Building Scalable Cisco Internetworks (BSCI)

Enhanced Interior Gateway Routing Protocol (EIGRP)

http://www.INE.com

What is EIGRP?

- Enhanced Interior Gateway Routing Protocol
  - Successor to Interior Gateway Routing Protocol (IGRP)
- Cisco proprietary "hybrid" protocol
  - Both Distance Vector and Link State Behavior
  - Really "Advanced Distance Vector"
- "Classless" protocol
  - Supports VLSM and summarization

Why Use EIGRP?

- Guarantees loop-free topology
  - Diffusing Update Algorithm (DUAL)
- Fast convergence
  - Fastest of all IGP in certain designs
- Reliable & Efficient Updating
  - Forms active neighbor adjacencies
  - Guarantees packet delivery with Reliable Transport Protocol (RTP)
  - Supports partial updates
    - Not all neighbors need all routes

Why Use EIGRP? (cont.)

- Multiple *routed* protocol support
  - IPv4, IPX, & Appletalk
  - Legacy now, but originally important in non-converged networks
- Granular Metric
  - Hybrid metric derived from multiple factors
- Unequal Cost Load Balancing
  - Only IGP that supports true load distribution
- Control Plane Security
  - Supports MD5 based authentication

How EIGRP Works

- Step 1 - Discover EIGRP Neighbors
- Step 2 - Exchange Topology Information
- Step 3 - Choose Best Path via DUAL
- Step 4 - Neighbor and Topology Table Maintenance

Step 1 - Discovering EIGRP Neighbors

- EIGRP uses multicast “HELLO” packets to discover neighbors on EIGRP enabled attached links
  - Transport via IP protocol 88 (EIGRP)
  - Destination address 224.0.0.10
- Hello packets contain…
  - Autonomous System Number
  - Hold Time
  - Authentication
  - Metric Weightings (K values)
- Neighbors found are inserted into EIGRP “neighbor table”
  - **`show ip eigrp neighbors`**
- Neighbors that agree on attributes and exchange updates form active “adjacency”

Step 2 - Exchanging Topology Information

- Once neighbors are found, EIGRP "UPDATE" messages used to exchange routes
  - Sent as multicast to 224.0.0.10 or as unicast
- RTP uses sequence numbers and acknowledgements (ACKs) to ensure delivery
- Update messages describe attributes of a route
  - Prefix + Length
  - Next-Hop
  - Bandwidth
  - Delay
  - Load
  - Reliability
  - MTU
  - Hop Count
  - External Attributes
- All routes learned from all neighbors make up the EIGRP "topology table"
  - **`show ip eigrp topology`**

Step 3 - Choosing The Best Path

- Once topology is learned, DUAL runs to choose loop-free best path to each destination
- Unlike other protocols, EIGRP uses complex "composite" metric to choose best path
- Composite metric calculated from…
  - Administrative Weighting
  - Bandwidth
  - Delay
  - Load
  - Reliability
- Path with lowest composite metric is considered best and installed in IP routing table
- One or more backup routes can also be pre-calculated per destination
- ***Only best route is advertised to other EIGRP neighbors***

Step 4 - Neighbor and Topology Table Maintenance

- Unlike RIP or IGRP, active EIGRP neighbor adjacency reduces convergence time in event of network failure
- Adjacent neighbors' hello packets contain "hold time"
  - If no hello is received within hold time, neighbor declared unreachable
- When neighbor is lost…
  - Paths via that neighbor are removed from topology and routing table
  - If backup routes exist, they become new best paths and are inserted in routing table
    - In this case EIGRP can have sub-second convergence
  - If no backup routes exist, DUAL must run again

DUAL Reconvergence

- When best path is lost and no backup routes exist, route goes into "active" state and "active timer" starts
  - Stable routes not in active state are considered "passive"
- EIGRP "QUERY" message is reliably sent to remaining neighbors asking if there is an alternate route
- QUERY is propagated to all neighbors within EIGRP "query domain" or "flooding domain"
  - More on this later…
- Neighbors respond with EIGRP "REPLY" packet indicating if alternate route is available
  - If alternate route exists, DUAL recalculates new best path
  - If no alternate route, prefix removed from topology table
  - If active timer expires and no REPLY received, route is declared "Stuck-In-Active" (SIA) and removed from topology table

EIGRP Loop Prevention

- EIGRP guarantees loop-free topology through usage of…
  - Split Horizon
    - Don't advertise routes out the link they came in on
  - DUAL Feasibility Condition
    - If your metric is lower than mine, you are loop-free

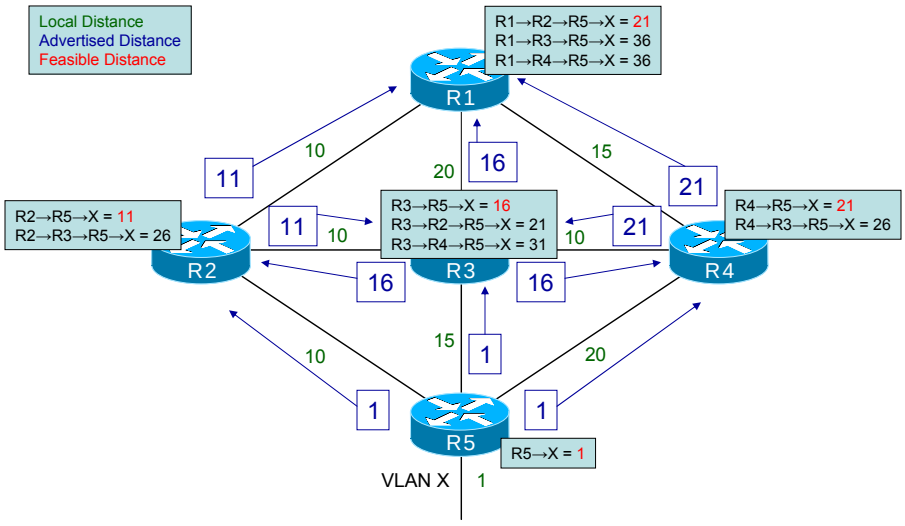
DUAL Terms in Detail

- Successor – Best path to a destination
- Feasible Distance (FD) – Composite metric of best path
- Feasible Successor (FS) – Backup path to a destination
- Advertised Distance (AD) – Composite metric learned from neighbor
- Local Distance (LD) – Composite metric to reach local neighbor
- Feasibility Condition (FC) – Criteria for valid backup paths

