

Introduction to Troubleshooting Routing Protocols

Layer 3 Trouleshooting

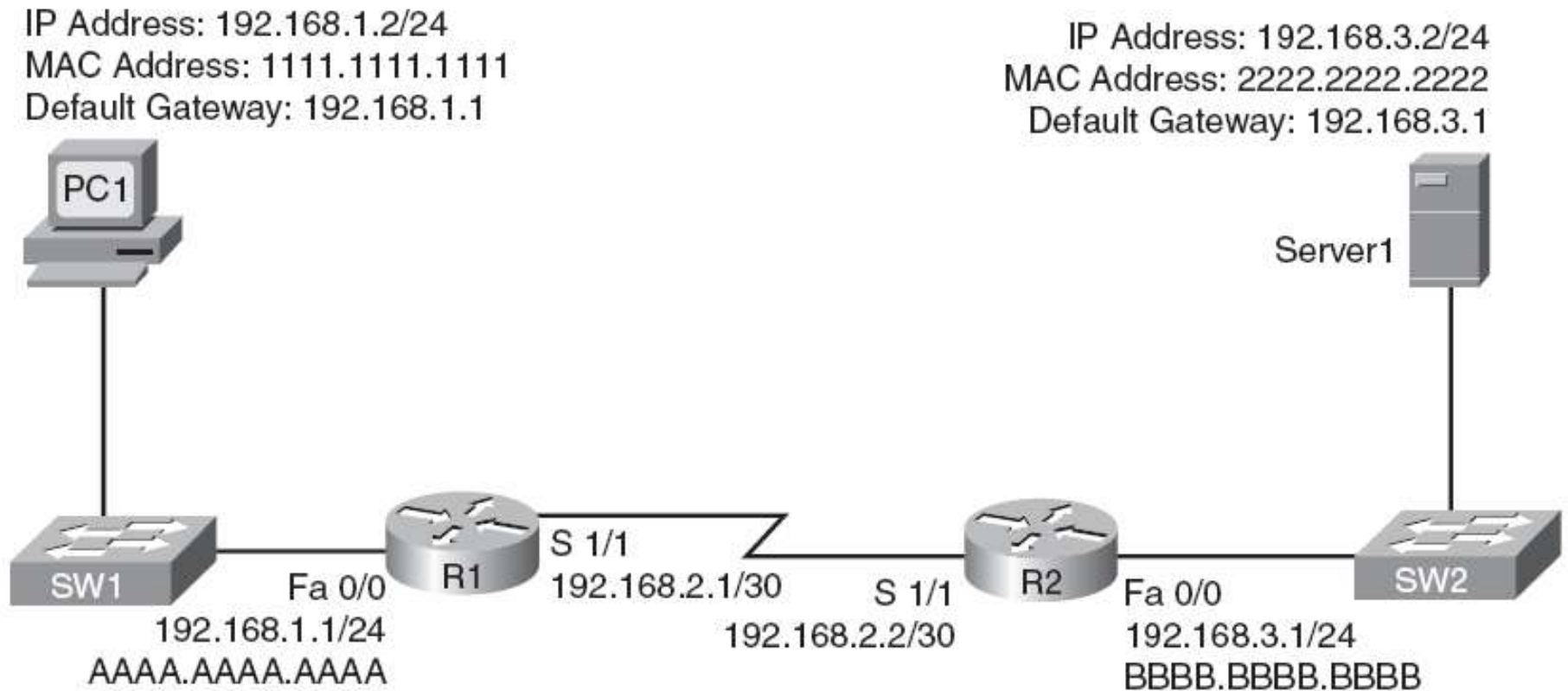
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For IP network connectivity issues, Layer 3 (network layer) of the OSI model is often the best starting point for troubleshooting.

Đối với sự cố kết nối mạng IP, Layer 3 (tầng mạng) của mô hình OSI thường là điểm bắt đầu tốt nhất để xử lý sự cố.

