16 Routing Fundamentals - Answer Key

In this lab you will configure and verify connected, local, static, summary and default routes. You will also examine the effect of longest prefix match routing.

Connected and Local Routes

1) Configure the PCs with an IP address and default gateway according to the Lab Topology diagram

```
PC1> ip 10.0.1.10 /24 10.0.1.1

PC2> ip 10.0.2.10 /24 10.0.2.1

PC3> ip 10.1.2.10 /24 10.1.2.1
```

2) Configure IP addresses on R1 according to the Lab Topology diagram

```
R1(config)#int f0/0
R1(config-if)#ip address 10.0.0.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#int f1/0
R1(config-if)#ip address 10.0.1.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#int f2/0
R1(config-if)#ip address 10.0.2.1 255.255.255.0
R1(config-if)#no shut
R1(config-if)#int f3/0
R1(config-if)#ip address 10.0.3.1 255.255.255.0
R1(config-if)#no shut
```

3) Verify routes have been automatically added for the connected and local networks (note that local routes only appear from IOS 15)

```
R1#sh ip route
Codes: C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route
```

```
Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 8 subnets, 2 masks
C        10.0.0.0/24 is directly connected, FastEthernet0/0
L        10.0.0.1/32 is directly connected, FastEthernet0/0
C        10.0.1.0/24 is directly connected, FastEthernet1/0
L        10.0.1.1/32 is directly connected, FastEthernet1/0
C        10.0.2.0/24 is directly connected, FastEthernet2/0
L        10.0.2.1/32 is directly connected, FastEthernet2/0
C        10.0.3.0/24 is directly connected, FastEthernet3/0
L        10.0.3.1/32 is directly connected, FastEthernet3/0
```

4) Should you be able to ping from PC1 to PC2? Verify this.

Ping from PC1 to PC2 should be successful as both PCs are in networks which R1 is directly connected to.

```
PC1> ping 10.0.2.10
84 bytes from 10.0.2.10 icmp_seq=1 ttl=63 time=58.045 ms
```

5) Verify the traffic path from PC1 to PC2.

The ping went via R1 at 10.0.1.1

```
PC1> trace 10.0.2.10
trace to 10.0.2.10, 8 hops max, press Ctrl+C to stop
 1   10.0.1.1   19.013 ms  9.007 ms  9.007 ms
 2     *  *  *
 3   *10.0.2.10   14.009 ms (ICMP type:3, code:3,
Destination port unreachable)
```

6) Should you be able to ping from PC1 to PC3? Verify this.

Ping from PC1 to PC3 should fail as R1 does not have a route to the 10.1.2.0 network.

```
PC1> ping 10.1.2.10
*10.0.1.1 icmp_seq=1 ttl=255 time=20.013 ms (ICMP type:3,
code:1, Destination host unreachable)
```

Static Routes

7) Configure IP addresses on R2, R3 and R4 according to the Lab Topology diagram. Do not configure the Internet FastEthernet 3/0 interface on R4. Do not configure R5.

```
R2(config)#int f0/0
R2(config-if)#ip add 10.0.0.2 255.255.255.0
R2(config-if)#no shut
R2(config-if)#int f1/0
R2(config-if)#ip add 10.1.0.2 255.255.255.0
R2(config-if)#no shut

R3(config)#int f1/0
R3(config-if)#ip add 10.1.0.1 255.255.255.0
R3(config-if)#no shut
R3(config-if)#int f0/0
R3(config-if)#ip add 10.1.1.2 255.255.255.0
R3(config-if)#no shut

R4(config)#int f0/0
R4(config-if)#ip add 10.1.1.1 255.255.255.0
R4(config-if)#no shut
R4(config-if)#int f1/0
R4(config-if)#ip add 10.1.2.1 255.255.255.0
R4(config-if)#no shut
R4(config-if)#int f2/0
R4(config-if)#ip add 10.1.3.1 255.255.255.0
R4(config-if)#no shut
```

