet cable. The team needs evidence that the repair carries inter-area reachability while Area 10 remains healthy. Explain why the peer argument is the remote Router ID, why Stub/NSSA cannot serve as transit, and why a successful FULL state alone does not prove bidirectional client forwarding.

4. Prerequisites

Complete Labs 01-04. Know /30 and /24 addressing, OSPF FULL adjacency, Area 0 and ABR roles, Type 1 and Type 3 LSAs, passive user interfaces, and source-based ping. A Router ID labels the OSPF speaker; it is not the physical next hop. A virtual link depends on intra-area reachability across its transit area and is configured at both endpoints.

5. Topology and roles

R1-R2 is Area 0. R2-R5-R3 is normal Area 10 and contains both virtual endpoints with R5 in the middle. R3-R4 is Area 20. PC1 attaches to R1 and PC4 to R4. R2 and R3 are ABRs when the virtual link is operational. The virtual link is drawn as a logical dashed relation; there is no extra physical EVE connection. All five routers use the approved IOL L3 image.



R5 is an Area 10 hop; there is no physical R2-R3 cable.

Node roles

Router	Role	Loopback0	Area
R1	Core gateway	1.1.1.1/32	0
R2	Backbone ABR / endpoint	2.2.2.2/32	0
R3	Remote ABR / endpoint	3.3.3.3/32	10
R4	Branch gateway	4.4.4.4/32	20
R5	Transit internal	5.5.5.5/32	10

Physical connection table

Endpoint A	Endpoint B	Area
R1 Ethernet0/0	R2 Ethernet0/0	0
R2 Ethernet0/1	R5 Ethernet0/0	10
R5 Ethernet0/1	R3 Ethernet0/0	10
R3 Ethernet0/1	R4 Ethernet0/0	20
R1 Ethernet0/1	PC1 eth0	0
R4 Ethernet0/1	PC4 eth0	20

IP addressing

Link	IPv4 subnet	Endpoint addresses	Area
R1-R2	10.12.12.0/30	R1: 10.12.12.1 / R2: 10.12.12.2	0

Link	IPv4 subnet	Endpoint addresses	Area
R2-R5	10.25.25.0/30	R2: 10.25.25.1 / R5: 10.25.25.2	10
R5-R3	10.53.53.0/30	R5: 10.53.53.1 / R3: 10.53.53.2	10
R3-R4	10.34.34.0/30	R3: 10.34.34.1 / R4: 10.34.34.2	20
PC1 LAN	192.168.10.0/24	R1: 192.168.10.1 / PC1: 192.168.10.10	0
PC4 LAN	192.168.40.0/24	R4: 192.168.40.1 / PC4: 192.168.40.10	20

The virtual R2-R3 relationship has no separate interface, cable or subnet. Each PC uses its local .1 gateway.

6. Starting states

raw has the connected seven-node topology only. Configure addresses, VPCS names and gateways in section 9. save-ip-configuration already has those prerequisites; verify them and start section 10. It has no OSPF. save-config is the completed healthy virtual-link network; after independent boot and convergence, run section 15 without entering configuration. All three variants have exactly the same nodes, ports, links and canvas positions.

Item	raw	save-ip-configuration	save-config
Topology	Identical	Identical	Identical
Names / IPs	Absent	Present	Present
OSPF	Absent	Absent	Complete / healthy
Learner action	Build all	Build OSPF	Verify only

7.1 Deep dive - Why the backbone matters

An OSPF ABR distributes routes between a non-backbone area and Area 0. A remote area attached to a router without a valid backbone connection is an unsupported hierarchy even if its local physical adjacencies are FULL. Before repair, R3 may already learn a core summary through Area 10, yet the client path can still fail. Check both directions instead of equating one installed route with end-to-end service. A virtual link logically extends Area 0 between two ABRs through a normal transit area. Its endpoints are Router IDs, while actual data packets follow the best reachable transit path. The virtual link does not create an Ethernet cable, tunnel interface, or new IP subnet.

7.2 Deep dive - Transit constraints and evidence

Area 10 must retain complete routing information; it cannot be Stub or NSSA for this virtual link. The peer Router ID must be reachable within Area 10 through R5. Both R2 and R3 need symmetric area 10 virtual-link commands. show ip ospf virtual-links reports the peer, transit area, state and timers; show ip ospf neighbor proves the logical Area 0 relationship. Route tables, Type 3 LSAs and the two client pings establish whether remote networks really propagate. Neighbor state and forwarding are separate release checks.

7.3 Deep dive - Change safety

A wrong virtual peer ID should remove the logical backbone repair while normal Area 10 physical adjacencies remain FULL. Compare an affected remote destination with an unaffected core-to-transit destination and both local client gateways. A failed Ping alone is weak evidence: inspect the OSPF virtual state, the actual route and next hop, and the return direction. A route may remain installed even while client forwarding fails. Restore the exact peer ID on the modified endpoint, wait for LSDB convergence, then rerun the full regression. Avoid making Area 10 stub merely to demonstrate a failure, because that would also disturb the underlay.

