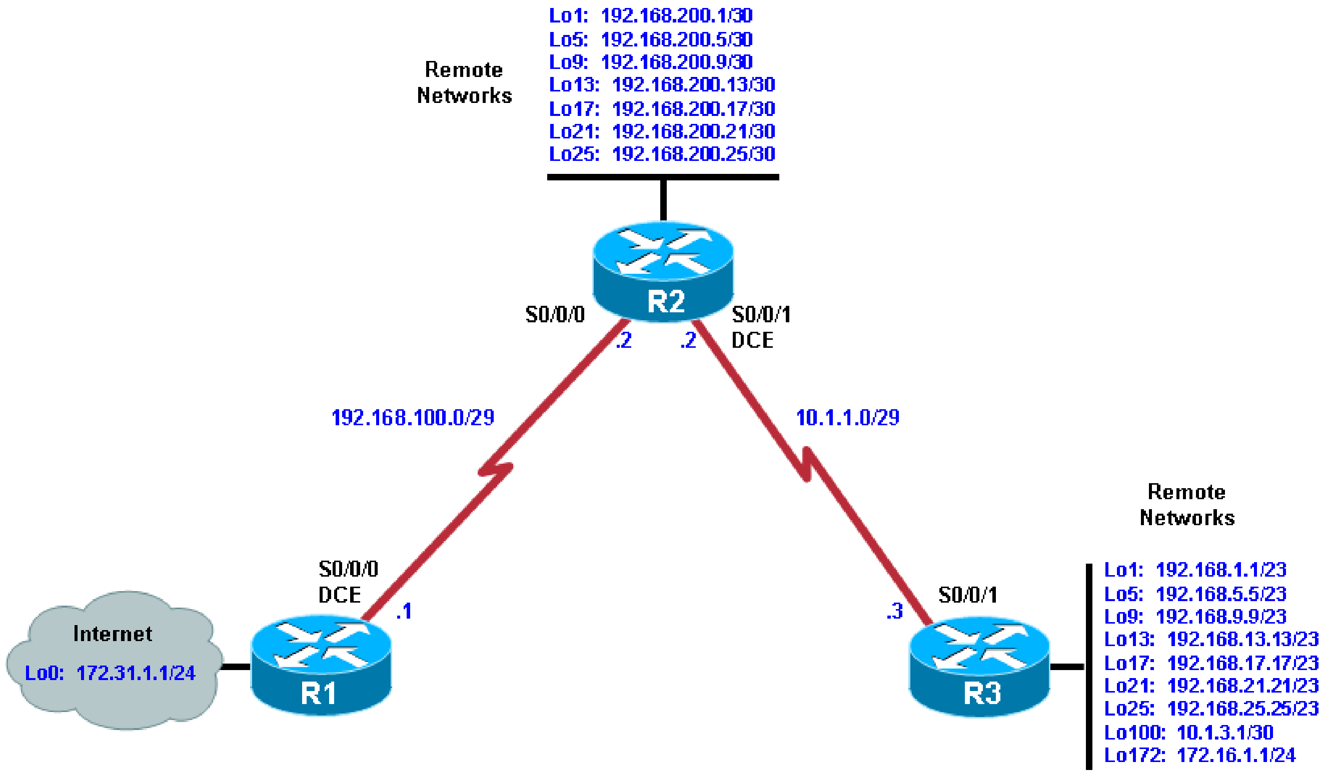
Chapter 2 Lab 2-3, EIGRP Summarization and Default Network Advertisement

Topology



Objectives

- Review a basic EIGRP configuration.
- Configure and verify EIGRP auto-summarization.
- Configure and verify EIGRP manual summarization.
- Use **show** and **debug** commands for EIGRP summarization.
- Configure default network advertisement.
- Consider the effects of summarization and default routes in a large internetwork.

Background

A network engineer has been having trouble with high memory, bandwidth, and CPU utilization on routers that are running EIGRP. Over lunch, the engineer mentions to you that routes in remote parts of the EIGRP autonomous system are flapping, indicating a performance impediment. The engineer's network has only one path out to the Internet, and the ISP has mandated that 172.31.1.1/24 be used on the end of the backbone connection.

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After asking if you could take a look at the network, you discover that the routing tables are filled with 29-bit and 30-bit IP network prefixes, some of which are unstable and flapping. You observe that summarization would result in a dramatic improvement in network performance and volunteer to implement it.

The engineer asks you to show proof-of-concept in the lab first, so you copy the configuration files to paste into your lab routers.

Note: This lab uses Cisco 1841 routers with Cisco IOS Release 12.4(24)T1 and the Advanced IP Services image c1841-advipservicesk9-mz.124-24.T1.bin. You can use other routers (such as a 2801 or 2811) and Cisco IOS Software versions if they have comparable capabilities and features. Depending on the router model and Cisco IOS Software version, the commands available and output produced might vary from what is shown in this lab.

Required Resources

- 3 routers (Cisco 1841 with Cisco IOS Release 12.4(24)T1 Advanced IP Services or comparable)
- Serial and console cables

Step 1: Configure the addressing and serial links.

a. Paste the following configurations into your routers to simulate this network. Save the configurations.

Router R1

```
hostname R1
!
interface Loopback0
 ip address 172.31.1.1 255.255.255.0
!
interface Serial0/0/0
 bandwidth 64
 ip address 192.168.100.1 255.255.255.248
 clock rate 64000
 no shutdown
!
router eigrp 100
 network 172.31.0.0
 network 192.168.100.0
 no auto-summary
!
end
```

Router R2

```
hostname R2
!
interface Loopback1
 ip address 192.168.200.1 255.255.255.252
!
interface Loopback5
 ip address 192.168.200.5 255.255.255.252
!
interface Loopback9
 ip address 192.168.200.9 255.255.255.252
!
interface Loopback13
 ip address 192.168.200.13 255.255.255.252
!
interface Loopback17
```