8) Configure static routes on R1, R2, R3 and R4 to allow connectivity between all their subnets. Use /24 prefixes for each network.

```
R1(config)#ip route 10.1.0.0 255.255.255.0 10.0.0.2
R1(config)#ip route 10.1.1.0 255.255.255.0 10.0.0.2
R1(config)#ip route 10.1.2.0 255.255.255.0 10.0.0.2
R1(config)#ip route 10.1.3.0 255.255.255.0 10.0.0.2

R2(config)#ip route 10.0.1.0 255.255.255.0 10.0.0.1
R2(config)#ip route 10.0.2.0 255.255.255.0 10.0.0.1
R2(config)#ip route 10.0.3.0 255.255.255.0 10.0.0.1
R2(config)#ip route 10.1.1.0 255.255.255.0 10.1.0.1
R2(config)#ip route 10.1.2.0 255.255.255.0 10.1.0.1
R2(config)#ip route 10.1.3.0 255.255.255.0 10.1.0.1
```

```
R3(config)#ip route 10.0.0.0 255.255.255.0 10.1.0.2
R3(config)#ip route 10.0.1.0 255.255.255.0 10.1.0.2
R3(config)#ip route 10.0.2.0 255.255.255.0 10.1.0.2
R3(config)#ip route 10.0.3.0 255.255.255.0 10.1.0.2
R3(config)#ip route 10.1.2.0 255.255.255.0 10.1.1.1
R3(config)#ip route 10.1.3.0 255.255.255.0 10.1.1.1

R4(config)#ip route 10.1.0.0 255.255.255.0 10.1.1.2
R4(config)#ip route 10.0.0.0 255.255.255.0 10.1.1.2
R4(config)#ip route 10.0.1.0 255.255.255.0 10.1.1.2
R4(config)#ip route 10.0.2.0 255.255.255.0 10.1.1.2
R4(config)#ip route 10.0.3.0 255.255.255.0 10.1.1.2
```

9) Verify connectivity between PC1, PC2 and PC3.

Ping PC2 and PC3 from PC1.

```
PC1> ping 10.0.2.10
84 bytes from 10.0.2.10 icmp_seq=1 ttl=63 time=25.018 ms

PC1> ping 10.1.2.10
84 bytes from 10.1.2.10 icmp_seq=1 ttl=60 time=114.081 ms
```

Ping PC3 from PC2.

```
PC2> ping 10.1.2.10
84 bytes from 10.1.2.10 icmp_seq=1 ttl=60 time=77.868 ms
```

Ping verifies two way reachability so we have now verified full connectivity.

10) Verify the path traffic takes from PC1 to PC3.

```
PC1> trace 10.1.2.10
trace to 10.1.2.10, 8 hops max, press Ctrl+C to stop
 1   10.0.1.1   9.006 ms  8.007 ms  8.005 ms
 2   10.0.0.2   39.026 ms  30.026 ms  28.020 ms
 3   10.1.0.1   58.039 ms  48.537 ms  48.040 ms
 4   10.1.1.1   79.640 ms  69.557 ms  69.052 ms
 5     *  *  *
 6   *10.1.2.10   76.558 ms (ICMP type:3, code:3,
Destination port unreachable)
```

The traffic goes via the path R1 > R2 > R3 > R4
Note that IP return traffic (PC3 to PC1 in this case) does not necessarily have to come back along the same path, although it typically will.

Summary Routes

11) Remove all the static routes on R1

```
R1(config)#no ip route 10.1.0.0 255.255.255.0 10.0.0.2
R1(config)#no ip route 10.1.1.0 255.255.255.0 10.0.0.2
R1(config)#no ip route 10.1.2.0 255.255.255.0 10.0.0.2
R1(config)#no ip route 10.1.3.0 255.255.255.0 10.0.0.2
```

12) Verify that PC1 loses connectivity to PC3

```
PC1> ping 10.1.2.10
*10.0.1.1 icmp_seq=1 ttl=255 time=19.012 ms (ICMP type:3,
code:1, Destination host unreachable)
```

13) Restore connectivity to all subnets with a single command on R1.

A summary route to 10.1.0.0/16 will add all remote subnets with one command.

```
R1(config)#ip route 10.1.0.0 255.255.0.0 10.0.0.2
```

14) Verify the routing table on R1 does not contain /24 routes to remote subnets.

```
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is not set

      10.0.0.0/8 is variably subnetted, 9 subnets, 3 masks
C        10.0.0.0/24 is directly connected, FastEthernet0/0
L        10.0.0.1/32 is directly connected, FastEthernet0/0
C        10.0.1.0/24 is directly connected, FastEthernet1/0
L        10.0.1.1/32 is directly connected, FastEthernet1/0
C        10.0.2.0/24 is directly connected, FastEthernet2/0
L        10.0.2.1/32 is directly connected, FastEthernet2/0
C        10.0.3.0/24 is directly connected, FastEthernet3/0
L        10.0.3.1/32 is directly connected, FastEthernet3/0
S        10.1.0.0/16 [1/0] via 10.0.0.2
```

15) Ensure that connectivity is restored between PC1 and PC3.

```
PC1> ping 10.1.2.10
84 bytes from 10.1.2.10 icmp_seq=1 ttl=60 time=77.055 ms
```

Longest Prefix Match

16) Configure IP addresses on R5 according to the Lab Topology diagram

```
R5(config)#int f2/0
R5(config-if)#ip add 10.1.3.2 255.255.255.0
R5(config-if)#no shut
R5(config-if)#int f3/0
R5(config-if)#ip add 10.0.3.2 255.255.255.0
R5(config-if)#no shut
```

17) Do not add any additional routes. Does PC1 have reachability to the FastEthernet 2/0 interface on R5? If so, which path will the traffic take?