9.1 Set baseline on R1

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

R1

```
enable
conf t
hostname R1
no ip domain lookup
interface Loopback0
description ROUTER_ID
ip address 1.1.1.1 255.255.255.255
interface Ethernet0/0
description TO_R2_AREA0
ip address 10.12.12.1 255.255.255.252
no shutdown
interface Ethernet0/1
description USER_LAN_AREA0
ip address 192.168.10.1 255.255.255.0
no shutdown

end
```

9.2 Set baseline on R2

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

R2

```
enable
conf t
hostname R2
no ip domain lookup
interface Loopback0
description ROUTER_ID
ip address 2.2.2.2 255.255.255.255
interface Ethernet0/0
description TO_R1_AREA0
ip address 10.12.12.2 255.255.255.252
no shutdown
interface Ethernet0/1
description TO_R5_AREA10
ip address 10.25.25.1 255.255.255.252
no shutdown

end
```

9.3 Set baseline on R3

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

R3

```
enable
conf t
hostname R3
no ip domain lookup
interface Loopback0
description ROUTER_ID
ip address 3.3.3.3 255.255.255.255
interface Ethernet0/0
description TO_R5_AREA10
ip address 10.53.53.2 255.255.255.252
no shutdown
interface Ethernet0/1
description TO_R4_AREA20
ip address 10.34.34.1 255.255.255.252
no shutdown

end
```

9.4 Set baseline on R4

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

R4

```
enable
conf t
hostname R4
no ip domain lookup
interface Loopback0
description ROUTER_ID
ip address 4.4.4.4 255.255.255.255
interface Ethernet0/0
description TO_R3_AREA20
ip address 10.34.34.2 255.255.255.252
no shutdown
interface Ethernet0/1
description USER_LAN_AREA20
ip address 192.168.40.1 255.255.255.0
no shutdown

end
```

9.5 Set baseline on R5

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

R5

```
enable
conf t
hostname R5
no ip domain lookup
interface Loopback0
description ROUTER_ID
ip address 5.5.5.5 255.255.255.255
interface Ethernet0/0
description TO_R2_AREA10
ip address 10.25.25.2 255.255.255.252
no shutdown
interface Ethernet0/1
description TO_R3_AREA10
ip address 10.53.53.1 255.255.255.252
no shutdown

end
```

9.6 Set baseline on PC1

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

PC1

```
set pcname PC1
ip 192.168.10.10 192.168.10.1 24
```

9.7 Set baseline on PC4

Assign the documented name, IP addresses and local gateway before OSPF. These commands provide only local Layer 3 reachability; they do not solve the routing objective.

PC4

```
set pcname PC4
ip 192.168.40.10 192.168.40.1 24
```

9.8 Verify R1 baseline

Confirm the assigned IP interfaces are up/up and no OSPF process has been configured. A local transit ping checks the immediate link only.

R1

```
enable
terminal length 0
show ip interface brief
show running-config | section router ospf
```

Actual CLI output - R1

```
R1# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Ethernet0/0            10.12.12.1      YES manual up                    up
Ethernet0/1            192.168.10.1    YES manual up                    up
Ethernet0/2            unassigned      YES unset  administratively down down
Ethernet0/3            unassigned      YES unset  administratively down down
Loopback0              1.1.1.1         YES manual up                    up
```

Actual CLI output - R1

```
R1# show running-config | section router ospf
```

9.9 Verify R2 baseline

Confirm the assigned IP interfaces are up/up and no OSPF process has been configured. A local transit ping checks the immediate link only.

R2

```
enable
terminal length 0
show ip interface brief
show running-config | section router ospf
```

Actual CLI output - R2

```
R2# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Ethernet0/0            10.12.12.2      YES manual up                    up
Ethernet0/1            10.25.25.1      YES manual up                    up
Ethernet0/2            unassigned      YES unset  administratively down down
Ethernet0/3            unassigned      YES unset  administratively down down
Loopback0              2.2.2.2         YES manual up                    up
```

Actual CLI output - R2

```
R2# show running-config | section router ospf
```

9.10 Verify R3 baseline

Confirm the assigned IP interfaces are up/up and no OSPF process has been configured. A local transit ping checks the immediate link only.

R3

```
enable
terminal length 0
show ip interface brief
show running-config | section router ospf
```

Actual CLI output - R3

```
R3# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Ethernet0/0            10.53.53.2      YES manual up                    up
Ethernet0/1            10.34.34.1      YES manual up                    up
Ethernet0/2            unassigned      YES unset  administratively down down
Ethernet0/3            unassigned      YES unset  administratively down down
Loopback0              3.3.3.3         YES manual up                    up
```

Actual CLI output - R3

```
R3# show running-config | section router ospf
```

9.11 Verify R4 baseline

Confirm the assigned IP interfaces are up/up and no OSPF process has been configured. A local transit ping checks the immediate link only.

R4

```
enable
terminal length 0
show ip interface brief
show running-config | section router ospf
```

Actual CLI output - R4

```
R4# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Ethernet0/0            10.34.34.2      YES manual up                    up
Ethernet0/1            192.168.40.1    YES manual up                    up
Ethernet0/2            unassigned      YES unset  administratively down down
Ethernet0/3            unassigned      YES unset  administratively down down
Loopback0              4.4.4.4         YES manual up                    up
```

Actual CLI output - R4

```
R4# show running-config | section router ospf
```

9.12 Verify R5 baseline

Confirm the assigned IP interfaces are up/up and no OSPF process has been configured. A local transit ping checks the immediate link only.

R5

```
enable
terminal length 0
show ip interface brief
show running-config | section router ospf
```

Actual CLI output - R5

```
R5# show ip interface brief
Interface              IP-Address      OK? Method Status                Protocol
Ethernet0/0            10.25.25.2      YES manual up                    up
Ethernet0/1            10.53.53.1      YES manual up                    up
Ethernet0/2            unassigned      YES unset  administratively down down
Ethernet0/3            unassigned      YES unset  administratively down down
Loopback0              5.5.5.5         YES manual up                    up
```

Actual CLI output - R5

```
R5# show running-config | section router ospf
```

9.13 Verify PC1 baseline

Check the saved VPCS name, /24 address and .1 gateway. Require a complete successful result on the repeated local gateway test.