DUAL Path Selection in Detail

- Once adjacency occurs and update messages are exchanged, path selection begins
- Each update includes the metric the upstream router uses to reach destination (AD)
- Local router knows the metric to reach each upstream router (LD)
- Best path (successor) is chosen based on lowest AD + LD

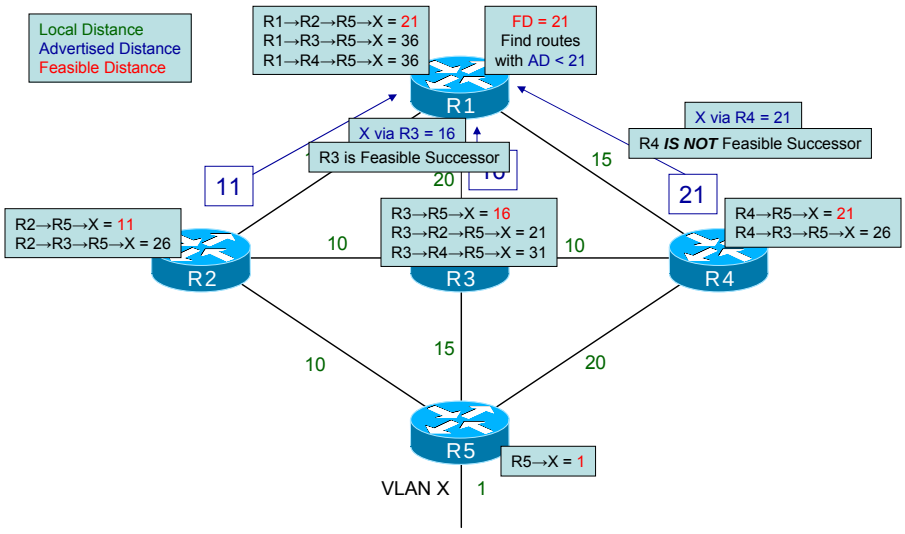
DUAL Example



Feasibility Condition in Detail

- Once best path is chosen, additional paths are examined for backup routes
- Feasibility Condition (FC) finds loop-free backup routes via logic…
  - If AD < FD, path is loop-free and viable backup
  - e.g. if your metric is lower than mine, you are closer to the destination and loop-free
- Paths that meet the FC are Feasible Successors (FS)
- Only Feasible Successors can be used for unequal cost load balancing

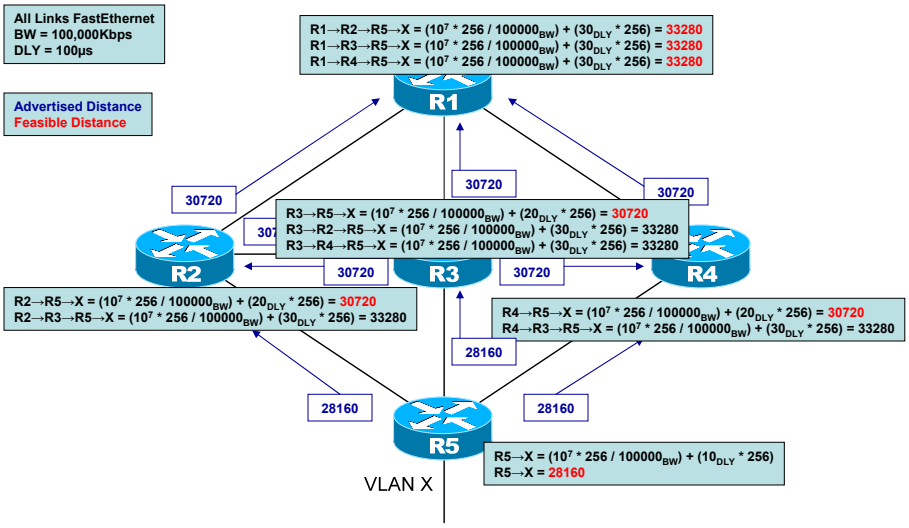
Feasibility Condition Example



Composite Metric Calculation in Detail

- Unlike other IGPs' hop count or BW-based cost, EIGRP metric is a hybrid value comprised of…
  - Inverse lowest bandwidth along path in Kbps scaled by 10^7 * 256
  - Cumulative delay along path in tens of microseconds (µs) scaled by 256
  - Worst load along path
  - Worst reliability along path
- Composite metric is computed as…
  - metric = [k1 * bandwidth + (k2 * bandwidth)/(256 - load) + k3 * delay]
  - If k5 != 0, metric = metric * [k5/(reliability + k4)]
- "K" values allow for manual administrative weighting
  - Must match for adjacency to occur
- Default K values are K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0
  - Implies default composite is bandwidth + delay
  - Reliability and load typically not used since they are constantly changing