The summary route on R1 to 10.1.0.0/16 will provide a route to R5 over the path R1 > R2 > R3 > R4 > R5, but R5 does not have a route back to R1.

A ping from PC1 to 10.1.3.2 on R5 will fail.

```
PC1> ping 10.1.3.2
10.1.3.2 icmp_seq=1 timeout
```

Traceroute will show replies from R1 > R2 > R3 > R4 before failing.

```
PC1> trace 10.1.3.2
trace to 10.1.3.2, 8 hops max, press Ctrl+C to stop
 1   10.0.1.1   29.020 ms  9.004 ms  9.008 ms
 2   10.0.0.2   29.524 ms  19.123 ms  18.012 ms
 3   10.1.0.1   48.034 ms  39.157 ms  38.025 ms
 4   10.1.1.1   59.550 ms  48.029 ms  50.042 ms
 5     *  *  *
 6     *  *  *
 7     *  *  *
 8     *  *  *
```

18) Ensure reachability over the shortest possible path from R5 to all directly connected networks on R1. Achieve this with a single command.

Add a summary route on R5 for all the directly connected networks on R1.

```
R5(config)#ip route 10.0.0.0 255.255.0.0 10.0.3.1
```

19) Verify the path traffic takes from PC1 to the FastEthernet 2/0 interface on R5.

```
PC1> trace 10.1.3.2
trace to 10.1.3.2, 8 hops max, press Ctrl+C to stop
 1   10.0.1.1   9.006 ms  9.007 ms  8.007 ms
 2   10.0.0.2   28.530 ms  28.017 ms  29.020 ms
 3   10.1.0.1   49.038 ms  49.033 ms  49.040 ms
 4   10.1.1.1   69.548 ms  69.565 ms  68.644 ms
 5   *10.1.3.2   60.047 ms (ICMP type:3, code:3,
Destination port unreachable)
```

Traffic takes the path R1 > R2 > R3 > R4 > R5

20) Verify the path the return traffic takes from R5 to PC1.

```
R5#traceroute 10.0.1.10
Type escape sequence to abort.
Tracing the route to 10.0.1.10
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.3.1 16 msec 20 msec 20 msec
  2 10.0.1.10 32 msec 28 msec 32 msec
```

Traffic takes the path R5 > R1. This shows that routers make independent decisions based on their routing table and it is possible (though not common) for return traffic to take an asynchronous path.

21) Ensure that traffic between PC1 and the FastEthernet 2/0 interface on R5 takes the most direct path in both directions.

A route from R1 to the 10.1.3.0/24 network on R5 will achieve this.

```
R1(config)#ip route 10.1.3.0 255.255.255.0 10.0.3.2
```

Traffic to 10.1.3.0/24 will now match two routes in the routing table.

```
S        10.1.0.0/16 [1/0] via 10.0.0.2
S        10.1.3.0/24 [1/0] via 10.0.3.2
```

The new route has a longer prefix match so will be preferred.

22) Verify that traffic between PC1 and the FastEthernet 2/0 interface on R5 takes the most direct path in both directions.

```
PC1> ping 10.1.3.2
84 bytes from 10.1.3.2 icmp_seq=1 ttl=254 time=21.020 ms
84 bytes from 10.1.3.2 icmp_seq=2 ttl=254 time=28.131 ms
84 bytes from 10.1.3.2 icmp_seq=3 ttl=254 time=26.017 ms
84 bytes from 10.1.3.2 icmp_seq=4 ttl=254 time=28.018 ms
84 bytes from 10.1.3.2 icmp_seq=5 ttl=254 time=27.525 ms

PC1> trace 10.1.3.2
trace to 10.1.3.2, 8 hops max, press Ctrl+C to stop
 1   10.0.1.1   9.008 ms  10.009 ms  9.008 ms
 2   *10.0.3.2   28.019 ms (ICMP type:3, code:3,
Destination port unreachable)

R5#traceroute 10.0.1.10
Type escape sequence to abort.
Tracing the route to 10.0.1.10
VRF info: (vrf in name/id, vrf out name/id)
  1 10.0.3.1 20 msec 16 msec 20 msec
  2 10.0.1.10 32 msec 28 msec 32 msec
```

Default Route and Load Balancing

23) Configure an IP address on the Internet FastEthernet 3/0 interface on R4 according to the lab topology diagram.

```
R4(config)#int f3/0
R4(config-if)#ip add 203.0.113.1 255.255.255.0
R4(config-if)#no shut
```