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```
 ip address 192.168.200.17 255.255.255.252
!
interface Loopback21
 ip address 192.168.200.21 255.255.255.252
!
interface Loopback25
 ip address 192.168.200.25 255.255.255.252
!
interface Serial0/0/0
 bandwidth 64
 ip address 192.168.100.2 255.255.255.248
 no shutdown
!
interface Serial0/0/1
 bandwidth 64
 ip address 10.1.1.2 255.255.255.248
 clock rate 64000
 no shutdown
!
router eigrp 100
 network 10.0.0.0
 network 192.168.100.0
 network 192.168.200.0
 no auto-summary
!
end
```

Router R3

```
hostname R3
!
interface Loopback1
 ip address 192.168.1.1 255.255.254.0
!
interface Loopback5
 ip address 192.168.5.5 255.255.254.0
!
interface Loopback9
 ip address 192.168.9.9 255.255.254.0
!
interface Loopback13
 ip address 192.168.13.13 255.255.254.0
!
interface Loopback17
 ip address 192.168.17.17 255.255.254.0
!
interface Loopback21
 ip address 192.168.21.21 255.255.254.0
!
interface Loopback25
 ip address 192.168.25.25 255.255.254.0
!
interface Loopback100
 ip address 10.1.3.1 255.255.255.252
!
interface Loopback172
 ip address 172.16.1.1 255.255.255.0
!
interface Serial0/0/1
```

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```
 bandwidth 64
 ip address 10.1.1.3 255.255.255.248
 no shutdown
!
router eigrp 100
 network 10.0.0.0
 network 172.16.0.0
 network 192.168.0.0 0.0.31.255
 no auto-summary
!
end
```

b. Verify that you have full EIGRP adjacency between routers R1 and R2 and between R2 and R3 using the **show ip eigrp neighbors** command.

```
R1# show ip eigrp neighbors
IP-EIGRP neighbors for process 100
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   192.168.100.2           Se0/0/0           10 00:00:13   40  2280  0  38

R2# show ip eigrp neighbors
IP-EIGRP neighbors for process 100
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
1   10.1.1.3                Se0/0/1           14 00:00:33    6  2280  0  28
0   192.168.100.1           Se0/0/0           10 00:00:40   21  2280  0  21

R3# show ip eigrp neighbors
IP-EIGRP neighbors for process 100
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   10.1.1.2                Se0/0/1           13 00:00:52   13  2280  0  37
```

c. Ping all the IP addresses to ensure full connectivity, or use the following Tcl script. If you have never used Tcl scripts or need a refresher, see Lab 1-1.

```
R1# tclsh

foreach address {
10.1.1.2
10.1.1.3
10.1.3.1
172.16.1.1
172.31.1.1
192.168.1.1
192.168.5.5
192.168.9.9
192.168.13.13
192.168.17.17
192.168.21.21
192.168.25.25
192.168.100.1
192.168.200.1
192.168.200.5
192.168.200.9
192.168.200.13
192.168.200.17
192.168.200.21
```

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```
192.168.200.25
192.168.100.2
} { ping $address }
```

You should receive ICMP echo replies for each address pinged. Make sure that you run the Tcl script on each router and verify connectivity before you continue with the lab.

Step 2: Analyze summarization options.

Currently, the engineer has the following networks configured within the network:

Router	Interface	IP Address/Mask
R1	Loopback0	172.31.1.1/24
R1	Serial0/0/0	192.168.100.1/29
R2	Loopback1	192.168.200.1/30
R2	Loopback5	192.168.200.5/30
R2	Loopback9	192.168.200.9/30
R2	Loopback13	192.168.200.13/30
R2	Loopback17	192.168.200.17/30
R2	Loopback21	192.168.200.21/30
R2	Loopback25	192.168.200.25/30
R2	Serial0/0/0	192.168.100.2/29
R2	Serial0/0/1	10.1.1.2/29
R3	Loopback1	192.168.1.1/23
R3	Loopback5	192.168.5.5/23
R3	Loopback9	192.168.9.9/23
R3	Loopback13	192.168.13.13/23
R3	Loopback17	192.168.17.17/23
R3	Loopback21	192.168.21.21/23
R3	Loopback25	192.168.25.25/23
R3	Loopback100	10.1.3.1/30
R3	Loopback172	172.16.1.1/24
R3	Serial 0/0/1	10.1.1.3/29

a. Given this addressing scheme, how many major networks are involved in this simulation? What are they?

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Note: If you are unsure, use the **show ip route** command on R1 and look at the analysis of the output in Appendix A.

b. The engineer has not configured any automatic or manual EIGRP summarization in the network. How would summarization benefit the network, especially in light of the fact that outlying routes are flapping? List at least two reasons.

c. For the following networks, which router should you summarize to minimize the size of the routing table for all the involved routers? Which summary should you use?

- 10.0.0.0/8 –
- 172.16.0.0/16 –
- 172.31.0.0/16 –
- 192.168.100.0/24 –
- 192.168.200.0/24 –
- 192.168.0.0/23 through 192.168.24.0/23 –

If EIGRP auto-summarization is turned on in this topology, will 192.168.0.0/23 through 192.168.24.0/23 be summarized?

d. Because all routes involved in this lab, including later summary routes, will be installed in the routing table by EIGRP, observe the routing table on each router with the **show ip route eigrp** command. You will use this command throughout the lab to periodically observe the routing table.