PC1

```
show ip
ping 192.168.10.1
ping 192.168.10.1
```

Actual CLI output - PC1

```
PC1> show ip
NAME        : PC1[1]
IP/MASK     : 192.168.10.10/24
GATEWAY     : 192.168.10.1
MAC         : 00:50:79:66:68:06
LPORT       : 20000
RHOST:PORT  : 127.0.0.1:30000
MTU         : 1500
```

Actual CLI output - PC1

```
PC1> ping 192.168.10.1
84 bytes from 192.168.10.1 icmp_seq=1 ttl=255 time=0.526 ms
84 bytes from 192.168.10.1 icmp_seq=2 ttl=255 time=1.245 ms
84 bytes from 192.168.10.1 icmp_seq=3 ttl=255 time=2.189 ms
84 bytes from 192.168.10.1 icmp_seq=4 ttl=255 time=0.790 ms
84 bytes from 192.168.10.1 icmp_seq=5 ttl=255 time=1.500 ms
```

9.14 Verify PC4 baseline

Check the saved VPCS name, /24 address and .1 gateway. Require a complete successful result on the repeated local gateway test.

PC4

```
show ip
ping 192.168.40.1
ping 192.168.40.1
```

Actual CLI output - PC4

```
PC4> show ip
NAME        : PC4[1]
IP/MASK     : 192.168.40.10/24
GATEWAY     : 192.168.40.1
MAC         : 00:50:79:66:68:07
LPORT       : 20000
RHOST:PORT  : 127.0.0.1:30000
MTU         : 1500
```

Actual CLI output - PC4

```
PC4> ping 192.168.40.1
84 bytes from 192.168.40.1 icmp_seq=1 ttl=255 time=1.481 ms
84 bytes from 192.168.40.1 icmp_seq=2 ttl=255 time=1.391 ms
84 bytes from 192.168.40.1 icmp_seq=3 ttl=255 time=0.737 ms
84 bytes from 192.168.40.1 icmp_seq=4 ttl=255 time=0.540 ms
84 bytes from 192.168.40.1 icmp_seq=5 ttl=255 time=2.473 ms
```

10.1 Enable OSPF on R1

Set an explicit Router ID and passive-by-default policy. Only the physical router-to-router interfaces send Hellos. Advertise Loopback0 and the attached user LAN in its stated area. Point-to-point mode avoids a DR election on each /30 transit.

R1

```
enable
conf t
router ospf 10
router-id 1.1.1.1
passive-interface default
no passive-interface Ethernet0/0
exit
interface Loopback0
ip ospf 10 area 0
interface Ethernet0/0
ip ospf network point-to-point
ip ospf 10 area 0
interface Ethernet0/1
ip ospf 10 area 0

end
```

10.2 Enable OSPF on R2

Set an explicit Router ID and passive-by-default policy. Only the physical router-to-router interfaces send Hellos. Advertise Loopback0 and the attached user LAN in its stated area. Point-to-point mode avoids a DR election on each /30 transit.

R2

```
enable
conf t
router ospf 10
router-id 2.2.2.2
passive-interface default
no passive-interface Ethernet0/0
no passive-interface Ethernet0/1
exit
interface Loopback0
ip ospf 10 area 0
interface Ethernet0/0
ip ospf network point-to-point
ip ospf 10 area 0
interface Ethernet0/1
ip ospf network point-to-point
ip ospf 10 area 10

end
```

10.3 Enable OSPF on R3

Set an explicit Router ID and passive-by-default policy. Only the physical router-to-router interfaces send Hellos. Advertise Loopback0 and the attached user LAN in its stated area. Point-to-point mode avoids a DR election on each /30 transit.

R3

```
enable
conf t
router ospf 10
router-id 3.3.3.3
passive-interface default
no passive-interface Ethernet0/0
no passive-interface Ethernet0/1
exit
interface Loopback0
ip ospf 10 area 10
interface Ethernet0/0
ip ospf network point-to-point
ip ospf 10 area 10
interface Ethernet0/1
ip ospf network point-to-point
ip ospf 10 area 20

end
```

10.4 Enable OSPF on R4

Set an explicit Router ID and passive-by-default policy. Only the physical router-to-router interfaces send Hellos. Advertise Loopback0 and the attached user LAN in its stated area. Point-to-point mode avoids a DR election on each /30 transit.

R4

```
enable
conf t
router ospf 10
router-id 4.4.4.4
passive-interface default
no passive-interface Ethernet0/0
exit
interface Loopback0
ip ospf 10 area 20
interface Ethernet0/0
ip ospf network point-to-point
ip ospf 10 area 20
interface Ethernet0/1
ip ospf 10 area 20

end
```

10.5 Enable OSPF on R5

Set an explicit Router ID and passive-by-default policy. Only the physical router-to-router interfaces send Hellos. Advertise Loopback0 and the attached user LAN in its stated area. Point-to-point mode avoids a DR election on each /30 transit.

R5

```
enable
conf t
router ospf 10
router-id 5.5.5.5
passive-interface default
no passive-interface Ethernet0/0
no passive-interface Ethernet0/1
exit
interface Loopback0
ip ospf 10 area 10
interface Ethernet0/0
ip ospf network point-to-point
ip ospf 10 area 10
interface Ethernet0/1
ip ospf network point-to-point
ip ospf 10 area 10

end
```

Allow at least 60 seconds for convergence before the next observation.

11.1 Inspect physical Area 10 before repair

R2 must see R1 and R5 FULL; R3 is reached only through R5. A physical Area 10 path does not itself create a virtual Area 0 adjacency.

R2

```
enable
terminal length 0
show ip ospf neighbor
show ip route 3.3.3.3
show ip ospf virtual-links
```

Actual CLI output - R2

```
R2# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           0   FULL/  -        00:00:39    10.12.12.1      Ethernet0/0
5.5.5.5           0   FULL/  -        00:00:37    10.25.25.2      Ethernet0/1
```

Actual CLI output - R2

```
R2# show ip route 3.3.3.3
Routing entry for 3.3.3.3/32
  Known via "ospf 10", distance 110, metric 21, type intra area
  Last update from 10.25.25.2 on Ethernet0/1, 00:00:49 ago
  Routing Descriptor Blocks:
  * 10.25.25.2, from 3.3.3.3, 00:00:49 ago, via Ethernet0/1
      Route metric is 21, traffic share count is 1
```

Actual CLI output - R2

```
R2# show ip ospf virtual-links
```

11.2 Inspect disconnected backbone at R3

R3 must see R5 and R4 physically. In this tested image it already has an OSPF inter-area route to the core client via Area 10, despite lacking a virtual Area 0 adjacency. This one route does not prove PC4 can reach PC1. Inspect the actual next hop and compare with the next client probe.