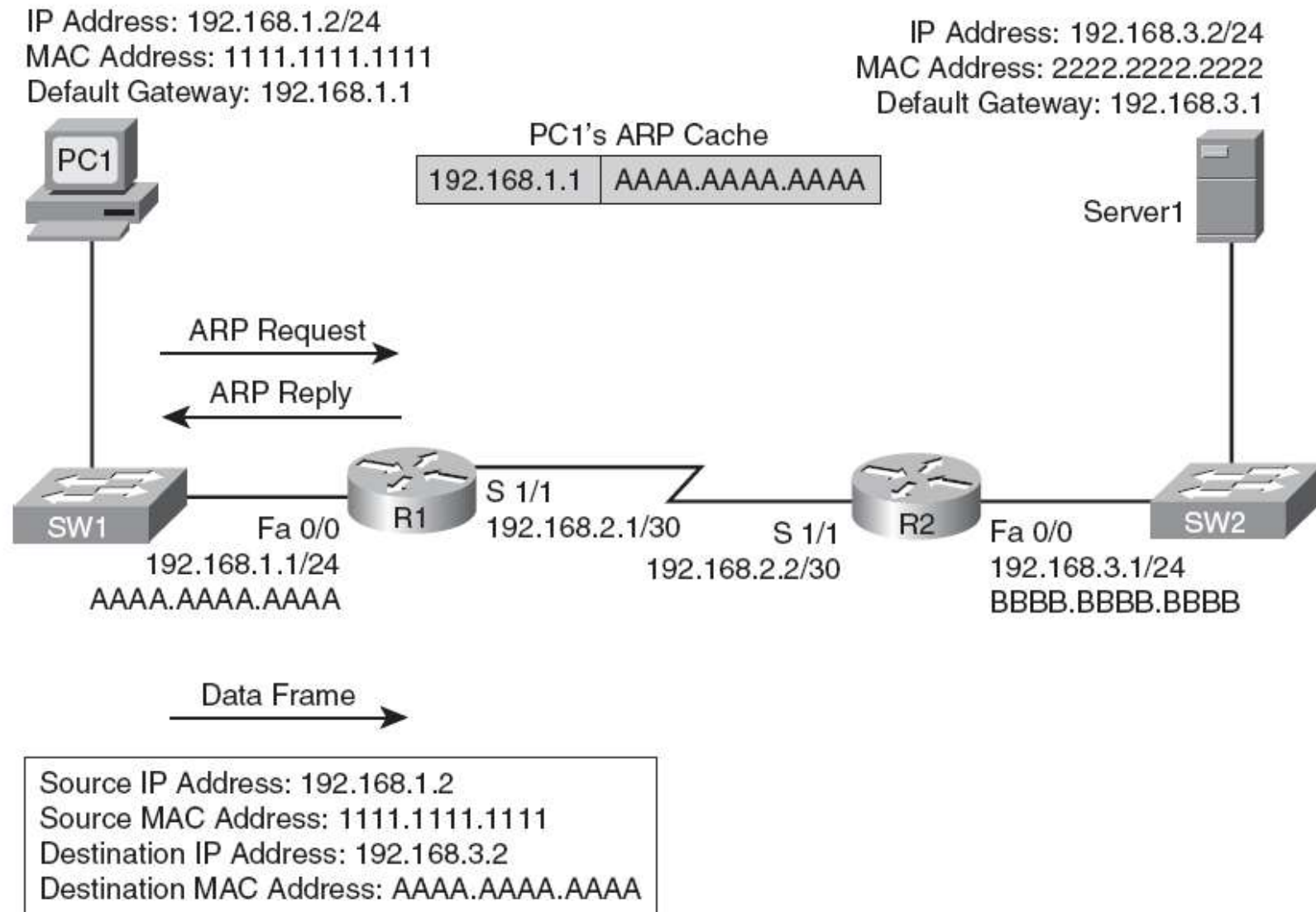
Basic Routing Processes

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Basic Routing Processes (cont)

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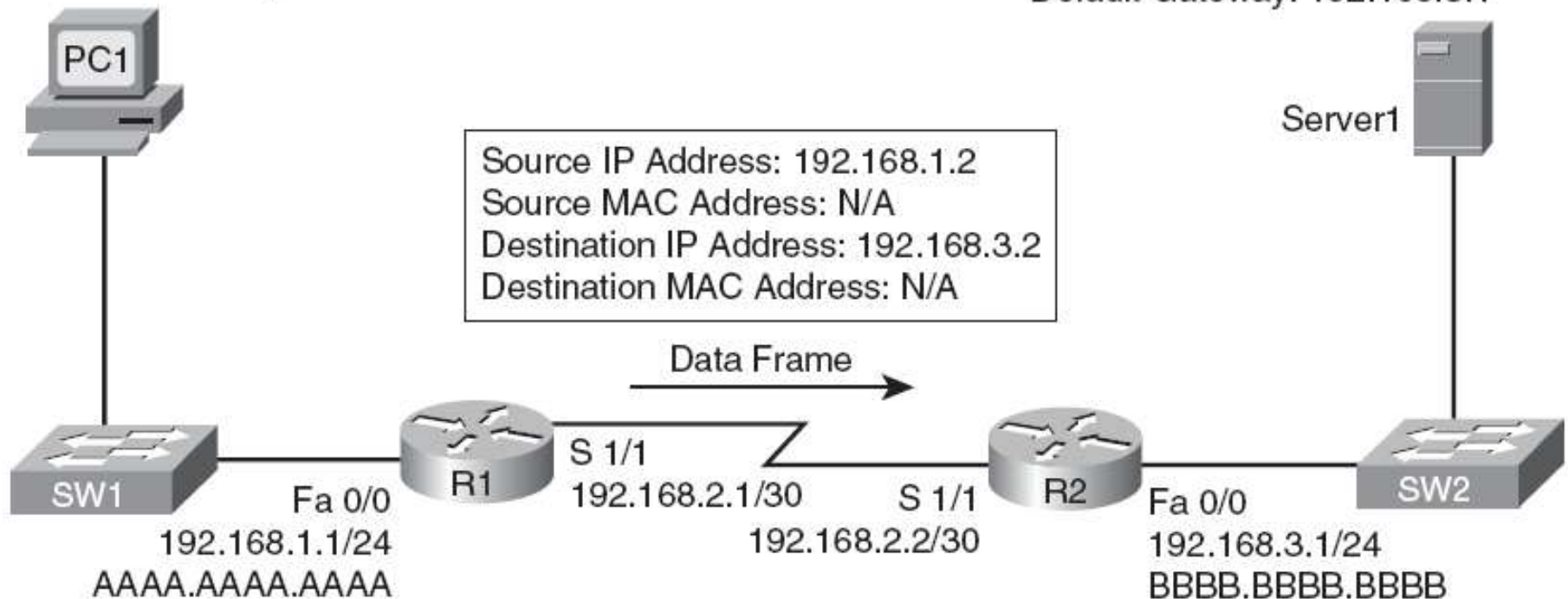