Composite Metric Calculation Example



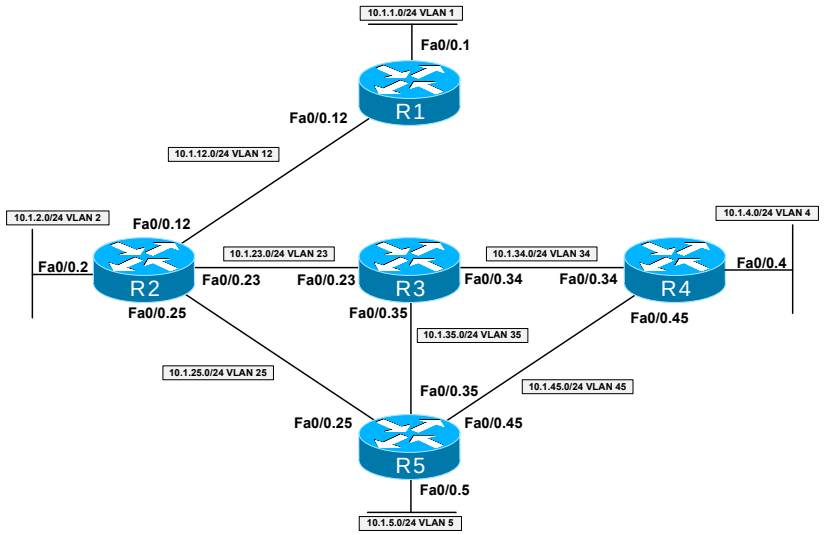
Implementing Basic EIGRP

- Initialize EIGRP process
  - **`router eigrp [asn]`**
- Enable EIGRP on links
  - **`network [address] [wildcard]`**
- Network statement does not control what is advertised, controls what interfaces run the protocol

Verifying Basic EIGRP

- Verify EIGRP interfaces
  - **`show ip eigrp interfaces`**
- Verify EIGRP neighbors
  - **`show ip eigrp neighbors`**
- Verify EIGRP topology
  - **`show ip eigrp topology`**
- Verify EIGRP routes in routing table
  - **`show ip route [eigrp]`**

Implementing Basic EIGRP Example



Basic EIGRP Configuration

```
R1#show run | section router eigrp 1
router eigrp 1
 network 10.0.0.0
 no auto-summary

R2#show run | section router eigrp 1
router eigrp 1
 network 10.1.0.0 0.0.255.255
 no auto-summary

R3#show run | section router eigrp 1
router eigrp 1
 network 10.1.23.0 0.0.0.255
 network 10.1.34.0 0.0.0.255
 network 10.1.35.0 0.0.0.255
 no auto-summary

R4#show run | section router eigrp 1
router eigrp 1
 network 10.1.4.4 0.0.0.0
 network 10.1.34.4 0.0.0.0
 network 10.1.45.4 0.0.0.0
 no auto-summary

R5#show run | section router eigrp 1
router eigrp 1
 network 0.0.0.0
 no auto-summary
```

EIGRP Interface Verification

```
R1#show ip eigrp interfaces
IP-EIGRP interfaces for process 1
                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.1            0        0/0         0       0/1           0           0
Fa0/0.12           1        0/0         8       0/1           50          0
Fa0/0.13           0        0/0         0       0/1           0           0
Fa0/0.14           0        0/0         0       0/1           0           0

R2#show ip eigrp interfaces
IP-EIGRP interfaces for process 1
                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.2            0        0/0         0       0/1           0           0
Fa0/0.12           1        0/0         4       0/1           50          0
Fa0/0.23           1        0/0         6       0/1           50          0
Fa0/0.25           1        0/0         9       0/1           50          0

R3#show ip eigrp interfaces
IP-EIGRP interfaces for process 1
                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.23           1        0/0         6       0/1           50          0
Fa0/0.34           1        0/0         1       0/1           50          0
Fa0/0.35           1        0/0         8       0/1           50          0

R4#show ip eigrp interfaces
IP-EIGRP interfaces for process 1
                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.34           1        0/0         1       0/1           50          0
Fa0/0.4            0        0/0         0       0/1           0           0
Fa0/0.45           1        0/0         4       0/1           50          0

R5#show ip eigrp interfaces
IP-EIGRP interfaces for process 1
                        Xmit Queue   Mean   Pacing Time   Multicast    Pending
Interface        Peers  Un/Reliable  SRTT   Un/Reliable   Flow Timer   Routes
Fa0/0.5            0        0/0         0       0/1           0           0
Fa0/0.25           1        0/0        13       0/1           80          0
Fa0/0.35           1        0/0        15       0/1           80          0
Fa0/0.45           1        0/0         7       0/1           50          0
```


EIGRP Packet Level Debug

```
R1#debug ip packet detail
IP packet debugging is on (detailed)
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#router eigrp 1
R1(config-router)#no auto-summary
R1(config-router)#network 10.0.0.0
R1(config-router)#end
R1#
IP: s=10.1.1.1 (local), d=224.0.0.10 (FastEthernet0/0.1), len 60, sending broad/multicast, proto=88
IP: s=10.1.12.1 (local), d=224.0.0.10 (FastEthernet0/0.12), len 60, sending broad/multicast, proto=88
IP: s=10.1.12.2 (FastEthernet0/0.12), d=224.0.0.10, len 60, rcvd 2, proto=88
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.12.2 (FastEthernet0/0.12) is up: new adjacency
IP: tableid=0, s=10.1.12.2 (FastEthernet0/0.12), d=10.1.12.1 (FastEthernet0/0.12), routed via RIB
IP: s=10.1.12.2 (FastEthernet0/0.12), d=10.1.12.1 (FastEthernet0/0.12), len 40, rcvd 3, proto=88
IP: s=10.1.12.1 (local), d=224.0.0.10 (FastEthernet0/0.12), len 60, sending broad/multicast, proto=88
IP: s=10.1.12.1 (local), d=10.1.12.2 (FastEthernet0/0.12), len 40, sending, proto=88
IP: s=10.1.12.2 (FastEthernet0/0.12), d=224.0.0.10, len 77, rcvd 2, proto=88
IP: s=10.1.12.2 (FastEthernet0/0.12), d=224.0.0.10, len 320, rcvd 2, proto=88
IP: s=10.1.12.1 (local), d=224.0.0.10 (FastEthernet0/0.12), len 77, sending
R1(config-routbroad/multicast, proto=88
IP: s=10.1.12.1 (local), d=224.0.0.10 (FastEthernet0/0.12), len 68, sending broad/multicast, proto=88
IP: tableid=0, s=10.1.12.2 (FastEthernet0/0.12), d=10.1.12.1 (FastEthernet0/0.12), routed via RIB
IP: s=10.1.12.2 (FastEthernet0/0.12), d=10.1.12.1 (FastEthernet0/0.12), len 320, rcvd 3, proto=88
<output omitted>
```