R3

```
enable
terminal length 0
show ip ospf neighbor
show ip route 192.168.10.0
show ip ospf virtual-links
```

Actual CLI output - R3

```
R3# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
5.5.5.5           0   FULL/  -        00:00:35    10.53.53.1      Ethernet0/0
4.4.4.4           0   FULL/  -        00:00:33    10.34.34.2      Ethernet0/1
```

Actual CLI output - R3

```
R3# show ip route 192.168.10.0
Routing entry for 192.168.10.0/24
  Known via "ospf 10", distance 110, metric 40, type inter area
  Last update from 10.53.53.1 on Ethernet0/0, 00:00:55 ago
  Routing Descriptor Blocks:
  * 10.53.53.1, from 2.2.2.2, 00:00:55 ago, via Ethernet0/0
      Route metric is 40, traffic share count is 1
```

Actual CLI output - R3

```
R3# show ip ospf virtual-links
```

11.3 Probe client forwarding before repair

The pre-change probe documents whether the remote destination is reachable. Compare it to the local gateway; do not label a failed remote probe an underlay failure when the local gateway is healthy.

PC4

```
ping 192.168.40.1
ping 192.168.10.10
```

Actual CLI output - PC4

```
PC4> ping 192.168.40.1
84 bytes from 192.168.40.1 icmp_seq=1 ttl=255 time=1.348 ms
84 bytes from 192.168.40.1 icmp_seq=2 ttl=255 time=0.521 ms
84 bytes from 192.168.40.1 icmp_seq=3 ttl=255 time=0.887 ms
84 bytes from 192.168.40.1 icmp_seq=4 ttl=255 time=1.113 ms
84 bytes from 192.168.40.1 icmp_seq=5 ttl=255 time=0.971 ms
```

Actual CLI output - PC4

```
PC4> ping 192.168.10.10
*192.168.40.1 icmp_seq=1 ttl=255 time=1.188 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=2 ttl=255 time=1.109 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=3 ttl=255 time=2.184 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=4 ttl=255 time=0.566 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=5 ttl=255 time=1.293 ms (ICMP type:3, code:1, Destination host unreachable)
```

WARNING - The remote area has no valid backbone attachment yet; compare local gateway and route evidence.

12.1 Configure R2 virtual endpoint

Point R2 at R3 Router ID 3.3.3.3 using transit Area 10. R5 does not receive a virtual-link command because it is an internal transit router.

R2

```
enable
conf t
router ospf 10
area 10 virtual-link 3.3.3.3
end
```

Allow at least 3 seconds for convergence before the next observation.

12.2 Configure R3 virtual endpoint

Use the reciprocal Router ID 2.2.2.2 and the same transit Area 10. The two ends should form the logical Area 0 adjacency after normal convergence.

R3

```
enable
conf t
router ospf 10
area 10 virtual-link 2.2.2.2
end
```

Allow at least 45 seconds for convergence before the next observation.

13.1 Read R2 virtual-link state

Require the virtual link to R3 to reach FULL and inspect transit Area 10 details. Confirm both physical neighbors remain FULL.

R2

```
enable
terminal length 0
show ip ospf virtual-links
show ip ospf neighbor
show ip ospf database summary
show ip route 192.168.40.0
```

Actual CLI output - R2

```
R2# show ip ospf virtual-links
Virtual Link OSPF_VL0 to router 3.3.3.3 is up
  Transit area 10, via interface Ethernet0/1
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:02
    Adjacency State FULL (Hello suppressed)
```

Actual CLI output - R2

```
R2# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -            -        10.53.53.2      OSPF_VL0
1.1.1.1           0   FULL/  -        00:00:35    10.12.12.1      Ethernet0/0
5.5.5.5           0   FULL/  -        00:00:33    10.25.25.2      Ethernet0/1
```

Actual CLI output - R2

```
R2# show ip ospf database summary
Summary Net Link States (Area 0)
  Link State ID: 192.168.40.0 (summary Network Number)
Summary Net Link States (Area 10)
  Link State ID: 192.168.10.0 (summary Network Number)
  Link State ID: 192.168.40.0 (summary Network Number)
```

Actual CLI output - R2

```
R2# show ip route 192.168.40.0
Routing entry for 192.168.40.0/24
  Known via "ospf 10", distance 110, metric 40, type inter area
  Last update from 10.25.25.2 on Ethernet0/1, 00:00:46 ago
  Routing Descriptor Blocks:
  * 10.25.25.2, from 3.3.3.3, 00:00:46 ago, via Ethernet0/1
      Route metric is 40, traffic share count is 1
```

13.2 Read R3 virtual-link state

Require reciprocal FULL and an installed route to the core client network. Read the selected next hop; the virtual adjacency and the physical data path are distinct.

