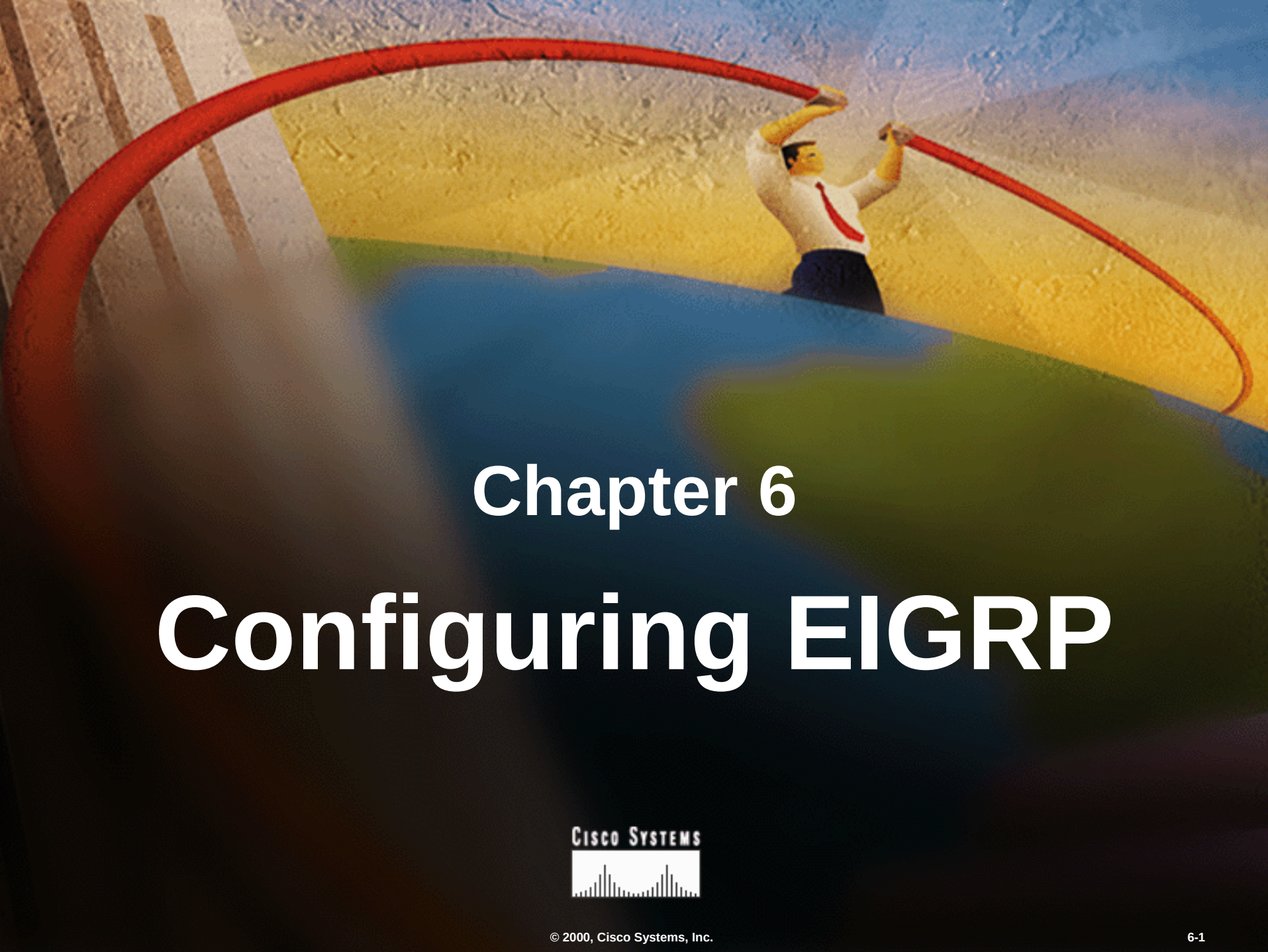


Chapter 6

Configuring EIGRP

Objectives

Upon completion of this chapter, you will be able to perform the following tasks:

- **Describe EIGRP features and operation**
- **Explain how EIGRP discovers, chooses, and maintains routes**
- **Explain how EIGRP supports the use of VLSM**
- **Explain how EIGRP operates in an NBMA environment**
- **Explain how EIGRP supports the use of route summarization**

Objectives (cont.)

- Describe how EIGRP supports large networks
- Configure EIGRP
- Verify EIGRP operation
- Given a set of network requirements, configure an EIGRP environment and verify proper operation (within described guidelines) of your routers
- Given a set of network requirements, configure EIGRP in an NBMA environment and verify proper operation (within described guidelines) of your routers

EIGRP Overview

What Is Enhanced IGRP (EIGRP)?

- **EIGRP supports:**
  - **Rapid convergence**
  - **Reduced bandwidth usage**
  - **Multiple network-layer protocols**

EIGRP Features

- Advanced distance vector
- 100% loop free
- Fast convergence
- Easy configuration
- Less network design constraints than OSPF

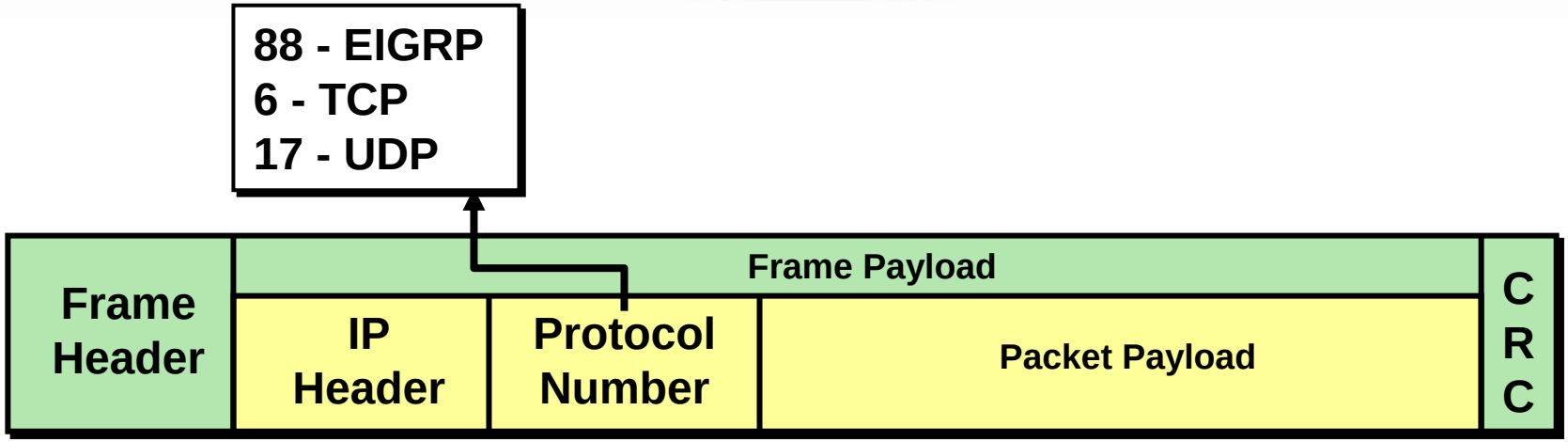
EIGRP Features (cont.)