EIGRP Neighbor Adjacency Verification

```
R1#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   10.1.12.2               Fa0/0.12          11 00:03:10   17   200  0  57

R2#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
2   10.1.12.1               Fa0/0.12          11 00:03:18   10   200  0  4
1   10.1.25.5               Fa0/0.25          10 01:27:25    1   200  0  54
0   10.1.23.3               Fa0/0.23          11 01:27:38    1   200  0  85

R3#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
3   10.1.35.5               Fa0/0.35          11 01:27:28   42   252  0  56
1   10.1.23.2               Fa0/0.23          11 01:27:41   18   200  0  59
0   10.1.34.4               Fa0/0.34          10 01:27:41   69   414  0  47

R4#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
2   10.1.45.5               Fa0/0.45          14 01:27:30  122   732  0  55
1   10.1.34.3               Fa0/0.34          13 01:27:44   35   210  0  86

R5#show ip eigrp neighbors
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
2   10.1.45.4               Fa0/0.45          11 01:27:33   12   200  0  46
1   10.1.25.2               Fa0/0.25          13 01:27:33    1   200  0  58
0   10.1.35.3               Fa0/0.35          13 01:27:33    5   200  0  87
```


EIGRP Topology Verification

```
R2#show ip eigrp topology
IP-EIGRP Topology Table for AS(1)/ID(10.1.25.2)

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

P 10.1.14.0/24, 2 successors, FD is 33280
        via 10.1.23.3 (33280/30720), FastEthernet0/0.23
        via 10.1.25.5 (33280/30720), FastEthernet0/0.25
P 10.1.13.0/24, 1 successors, FD is 30720
        via 10.1.23.3 (30720/28160), FastEthernet0/0.23
P 10.1.12.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0/0.12
P 10.1.2.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0/0.2
P 10.1.1.0/24, 1 successors, FD is 30720
        via 10.1.12.1 (30720/28160), FastEthernet0/0.12
P 10.1.5.0/24, 1 successors, FD is 30720
        via 10.1.25.5 (30720/28160), FastEthernet0/0.25
P 10.1.4.0/24, 2 successors, FD is 33280
        via 10.1.23.3 (33280/30720), FastEthernet0/0.23
        via 10.1.25.5 (33280/30720), FastEthernet0/0.25
P 10.1.25.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0/0.25
P 10.1.23.0/24, 1 successors, FD is 28160
        via Connected, FastEthernet0/0.23
P 10.1.45.0/24, 1 successors, FD is 30720
        via 10.1.25.5 (30720/28160), FastEthernet0/0.25
P 10.1.35.0/24, 2 successors, FD is 30720
        via 10.1.23.3 (30720/28160), FastEthernet0/0.23
        via 10.1.25.5 (30720/28160), FastEthernet0/0.25
P 10.1.34.0/24, 1 successors, FD is 30720
        via 10.1.23.3 (30720/28160), FastEthernet0/0.23
```


EIGRP Topology Verification Detail

```
R2#show ip eigrp topology 10.1.5.0 255.255.255.0
IP-EIGRP (AS 1): Topology entry for 10.1.5.0/24
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is 30720
  Routing Descriptor Blocks:
  10.1.25.5 (FastEthernet0/0.25), from 10.1.25.5, Send flag is 0x0
      Composite metric is (30720/28160), Route is Internal
      Vector metric:
        Minimum bandwidth is 100000 Kbit
        Total delay is 200 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
  10.1.23.3 (FastEthernet0/0.23), from 10.1.23.3, Send flag is 0x0
      Composite metric is (33280/30720), Route is Internal
      Vector metric:
        Minimum bandwidth is 100000 Kbit
        Total delay is 300 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 2
```


EIGRP Routing Table Verification

```
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 not set

     10.0.0.0/24 is subnetted, 12 subnets
D       10.1.14.0 [90/33280] via 10.1.25.5, 00:19:40, FastEthernet0/0.25
                  [90/33280] via 10.1.23.3, 00:19:40, FastEthernet0/0.23
D       10.1.13.0 [90/30720] via 10.1.23.3, 00:19:42, FastEthernet0/0.23
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:07:41, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 01:30:23, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:19:41, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:19:41, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 01:31:20, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 01:31:20, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 01:31:20, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 01:31:20, FastEthernet0/0.23
```

EIGRP Routing Table Verification Detail

```
R2#show ip route 10.1.5.0 255.255.255.0
Routing entry for 10.1.5.0/24
  Known via "eigrp 1", distance 90, metric 30720, type internal
  Redistributing via eigrp 1
  Last update from 10.1.25.5 on FastEthernet0/0.25, 01:30:53 ago
  Routing Descriptor Blocks:
  * 10.1.25.5, from 10.1.25.5, 01:30:53 ago, via FastEthernet0/0.25
      Route metric is 30720, traffic share count is 1
      Total delay is 200 microseconds, minimum bandwidth is 100000 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 1
```