R3

```
enable
terminal length 0
show ip ospf virtual-links
show ip ospf neighbor
show ip route 192.168.10.0
```

Actual CLI output - R3

```
R3# show ip ospf virtual-links
Virtual Link OSPF_VL0 to router 2.2.2.2 is up
  Transit area 10, via interface Ethernet0/0
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
    Adjacency State FULL (Hello suppressed)
```

Actual CLI output - R3

```
R3# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -            -        10.25.25.1      OSPF_VL0
5.5.5.5           0   FULL/  -        00:00:32    10.53.53.1      Ethernet0/0
4.4.4.4           0   FULL/  -        00:00:38    10.34.34.2      Ethernet0/1
```

Actual CLI output - R3

```
R3# show ip route 192.168.10.0
Routing entry for 192.168.10.0/24
  Known via "ospf 10", distance 110, metric 40, type intra area
  Last update from 10.53.53.1 on Ethernet0/0, 00:00:46 ago
  Routing Descriptor Blocks:
  * 10.53.53.1, from 1.1.1.1, 00:00:46 ago, via Ethernet0/0
      Route metric is 40, traffic share count is 1
```

13.3 Prove bidirectional clients

Use two VPCS at real /24 addresses. Require the repeated probe to return five replies from the opposite site.

PC1

```
ping 192.168.40.10
ping 192.168.40.10
```

Actual CLI output - PC1

```
PC1> ping 192.168.40.10
84 bytes from 192.168.40.10 icmp_seq=1 ttl=59 time=3.868 ms
84 bytes from 192.168.40.10 icmp_seq=2 ttl=59 time=4.465 ms
84 bytes from 192.168.40.10 icmp_seq=3 ttl=59 time=6.393 ms
84 bytes from 192.168.40.10 icmp_seq=4 ttl=59 time=2.642 ms
84 bytes from 192.168.40.10 icmp_seq=5 ttl=59 time=2.432 ms
```

13.4 Prove reverse forwarding

Verify PC4 reaches PC1, proving the return path and both gateways.

PC4

```
ping 192.168.10.10
ping 192.168.10.10
```

Actual CLI output - PC4

```
PC4> ping 192.168.10.10
84 bytes from 192.168.10.10 icmp_seq=1 ttl=59 time=2.594 ms
84 bytes from 192.168.10.10 icmp_seq=2 ttl=59 time=6.427 ms
84 bytes from 192.168.10.10 icmp_seq=3 ttl=59 time=4.139 ms
84 bytes from 192.168.10.10 icmp_seq=4 ttl=59 time=5.648 ms
84 bytes from 192.168.10.10 icmp_seq=5 ttl=59 time=2.408 ms
```

14.1 Introduce a scoped peer-ID fault

Change only the R3 virtual-link peer reference to an incorrect Router ID. This deliberately breaks the logical repair without shutting a physical transit interface. The fault is confined to the Lab 05 runtime.

R3

```
enable
conf t
router ospf 10
no area 10 virtual-link 2.2.2.2
area 10 virtual-link 2.2.2.22
end
```

Allow at least 45 seconds for convergence before the next observation.

14.2 Diagnose virtual-link and surviving underlay

The virtual adjacency is not FULL while R3-R5 and R3-R4 stay FULL. Core-to-transit reachability is the unaffected reference. Inspect the route before interpreting client traffic.

R3

```
enable
terminal length 0
show ip ospf virtual-links
show ip ospf neighbor
show ip route 192.168.10.0
ping 5.5.5.5 source Loopback0
```

Actual CLI output - R3

```
R3# show ip ospf virtual-links
Virtual Link OSPF_VL1 to router 2.2.2.22 is down
  Transit area 10
  Transmit Delay is 1 sec, State DOWN,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
```

ERROR - The wrong virtual peer Router ID removes the logical backbone repair while physical Area 10 remains up.

Actual CLI output - R3

```
R3# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
5.5.5.5           0   FULL/  -        00:00:30    10.53.53.1      Ethernet0/0
4.4.4.4           0   FULL/  -        00:00:36    10.34.34.2      Ethernet0/1
```

Actual CLI output - R3

```
R3# show ip route 192.168.10.0
Routing entry for 192.168.10.0/24
  Known via "ospf 10", distance 110, metric 40, type inter area
  Last update from 10.53.53.1 on Ethernet0/0, 00:00:46 ago
  Routing Descriptor Blocks:
  * 10.53.53.1, from 2.2.2.2, 00:00:46 ago, via Ethernet0/0
      Route metric is 40, traffic share count is 1
```

Actual CLI output - R3

```
R3# ping 5.5.5.5 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

14.3 Measure client scope

PC4 local gateway must still answer. Record whether PC1 is reachable after the logical backbone is lost; routing-table evidence determines the meaning of the ping result.

PC4

```
ping 192.168.40.1
ping 192.168.40.1
ping 192.168.10.10
```

Actual CLI output - PC4

```
PC4> ping 192.168.40.1
84 bytes from 192.168.40.1 icmp_seq=1 ttl=255 time=0.762 ms
84 bytes from 192.168.40.1 icmp_seq=2 ttl=255 time=0.615 ms
84 bytes from 192.168.40.1 icmp_seq=3 ttl=255 time=0.845 ms
84 bytes from 192.168.40.1 icmp_seq=4 ttl=255 time=0.643 ms
84 bytes from 192.168.40.1 icmp_seq=5 ttl=255 time=1.015 ms
```

Actual CLI output - PC4

```
PC4> ping 192.168.10.10
*192.168.40.1 icmp_seq=1 ttl=255 time=0.584 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=2 ttl=255 time=0.556 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=3 ttl=255 time=0.912 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=4 ttl=255 time=0.588 ms (ICMP type:3, code:1, Destination host unreachable)
*192.168.40.1 icmp_seq=5 ttl=255 time=0.587 ms (ICMP type:3, code:1, Destination host unreachable)
```

ERROR - The wrong virtual peer Router ID removes the logical backbone repair while physical Area 10 remains up.

14.4 Restore the exact Router ID

Remove the bad peer ID and configure the R2 Router ID on R3. Wait for FULL and LSA convergence before declaring recovery.

R3

```
enable
conf t
router ospf 10
no area 10 virtual-link 2.2.2.22
area 10 virtual-link 2.2.2.2
end
```

Allow at least 45 seconds for convergence before the next observation.

15.1 Final R1 regression

Verify expected physical neighbors and all remote Router IDs. R2 and R3 additionally need FULL virtual-link evidence. Check both client LANs from the router loopback source; the path must work in both directions.

R1