- Incremental updates
- Supports VLSM and discontiguous networks
- Classless routing
- Compatible with existing IGRP networks
- Protocol independent (supports IPX and AppleTalk)

Advantages of EIGRP

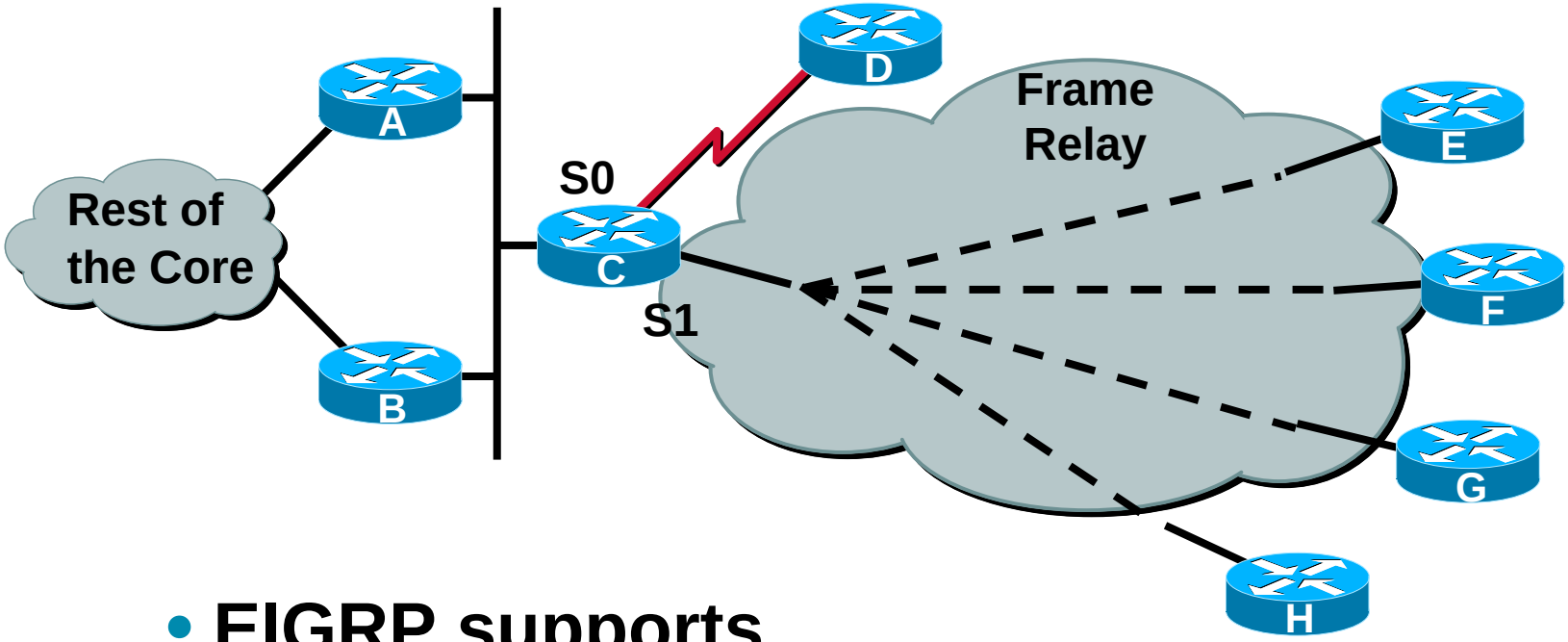
- Uses multicast instead of broadcast
- Utilizes link bandwidth and delay
  - EIGRP metric = IGRP metric x 256 (32 bit vs. 24 bit)
- Unequal cost path load balancing
- More flexible than OSPF
  - Manual summarization can be done in any interface at any router within the network

EIGRP—In IP Packets



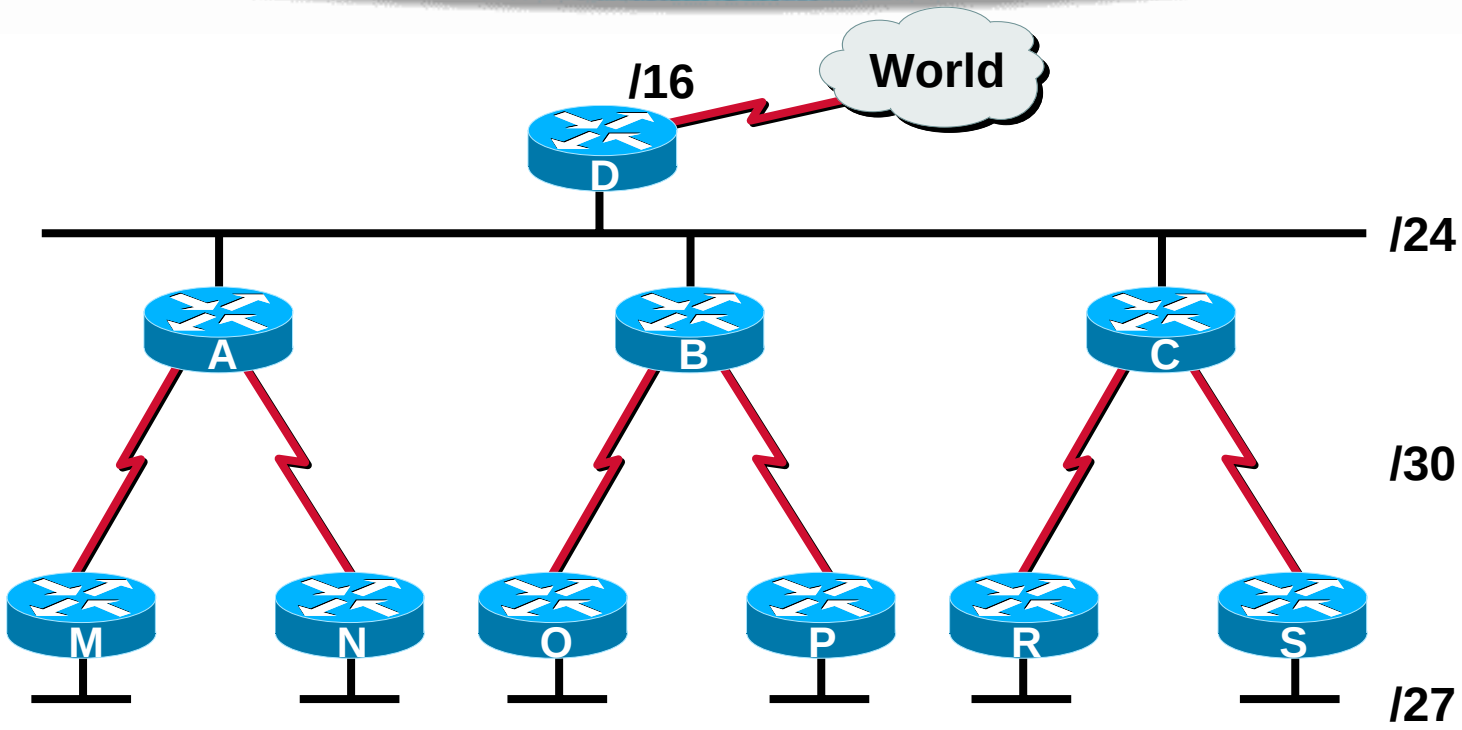
- EIGRP is an advanced distance vector routing protocol
  - Automatically establishes neighbor relationships with peer devices
  - Relies on IP packets for delivery of routing information

EIGRP Support for Different Topologies



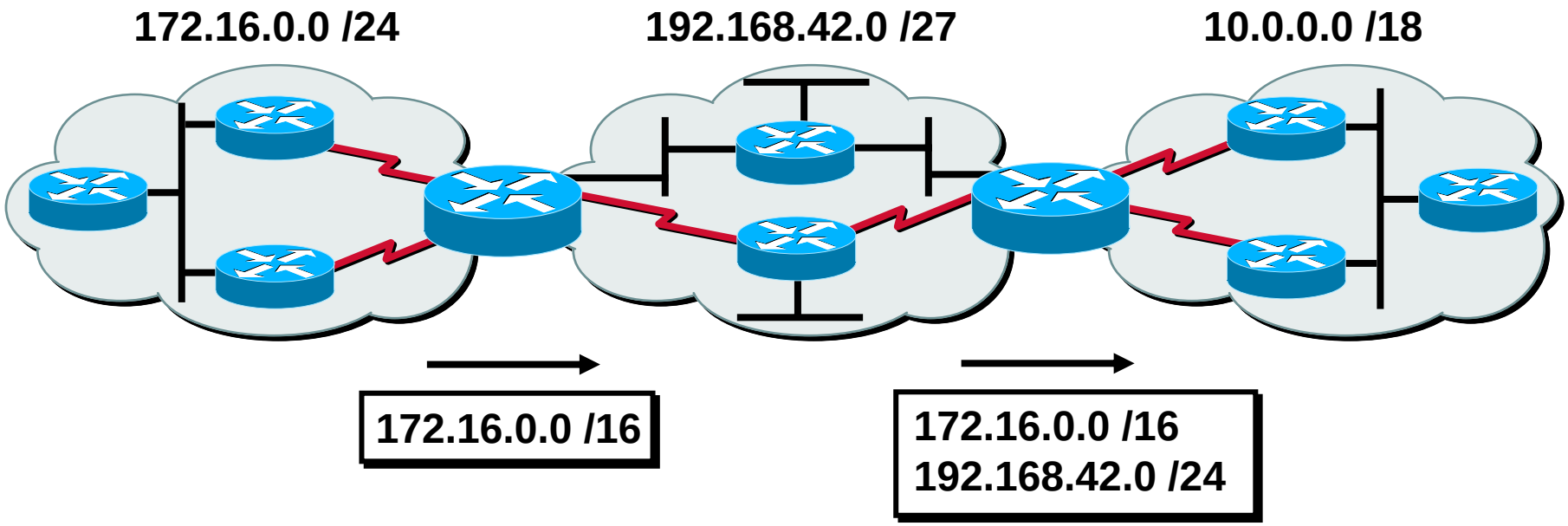
- EIGRP supports
  - Multiaccess (LANs)
  - Point-to-point (HDLC)
  - NBMA (Frame Relay)