Basic Routing Processes

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IP Address: 192.168.1.2/24
MAC Address: 1111.1111.1111
Default Gateway: 192.168.1.1

IP Address: 192.168.3.2/24
MAC Address: 2222.2222.2222
Default Gateway: 192.168.3.1

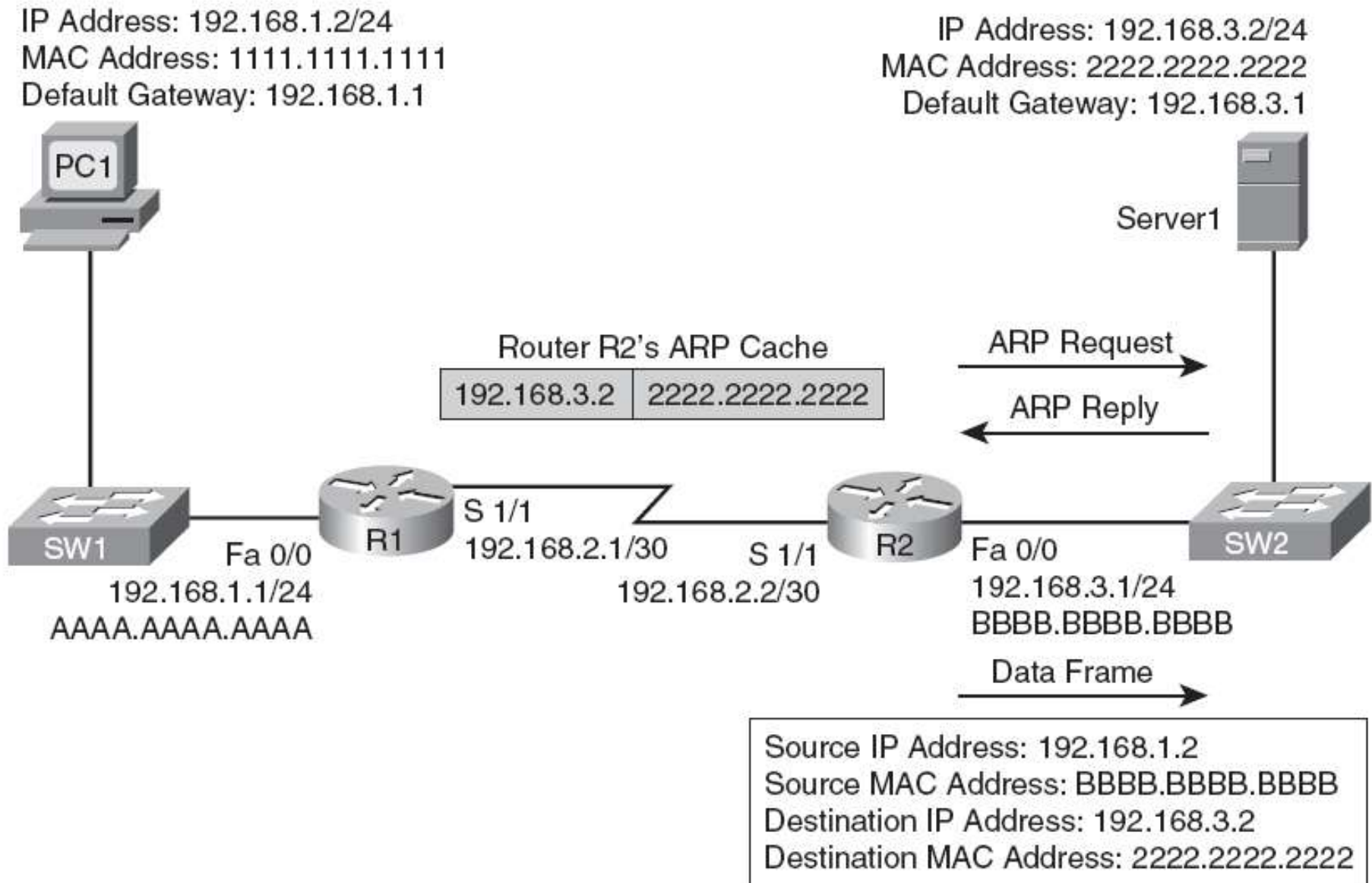


Router R1's Route Entry

192.168.3.0/24	Serial 1/1
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Basic Routing Processes

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Data Structures

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IP routing table: Router consults IP routing table for best match (*longest prefix*).