```
enable
terminal length 0
show ip ospf neighbor
show ip ospf interface brief
show ip route ospf
ping 2.2.2.2 source Loopback0
ping 3.3.3.3 source Loopback0
ping 4.4.4.4 source Loopback0
ping 5.5.5.5 source Loopback0
ping 192.168.10.10 source Loopback0
ping 192.168.40.10 source Loopback0
```

Actual CLI output - R1

```
R1# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -        00:00:38    10.12.12.2      Ethernet0/0
```

Actual CLI output - R1

```
R1# show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          10    0               1.1.1.1/32         1     LOOP  0/0
Et0/1        10    0               192.168.10.1/24    10    DR    0/0
Et0/0        10    0               10.12.12.1/30      10    P2P   1/1
```

Actual CLI output - R1

```
R1# show ip route ospf
Gateway of last resort is not set
O        2.2.2.2 [110/11] via 10.12.12.2, 00:04:08, Ethernet0/0
O IA     3.3.3.3 [110/31] via 10.12.12.2, 00:00:45, Ethernet0/0
O IA     4.4.4.4 [110/41] via 10.12.12.2, 00:00:45, Ethernet0/0
O IA     5.5.5.5 [110/21] via 10.12.12.2, 00:04:06, Ethernet0/0
O IA     10.25.25.0/30 [110/20] via 10.12.12.2, 00:04:08, Ethernet0/0
O IA     10.34.34.0/30 [110/40] via 10.12.12.2, 00:00:45, Ethernet0/0
O IA     10.53.53.0/30 [110/30] via 10.12.12.2, 00:04:06, Ethernet0/0
O IA  192.168.40.0/24 [110/50] via 10.12.12.2, 00:00:45, Ethernet0/0
```

Actual CLI output - R1

```
R1# ping 2.2.2.2 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R1

```
R1# ping 3.3.3.3 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R1

```
R1# ping 4.4.4.4 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R1

```
R1# ping 5.5.5.5 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R1

```
R1# ping 192.168.10.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.10, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R1

```
R1# ping 192.168.40.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.10, timeout is 2 seconds:
Packet sent with a source address of 1.1.1.1
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/2/4 ms
```

15.2 Final R2 regression

Verify expected physical neighbors and all remote Router IDs. R2 and R3 additionally need FULL virtual-link evidence. Check both client LANs from the router loopback source; the path must work in both directions.

R2

```
enable
terminal length 0
show ip ospf neighbor
show ip ospf virtual-links
show ip ospf interface brief
show ip route ospf
ping 1.1.1.1 source Loopback0
ping 3.3.3.3 source Loopback0
ping 4.4.4.4 source Loopback0
ping 5.5.5.5 source Loopback0
ping 192.168.10.10 source Loopback0
ping 192.168.40.10 source Loopback0
```

Actual CLI output - R2

```
R2# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -            -        10.53.53.2      OSPF_VL0
1.1.1.1           0   FULL/  -        00:00:38    10.12.12.1      Ethernet0/0
5.5.5.5           0   FULL/  -        00:00:35    10.25.25.2      Ethernet0/1
```

Actual CLI output - R2

```
R2# show ip ospf virtual-links
Virtual Link OSPF_VL0 to router 3.3.3.3 is up
  Transit area 10, via interface Ethernet0/1
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:01
    Adjacency State FULL (Hello suppressed)
```

Actual CLI output - R2

```
R2# show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          10    0               2.2.2.2/32         1     LOOP  0/0
Et0/0        10    0               10.12.12.2/30      10    P2P   1/1
Et0/1        10    10              10.25.25.1/30      10    P2P   1/1
```

Actual CLI output - R2

```
R2# show ip route ospf
Gateway of last resort is not set
O        1.1.1.1 [110/11] via 10.12.12.1, 00:04:09, Ethernet0/0
O        3.3.3.3 [110/21] via 10.25.25.2, 00:04:01, Ethernet0/1
O IA     4.4.4.4 [110/31] via 10.25.25.2, 00:00:46, Ethernet0/1
O        5.5.5.5 [110/11] via 10.25.25.2, 00:04:08, Ethernet0/1
O IA     10.34.34.0/30 [110/30] via 10.25.25.2, 00:00:46, Ethernet0/1
O        10.53.53.0/30 [110/20] via 10.25.25.2, 00:04:08, Ethernet0/1
O     192.168.10.0/24 [110/20] via 10.12.12.1, 00:04:09, Ethernet0/0
O IA  192.168.40.0/24 [110/40] via 10.25.25.2, 00:00:46, Ethernet0/1
```

Actual CLI output - R2

```
R2# ping 1.1.1.1 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R2

```
R2# ping 3.3.3.3 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R2

```
R2# ping 4.4.4.4 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R2

```
R2# ping 5.5.5.5 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R2

```
R2# ping 192.168.10.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.10, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R2

```
R2# ping 192.168.40.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.10, timeout is 2 seconds:
Packet sent with a source address of 2.2.2.2
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

15.3 Final R3 regression

Verify expected physical neighbors and all remote Router IDs. R2 and R3 additionally need FULL virtual-link evidence. Check both client LANs from the router loopback source; the path must work in both directions.