```
R1# show ip route eigrp
     172.16.0.0/24 is subnetted, 1 subnets
D       172.16.1.0 [90/41152000] via 192.168.100.2, 00:01:14, Serial0/0/0
     192.168.200.0/30 is subnetted, 7 subnets
D       192.168.200.0 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       192.168.200.4 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       192.168.200.8 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       192.168.200.12 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       192.168.200.16 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
```

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```
D       192.168.200.20 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       192.168.200.24 [90/40640000] via 192.168.100.2, 00:03:09, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.3.0/30 [90/41152000] via 192.168.100.2, 00:03:09, Serial0/0/0
D       10.1.1.0/29 [90/41024000] via 192.168.100.2, 00:03:09, Serial0/0/0
D    192.168.12.0/23 [90/41152000] via 192.168.100.2, 00:03:09, Serial0/0/0
D    192.168.8.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0
D    192.168.24.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0
D    192.168.4.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0
D    192.168.20.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0
D    192.168.0.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0
D    192.168.16.0/23 [90/41152000] via 192.168.100.2, 00:03:11, Serial0/0/0

R2# show ip route eigrp
     172.16.0.0/24 is subnetted, 1 subnets
D       172.16.1.0 [90/40640000] via 10.1.1.3, 00:01:40, Serial0/0/1
     172.31.0.0/24 is subnetted, 1 subnets
D       172.31.1.0 [90/40640000] via 192.168.100.1, 00:03:35, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.3.0/30 [90/40640000] via 10.1.1.3, 00:06:21, Serial0/0/1
D    192.168.12.0/23 [90/40640000] via 10.1.1.3, 00:04:04, Serial0/0/1
D    192.168.8.0/23 [90/40640000] via 10.1.1.3, 00:04:04, Serial0/0/1
D    192.168.24.0/23 [90/40640000] via 10.1.1.3, 00:04:04, Serial0/0/1
D    192.168.4.0/23 [90/40640000] via 10.1.1.3, 00:04:05, Serial0/0/1
D    192.168.20.0/23 [90/40640000] via 10.1.1.3, 00:04:04, Serial0/0/1
D    192.168.0.0/23 [90/40640000] via 10.1.1.3, 00:04:05, Serial0/0/1
D    192.168.16.0/23 [90/40640000] via 10.1.1.3, 00:04:04, Serial0/0/1

R3# show ip route eigrp
     172.31.0.0/24 is subnetted, 1 subnets
D       172.31.1.0 [90/41152000] via 10.1.1.2, 00:04:12, Serial0/0/1
     192.168.200.0/30 is subnetted, 7 subnets
D       192.168.200.0 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.4 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.8 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.12 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.16 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.20 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
D       192.168.200.24 [90/40640000] via 10.1.1.2, 00:06:58, Serial0/0/1
     192.168.100.0/29 is subnetted, 1 subnets
D       192.168.100.0 [90/41024000] via 10.1.1.2, 00:06:58, Serial0/0/1
```

How do you expect the output of this command to change if you implement the summarization you described above? Record your answer and compare it with the results you observe later.

e. You can also look at the size of each router's routing table with the **show ip route summary** command.

```
R1# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           2           128         304
static          0           0           0           0
eigrp 100       7           10          1088        2584
```

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```
internal        5                                       5860
Total           12          12          1216            8748

R2# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           9           576         1368
static          0           0           0           0
eigrp 100       7           3           640         1520
internal        5                                   5860
Total           12          12          1216        8748

R3# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       7           3           640         1520
static          0           0           0           0
eigrp 100       0           9           576         1368
internal        5                                   5860
Total           12          12          1216        8748
```

Step 3: Configure EIGRP auto-summarization.

The network engineer reminds you that EIGRP auto-summarization is turned on by default, but that it was turned off because of discontiguous networks that were later removed. It is now safe to begin using auto-summarization again.

a. Verify that EIGRP AS 100 is not using auto-summarization on R1 with the **show ip protocols** command.

```
R1# show ip protocols
Routing Protocol is "eigrp 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 100
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    172.31.0.0
    192.168.100.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.100.2         90      00:04:31
  Distance: internal 90 external 170
```

You will use this command to check whether the following is occurring:

- EIGRP is flagging default networks sent to other routers.
- EIGRP is accepting default networks advertised to this router.
- Auto-summarization is turned on.

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b. You can enable EIGRP route and summary route debugging on each router, which allows you to observe when summary routes are advertised from the router, with the **debug ip eigrp 100** and **debug ip eigrp summary** commands.

```
R1# debug ip eigrp 100
R1# debug ip eigrp summary

R2# debug ip eigrp 100
R2# debug ip eigrp summary

R3# debug ip eigrp 100
R3# debug ip eigrp summary
```

c. On R3, issue the **auto-summary** command in the EIGRP configuration menu. This command produces system logging messages on both routers and debug output on R3.

```
R3(config)# router eigrp 100
R3(config-router)# auto-summary
```

You should see the following types of log messages.

On R3:

```
*Feb 6 16:55:03.035: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 100: Neighbor 10.1.1.2
(Serial0/0/1) is resync: summary configured
```

On R2:

```
*Feb 6 16:56:54.539: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 100: Neighbor 10.1.1.3
(Serial0/0/1) is resync: peer graceful-restart
```

Your router issues a notification similar to the message on R3 when you either configure or disable auto-summary on the local router. You receive a notification similar to the message on R2 when you configure auto-summary on an adjacent router. The adjacency must be resynchronized so that EIGRP update packets advertising the new summary routing information are sent.

Following the log messages, you get a flood of debug output on R3 as it searches its topology table for routes that can be summarized. EIGRP attempts to automatically summarize both 172.16.0.0/16 and 10.0.0.0/8 on R3 because it hosts the classful boundary between those networks. However, the output has been limited to only the debug messages concerning the 172.16.0.0/16 network. You should receive the same messages for 10.0.0.0/8, with the exception of the addition of the Serial0/0/1 interface. The reason for this exception is explained later.

```
<Output regarding network 10.0.0.0/8 is omitted.>

*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Serial0/0/1 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new sum: 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new if: Serial0/0/1 to
172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Loopback100 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new if: Loopback100 to
172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Loopback1 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new if: Loopback1 to
172.16.0.0/16 5
```

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```
*Feb  6 19:23:37.811: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Loopback5 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new if: Loopback5 to
172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Loopback9 172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP: find_summary: add new if: Loopback9 to
172.16.0.0/16 5
*Feb  6 19:23:37.811: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.811: IP-EIGRP: add_auto_summary: Loopback13 172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP: find_summary: add new if: Loopback13 to
172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.815: IP-EIGRP: add_auto_summary: Loopback17 172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP: find_summary: add new if: Loopback17 to
172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.815: IP-EIGRP: add_auto_summary: Loopback21 172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP: find_summary: add new if: Loopback21 to
172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.815: IP-EIGRP: add_auto_summary: Loopback25 172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP: find_summary: add new if: Loopback25 to
172.16.0.0/16 5
*Feb  6 19:23:37.815: IP-EIGRP(Default-IP-Routing-Table:100):
process_summary: 172.16.0.0/16 1
*Feb  6 19:23:37.815: %DUAL-5-NBRCHANGE: IP-EIGRP(0) 100: Neighbor 10.1.1.2
(Serial0/0/1) is resync: summary configured
*Feb  6 19:23:37.815: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.819: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.819: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.823: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.823: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.823: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.827: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.827: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
*Feb  6 19:23:37.831: IP-EIGRP(Default-IP-Routing-Table:100):
get_summary_metric: 172.16.0.0/16
```

Each get_summary_metric message at the end represents a function call to create a composite metric for the summary route for each outbound interface.