Bảng định tuyến IP: Router tra cứu bảng định tuyến để tìm kết quả khớp tốt nhất (tiền tố dài nhất).

Layer 3 to Layer 2 mapping: ARP cache stores Layer 3 to Layer 2 mappings.

Ánh xạ Layer 3 sang Layer 2: Bộ nhớ đệm ARP lưu trữ ánh xạ Layer 3 sang Layer 2.

Data Structures

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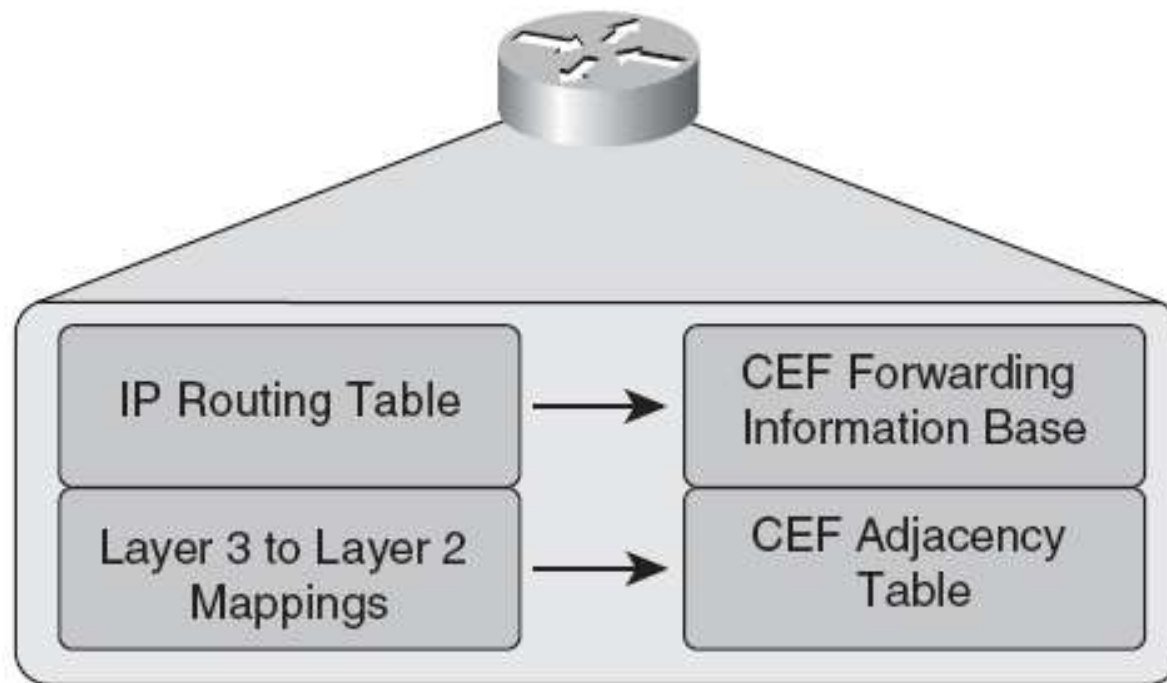
Cisco Express Forwarding (CEF) improves lookup efficiency using data from the IP routing table and L3-to-L2 mapping tables.

CEF cải thiện hiệu suất tra cứu bằng dữ liệu từ bảng định tuyến IP và bảng ánh xạ L3-sang-L2.

CEF data structures are referenced during packet forwarding.

Cấu trúc dữ liệu CEF được tham chiếu khi chuyển tiếp gói tin.

Data Structures



Data Structures

Two primary CEF data structures:

Hai cấu trúc dữ liệu chính của CEF:

- **Forwarding Information Base (FIB):** Contains Layer 3 info similar to IP routing table, plus multicast routes and directly connected hosts.

FIB: Chứa thông tin Layer 3 tương tự bảng định tuyến IP, cộng thêm tuyến multicast và host kết nối trực tiếp.

- **Adjacency table:** FIB references this table during CEF route lookups.

Bảng kề: FIB tham chiếu bảng này khi tra cứu tuyến CEF.

Troubleshooting Layer 3 Forwarding Information Commands

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<code>show ip route <i>ip-address</i></code>	Displays a router's best route to the specified IP address.
<code>show ip route <i>network subnet-mask</i></code>	Displays a router's best route to the specified network, if the specific route (with a matching subnet mask length) is found in the router's IP routing table.
<code>show ip route <i>network subnet-mask</i> longer-prefixes</code>	Displays all routes in a router's IP routing table that are encompassed by the specified network address and subnet mask. (NOTE: This command is often useful when troubleshooting route summarization issues.)
<code>show ip cef <i>ip-address</i></code>	Displays information (for example, next-hop IP address and egress interface) required to forward a packet, similar to the output of the <code>show ip route <i>ip-address</i></code> command. (NOTE: The output of this command comes from CEF. Therefore, routing protocol information is not presented in the output.)
<code>show ip cef <i>network subnet-mask</i></code>	Displays information from a router's FIB showing the information needed to route a packet to the specified network with the specified subnet mask.