R3

```
enable
terminal length 0
show ip ospf neighbor
show ip ospf virtual-links
show ip ospf interface brief
show ip route ospf
ping 1.1.1.1 source Loopback0
ping 2.2.2.2 source Loopback0
ping 4.4.4.4 source Loopback0
ping 5.5.5.5 source Loopback0
ping 192.168.10.10 source Loopback0
ping 192.168.40.10 source Loopback0
```

Actual CLI output - R3

```
R3# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           0   FULL/  -            -        10.25.25.1      OSPF_VL2
5.5.5.5           0   FULL/  -        00:00:32    10.53.53.1      Ethernet0/0
4.4.4.4           0   FULL/  -        00:00:38    10.34.34.2      Ethernet0/1
```

Actual CLI output - R3

```
R3# show ip ospf virtual-links
Virtual Link OSPF_VL2 to router 2.2.2.2 is up
  Transit area 10, via interface Ethernet0/0
  Transmit Delay is 1 sec, State POINT_TO_POINT,
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:08
    Adjacency State FULL (Hello suppressed)
```

Actual CLI output - R3

```
R3# show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          10    10              3.3.3.3/32         1     LOOP  0/0
Et0/0        10    10              10.53.53.2/30      10    P2P   1/1
Et0/1        10    20              10.34.34.1/30      10    P2P   1/1
```

Actual CLI output - R3

```
R3# show ip route ospf
Gateway of last resort is not set
O        1.1.1.1 [110/31] via 10.53.53.1, 00:00:48, Ethernet0/0
O        2.2.2.2 [110/21] via 10.53.53.1, 00:00:48, Ethernet0/0
O        4.4.4.4 [110/11] via 10.34.34.2, 00:00:48, Ethernet0/1
O        5.5.5.5 [110/11] via 10.53.53.1, 00:00:48, Ethernet0/0
O        10.12.12.0/30 [110/30] via 10.53.53.1, 00:00:48, Ethernet0/0
O        10.25.25.0/30 [110/20] via 10.53.53.1, 00:00:48, Ethernet0/0
O     192.168.10.0/24 [110/40] via 10.53.53.1, 00:00:48, Ethernet0/0
O     192.168.40.0/24 [110/20] via 10.34.34.2, 00:00:48, Ethernet0/1
```

Actual CLI output - R3

```
R3# ping 1.1.1.1 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R3

```
R3# ping 2.2.2.2 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R3

```
R3# ping 4.4.4.4 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R3

```
R3# ping 5.5.5.5 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R3

```
R3# ping 192.168.10.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.10, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/2 ms
```

Actual CLI output - R3

```
R3# ping 192.168.40.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.10, timeout is 2 seconds:
Packet sent with a source address of 3.3.3.3
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

15.4 Final R4 regression

Verify expected physical neighbors and all remote Router IDs. R2 and R3 additionally need FULL virtual-link evidence. Check both client LANs from the router loopback source; the path must work in both directions.

R4

```
enable
terminal length 0
show ip ospf neighbor
show ip ospf interface brief
show ip route ospf
ping 1.1.1.1 source Loopback0
ping 2.2.2.2 source Loopback0
ping 3.3.3.3 source Loopback0
ping 5.5.5.5 source Loopback0
ping 192.168.10.10 source Loopback0
ping 192.168.40.10 source Loopback0
```

Actual CLI output - R4

```
R4# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:37    10.34.34.1      Ethernet0/0
```

Actual CLI output - R4

```
R4# show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          10    20              4.4.4.4/32         1     LOOP  0/0
Et0/1        10    20              192.168.40.1/24    10    DR    0/0
Et0/0        10    20              10.34.34.2/30      10    P2P   1/1
```

Actual CLI output - R4

```
R4# show ip route ospf
Gateway of last resort is not set
O IA     1.1.1.1 [110/41] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     2.2.2.2 [110/31] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     3.3.3.3 [110/11] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     5.5.5.5 [110/21] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     10.12.12.0/30 [110/40] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     10.25.25.0/30 [110/30] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA     10.53.53.0/30 [110/20] via 10.34.34.1, 00:00:49, Ethernet0/0
O IA  192.168.10.0/24 [110/50] via 10.34.34.1, 00:00:49, Ethernet0/0
```

Actual CLI output - R4

```
R4# ping 1.1.1.1 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/4 ms
```

Actual CLI output - R4

```
R4# ping 2.2.2.2 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/3 ms
```

Actual CLI output - R4

```
R4# ping 3.3.3.3 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R4

```
R4# ping 5.5.5.5 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 5.5.5.5, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R4

```
R4# ping 192.168.10.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.10, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 2/2/3 ms
```

Actual CLI output - R4

```
R4# ping 192.168.40.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.10, timeout is 2 seconds:
Packet sent with a source address of 4.4.4.4
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

15.5 Final R5 regression

Verify expected physical neighbors and all remote Router IDs. R2 and R3 additionally need FULL virtual-link evidence. Check both client LANs from the router loopback source; the path must work in both directions.

R5

```
enable
terminal length 0
show ip ospf neighbor
show ip ospf interface brief
show ip route ospf
ping 1.1.1.1 source Loopback0
ping 2.2.2.2 source Loopback0
ping 3.3.3.3 source Loopback0
ping 4.4.4.4 source Loopback0
ping 192.168.10.10 source Loopback0
ping 192.168.40.10 source Loopback0
```

Actual CLI output - R5

```
R5# show ip ospf neighbor
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           0   FULL/  -        00:00:37    10.53.53.2      Ethernet0/1
2.2.2.2           0   FULL/  -        00:00:34    10.25.25.1      Ethernet0/0
```

Actual CLI output - R5

```
R5# show ip ospf interface brief
Interface    PID   Area            IP Address/Mask    Cost  State Nbrs F/C
Lo0          10    10              5.5.5.5/32         1     LOOP  0/0
Et0/1        10    10              10.53.53.1/30      10    P2P   1/1
Et0/0        10    10              10.25.25.2/30      10    P2P   1/1
```