EIGRP Support for IP Addresses



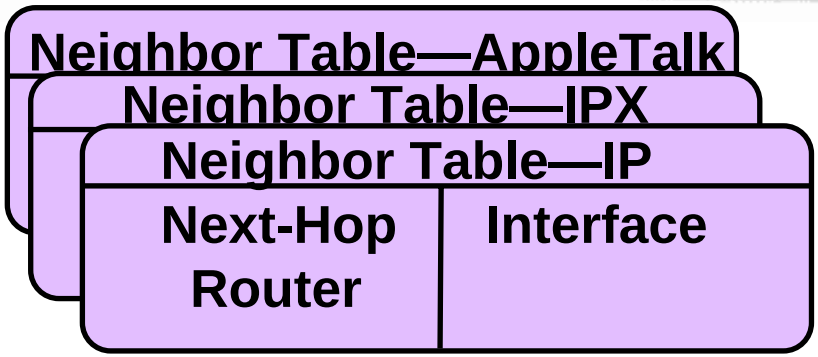
- EIGRP supports
  - Variable-length subnet masks (VLSMs)
  - Hierarchical designs

EIGRP Support for Route Summarization

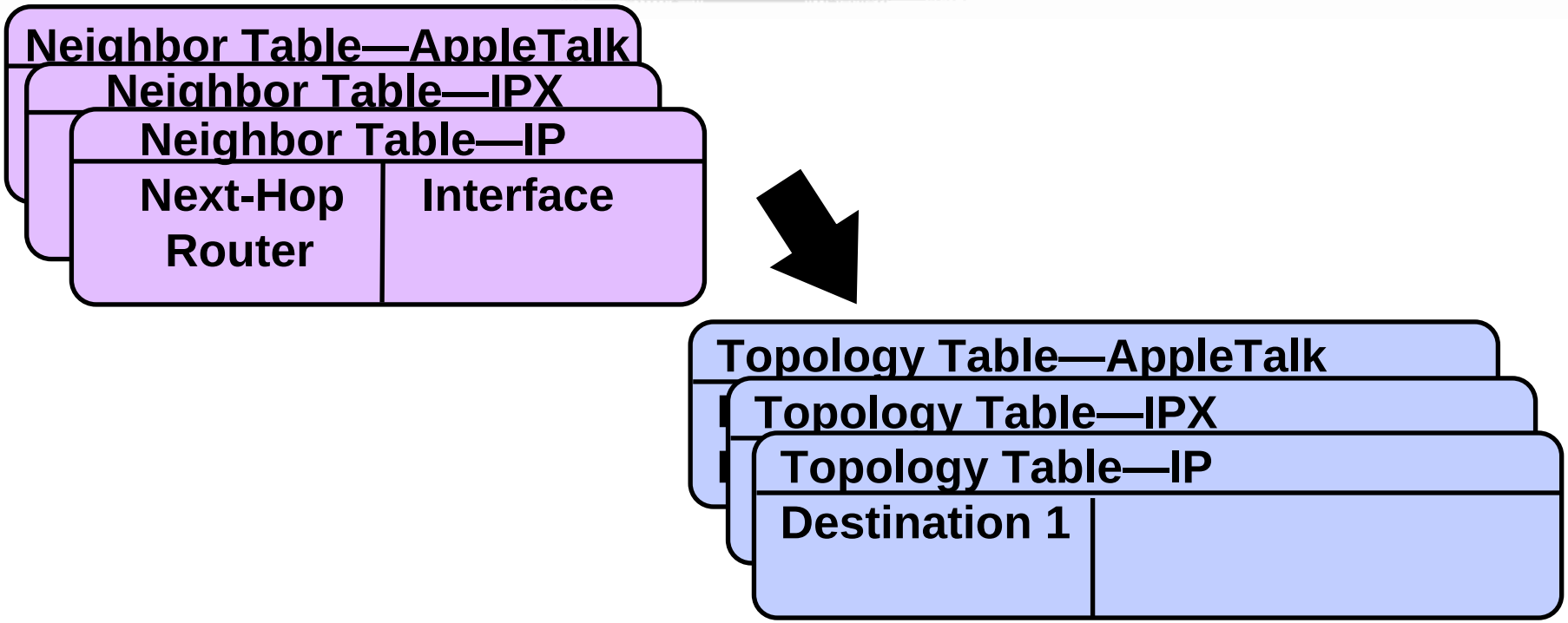


- EIGRP performs route summarization
  - Classful network boundaries (default)
  - Arbitrary network boundaries (manual)