Troubleshooting Layer 3 Forwarding Information Commands

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Command	Description
<code>show ip cef exact-route source-ip-address destination-ip- address</code>	Displays the adjacency that will be used to forward a packet from the specified source IP address to the specified destination IP address. (NOTE: This command is useful if the router is load balancing across multiple adjacencies, and you want to see which adjacency will be used for a certain combination of source and destination IP addresses.)

Troubleshooting Layer 3 Forwarding Information Commands

```
R2# show ip route 192.168.1.11
Routing entry for 192.168.1.0/24
  Known via "ospf 1", distance 110, metric 11, type intra area
  Last update from 192.168.0.11 on FastEthernet0/0, 00:06:45 ago
  Routing Descriptor Blocks:
    * 192.168.0.11, from 10.1.1.1, 00:06:45 ago, via FastEthernet0/0
      Route metric is 11, traffic share count is 1
```

```
R2# show ip route 192.168.1.0 255.255.255.0
Routing entry for 192.168.1.0/24
  Known via "ospf 1", distance 110, metric 11, type intra area
  Last update from 192.168.0.11 on FastEthernet0/0, 00:06:57 ago
  Routing Descriptor Blocks:
    * 192.168.0.11, from 10.1.1.1, 00:06:57 ago, via FastEthernet0/0
      Route metric is 11, traffic share count is 1
```

Troubleshooting Layer 3 Forwarding Information Commands

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```
R2# show ip route 172.16.0.0 255.255.0.0
```

```
% Subnet not in table
```

```
R2# show ip route 172.16.0.0 255.255.0.0 longer-prefixes
```

```
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
```

```
172.16.0.0/30 is subnetted, 2 subnets
```

```
C      172.16.1.0 is directly connected, Serial1/0.1
```

```
C      172.16.2.0 is directly connected, Serial1/0.2
```

Troubleshooting Layer 3 Forwarding Information Commands

```
R2# show ip cef 192.168.1.11
192.168.1.0/24, version 42, epoch 0, cached adjacency 192.168.0.11
0 packets, 0 bytes
  via 192.168.0.11, FastEthernet0/0, 0 dependencies
    next hop 192.168.0.11, FastEthernet0/0
    valid cached adjacency
```

```
R2# show ip cef 192.168.1.0 255.255.255.0
192.168.1.0/24, version 42, epoch 0, cached adjacency 192.168.0.11
0 packets, 0 bytes
  via 192.168.0.11, FastEthernet0/0, 0 dependencies
    next hop 192.168.0.11, FastEthernet0/0
    valid cached adjacency
```

```
R2# show ip cef exact-route 10.2.2.2 192.168.1.11
10.2.2.2      -> 192.168.1.11    : FastEthernet0/0 (next hop 192.168.0.11)
```


Troubleshooting Layer 3 Forwarding Information Commands

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Command	Description
<code>show ip arp</code>	Displays a router's ARP cache, containing IP address to MAC address mappings. (NOTE: By default, a router's ARP cache stores information for four hours. Therefore, you might need to execute a <code>clear ip arp</code> command to allow a router to relearn information after you make a topology change.)
<code>show frame-relay map</code>	Displays Frame Relay DLCIs associated with different next-hop IP addresses.
<code>show adjacency detail</code>	Displays the frame headers in a router's CEF adjacency table used to encapsulate a frame being sent to an adjacency.

Troubleshooting Layer 3 Forwarding Information Commands

```
R2# show ip arp
```

Protocol	Address	Age (min)	Hardware Addr	Type	Interface
Internet	192.168.0.11	0	0009.b7fa.d1e1	ARPA	FastEthernet0/0
Internet	192.168.0.22	-	c001.0f70.0000	ARPA	FastEthernet0/0

```
R2# show frame-relay map
```

```
Serial1/0.2 (up): point-to-point dlci, dlci 182(0xB6,0x2C60), broadcast  
                  status defined, active  
Serial1/0.1 (up): point-to-point dlci, dlci 181(0xB5,0x2C50), broadcast  
                  status defined, active
```

Troubleshooting Layer 3 Forwarding Information Commands

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```
R2# show adjacency detail
```

Protocol	Interface	Address
IP	Serial1/0.1	point2point(25) 0 packets, 0 bytes 2C510800 CEF expires: 00:02:18 refresh: 00:00:19 Epoch: 0
IP	Serial1/0.2	point2point(25) 0 packets, 0 bytes 2C610800 CEF expires: 00:02:18 refresh: 00:00:19 Epoch: 0
IP	FastEthernet0/0	192.168.0.11(9) 0 packets, 0 bytes 0009B7FAD1E1C0010F7000000800 ARP 04:02:59 Epoch: 0

EIGRP Trouleshooting

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EIGRP is a Cisco proprietary hybrid routing protocol (advanced distance-vector).

EIGRP là giao thức định tuyến lai độc quyền của Cisco (distance-vector nâng cao).

Advertises routes to neighbors like distance vector, but uses tables like link-state protocols.

Quảng bá tuyến cho neighbor như distance vector, nhưng dùng bảng như giao thức link-state.