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Imagine that you have EIGRP neighbors out each loopback interface connected to R3. How many interfaces will receive the 172.16.0.0/16 summary route?

Which summary routes are sent to R2 from R3?

d. Check which summary routes are sent with the **show ip route eigrp** command.

```
R2# show ip route eigrp
D    172.16.0.0/16 [90/40640000] via 10.1.1.3, 00:38:38, Serial0/0/1
     172.31.0.0/24 is subnetted, 1 subnets
D       172.31.1.0 [90/40640000] via 192.168.100.1, 00:47:51, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.3.0/30 [90/40640000] via 10.1.1.3, 00:50:36, Serial0/0/1
D    192.168.12.0/23 [90/40640000] via 10.1.1.3, 00:48:20, Serial0/0/1
D    192.168.8.0/23 [90/40640000] via 10.1.1.3, 00:48:20, Serial0/0/1
D    192.168.24.0/23 [90/40640000] via 10.1.1.3, 00:48:19, Serial0/0/1
D    192.168.4.0/23 [90/40640000] via 10.1.1.3, 00:48:20, Serial0/0/1
D    192.168.20.0/23 [90/40640000] via 10.1.1.3, 00:48:19, Serial0/0/1
D    192.168.0.0/23 [90/40640000] via 10.1.1.3, 00:48:20, Serial0/0/1
D    192.168.16.0/23 [90/40640000] via 10.1.1.3, 00:48:20, Serial0/0/1
```

Notice that the summary route has the same composite metric as the previous single route to 172.16.1.0/30.

When the summary route is generated, what happens in the R3 routing table?

e. Issue the **show ip route eigrp** command to check for the summary routes to null0.

```
R3# show ip route eigrp
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
D       172.16.0.0/16 is a summary, 00:14:57, Null0
     172.31.0.0/24 is subnetted, 1 subnets
D       172.31.1.0 [90/41152000] via 10.1.1.2, 00:15:24, Serial0/0/1
     192.168.200.0/30 is subnetted, 7 subnets
D       192.168.200.0 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.4 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.8 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.12 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.16 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.20 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
D       192.168.200.24 [90/40640000] via 10.1.1.2, 00:15:24, Serial0/0/1
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
D       10.0.0.0/8 is a summary, 00:14:57, Null0
     192.168.100.0/29 is subnetted, 1 subnets
D       192.168.100.0 [90/41024000] via 10.1.1.2, 00:15:24, Serial0/0/1
```

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The output of the **debug ip eigrp summary** command also contained messages pertaining to 10.0.0.0/8. Although R3 has a summary route for 10.0.0.0/8 installed in its routing table to Null0, why did R3 not send the summary route for 10.0.0.0/8 to R2?

The 10.0.0.0/8 summary will not be sent out to a connected subnet within that major network. Automatic summarization takes place at the classful boundary by sending a classful network summary to all local EIGRP interfaces not in the summarized network. The automatic summarization takes place only if a subnet of a particular major network is going to be advertised through an interface that is itself in a different major network. Because Serial0/0/1 has an IP address that is part of the 10.0.0.0/8 network, R3 does not send that summary to R2 through the Serial0/0/1 interface. Notice that it is not in the EIGRP topology table on R2.

```
R2# show ip eigrp topology
IP-EIGRP Topology Table for AS(100)/ID(192.168.200.25)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 10.1.3.0/30, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 10.1.1.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/1
P 192.168.100.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/0
P 192.168.8.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.12.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.0.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.4.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.24.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.16.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.20.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.200.0/30, 1 successors, FD is 128256
        via Connected, Loopback1
P 192.168.200.4/30, 1 successors, FD is 128256
        via Connected, Loopback5
P 192.168.200.8/30, 1 successors, FD is 128256
        via Connected, Loopback9
P 192.168.200.12/30, 1 successors, FD is 128256
        via Connected, Loopback13
P 192.168.200.16/30, 1 successors, FD is 128256
        via Connected, Loopback17
P 172.31.1.0/24, 1 successors, FD is 40640000
        via 192.168.100.1 (40640000/128256), Serial0/0/0
P 192.168.200.20/30, 1 successors, FD is 128256
        via Connected, Loopback21
P 192.168.200.24/30, 1 successors, FD is 128256
        via Connected, Loopback25
P 172.16.0.0/16, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
```

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Which of the R3 connected networks are not being summarized?

Review your answers to the questions at the end of Step 2. Why is this summarization not occurring?

f. Because the engineer has no discontiguous networks in the internetwork, you decide to enable EIGRP auto-summary on all routers.

```
R1(config)# router eigrp 100
R1(config-router)# auto-summary

R2(config)# router eigrp 100
R2(config-router)# auto-summary
```

g. Verify that the summaries are shown by issuing the **show ip eigrp topology** command on each router. You should see summary routes on each router for each major network that is not part of the /23 supernet. Supernets are not included in auto-summary routes because EIGRP automatically summarizes only to the classful boundary and no further. Compare your output with the output below.

```
R1# show ip eigrp topology
IP-EIGRP Topology Table for AS(100)/ID(172.31.1.1)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 10.0.0.0/8, 1 successors, FD is 41024000
        via 192.168.100.2 (41024000/40512000), Serial0/0/0
P 192.168.100.0/24, 1 successors, FD is 40512000
        via Summary (40512000/0), Null0
P 192.168.100.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/0
P 192.168.8.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.12.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.0.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.4.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.24.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.16.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.20.0/23, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0
P 192.168.200.0/24, 1 successors, FD is 40640000
```

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```
        via 192.168.100.2 (40640000/128256), Serial0/0/0
P 172.31.1.0/24, 1 successors, FD is 128256
        via Connected, Loopback0
P 172.31.0.0/16, 1 successors, FD is 128256
        via Summary (128256/0), Null0
P 172.16.0.0/16, 1 successors, FD is 41152000
        via 192.168.100.2 (41152000/40640000), Serial0/0/0