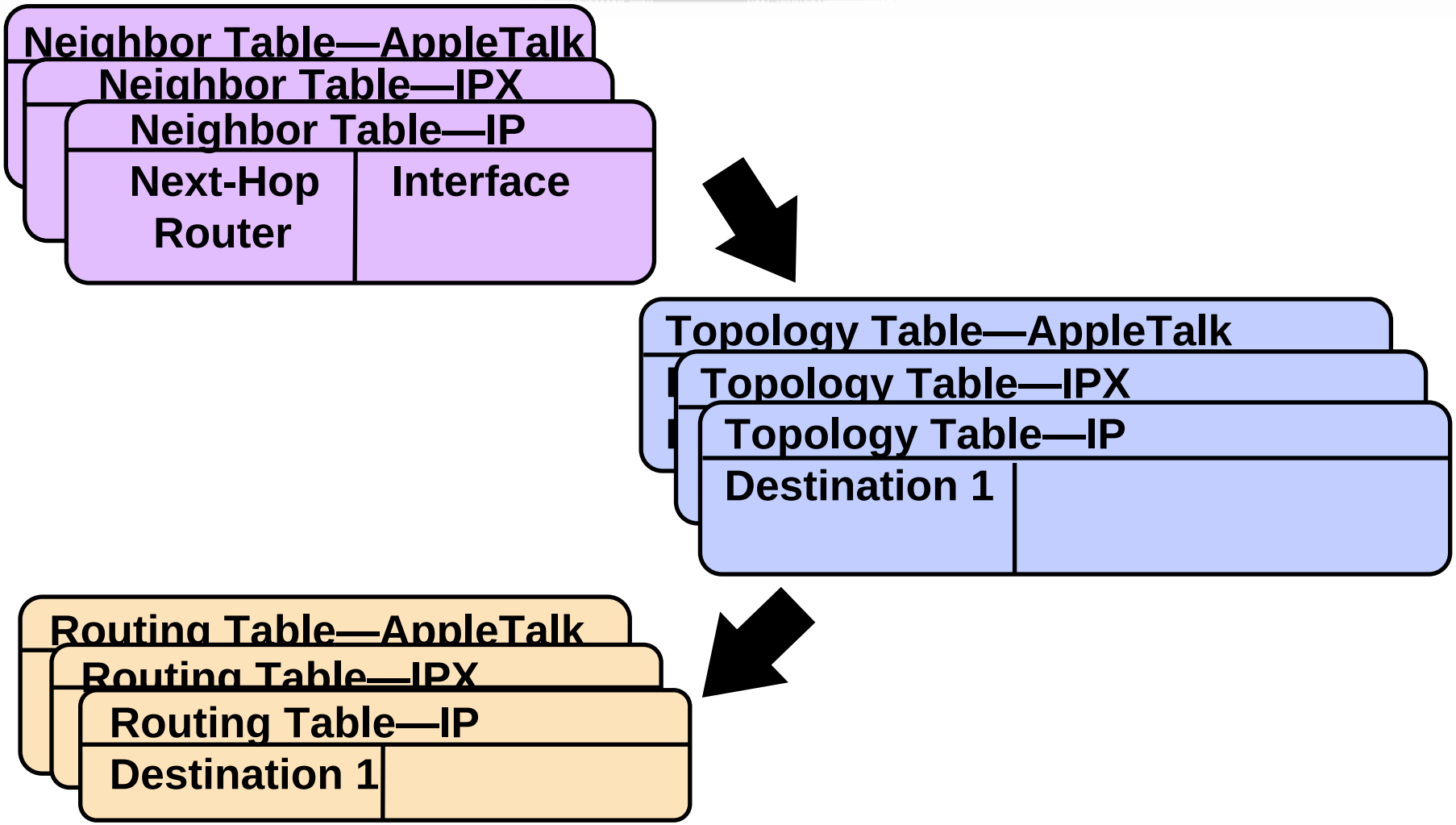
EIGRP Terminology



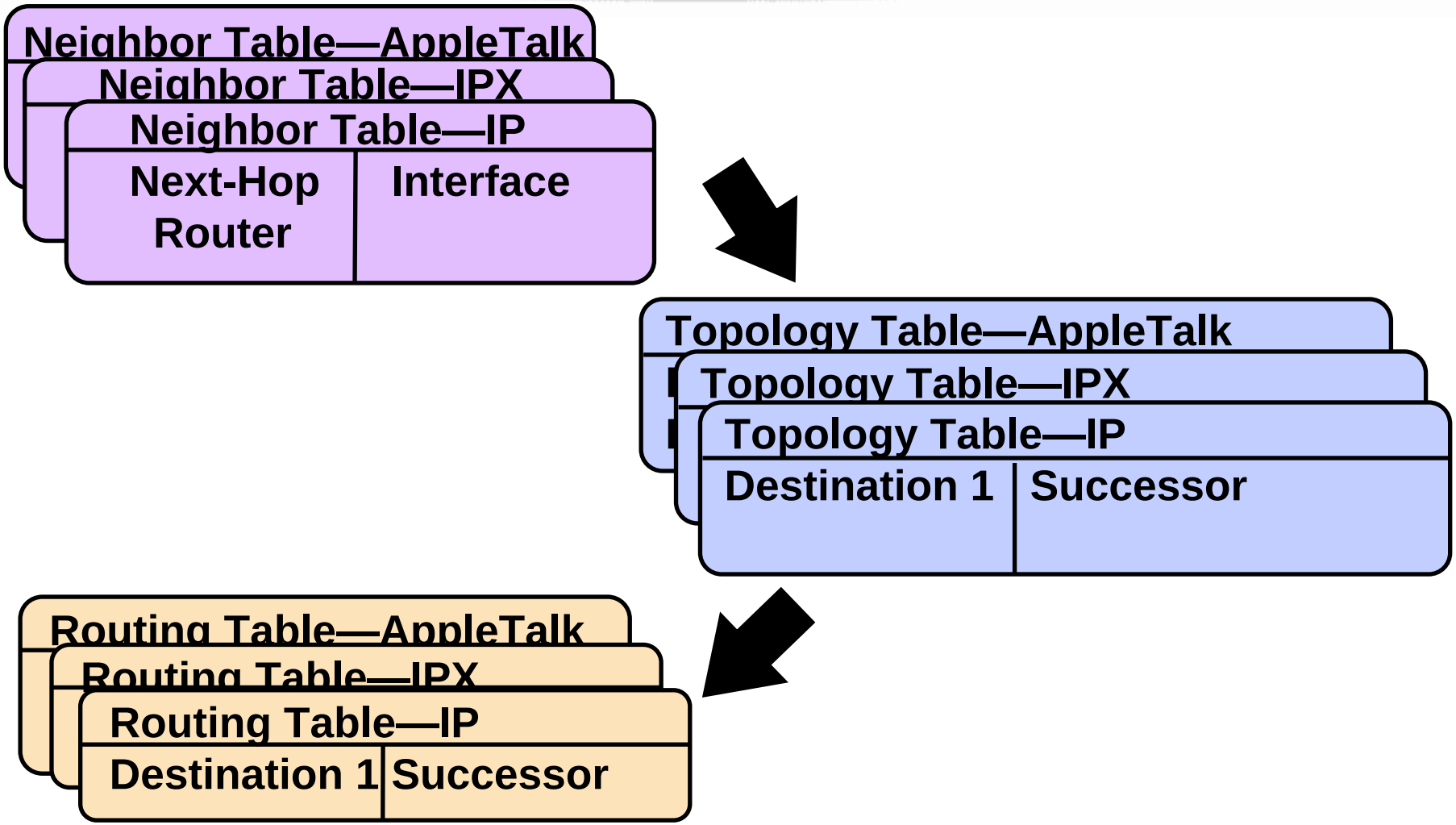
EIGRP Terminology



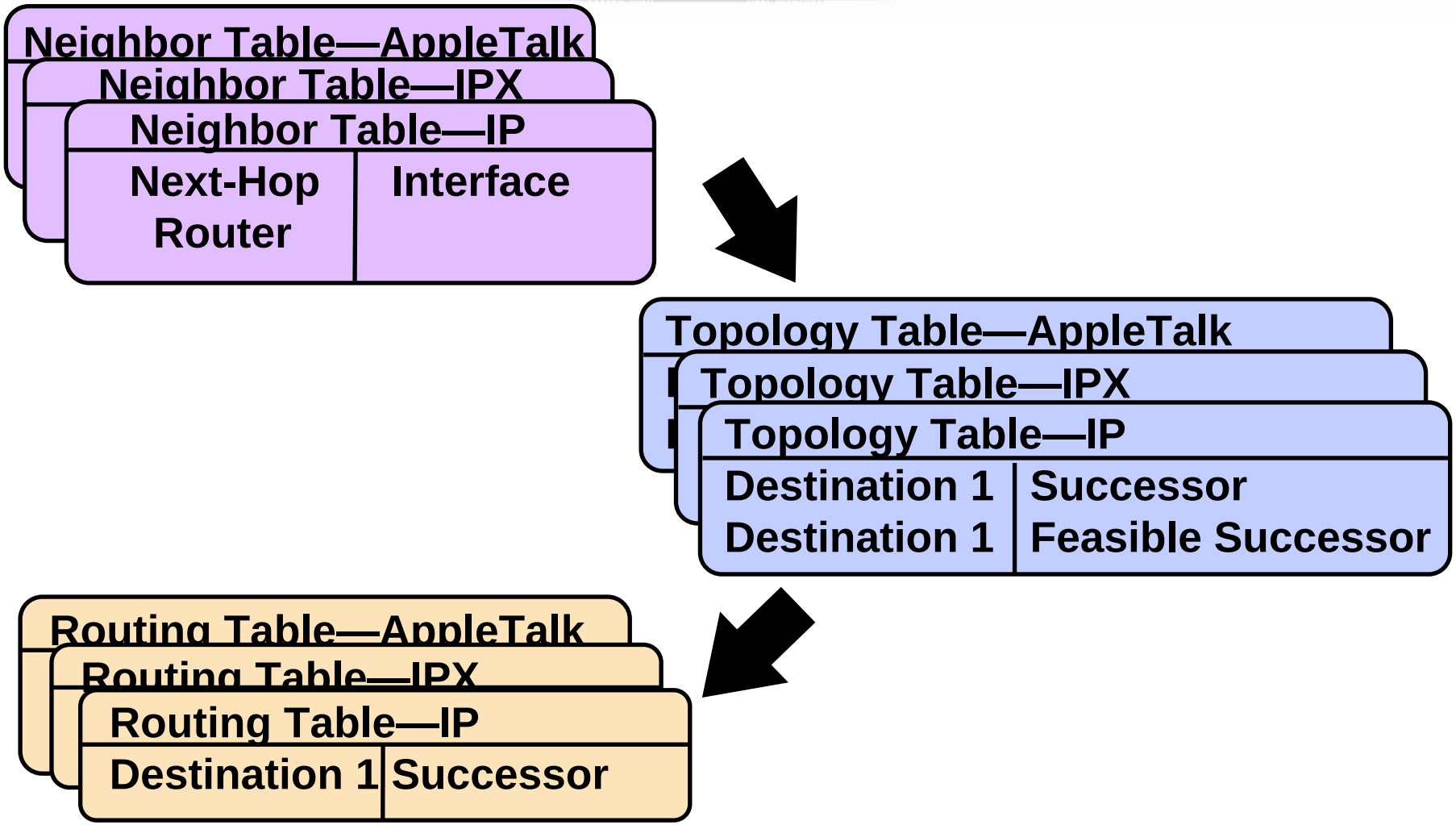
EIGRP Terminology



EIGRP Terminology



EIGRP Terminology



EIGRP Operation

EIGRP Packets

- Hello: Establish neighbor relationships
- Update: Send routing updates
- Query: Ask neighbors about routing information
- Reply: Response to query about routing information
- ACK: Acknowledgement of a reliable packet