EIGRP Default Routing

- EIGRP supports default routing two ways
  - Candidate default network
    - **`ip default-network [`*`network`*`]`**
  - Native advertisement of 0.0.0.0/0 prefix
- **`default-information`** command in EIGRP does not behave the same as other protocols

IP Default-Network

- Candidate default network is backwards compatible with IGRP
  - IGRP didn't support native 0.0.0.0/0 advertisement
- Default network must be…
  - Dynamically learned through EIGRP
  - Not directly connected
  - Classful network
- Limited application due to these restrictions

IP Default-Network Example

```
R1#
interface Loopback0
 ip address 1.0.0.1 255.0.0.0
!
router eigrp 1
 network 1.0.0.0

R2#
ip default-network 1.0.0.0

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 10.1.12.1 to network 1.0.0.0

D*   1.0.0.0/8 [90/156160] via 10.1.12.1, 00:01:43, FastEthernet0/0.12
     10.0.0.0/24 is subnetted, 10 subnets
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:20:11, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:31:28, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:31:28, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:31:28, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:31:29, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:31:29, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:31:29, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:31:29, FastEthernet0/0.23
```

Native Default Advertisement

- Native 0.0.0.0/0 network can be advertised via…
  - Static default route to an interface + **`network 0.0.0.0`** under EIGRP process
  - Redistribution from static or another protocol
  - Summarization

0.0.0.0/0 Advertisement Examples

```
R1#
router eigrp 1
 network 0.0.0.0
!
ip route 0.0.0.0 0.0.0.0 Null0

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 10.1.12.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 10 subnets
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:23:33, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:34:50, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:34:50, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:34:50, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:34:51, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:34:51, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:34:51, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:34:51, FastEthernet0/0.23
D*   0.0.0.0/0 [90/28160] via 10.1.12.1, 00:01:05, FastEthernet0/0.12
```


0.0.0.0/0 Advertisement Examples (cont.)

```
R1#
router eigrp 1
 redistribute static metric 100000 100 255 1 1500
!
ip route 0.0.0.0 0.0.0.0 Null0

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 10.1.12.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 10 subnets
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:24:53, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:36:10, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:36:10, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:36:10, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:36:11, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:36:11, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:36:11, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:36:11, FastEthernet0/0.23
D*EX 0.0.0.0/0 [170/53760] via 10.1.12.1, 00:00:27, FastEthernet0/0.12
```


0.0.0.0/0 Advertisement Examples (cont.)

```
R1#
interface FastEthernet0/0.12
 ip summary-address eigrp 1 0.0.0.0 0.0.0.0 5

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 10.1.12.1 to network 0.0.0.0

     10.0.0.0/24 is subnetted, 9 subnets
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:38:16, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:38:16, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:38:16, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:38:17, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:38:17, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:38:17, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:38:17, FastEthernet0/0.23
D*   0.0.0.0/0 [90/30720] via 10.1.12.1, 00:00:26, FastEthernet0/0.12
```


EIGRP Summarization

- EIGRP summarization (aggregation) serves two purposes
  - Minimize routing information needed in topology
  - Limit EIGRP query domain
    - More on this later
- Process level **`auto-summary`** automatically summarizes to classful boundary when passing major network boundaries
  - On by default
- Interface level **`ip summary-address eigrp [`*`network`*`] [`*`mask`*`] [`*`AD`*`]`** supports any bit boundary
  - Automatically suppresses subnet advertisements
  - Administrative Distance defaults to 5 to allow for floating summaries

EIGRP Auto-Summary Example

```
R1#
interface Loopback0
 ip address 1.0.0.1 255.255.0.0
!
interface Loopback1
 ip address 1.1.0.1 255.255.0.0
!
interface Loopback2
 ip address 1.2.0.1 255.255.0.0
!
interface Loopback3
 ip address 1.3.0.1 255.255.0.0
!
router eigrp 1
 network 1.0.0.0
 auto-summary

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 not set

D    1.0.0.0/8 [90/156160] via 10.1.12.1, 00:00:44, FastEthernet0/0.12
     10.0.0.0/24 is subnetted, 10 subnets
C       10.1.12.0 is directly connected, FastEthernet0/0.12
C       10.1.2.0 is directly connected, FastEthernet0/0.2
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:02:25, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:49:15, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:49:15, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:49:15, FastEthernet0/0.23
C       10.1.25.0 is directly connected, FastEthernet0/0.25
C       10.1.23.0 is directly connected, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:49:16, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:49:16, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:49:16, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:49:16, FastEthernet0/0.23
```