R2# show ip eigrp topology
IP-EIGRP Topology Table for AS(100)/ID(192.168.200.25)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 10.1.3.0/30, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 10.0.0.0/8, 1 successors, FD is 40512000
        via Summary (40512000/0), Null0
P 10.1.1.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/1
P 192.168.100.0/24, 1 successors, FD is 40512000
        via Summary (40512000/0), Null0
P 192.168.100.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/0
P 192.168.8.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.12.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.0.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.4.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.24.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.16.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.20.0/23, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
P 192.168.200.0/24, 1 successors, FD is 128256
        via Summary (128256/0), Null0
P 192.168.200.0/30, 1 successors, FD is 128256
        via Connected, Loopback1
P 192.168.200.4/30, 1 successors, FD is 128256
        via Connected, Loopback5
P 192.168.200.8/30, 1 successors, FD is 128256
        via Connected, Loopback9
P 192.168.200.12/30, 1 successors, FD is 128256
        via Connected, Loopback13
P 192.168.200.16/30, 1 successors, FD is 128256
        via Connected, Loopback17
P 172.31.0.0/16, 1 successors, FD is 40640000
        via 192.168.100.1 (40640000/128256), Serial0/0/0
P 192.168.200.20/30, 1 successors, FD is 128256
        via Connected, Loopback21
P 192.168.200.24/30, 1 successors, FD is 128256
        via Connected, Loopback25
P 172.16.0.0/16, 1 successors, FD is 40640000
        via 10.1.1.3 (40640000/128256), Serial0/0/1
```

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```
R3# show ip eigrp topology
IP-EIGRP Topology Table for AS(100)/ID(192.168.25.25)

Codes: P - Passive, A - Active, U - Update, Q - Query, R - Reply,
       r - reply Status, s - sia Status

P 10.1.3.0/30, 1 successors, FD is 128256
        via Connected, Loopback100
P 10.0.0.0/8, 1 successors, FD is 128256
        via Summary (128256/0), Null0
P 10.1.1.0/29, 1 successors, FD is 40512000
        via Connected, Serial0/0/1
P 192.168.100.0/24, 1 successors, FD is 41024000
        via 10.1.1.2 (41024000/40512000), Serial0/0/1
P 192.168.8.0/23, 1 successors, FD is 128256
        via Connected, Loopback9
P 192.168.12.0/23, 1 successors, FD is 128256
        via Connected, Loopback13
P 192.168.0.0/23, 1 successors, FD is 128256
        via Connected, Loopback1
P 192.168.4.0/23, 1 successors, FD is 128256
        via Connected, Loopback5
P 192.168.24.0/23, 1 successors, FD is 128256
        via Connected, Loopback25
P 192.168.16.0/23, 1 successors, FD is 128256
        via Connected, Loopback17
P 192.168.20.0/23, 1 successors, FD is 128256
        via Connected, Loopback21
P 192.168.200.0/24, 1 successors, FD is 40640000
        via 10.1.1.2 (40640000/128256), Serial0/0/1
P 172.31.0.0/16, 1 successors, FD is 41152000
        via 10.1.1.2 (41152000/40640000), Serial0/0/1
P 172.16.0.0/16, 1 successors, FD is 128256
        via Summary (128256/0), Null0
P 172.16.1.0/24, 1 successors, FD is 128256
        via Connected, Loopback172
```

Step 4: Configure EIGRP manual summarization.

EIGRP calculates summaries, whether manually or automatically, on a per-interface basis. Recall that when you configured auto-summary, the debug output showed that EIGRP summary routes were generated on a per-interface basis. The EIGRP **auto-summary** command turns auto-summarization on globally on a router, but you can also configure summary routes manually with the interface-level command **ip summary-address eigrp** *as* ***network*** *mask*.

Note: Combining manual and automatic summarization is not a best practice. If both manual and automatic summarization are activated, EIGRP sends both the automatic and the manual summary route out an interface. Normally, you need to leave EIGRP auto-summarization off, especially in topologies with discontiguous networks, and create manual summary routes instead. For this scenario, you enable manual summarization on the R3 Serial0/0/1 interface to show the engineer how summarization can further benefit the network. R3 should advertise the /23 subnets to R2.

a. What is the most efficient mask to summarize these routes?

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b. Implement the summarization on R3.

```
R3(config)# interface Serial 0/0/1
R3(config-if)# ip summary-address eigrp 100 192.168.0.0 255.255.224.0
```

The **100** parameter specifies that the summarization be sent out only to neighbors in EIGRP AS 100.

Note: If you are unfamiliar with the parameters of this command, use the **?** for the inline Cisco IOS help system. It is recommended that you use the help system to familiarize yourself with parameters when working through these labs.

The adjacency between R2 and R3 resynchronizes after the summary is configured, as indicated by the debug messages. The routing tables should appear similar to the following.

```
R1# show ip route
<output omitted>

Gateway of last resort is not set

D    172.16.0.0/16 [90/41152000] via 192.168.100.2, 04:04:11, Serial0/0/0
     172.31.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.31.1.0/24 is directly connected, Loopback0
D       172.31.0.0/16 is a summary, 02:47:43, Null0
D    192.168.200.0/24 [90/40640000] via 192.168.100.2, 02:47:34, Serial0/0/0
D    10.0.0.0/8 [90/41024000] via 192.168.100.2, 02:47:34, Serial0/0/0
     192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.100.0/29 is directly connected, Serial0/0/0
D       192.168.100.0/24 is a summary, 02:47:44, Null0
D    192.168.0.0/19 [90/41152000] via 192.168.100.2, 02:32:07, Serial0/0/0

R2# show ip route
<output omitted>

Gateway of last resort is not set

D    172.16.0.0/16 [90/40640000] via 10.1.1.3, 02:33:29, Serial0/0/1
D    172.31.0.0/16 [90/40640000] via 192.168.100.1, 02:48:58, Serial0/0/0
     192.168.200.0/24 is variably subnetted, 8 subnets, 2 masks
C       192.168.200.0/30 is directly connected, Loopback1
D       192.168.200.0/24 is a summary, 02:48:58, Null0
C       192.168.200.4/30 is directly connected, Loopback5
C       192.168.200.8/30 is directly connected, Loopback9
C       192.168.200.12/30 is directly connected, Loopback13
C       192.168.200.16/30 is directly connected, Loopback17
C       192.168.200.20/30 is directly connected, Loopback21
C       192.168.200.24/30 is directly connected, Loopback25
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
D       10.1.3.0/30 [90/40640000] via 10.1.1.3, 02:33:30, Serial0/0/1
C       10.1.1.0/29 is directly connected, Serial0/0/1
D       10.0.0.0/8 is a summary, 02:49:00, Null0
     192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.100.0/29 is directly connected, Serial0/0/0
D       192.168.100.0/24 is a summary, 02:49:00, Null0
D    192.168.0.0/19 [90/40640000] via 10.1.1.3, 02:33:31, Serial0/0/1

R3# show ip route
<output omitted>

Gateway of last resort is not set
```