EIGRP Neighbor Relationship

- Two routers become neighbors when they see each other's hello packet
  - Hello address = 224.0.0.10
- Hellos sent once every 5 seconds on the following links:
  - Broadcast media: Ethernet, Token Ring, FDDI
  - Point-to-point serial links: PPP, HDLC, point-to-point Frame Relay/ATM subinterfaces
  - Multipoint circuits with bandwidth greater than T1: ISDN PRI, SMDS, Frame Relay

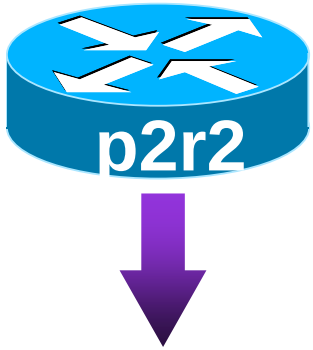
EIGRP Neighbor Relationship (cont.)

- Hellos sent once every 60 seconds on the following links:
  - Multipoint circuits with bandwidth less than T1: ISDN BRI, Frame Relay, SMDS, and so on
- Neighbor declared dead when no EIGRP packets are received within hold interval
  - Not only hello can reset the hold timer
- Hold time by default is three times the hello time

EIGRP Neighbor Relationship (cont.)

- EIGRP will form neighbors even though hello time and hold time don’t match
- EIGRP sources hello packets from primary address of the interface
- EIGRP will not form neighbor if K-values are mismatched
- EIGRP will not form neighbor if AS numbers are mismatched

What Is in a Neighbor Table?




```
p2r2#show ip eigrp neighbors
IP-EIGRP neighbors for process 400
H Address         Interface  Hold Uptime  SRTT  RTO Q  Seq
                             (sec)        (ms)     Cnt Num
1 172.68.2.2      To0        13 02:15:30    8   200  0  9
0 172.68.16.2     Se1        10 02:38:29   29   200  0  6
```

EIGRP Reliability

- EIGRP reliable packets are packets that require explicit acknowledgement:
  - Update
  - Query
  - Reply
- EIGRP unreliable packets are packets that do not require explicit acknowledgement:
  - Hello
  - ACK

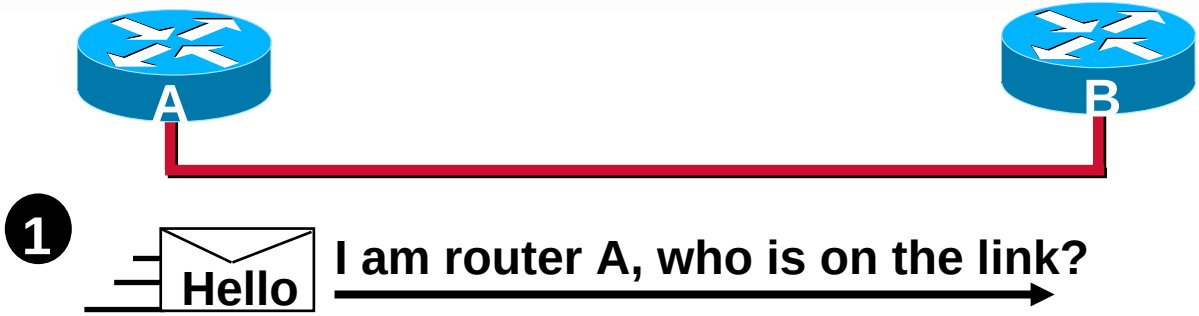
EIGRP Reliability (cont.)

- The router keeps a neighbor list and a retransmission list for every neighbor
- Each reliable packet (update, query, reply) will be retransmitted when packet is not acknowledged
- Neighbor relationship is reset when retry limit (limit = 16) for reliable packets is reached

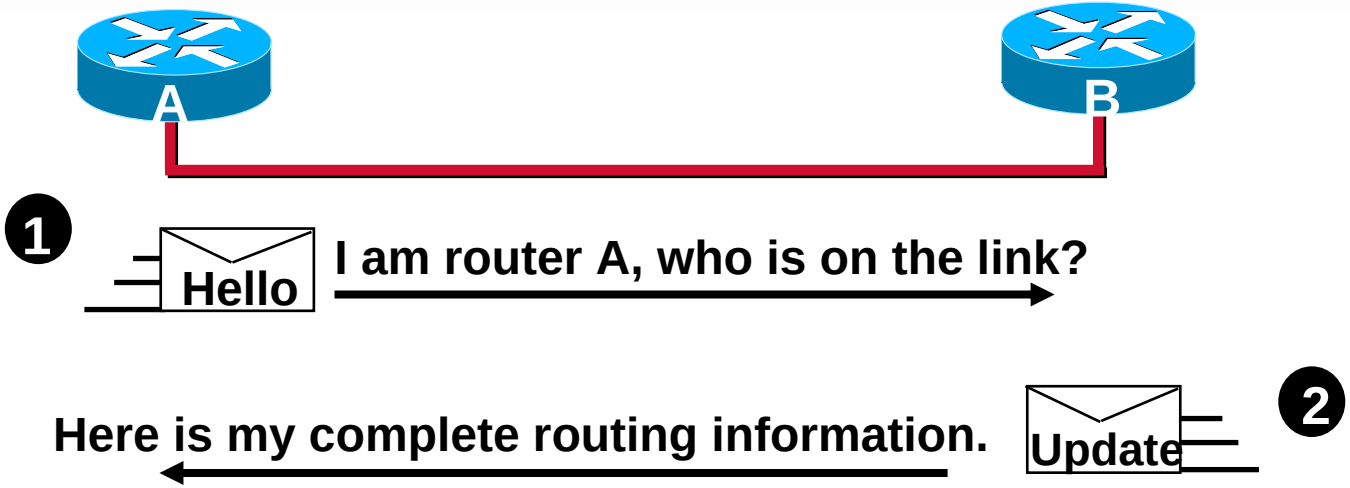
EIGRP Reliability (cont.)

- EIGRP transport has window size of one (stop and wait mechanism)
  - Every single reliable packet needs to be acknowledged before the next sequenced packet can be sent
  - If one or more peers are slow in acknowledging, all other peers suffer from this
- Solution: The nonacknowledged multicast packet will be retransmitted as a unicast to the slow neighbor