EIGRP Troubleshooting

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**Fast convergence after link failure.
Supports load balancing over equal-cost
(default) and unequal-cost paths (via
variance).**

***Hội tụ nhanh sau khi liên kết bị lỗi. Hỗ trợ
cân bằng tải trên đường equal-cost (mặc
định) và unequal-cost (qua variance).***

Data Structures of IP Routing Protocols

Route info from neighbors is stored in the routing protocol's data structures. Local router can also populate these structures.

***Thông tin tuyến từ neighbor được lưu trong cấu trúc dữ liệu của giao thức định tuyến.
Router cục bộ cũng có thể nạp dữ liệu vào.***

Data Structures of IP Routing Protocols

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The data structure selects the best route based on the best metric.

Cấu trúc dữ liệu chọn tuyến tốt nhất dựa trên metric tốt nhất.

This best route is injected into the IP routing table unless already learned from a more trusted source.

Tuyến tốt nhất này được đưa vào bảng định tuyến IP trừ khi đã học từ nguồn đáng tin cậy hơn.

Administrative Distance

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Each routing protocol has a different *administrative distance*, representing its *believability*.

Mỗi giao thức định tuyến có administrative distance khác nhau, thể hiện độ tin cậy của nó.

The best route from a protocol's data structure is only a *candidate* for the IP routing table.

Tuyến tốt nhất từ cấu trúc dữ liệu của giao thức chỉ là ứng viên cho bảng định tuyến IP.

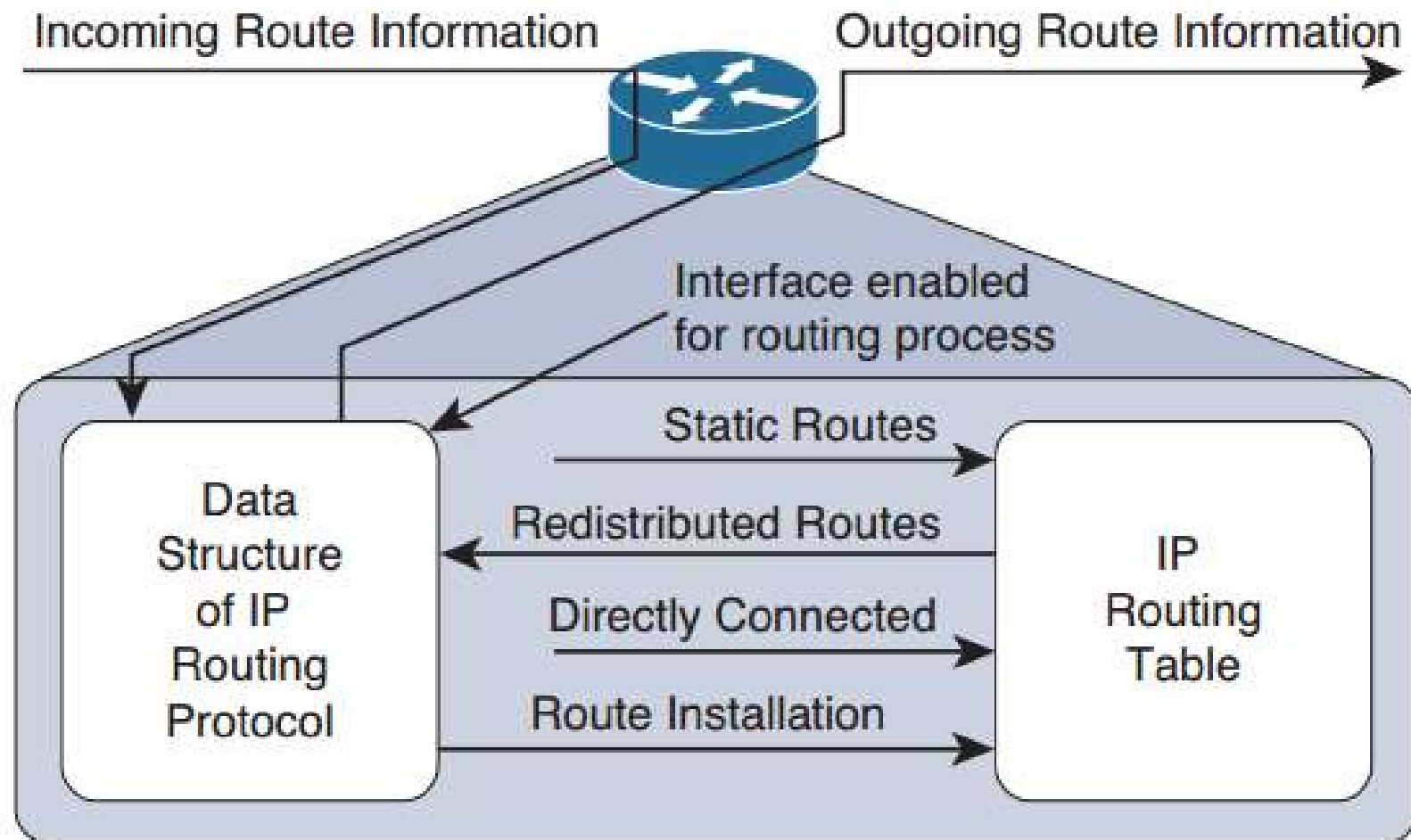
A list of the Administrative Distances

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Connected interface	0
Static route	1
Enhanced Interior Gateway Routing Protocol (EIGRP) summary route	5
External Border Gateway Protocol (BGP)	20
Internal EIGRP	90
IGRP	100
OSPF	110
Intermediate System-to-Intermediate System (IS-IS)	115
Routing Information Protocol (RIP)	120
Exterior Gateway Protocol (EGP)	140
On Demand Routing (ODR)	160
External EIGRP	170
Internal BGP	200
Unknown*	255

Interaction between IP Routing Protocol Data Structures and IP Routing Tables

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Data Structures of IP Routing Protocols

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Multiple equal-metric routes to the same destination can be injected into the routing table.