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```
     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
D       172.16.0.0/16 is a summary, 04:07:05, Null0
C       172.16.1.0/24 is directly connected, Loopback172
     172.31.0.0/16 is subnetted, 1 subnets
D       172.31.0.0 [90/41152000] via 10.1.1.2, 02:35:00, Serial0/0/1
D    192.168.200.0/24 [90/40640000] via 10.1.1.2, 02:50:28, Serial0/0/1
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
C       10.1.3.0/30 is directly connected, Loopback100
C       10.1.1.0/29 is directly connected, Serial0/0/1
D       10.0.0.0/8 is a summary, 04:07:06, Null0
D    192.168.100.0/24 [90/41024000] via 10.1.1.2, 02:50:29, Serial0/0/1
C    192.168.12.0/23 is directly connected, Loopback13
C    192.168.8.0/23 is directly connected, Loopback9
C    192.168.24.0/23 is directly connected, Loopback25
C    192.168.4.0/23 is directly connected, Loopback5
C    192.168.20.0/23 is directly connected, Loopback21
C    192.168.0.0/23 is directly connected, Loopback1
D    192.168.0.0/19 is a summary, 02:35:02, Null0
C    192.168.16.0/23 is directly connected, Loopback17
```

Notice that on each router the only EIGRP routes (marked as D) are summary routes to locally connected networks (Null0) or to remote networks, both of which reduce the number of advertised networks.

At this point, you have efficiently summarized the network. Based on your knowledge of routing protocols and techniques, are there any other ways to minimize the routing table even further for this topology without filtering routes?

Step 5: Configure default network advertisement.

Suppose this engineer has another branch office of the core network that is also running EIGRP in a different autonomous system, AS 200, connected to the FastEthernet0/0 interface on R1. However, the branch you are modeling is completely independent of that topology and vice versa.

Based on this corporation's new routing policies, EIGRP AS 100 only needs to know that all traffic out of its network is forwarded to R1. The engineer queries you as to how connectivity can be preserved to AS 200 networks, while minimizing routing tables within AS 100.

a. What solutions would you propose?

You decide that this company's policies are in line with the use of a default route out of the system. The default network that you will configure is 172.31.0.0/16, because this is the path to the Internet.

The IP network 0.0.0.0/0 matches all unknown destination prefixes because the routing table acts in a classless manner. Classless routing tables use the first match based on the longest IP subnet mask for that destination network. Therefore, if the routing table has no matches for a subnet mask greater than 0

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bits for a given destination network, the shortest subnet mask (/0) matches any of the 32 bits of a destination network.

For instance, if the router does not have a route to 192.168.7.0/24, it tries to match against any routes it has to 192.168.6.0/23, 192.168.4.0/22, 192.168.0.0/21, and so on. If it does not find any matching routes, it eventually gets to the 0.0.0.0/0 network, which matches all destination IP addresses, and sends the packet to its “gateway of last resort.”

b. The **ip default-network** command propagates through the EIGRP system so that each router sees its candidate default network as the path with the shortest feasible distance to the default network (172.31.0.0/16). Issue this command on R1.

Note: There are different methods to propagate a default route in EIGRP. Because EIGRP does not have the **default-information originate** command, this example uses the **ip default-network** command.

```
R1(config)# ip default-network 172.31.0.0
```

This command routes all traffic through R1 to destination networks not matching any other networks or subnets in the routing table to the 172.31.0.0 network. EIGRP flags this route as the default route in advertisements to other routers.

c. Verify that the flag is set on updates to R2 using the **show ip eigrp topology 172.31.0.0/16** command.

```
R2# show ip eigrp topology 172.31.0.0/16
IP-EIGRP (AS 100): Topology entry for 172.31.0.0/16
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is 40640000
  Routing Descriptor Blocks:
  192.168.100.1 (Serial0/0/0), from 192.168.100.1, Send flag is 0x0
      Composite metric is (40640000/128256), Route is Internal
      Vector metric:
        Minimum bandwidth is 64 Kbit
        Total delay is 25000 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
      Exterior flag is set
```

d. Use the **show ip route** command to view how the routing table has changed on each router.

```
R1# show 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 0.0.0.0 to network 172.31.0.0