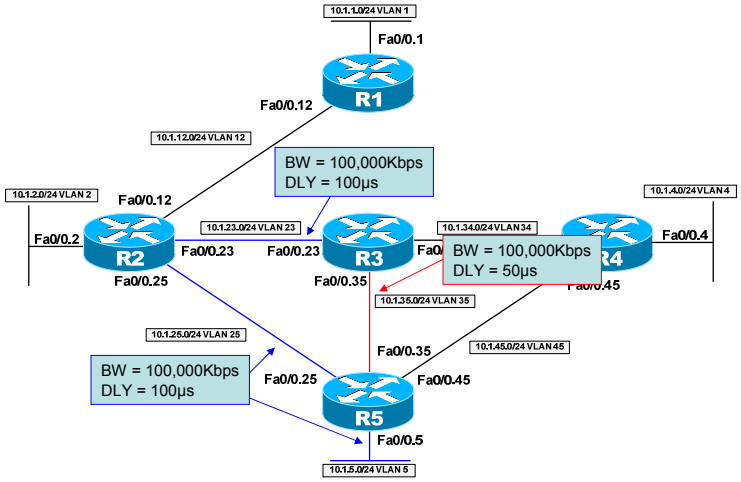
EIGRP Manual Summarization Example

```
R1#
interface Loopback0
 ip address 1.0.0.1 255.255.0.0
!
interface Loopback1
 ip address 1.1.0.1 255.255.0.0
!
interface Loopback2
 ip address 1.2.0.1 255.255.0.0
!
interface Loopback3
 ip address 1.3.0.1 255.255.0.0
!
interface FastEthernet0/0.12
 ip summary-address eigrp 1 1.0.0.0 255.252.0.0 5
!
router eigrp 1
 network 1.0.0.0
 no auto-summary

R2#show ip route eigrp
     1.0.0.0/14 is subnetted, 1 subnets
D       1.0.0.0 [90/156160] via 10.1.12.1, 00:05:01, FastEthernet0/0.12
     10.0.0.0/24 is subnetted, 10 subnets
D       10.1.1.0 [90/30720] via 10.1.12.1, 00:09:57, FastEthernet0/0.12
D       10.1.5.0 [90/30720] via 10.1.25.5, 00:56:46, FastEthernet0/0.25
D       10.1.4.0 [90/33280] via 10.1.25.5, 00:56:46, FastEthernet0/0.25
                 [90/33280] via 10.1.23.3, 00:56:46, FastEthernet0/0.23
D       10.1.45.0 [90/30720] via 10.1.25.5, 00:56:46, FastEthernet0/0.25
D       10.1.35.0 [90/30720] via 10.1.25.5, 00:56:46, FastEthernet0/0.25
                  [90/30720] via 10.1.23.3, 00:56:46, FastEthernet0/0.23
D       10.1.34.0 [90/30720] via 10.1.23.3, 00:56:46, FastEthernet0/0.23
```


EIGRP Load Balancing

- EIGRP allows load distribution among unequal paths
  - Not the same as other IGPs load balancing among *equal* cost paths
- Controlled by **`variance`** command
  - If feasible distance * variance > feasible successor, load balancing occurs
- Only feasible successors are candidate for load balancing
- Automatically calculated *traffic share count* causes links to be used in ratio proportional to their composite metrics

EIGRP Unequal Cost Load Balancing



EIGRP Unequal Cost Load Balancing

```
R2#
router eigrp 1
 variance 2

R3#
interface FastEthernet0/0.35
 delay 5

R2#show ip eigrp topology 10.1.5.0 255.255.255.0
IP-EIGRP (AS 1): Topology entry for 10.1.5.0/24
  State is Passive, Query origin flag is 1, 1 Successor(s), FD is 30720
  Routing Descriptor Blocks:
  10.1.25.5 (FastEthernet0/0.25), from 10.1.25.5, Send flag is 0x0
      Composite metric is (30720/28160), Route is Internal
      Vector metric:
        Minimum bandwidth is 100000 Kbit
        Total delay is 200 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 1
  10.1.23.3 (FastEthernet0/0.23), from 10.1.23.3, Send flag is 0x0
      Composite metric is (32000/29440), Route is Internal
      Vector metric:
        Minimum bandwidth is 100000 Kbit
        Total delay is 250 microseconds
        Reliability is 255/255
        Load is 1/255
        Minimum MTU is 1500
        Hop count is 2
```

EIGRP Unequal Cost Load Balancing (cont.)

```
R2#show ip route 10.1.5.0 255.255.255.0
Routing entry for 10.1.5.0/24
  Known via "eigrp 1", distance 90, metric 30720, type internal
  Redistributing via eigrp 1
  Last update from 10.1.23.3 on FastEthernet0/0.23, 00:03:39 ago
  Routing Descriptor Blocks:
  * 10.1.25.5, from 10.1.25.5, 00:03:39 ago, via FastEthernet0/0.25
      Route metric is 30720, traffic share count is 24
      Total delay is 200 microseconds, minimum bandwidth is 100000 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 1
    10.1.23.3, from 10.1.23.3, 00:03:39 ago, via FastEthernet0/0.23
      Route metric is 32000, traffic share count is 23
      Total delay is 250 microseconds, minimum bandwidth is 100000 Kbit
      Reliability 255/255, minimum MTU 1500 bytes
      Loading 1/255, Hops 2
```


EIGRP Link Utilization

- EIGRP control plane traffic is allowed to use up to 50% of each interface's configured **`bandwidth`** value
- Can be adjusted with interface level **`ip bandwidth-percent eigrp [`*`asn`*`] [`*`percent`*`]`**
- Can be an important design consideration when **`bandwidth`** is modified for routing policy, QoS, or where WAN link circuit speeds don't match underlying interface speeds (e.g. fractional T1)

EIGRP Authentication

- Routing control plane security is a must in today's networks to prevent DoS and other attacks
  - EIGRP neighbor authentication prevents against malicious route injection attacks or errors in configuration
- Configured Key ID and password are combined to generate MD5 hash
  - If MD5 hash does not match in Hello packets, adjacency cannot occur
- Multiple keys can be configured for manual or automated key rotation
  - key-chain accept & send lifetime

EIGRP Authentication Example

```
R1#
key chain EIGRP-KEY-CHAIN
 key 1
  key-string CISCO
!
interface FastEthernet0/0.12
 ip authentication mode eigrp 1 md5
 ip authentication key-chain eigrp 1 EIGRP-KEY-CHAIN

R2#
key chain EIGRP-KEY-CHAIN
 key 1
  key-string CISCO
!
interface FastEthernet0/0.12
 ip authentication mode eigrp 1 md5
 ip authentication key-chain eigrp 1 EIGRP-KEY-CHAIN

R1#show key chain
Key-chain EIGRP-KEY-CHAIN:
    key 1 -- text "CISCO"
        accept lifetime (always valid) - (always valid) [valid now]
        send lifetime (always valid) - (always valid) [valid now]

R1#debug eigrp packet hello

EIGRP: Sending HELLO on FastEthernet0/0.12
  AS 1, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
EIGRP: received packet with MD5 authentication, key id = 1
EIGRP: Received HELLO on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
```