24) Ensure that all PCs have a route out to the internet through the Internet Service Provider connection on R4. (Note that the lab does not actually have Internet connectivity.)

```
R1(config)#ip route 0.0.0.0 0.0.0.0 10.0.0.2

R2(config)#ip route 0.0.0.0 0.0.0.0 10.1.0.1

R3(config)#ip route 0.0.0.0 0.0.0.0 10.1.1.1

R4(config)#ip route 0.0.0.0 0.0.0.0 203.0.113.2
```

```
R5(config)#ip route 0.0.0.0 0.0.0.0 10.1.3.1
```

All routers should have a default route to the next hop IP on the path to the Internet.

```
R4#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is 203.0.113.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 203.0.113.2
      10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks
S        10.0.0.0/24 [1/0] via 10.1.1.2
S        10.0.1.0/24 [1/0] via 10.1.1.2
S        10.0.2.0/24 [1/0] via 10.1.1.2
S        10.0.3.0/24 [1/0] via 10.1.1.2
S        10.1.0.0/24 [1/0] via 10.1.1.2
C        10.1.1.0/24 is directly connected, FastEthernet0/0
L        10.1.1.1/32 is directly connected, FastEthernet0/0
C        10.1.2.0/24 is directly connected, FastEthernet1/0
L        10.1.2.1/32 is directly connected, FastEthernet1/0
C        10.1.3.0/24 is directly connected, FastEthernet2/0
L        10.1.3.1/32 is directly connected, FastEthernet2/0
      203.0.113.0/24 is variably subnetted, 2 subnets, 2 masks
C        203.0.113.0/24 is directly connected, FastEthernet3/0
L        203.0.113.1/32 is directly connected, FastEthernet3/0
```

25) Traffic from PC1 and PC2 going to the internet should be load balanced over R2 and R5.

Add an additional default route on R1 to send Internet traffic via R5.

```
R1(config)#ip route 0.0.0.0 0.0.0.0 10.0.3.2
```

The routing table will show that R1 will load balance traffic over both paths.

```
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override
```

```
Gateway of last resort is 10.0.3.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 10.0.3.2
                [1/0] via 10.0.0.2
      10.0.0.0/8 is variably subnetted, 10 subnets, 3 masks
C        10.0.0.0/24 is directly connected, FastEthernet0/0
L        10.0.0.1/32 is directly connected, FastEthernet0/0
C        10.0.1.0/24 is directly connected, FastEthernet1/0
L        10.0.1.1/32 is directly connected, FastEthernet1/0
C        10.0.2.0/24 is directly connected, FastEthernet2/0
L        10.0.2.1/32 is directly connected, FastEthernet2/0
C        10.0.3.0/24 is directly connected, FastEthernet3/0
L        10.0.3.1/32 is directly connected, FastEthernet3/0
S        10.1.0.0/16 [1/0] via 10.0.0.2
S        10.1.3.0/24 [1/0] via 10.0.3.2
```

Add additional routes on R4 to load balance the return traffic to PC1 and PC2 from the Internet.

```
R4(config)#ip route 10.0.1.0 255.255.255.0 10.1.3.2
R4(config)#ip route 10.0.2.0 255.255.255.0 10.1.3.2
```

R4's routing table should show both paths back to 10.0.1.0/24 and 10.0.2.0/24

```
R4#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2
       i - IS-IS, su - IS-IS summary, L1 - IS-IS level-1, L2 - IS-IS level-2
       ia - IS-IS inter area, * - candidate default, U - per-user static route
       o - ODR, P - periodic downloaded static route, H - NHRP, l - LISP
       + - replicated route, % - next hop override

Gateway of last resort is 203.0.113.2 to network 0.0.0.0

S*    0.0.0.0/0 [1/0] via 203.0.113.2
      10.0.0.0/8 is variably subnetted, 11 subnets, 2 masks
S        10.0.0.0/24 [1/0] via 10.1.1.2
S        10.0.1.0/24 [1/0] via 10.1.3.2
                     [1/0] via 10.1.1.2
S        10.0.2.0/24 [1/0] via 10.1.3.2
                     [1/0] via 10.1.1.2
S        10.0.3.0/24 [1/0] via 10.1.1.2
S        10.1.0.0/24 [1/0] via 10.1.1.2
C        10.1.1.0/24 is directly connected, FastEthernet0/0
L        10.1.1.1/32 is directly connected, FastEthernet0/0
C        10.1.2.0/24 is directly connected, FastEthernet1/0
```

```
L        10.1.2.1/32 is directly connected, FastEthernet1/0
C        10.1.3.0/24 is directly connected, FastEthernet2/0
L        10.1.3.1/32 is directly connected, FastEthernet2/0
      203.0.113.0/24 is variably subnetted, 2 subnets, 2 masks
C        203.0.113.0/24 is directly connected, FastEthernet3/0
L        203.0.113.1/32 is directly connected, FastEthernet3/0
```