D    172.16.0.0/16 [90/41152000] via 192.168.100.2, 06:32:23, Serial0/0/0
*   172.31.0.0/16 is variably subnetted, 2 subnets, 2 masks
C       172.31.1.0/24 is directly connected, Loopback0
D*      172.31.0.0/16 is a summary, 00:02:04, Null0
D    192.168.200.0/24 [90/40640000] via 192.168.100.2, 05:15:46, Serial0/0/0
D    10.0.0.0/8 [90/41024000] via 192.168.100.2, 05:15:46, Serial0/0/0
     192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.100.0/29 is directly connected, Serial0/0/0
```

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```
D       192.168.100.0/24 is a summary, 05:15:56, Null0
D    192.168.0.0/19 [90/41152000] via 192.168.100.2, 05:00:19, Serial0/0/0

R2# show 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 192.168.100.1 to network 172.31.0.0

D    172.16.0.0/16 [90/40640000] via 10.1.1.3, 04:58:38, Serial0/0/1
D*   172.31.0.0/16 [90/40640000] via 192.168.100.1, 00:00:09, Serial0/0/0
     192.168.200.0/24 is variably subnetted, 8 subnets, 2 masks
C       192.168.200.0/30 is directly connected, Loopback1
D       192.168.200.0/24 is a summary, 05:14:07, Null0
C       192.168.200.4/30 is directly connected, Loopback5
C       192.168.200.8/30 is directly connected, Loopback9
C       192.168.200.12/30 is directly connected, Loopback13
C       192.168.200.16/30 is directly connected, Loopback17
C       192.168.200.20/30 is directly connected, Loopback21
C       192.168.200.24/30 is directly connected, Loopback25
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
D       10.1.3.0/30 [90/40640000] via 10.1.1.3, 04:58:39, Serial0/0/1
C       10.1.1.0/29 is directly connected, Serial0/0/1
D       10.0.0.0/8 is a summary, 05:14:09, Null0
     192.168.100.0/24 is variably subnetted, 2 subnets, 2 masks
C       192.168.100.0/29 is directly connected, Serial0/0/0
D       192.168.100.0/24 is a summary, 05:14:09, Null0
D    192.168.0.0/19 [90/40640000] via 10.1.1.3, 04:58:40, Serial0/0/1

R3# show 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 10.1.1.2 to network 172.31.0.0

     172.16.0.0/16 is variably subnetted, 2 subnets, 2 masks
D       172.16.0.0/16 is a summary, 06:37:06, Null0
C       172.16.1.0/24 is directly connected, Loopback172
D*   172.31.0.0/16 [90/41152000] via 10.1.1.2, 00:06:32, Serial0/0/1
D    192.168.200.0/24 [90/40640000] via 10.1.1.2, 05:20:29, Serial0/0/1
     10.0.0.0/8 is variably subnetted, 3 subnets, 3 masks
C       10.1.3.0/30 is directly connected, Loopback100
C       10.1.1.0/29 is directly connected, Serial0/0/1
D       10.0.0.0/8 is a summary, 06:37:07, Null0
D    192.168.100.0/24 [90/41024000] via 10.1.1.2, 05:20:31, Serial0/0/1
C    192.168.12.0/23 is directly connected, Loopback13
```

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```
C    192.168.8.0/23 is directly connected, Loopback9
C    192.168.24.0/23 is directly connected, Loopback25
C    192.168.4.0/23 is directly connected, Loopback5
C    192.168.20.0/23 is directly connected, Loopback21
C    192.168.0.0/23 is directly connected, Loopback1
D    192.168.0.0/19 is a summary, 05:05:22, Null0
C    192.168.16.0/23 is directly connected, Loopback17
```

e. On R1, the gateway of last resort is designated as 172.31.0.0. What is the IP address of the gateway of last resort on R2 and R3?

f. What are the benefits of introducing the routing information of the other autonomous system into EIGRP AS 100?

g. What are the drawbacks of configuring the default network to propagate from R1?

h. If R3 were to ping a destination network that is not reachable from this internetwork, how far would the data travel?

If the packets must travel to R1 before being dropped, does this make the network more or less susceptible to denial of service (DoS) attacks from within?

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Which routers in this scenario could be overloaded by such unreachable traffic?

i. Always consider the benefits and drawbacks in summarization and using default routing techniques before implementing them in an internetwork. These tools are useful in decreasing the size of a routing table, but might have drawbacks as well based on your topology. For instance, auto-summarization should not be used in topologies with discontiguous networks.

What would happen if the connection to the Internet on R1 were a subnet of the 172.16.0.0/16 network?

Step 6: Verify summarization and routing table efficiencies achieved.

a. Issue the **show ip protocols** command again. How has the output changed?

```
R1# show ip protocols
Routing Protocol is "eigrp 100"
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Default networks flagged in outgoing updates
  Default networks accepted from incoming updates
  EIGRP metric weight K1=1, K2=0, K3=1, K4=0, K5=0
  EIGRP maximum hopcount 100
  EIGRP maximum metric variance 1
  Redistributing: eigrp 100
  EIGRP NSF-aware route hold timer is 240s
  Automatic network summarization is in effect
  Automatic address summarization:
    192.168.100.0/24 for Loopback0
      Summarizing with metric 40512000
    172.31.0.0/16 for Serial0/0/0
      Summarizing with metric 128256
  Maximum path: 4
  Routing for Networks:
    172.31.0.0
    192.168.100.0
  Routing Information Sources:
    Gateway         Distance      Last Update
    (this router)         90      00:23:10
    Gateway         Distance      Last Update
    192.168.100.2         90      00:30:32
  Distance: internal 90 external 170
```

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b. Run the Tcl script from Step 1 again. The pings should be successful.

   When configuring a major network change such as summarization and default network, always test to see whether you have achieved the desired effect within the core paths and the outlying branches.

c. The engineer still wants to know if all of these solutions decreased the size of the routing table as you claimed. Display the size of the routing table on R1, R2, and R3 with the **show ip route summary** command you used at the end of Step 2.

   Before snapshot (initial configuration from Step 1):

```
R1# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           2           128         304
static          0           0           0           0
eigrp 100       7           10          1088        2584
internal        5                                   5860
Total           12          12          1216        8748

R2# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           9           576         1368
static          0           0           0           0
eigrp 100       7           3           640         1520
internal        5                                   5860
Total           12          12          1216        8748

R3# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       7           3           640         1520
static          0           0           0           0
eigrp 100       0           9           576         1368
internal        5                                   5860
Total           12          12          1216        8748
```

   After snapshot (after configuring auto-summary, R3 summary address, and default network on R1)

```
R1# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           2           128         304
static          0           0           0           0
eigrp 100       4           2           384         2952
internal        2                                   2344
Total           6           4           512         5600

R2# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       0           9           576         1368
static          0           0           0           0
```

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```
eigrp 100       3           4           448         3104
internal        3                                   3516
Total           6           13          1024        7988

R3# show ip route summary
IP routing table name is Default-IP-Routing-Table(0)
IP routing table maximum-paths is 32
Route Source    Networks    Subnets     Overhead    Memory (bytes)
connected       7           3           640         1520
static          0           0           0           0
eigrp 100       3           3           384         3972
internal        3                                   3516
Total           13          6           1024        9008
```

d. By what amount has the total routing table size decreased on each router? Depending on the equipment in your lab, your answers may vary.