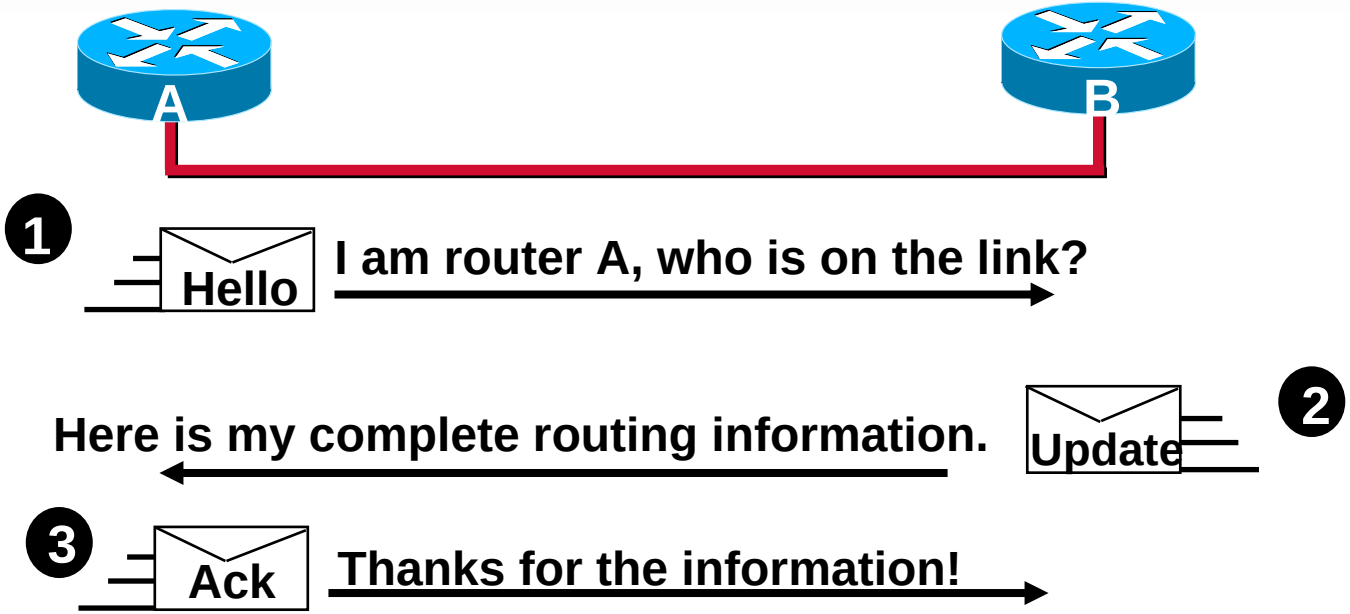
Initial Route Discovery



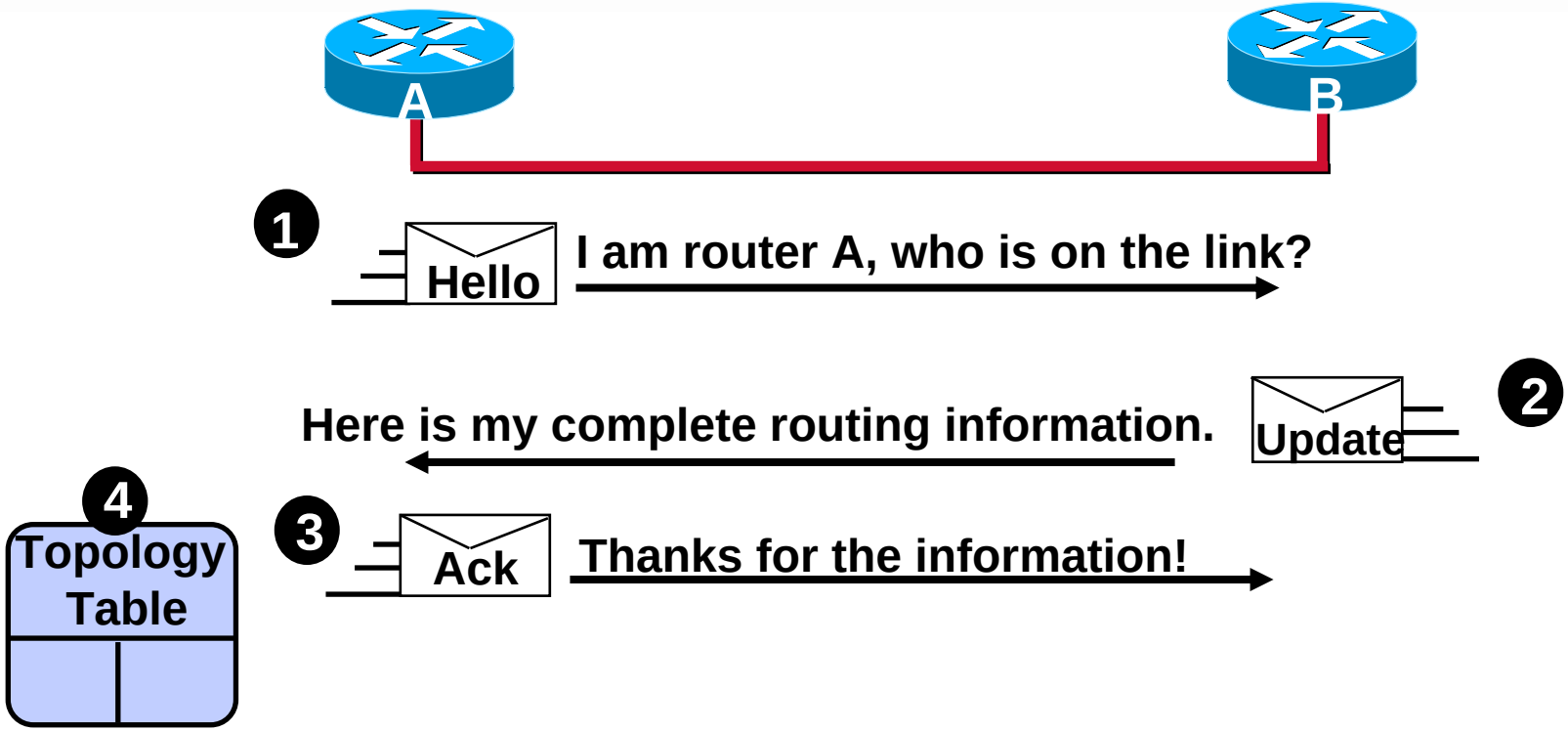
Initial Route Discovery



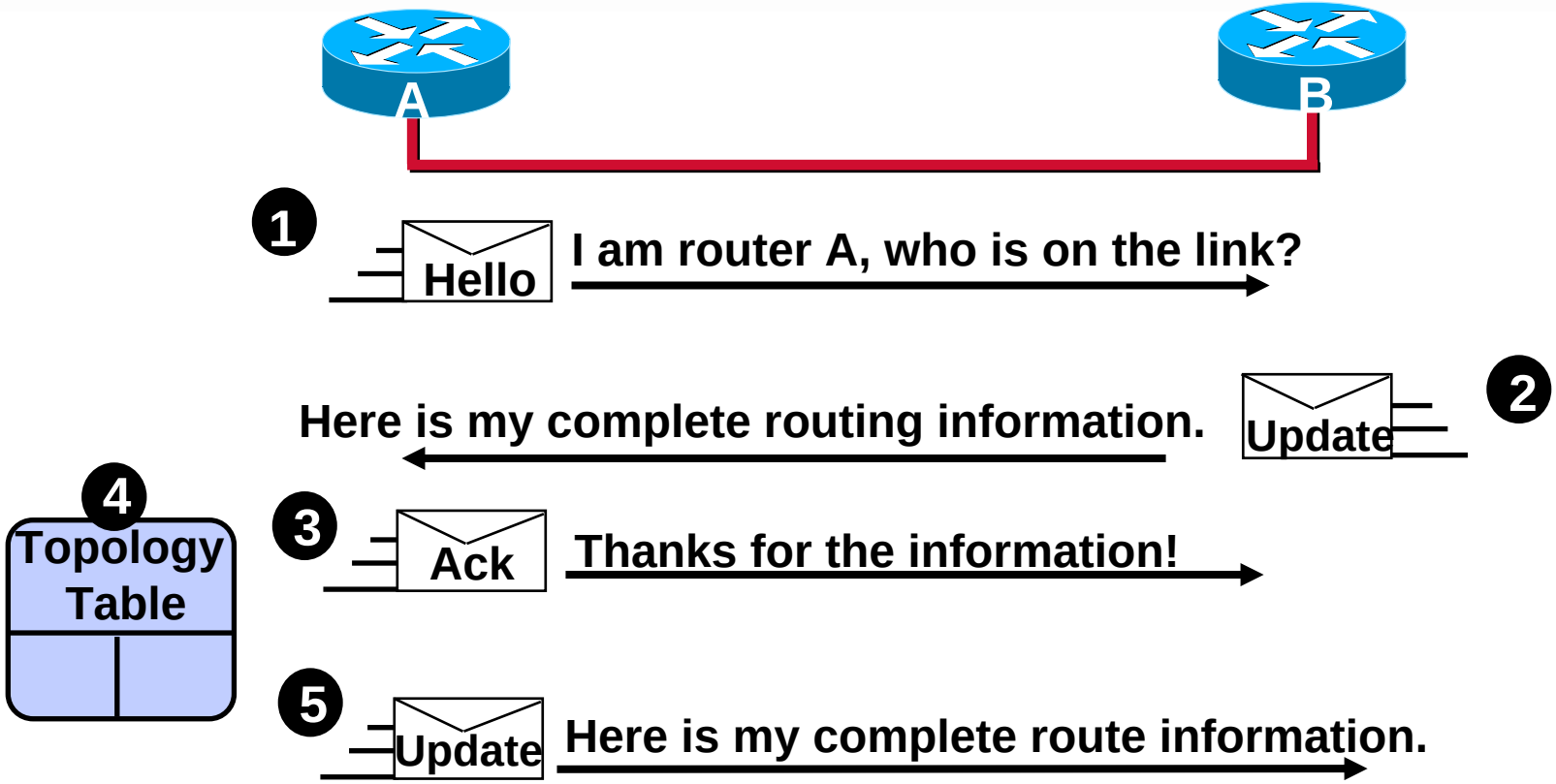
Initial Route Discovery



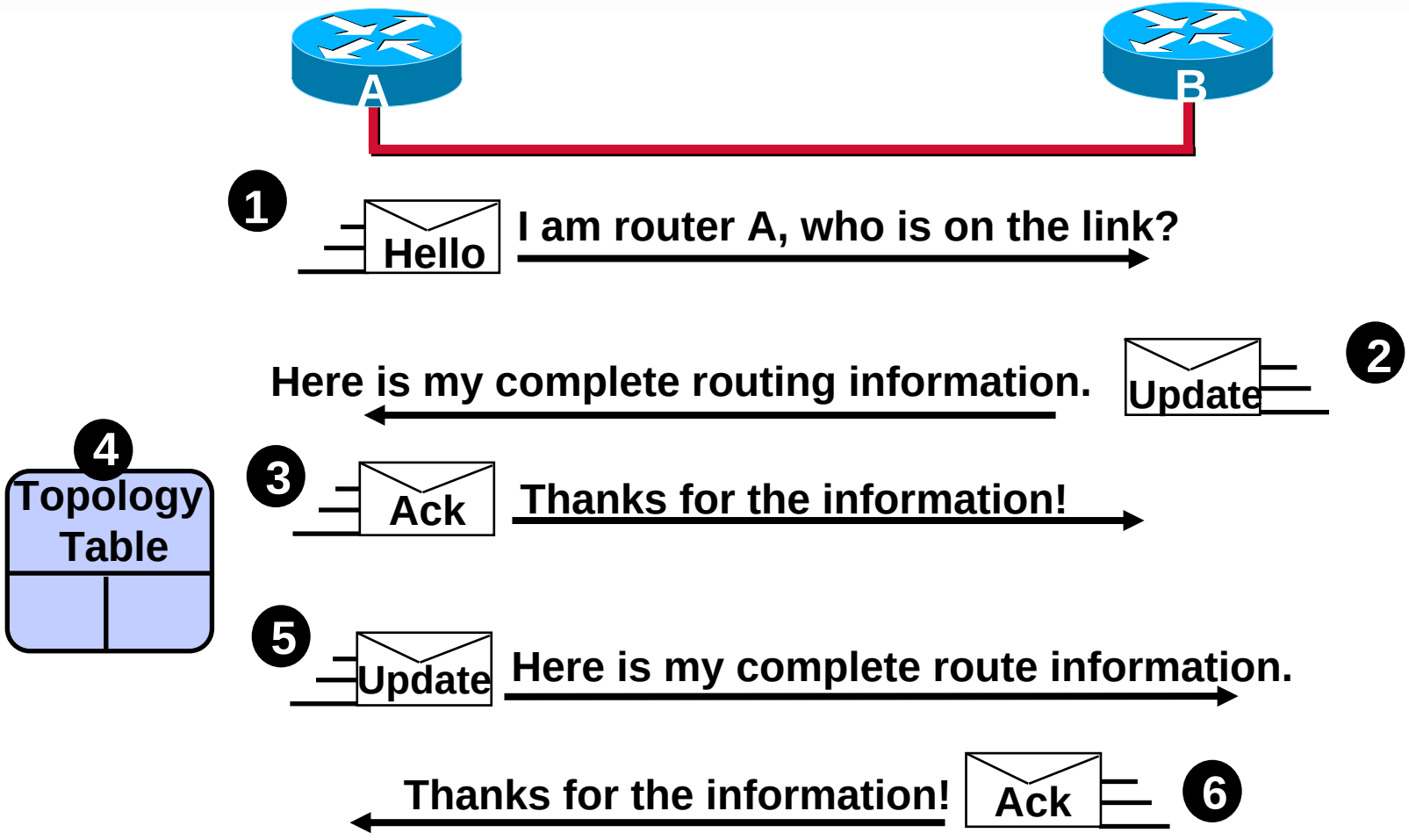
Initial Route Discovery



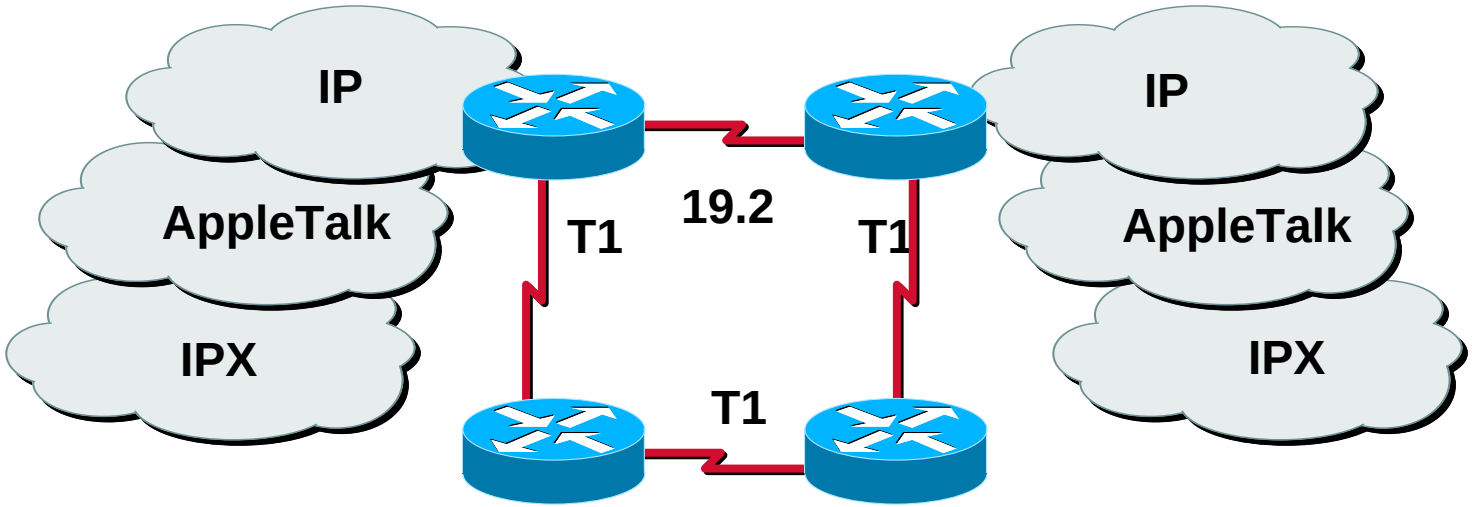
Initial Route Discovery



Initial Route Discovery



EIGRP Route Selection



- EIGRP uses a composite metric to pick the best path