Nhiều tuyến có metric bằng nhau đến cùng đích có thể được đưa vào bảng định tuyến.

Some protocols (e.g., EIGRP) also support load balancing across unequal-cost paths, injecting routes with different metrics.

Một số giao thức (vd: EIGRP) còn hỗ trợ cân bằng tải trên đường unequal-cost, đưa vào các tuyến có metric khác nhau.

Data Structures of IP Routing Protocols (cont)

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Routers periodically advertise routes or updates to neighbors. Some protocols require establishing an *adjacency* (*neighborship*) before exchanging route info.

Router định kỳ quảng bá tuyến hoặc cập nhật cho neighbor. Một số giao thức yêu cầu thiết lập adjacency (quan hệ neighbor) trước khi trao đổi thông tin tuyến.

Data Structures of EIGRP

Data Structure	Description
EIGRP interface table	All of a router's interfaces that have been configured to participate in an EIGRP routing process are listed in this table. However, if an interface has been configured as a passive interface (that is, an interface that does not send routing information), that interface does not appear in this table.
EIGRP neighbor table	This table lists a router's EIGRP neighbors (that is, neighboring routers from whom an EIGRP Hello message has been received). A neighbor is removed from this table if the neighbor has not been heard from for a period of time defined as the <i>hold-time</i> . Also, if an interface, from which a neighbor is known, is removed from the EIGRP interface table because it goes down, the neighbor is removed from this table unless there is a multiple link and one of the interfaces is still up. In that case, the second interface will still provide the neighborship.
EIGRP topology table	This table contains routes learned by a router's EIGRP routing process. The best route for a network in this table becomes a candidate to be injected into the router's IP routing table. If multiple routes in this table have an equal metric, or if EIGRP's variance feature is configured, more than one route might become candidates for injection into the IP routing table, but only to a maximum of 4 by default.

EIGRP Operation

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EIGRP supports VLSM and sends advertisements via multicast (224.0.0.10). Auto route summarization is enabled by default.

EIGRP hỗ trợ VLSM và gửi quảng bá qua multicast (224.0.0.10). Tóm tắt tuyến tự động được bật mặc định.

EIGRP Operation

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Upon receiving a Hello packet, EIGRP router performs full route exchange with the new neighbor.

Khi nhận gói Hello, router EIGRP thực hiện trao đổi tuyến đầy đủ với neighbor mới.

After neighborship forms, only route updates are exchanged.

Sau khi hình thành quan hệ neighbor, chỉ trao đổi cập nhật tuyến.

EIGRP Operation

EIGRP neighbor routes go into the topology table. The best route becomes a candidate for the IP routing table.

Tuyến từ neighbor EIGRP đi vào bảng topology. Tuyến tốt nhất trở thành ứng viên cho bảng định tuyến IP.

Once injected, this route is the *successor route* — advertised to neighboring routers.

Sau khi được đưa vào, tuyến này là successor route — được quảng bá cho các router lân cận.

EIGRP Operation (cont)

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Parameters for best route selection:

Tham số chọn tuyến tốt nhất:

■ **Advertised Distance (AD):** Distance from neighbor to destination network

AD: Khoảng cách từ neighbor đến mạng đích

■ **Feasible Distance (FD):** AD + metric to reach the advertising neighbor

FD: AD + metric để đến neighbor quảng bá

EIGRP Operation

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EIGRP metric = [K1 * bandwidth + ((K2 * bandwidth) / (256 – load)) + K3 * delay] *

[K5 / (reliability + K4)]

Default K values: / Giá trị K mặc định:

■ K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0

EIGRP metric = bandwidth + delay

- **bandwidth = 10,000,000 / minimum bandwidth in kbps * 256**
- **delay = sum of all interface delays in path (tens of ms) * 256**
- **delay = tổng độ trễ tất cả interface trên đường đi (đơn vị 10ms) * 256**

EIGRP Troubleshooting Commands

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Command	Routing Component or Data Structure	Description
show ip eigrp interfaces	EIGRP interface table	This command displays all of a router's interfaces configured to participate in an EIGRP routing process (with the exception of passive interfaces).
show ip eigrp neighbors	EIGRP neighbor table	This command shows a router's EIGRP neighbors.
show ip eigrp topology	EIGRP topology table	This command displays routes known to a router's EIGRP routing process. These routes are contained in the EIGRP topology table.
show ip route eigrp	IP routing table	This command shows routes known to a router's IP routing table that were injected by the router's EIGRP routing process.
debug ip routing	IP routing table	This command displays updates that occur in a router's IP routing table. Therefore, this command is not specific to EIGRP.
debug eigrp packets	Exchanging EIGRP information with neighbors	This command can be used to display all EIGRP packets exchanged with a router's EIGRP neighbors. However, the focus of the command can be narrowed to only display specific EIGRP packet types (for example, EIGRP Hello packets).
debug ip eigrp	Exchanging EIGRP information with neighbors	This command shows information contained in EIGRP packets and reveals how an EIGRP routing process responds to that information.