EIGRP Authentication Troubleshooting

```
R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#key chain EIGRP-KEY-CHAIN
R1(config-keychain)#key 1
R1(config-keychain-key)#key-string WRONG_PASSWORD
%DUAL-5-NBRCHANGE: IP-EIGRP(0) 1: Neighbor 10.1.12.2 (FastEthernet0/0.12) is down: Auth failure
R1(config-keychain-key)#do debug eigrp packet hello
EIGRP Packets debugging is on
    (HELLO)
R1(config-keychain-key)#
EIGRP: pkt key id = 1, authentication mismatch
<output omitted>
R1(config-keychain-key)#do undebug all
All possible debugging has been turned off

R1(config-keychain-key)#no key 1
R1(config)#key chain EIGRP-KEY-CHAIN
R1(config-keychain)#key 2
R1(config-keychain-key)#key-string WRONG_KEY_NUMBER
R1(config-keychain-key)#do debug eigrp packet hello
EIGRP Packets debugging is on
    (HELLO)
R1(config-keychain-key)#
EIGRP: Sending HELLO on FastEthernet0/0.12
  AS 1, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
EIGRP: pkt authentication key id = 1, key not defined or not live
```


EIGRP Scalability

- EIGRP Scalability is a combined function of…
  - Device CPU & memory
  - Protocol timers
  - Number of prefixes in topology
  - Size of query domain
- Physical resources are fixed, but software optimization can reduce convergence time and increase availability through
  - Modifying hello/hold timers
  - Ensuring Feasible Successors are available
  - Topology reduction through summarization
  - Query domain reduction through summarization & stub routing

EIGRP Query Domain and SIA

- When an EIGRP route is lost and there are no Feasible Successors, the route goes into “active” state and a QUERY message is sent to all neighbors
- EIGRP state machine must wait for REPLY messages from all neighbors indicating either a new route or no route for the active prefix
- If REPLY is not received before “active timer” expires, prefix is declared “Stuck-in-Active” (SIA), and EIGRP neighbors are reset and must be re-established
- The larger or more overloaded the network is, the more likely SIA events are to occur and to cause network downtime
- Occurrence of SIA events can be reduced by shrinking where QUERY message must be sent (i.e. “query domain”) through
  - EIGRP Summarization
  - EIGRP Stub

EIGRP Summarization and Query Reduction

- When a QUERY message is received from an EIGRP neighbor, a topology lookup occurs for an *exact match* of the prefix
  - I.e. if QUERY is received for 1.2.3.0/24, topology is checked for 1.2.3.0/24 exactly
- If exact match is found but no Feasible Successors exist, local device re-generates QUERY to all other neighbors
  - Process continues until REPLY is sent or SIA occurs
- If exact match is *not* found, REPLY is sent immediately and new QUERY is not generated
- Based on this logic, summarization terminates query domain for subnets of the summary
  - I.e. if QUERY is received for 1.2.3.0/24, but I have only 1.2.0.0/16, send REPLY and do not generate QUERY

EIGRP Query/Reply Verification

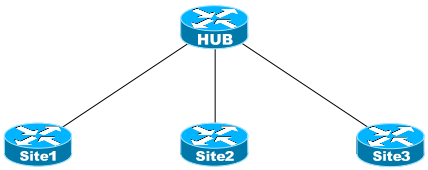
```
R1#debug eigrp packet query reply
EIGRP Packets debugging is on
    (QUERY, REPLY)

R2#debug eigrp packet query reply
EIGRP Packets debugging is on
    (QUERY, REPLY)

R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface Loopback0
R1(config-if)#shutdown
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 iidbQ un/rely 0/1 serno 77-77
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 nbr 10.1.12.2 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 77-77
EIGRP: Sending QUERY on FastEthernet0/0.12
  AS 1, Flags 0x0, Seq 58/0 idbQ 0/0 iidbQ un/rely 0/0 serno 77-77
EIGRP: Received REPLY on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 231/58 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0

R2#
EIGRP: Received QUERY on FastEthernet0/0.12 nbr 10.1.12.1
  AS 1, Flags 0x0, Seq 58/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Enqueueing QUERY on FastEthernet0/0.25 iidbQ un/rely 0/1 serno 135-135
EIGRP: Enqueueing QUERY on FastEthernet0/0.23 iidbQ un/rely 0/1 serno 135-135
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 iidbQ un/rely 0/1 serno 135-135
EIGRP: Enqueueing QUERY on FastEthernet0/0.25 nbr 10.1.25.5 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 135-135
EIGRP: Sending QUERY on FastEthernet0/0.25
  AS 1, Flags 0x0, Seq 228/0 idbQ 0/0 iidbQ un/rely 0/0 serno 135-135
EIGRP: Enqueueing QUERY on FastEthernet0/0.23 nbr 10.1.23.3 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 135-135
EIGRP: Sending QUERY on FastEthernet0/0.23
  AS 1, Flags 0x0, Seq 229/0 idbQ 0/0 iidbQ un/rely 0/0 serno 135-135
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 nbr 10.1.12.1 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 135-135
EIGRP: Received REPLY on FastEthernet0/0.25 nbr 10.1.25.5
  AS 1, Flags 0x0, Seq 201/228 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Received REPLY on FastEthernet0/0.23 nbr 10.1.23.3
  AS 1, Flags 0x0, Seq 248/229 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Enqueueing REPLY on FastEthernet0/0.12 nbr 10.1.12.1 iidbQ un/rely 0/1 peerQ un/rely 0/0 serno 136-136
EIGRP: Sending REPLY on FastEthernet0/0.12 nbr 10.1.12.1
  AS 1, Flags 0x0, Seq 231/58 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/1 serno 136-136
```