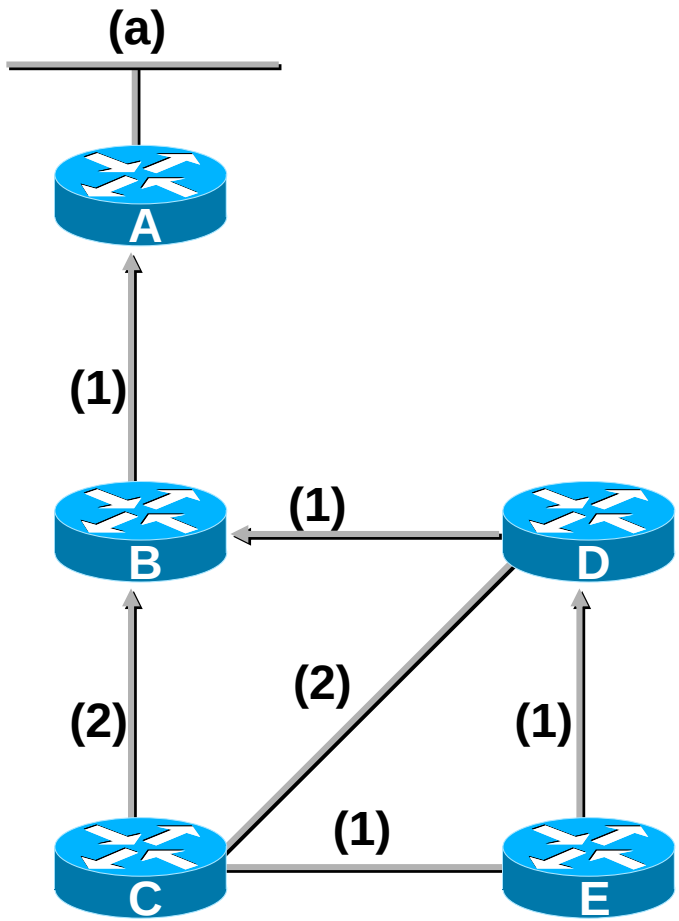
EIGRP Metrics Calculation

- Metric = [K1 x BW + (K2 x BW) / (256 - load) + K3 x delay] x [K5 / (reliability + K4)]
  - By default: K1 = 1, K2 = 0, K3 = 1, K4 = 0, K5 = 0
- Delay is sum of all the delays of the links along the paths
  - Delay = [Delay in 10s of microseconds] x 256
- Bandwidth is the lowest bandwidth of the links along the paths
  - Bandwidth = [10000000 / (bandwidth in Kbps)] x 256
- By default, metric = bandwidth + delay