EIGRP Troubleshooting Commands

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```
R2# show ip eigrp neighbors
```

```
IP-EIGRP neighbors for process 100
```

H	Address	Interface	Hold Uptime (sec)	SRTT RT0 (ms)	Q Cnt	Seq Num
1	192.168.0.11	Fa0/0	12 00:01:34	193 1158	0	3
0	172.16.1.1	Se1/0.1	12 00:01:39	880 5000	0	23

```
R2# show ip eigrp topology
```

```
IP-EIGRP Topology Table for AS(100)/ID(10.2.2.2)
```

```
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 2681856  
    via 172.16.1.1 (2681856/2169856), Serial1/0.1  
P 10.2.2.2/32, 1 successors, FD is 128256  
    via Connected, Loopback0  
P 10.3.3.3/32, 1 successors, FD is 2297856  
    via 172.16.1.1 (2297856/128256), Serial1/0.1  
P 10.1.2.0/24, 1 successors, FD is 2195456  
    via 172.16.1.1 (2195456/281600), Serial1/0.1  
P 10.0.0.0/8, 1 successors, FD is 128256  
    via Summary (128256/0), Null0
```

EIGRP Troubleshooting Commands

```
R2# show ip route eigrp
      172.16.0.0/16 is variably subnetted, 3 subnets, 2 masks
D      172.16.0.0/16 is a summary, 00:01:36, Null0
      10.0.0.0/8 is variably subnetted, 7 subnets, 4 masks
D      10.1.3.0/30 [90/2681856] via 172.16.1.1, 00:01:36, Serial1/0.1
D      10.3.3.3/32 [90/2297856] via 172.16.1.1, 00:01:36, Serial1/0.1
D      10.1.2.0/24 [90/2195456] via 172.16.1.1, 00:01:36, Serial1/0.1
D      10.0.0.0/8 is a summary, 00:01:36, Null0
D      10.1.1.1/32 [90/409600] via 192.168.0.11, 00:01:36, FastEthernet0/0
D      10.4.4.4/32 [90/2323456] via 172.16.1.1, 00:01:36, Serial1/0.1
D      192.168.1.0/24 [90/284160] via 192.168.0.11, 00:01:36, FastEthernet0/0
```

EIGRP Troubleshooting Commands (cont)

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```
R2# debug eigrp packets
EIGRP Packets debugging is on
  (UPDATE, REQUEST, QUERY, REPLY, HELLO, IPXSAP, PROBE, ACK, STUB, SIAQUERY,
  SIAREPLY)
*Mar  1 00:20:48.151: EIGRP: Received HELLO on FastEthernet0/0 nbr 192.168.0.11
*Mar  1 00:20:48.155:   AS 100, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
  peerQ un/rely 0/0
*Mar  1 00:20:48.187: EIGRP: Sending HELLO on FastEthernet0/0
*Mar  1 00:20:48.191:   AS 100, Flags 0x0, Seq 0/0 idbQ 0/0 iidbQ un/rely 0/0
...OUTPUT OMITTED...
*Mar  1 00:20:59.091: EIGRP: Received QUERY on FastEthernet0/0 nbr 192.168.0.11
*Mar  1 00:20:59.095:   AS 100, Flags 0x0, Seq 6/0 idbQ 0/0 iidbQ un/rely 0/0
  peerQ un/rely 0/0
...OUTPUT OMITTED...
*Mar  1 00:20:59.287: EIGRP: Received REPLY on Serial1/0.1 nbr 172.16.1.1
*Mar  1 00:20:59.291:   AS 100, Flags 0x0, Seq 25/16 idbQ 0/0 iidbQ un/rely 0/0
  peerQ un/rely 0/0
*Mar  1 00:20:59.295: EIGRP: Enqueueing ACK on Serial1/0.1 nbr 172.16.1.1
...OUTPUT OMITTED...
*Mar  1 00:21:06.915: EIGRP: Sending UPDATE on FastEthernet0/0
*Mar  1 00:21:06.915:   AS 100, Flags 0x0, Seq 19/0 idbQ 0/0 iidbQ un/rely 0/0
  serno 17-17
*Mar  1 00:21:06.919: EIGRP: Enqueueing UPDATE on Serial1/0.1 iidbQ un/rely 0/1
  serno 17-17
*Mar  1 00:21:06.923: EIGRP: Enqueueing UPDATE on Serial1/0.1 nbr 172.16.1.1 iidbQ
  un/rely 0/0 peerQ un/rely 0/0 serno 17-17
```