Actual CLI output - R5

```
R5# show ip route ospf
Gateway of last resort is not set
O IA     1.1.1.1 [110/21] via 10.25.25.1, 00:04:12, Ethernet0/0
O IA     2.2.2.2 [110/11] via 10.25.25.1, 00:04:12, Ethernet0/0
O        3.3.3.3 [110/11] via 10.53.53.2, 00:04:10, Ethernet0/1
O IA     4.4.4.4 [110/21] via 10.53.53.2, 00:00:51, Ethernet0/1
O IA     10.12.12.0/30 [110/20] via 10.25.25.1, 00:04:12, Ethernet0/0
O IA     10.34.34.0/30 [110/20] via 10.53.53.2, 00:00:51, Ethernet0/1
O IA  192.168.10.0/24 [110/30] via 10.25.25.1, 00:04:12, Ethernet0/0
O IA  192.168.40.0/24 [110/30] via 10.53.53.2, 00:00:51, Ethernet0/1
```

Actual CLI output - R5

```
R5# ping 1.1.1.1 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 1.1.1.1, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R5

```
R5# ping 2.2.2.2 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 2.2.2.2, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R5

```
R5# ping 3.3.3.3 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 3.3.3.3, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R5

```
R5# ping 4.4.4.4 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 4.4.4.4, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/1 ms
```

Actual CLI output - R5

```
R5# ping 192.168.10.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.10.10, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/1/2 ms
```

Actual CLI output - R5

```
R5# ping 192.168.40.10 source Loopback0
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.40.10, timeout is 2 seconds:
Packet sent with a source address of 5.5.5.5
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 1/3/4 ms
```

15.6 Final PC1 regression

Confirm saved name/IP/gateway and require a successful warmed client ping to the opposite site.

PC1

```
show ip
ping 192.168.40.10
ping 192.168.40.10
```

Actual CLI output - PC1

```
PC1> show ip
NAME        : PC1[1]
IP/MASK     : 192.168.10.10/24
GATEWAY     : 192.168.10.1
MAC         : 00:50:79:66:68:06
LPORT       : 20000
RHOST:PORT  : 127.0.0.1:30000
MTU         : 1500
```

Actual CLI output - PC1

```
PC1> ping 192.168.40.10
84 bytes from 192.168.40.10 icmp_seq=1 ttl=59 time=2.748 ms
84 bytes from 192.168.40.10 icmp_seq=2 ttl=59 time=1.802 ms
84 bytes from 192.168.40.10 icmp_seq=3 ttl=59 time=2.045 ms
84 bytes from 192.168.40.10 icmp_seq=4 ttl=59 time=3.045 ms
84 bytes from 192.168.40.10 icmp_seq=5 ttl=59 time=4.341 ms
```

15.7 Final PC4 regression

Confirm saved name/IP/gateway and require a successful warmed client ping to the opposite site.

PC4

```
show ip
ping 192.168.10.10
ping 192.168.10.10
```

Actual CLI output - PC4

```
PC4> show ip
NAME        : PC4[1]
IP/MASK     : 192.168.40.10/24
GATEWAY     : 192.168.40.1
MAC         : 00:50:79:66:68:07
LPORT       : 20000
RHOST:PORT  : 127.0.0.1:30000
MTU         : 1500
```

Actual CLI output - PC4

```
PC4> ping 192.168.10.10
84 bytes from 192.168.10.10 icmp_seq=1 ttl=59 time=2.616 ms
84 bytes from 192.168.10.10 icmp_seq=2 ttl=59 time=3.130 ms
84 bytes from 192.168.10.10 icmp_seq=3 ttl=59 time=2.084 ms
84 bytes from 192.168.10.10 icmp_seq=4 ttl=59 time=2.258 ms
84 bytes from 192.168.10.10 icmp_seq=5 ttl=59 time=2.290 ms
```

16.1 Save verified R1

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

R1

```
enable
write memory
```

Actual CLI output - R1

```
R1# write memory
Building configuration...
[OK]
```

16.2 Save verified R2

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

R2

```
enable
write memory
```

Actual CLI output - R2

```
R2# write memory
Building configuration...
[OK]
```

16.3 Save verified R3

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

R3

```
enable
write memory
```

Actual CLI output - R3

```
R3# write memory
Building configuration...
[OK]
```

16.4 Save verified R4

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

R4

```
enable
write memory
```

Actual CLI output - R4

```
R4# write memory
Building configuration...
[OK]
```

16.5 Save verified R5

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

R5

```
enable
write memory
```

Actual CLI output - R5

```
R5# write memory
Building configuration...
[OK]
```

16.6 Save verified PC1

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

PC1

```
save
```

Actual CLI output - PC1

```
PC1> save
Saving startup configuration to startup.vpc
.  done
```

16.7 Save verified PC4

Persist only the healthy repaired state. The final save-config variant must boot independently and pass section 15 with no configuration entry.

PC4

```
save
```

Actual CLI output - PC4

```
PC4> save
Saving startup configuration to startup.vpc
.  done
```

17. Diagnostic and interview review

Explain the transit-area rule, the remote Router ID in each command, the distinction between physical and virtual adjacency, the result of the deliberate peer-ID fault, and which evidence proves forwarding rather than adjacency alone. A virtual link repairs hierarchy during migration; a contiguous backbone remains the preferred permanent architecture.

18. Final validation record

All six release gates passed on the specified EVE-NG/IOL image.

Acceptance gate	Result
1. Workbook / UNL agreement	PASS
2. RAW and IP learner workflows	PASS
3. Independent complete-state boot	PASS
4. Stage-specific actual CLI evidence	PASS
5. Fault scope and documented recovery	PASS
6. PDF content and visual review	PASS

Scope: exact approved IOL L3 image on the pilot EVE-NG. Excerpts are actual RAW-stage outputs. Timers, route ages and sequence numbers may vary. RAW and IP workflows, fault/recovery, and a separate no-configuration save-config boot were validated.

References: Cisco 300-410 ENARSI v1.1 blueprint; Cisco: Understand OSPF Areas and Virtual Links; Cisco: Configure OSPF Connection in a Virtual Link Environment.