With the equipment used in this lab, the most significant change is on R1. On R1, the routing table has decreased by 3148 bytes, which is a 36 percent decrease from its initial size. On R2, the routing table has decreased by 760 bytes, which is a 9 percent decrease. On R3, the routing table has actually increased slightly by 260 bytes, which is a 3 percent increase. This increase is due to the increase in the memory usage by the major network entries in the routing table learned via EIGRP, as compared to the base configuration.

Although this may seem like a trivial amount in terms of bytes, it is important to understand the principles involved and the outcome of a much more converged, scalable routing table. Consider also that summaries cause less EIGRP query, reply, update, and ACK packets to be sent to neighbors every time an EIGRP interface flaps. Queries can be propagated far beyond the local link and, by default, EIGRP might consume up to 50 percent of the bandwidth with its traffic. This amount could have severe repercussions on bandwidth consumption on a link.

Consider also the routing table of the Internet and how candidate default routing within an enterprise network can help minimize routing tables by routing traffic to a dynamically identified outbound path from a network. For enterprise-level networks, the amount of space and CPU utilization saved in storing topology and routing tables and maintaining routing tables with constant changes can be an important method for developing a faster and more converged network.

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Appendix A: Analyzing Major Networks

The output of the **show ip route** command in this scenario is somewhat complicated but useful to understand because you will see similar output in production networks. This output involves both subnets and supernets as well as the major networks themselves as group headings.

```
R1# show ip route
<output omitted>

Gateway of last resort is not set

     172.16.0.0/24 is subnetted, 1 subnets
D       172.16.1.0 [90/41152000] via 192.168.100.2, 00:10:31, Serial0/0/0
     172.31.0.0/24 is subnetted, 1 subnets
C       172.31.1.0 is directly connected, Loopback0
     192.168.200.0/30 is subnetted, 7 subnets
D       192.168.200.0 [90/40640000] via 192.168.100.2, 00:11:14, Serial0/0/0
D       192.168.200.4 [90/40640000] via 192.168.100.2, 00:11:14, Serial0/0/0
D       192.168.200.8 [90/40640000] via 192.168.100.2, 00:11:14, Serial0/0/0
D       192.168.200.12 [90/40640000] via 192.168.100.2, 00:11:15, Serial0/0/0
D       192.168.200.16 [90/40640000] via 192.168.100.2, 00:11:15, Serial0/0/0
D       192.168.200.20 [90/40640000] via 192.168.100.2, 00:11:15, Serial0/0/0
D       192.168.200.24 [90/40640000] via 192.168.100.2, 00:11:15, Serial0/0/0
     10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
D       10.1.3.0/30 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D       10.1.1.0/29 [90/41024000] via 192.168.100.2, 00:10:39, Serial0/0/0
     192.168.100.0/29 is subnetted, 1 subnets
C       192.168.100.0 is directly connected, Serial0/0/0
D    192.168.12.0/23 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D    192.168.8.0/23 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D    192.168.24.0/23 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D    192.168.4.0/23 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D    192.168.20.0/23 [90/41152000] via 192.168.100.2, 00:10:32, Serial0/0/0
D    192.168.0.0/23 [90/41152000] via 192.168.100.2, 00:10:33, Serial0/0/0
D    192.168.16.0/23 [90/41152000] via 192.168.100.2, 00:10:33, Serial0/0/0
R1#
```

Notice that the output of the **show ip route** command displays all subnets of a given major network grouped by major network:

- 10.0.0.0/8
- 172.16.0.0/16
- 172.31.0.0/16
- 192.168.100.0/24
- 192.168.200.0/24

Each /23 supernet consists of two major networks combined into one /23. For example, the 192.168.0.0/23 network covers the major networks 192.168.0.0/24 and 192.168.1.0/24.

Why do 172.16.0.0/24, 172.31.0.0/24, 192.168.100.0/30, and 192.168.200.0/29 appear as group headings with longer masks than the classful mask?

When you subnet a major network into subnets that all have the same mask and advertise those networks to a router, the routing table simply decides that it will do all lookups for that major network in a classless way using the mask provided. The routing table is not expecting any variable-length subnet masks (VLSMs) for those major networks because it has not yet learned of any. Therefore, the headings listed above display as the headings in the routing table.

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Analyze the output of the **show ip route** command as follows:

- 172.16.0.0/24 indicates that the 172.16.0.0/16 major network is only divided into subnets of 24-bit masks.
- 172.31.0.0/24 indicates that the 172.31.0.0/16 major network is only divided into subnets of 24-bit masks.
- 192.168.100.0/30 indicates that the 192.168.100.0/24 major network is only divided into subnets of 30-bit masks.
- 192.168.200.0/29 indicates that the 192.168.200.0/24 major network is only divided into subnets of 29-bit masks.

You should not observe this behavior with the 10.0.0.0/8 network because the R1 routing table has had subnets installed with VLSMs within that major network. Because R1 cannot generalize its destination prefixes for the 10.0.0.0/8 network, it forces the subnet into VLSM mode and shows it as “variably subnetted.”

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Router Interface Summary Table

Router Interface Summary				
Router Model	Ethernet Interface #1	Ethernet Interface #2	Serial Interface #1	Serial Interface #2
1700	Fast Ethernet 0 (FA0)	Fast Ethernet 1 (FA1)	Serial 0 (S0)	Serial 1 (S1)
1800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
2600	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0 (S0/0)	Serial 0/1 (S0/1)
2800	Fast Ethernet 0/0 (FA0/0)	Fast Ethernet 0/1 (FA0/1)	Serial 0/0/0 (S0/0/0)	Serial 0/0/1 (S0/0/1)
Note: To find out how the router is configured, look at the interfaces to identify the type of router and how many interfaces the router has. Rather than list all combinations of configurations for each router class, this table includes identifiers for the possible combinations of Ethernet and serial interfaces in the device. The table does not include any other type of interface, even though a specific router might contain one. For example, for an ISDN BRI interface, the string in parenthesis is the legal abbreviation that can be used in Cisco IOS commands to represent the interface.				

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