EIGRP Query Reduction and Summarization

```
R1#
interface FastEthernet0/0.12
 ip summary-address eigrp 1 1.0.0.0 255.252.0.0 5

R1#debug eigrp packet query reply
EIGRP Packets debugging is on
    (QUERY, REPLY)

R2#debug eigrp packet query reply
EIGRP Packets debugging is on
    (QUERY, REPLY)

R1#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R1(config)#interface loopback0
R1(config-if)#shutdown
R1(config-if)#
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 iidbQ un/rely 0/1 serno 73-73
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 nbr 10.1.12.2 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 73-73
EIGRP: Sending QUERY on FastEthernet0/0.12
  AS 1, Flags 0x0, Seq 53/0 idbQ 0/0 iidbQ un/rely 0/0 serno 73-73
EIGRP: Received REPLY on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 216/53 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
%LINK-5-CHANGED: Interface Loopback0, changed state to administratively down
%LINEPROTO-5-UPDOWN: Line protocol on Interface Loopback0, changed state to down

R2#
EIGRP: Received QUERY on FastEthernet0/0.12 nbr 10.1.12.1
  AS 1, Flags 0x0, Seq 53/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Enqueueing REPLY on FastEthernet0/0.12 nbr 10.1.12.1 iidbQ un/rely 0/1 peerQ un/rely 0/0 serno 128-128
EIGRP: Sending REPLY on FastEthernet0/0.12 nbr 10.1.12.1
  AS 1, Flags 0x0, Seq 216/53 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/1 serno 128-128
```


EIGRP Stub and Query Reduction

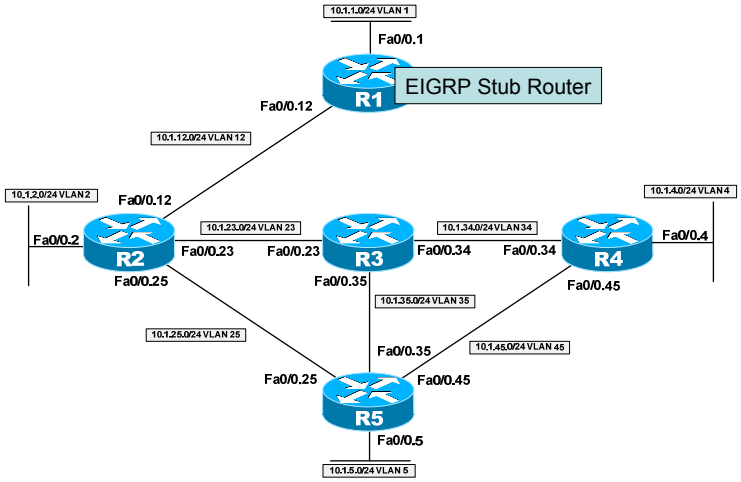
- In certain physical topologies, the query domain extends to portions of the network that can never be used as alternate paths
  - QUERY/REPLY messages sent into these portions waste network resources and increase convergence time
- Hub-and-Spoke Example:



EIGRP Stub and Query Reduction (cont.)

- EIGRP Stub is used to inform adjacent neighbors that QUERY messages should not be sent to them
- Useful whenever an EIGRP router is not used for transit for the rest of the network
  - Routes received by a stub router are not advertised to other adjacent neighbors
- Process level **`eigrp stub [connected] [leak-map] [receive-only] [redistributed] [static] [summary]`**
  - Arguments control what prefixes can be advertised outbound

EIGRP Stub Example



EIGRP Stub Verification

```
R1#
router eigrp 1
 eigrp stub connected summary

R2#show ip eigrp neighbors detail Fa0/0.12
IP-EIGRP neighbors for process 1
H   Address                 Interface       Hold Uptime   SRTT   RTO  Q  Seq
                                            (sec)         (ms)       Cnt Num
0   10.1.12.1               Fa0/0.12          11 00:00:53     7   200  0  61
   Version 12.4/1.2, Retrans: 0, Retries: 0, Prefixes: 4
   Stub Peer Advertising ( CONNECTED SUMMARY ) Routes
   Suppressing queries

R1#debug eigrp packet terse
EIGRP Packets debugging is on
    (UPDATE, REQUEST, QUERY, REPLY, IPXSAP, PROBE, ACK, STUB, SIAQUERY, SIAREPLY)

R2#config t
Enter configuration commands, one per line.  End with CNTL/Z.
R2(config)#interface Fa0/0.2
R2(config-subif)#shutdown

R1#
EIGRP: Received UPDATE on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 333/0 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Enqueueing ACK on FastEthernet0/0.12 nbr 10.1.12.2
  Ack seq 333 iidbQ un/rely 0/0 peerQ un/rely 1/0
EIGRP: Sending ACK on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 0/333 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 1/0
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 iidbQ un/rely 0/1 serno 103-103
EIGRP: Enqueueing QUERY on FastEthernet0/0.12 nbr 10.1.12.2 iidbQ un/rely 0/0 peerQ un/rely 0/0 serno 103-103
EIGRP: Sending QUERY on FastEthernet0/0.12
  AS 1, Flags 0x0, Seq 80/0 idbQ 0/0 iidbQ un/rely 0/0 serno 103-103
EIGRP: Received ACK on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 0/80 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/1
EIGRP: FastEthernet0/0.12 multicast flow blocking cleared
EIGRP: Received REPLY on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 336/80 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 0/0
EIGRP: Enqueueing ACK on FastEthernet0/0.12 nbr 10.1.12.2
  Ack seq 336 iidbQ un/rely 0/0 peerQ un/rely 1/0
EIGRP: Sending ACK on FastEthernet0/0.12 nbr 10.1.12.2
  AS 1, Flags 0x0, Seq 0/336 idbQ 0/0 iidbQ un/rely 0/0 peerQ un/rely 1/0
```

EIGRP Q&A