EIGRP DUAL

- Diffusing Update Algorithm (DUAL)
- Finite-state machine
  - Tracks all routes advertised by neighbors
  - Select loop-free path using a successor and remember any feasible successors
  - If successor lost:
    - Use feasible successor
  - If no feasible successor:
    - Query neighbors and recompute new successor

DUAL Example (Start)

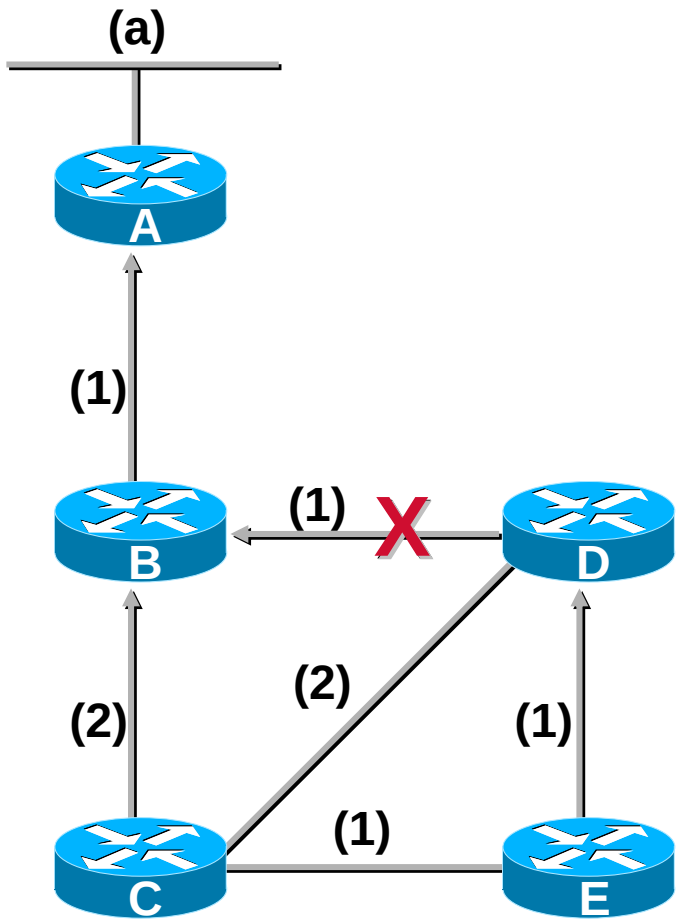


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D	4	2	(fs)
	via E	4	3	

D	EIGRP	FD	AD	Topology
(a)		2		(fd)
	via B	2	1	(Successor)
	via C	5	3	

E	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via D	3	2	(Successor)
	via C	4	3	

DUAL Example

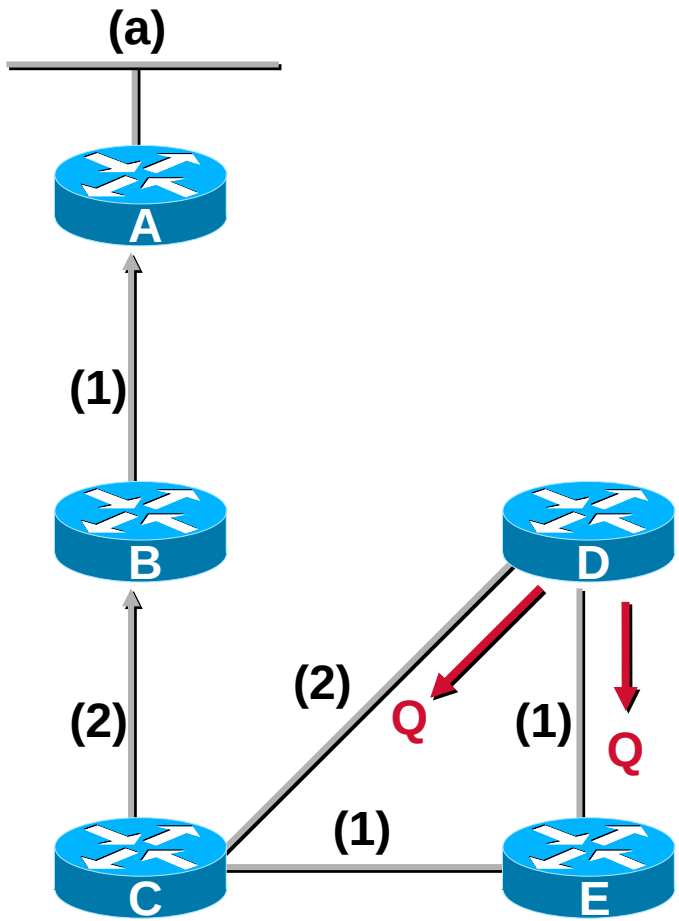


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D	4	2	(fs)
	via E	4	3	

D	EIGRP	FD	AD	Topology
(a)		2		(fd)
	~~via B~~	~~2~~	~~1~~	~~(Successor)~~
	via C	5	3	

E	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via D	3	2	(Successor)
	via C	4	3	

DUAL Example (cont.)

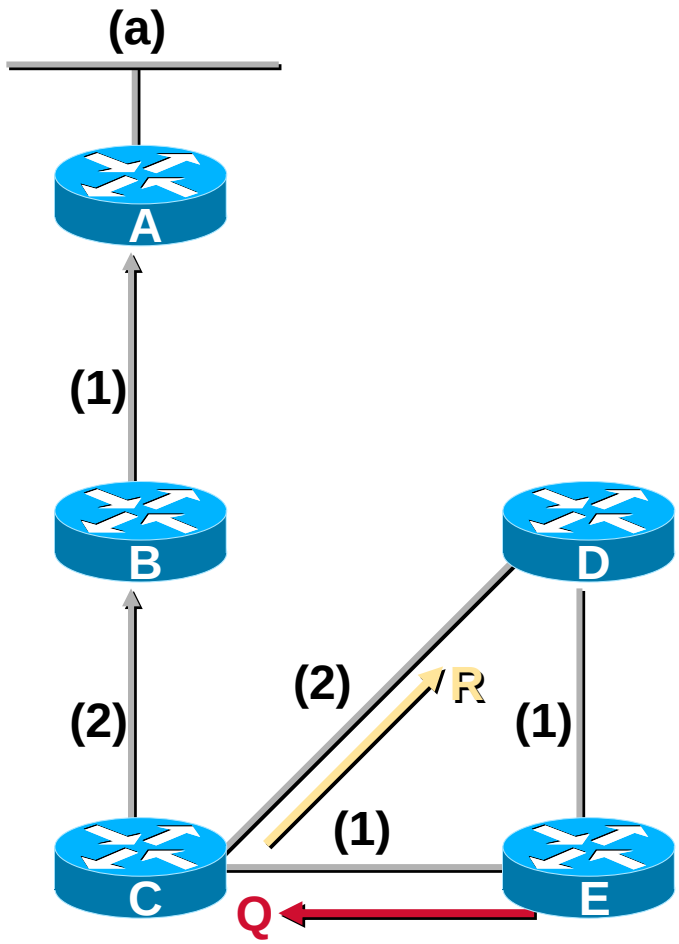


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E	4	3	

D	EIGRP	FD	AD	Topology
(a)	**ACTIVE**	-1		(fd)
	via E			(q)
	via C	5	3	(q)

E	EIGRP	FD	AD	Topology
(a)		3		(fd)
	~~via D~~	~~3~~	~~2~~	~~(Successor)~~
	via C	4	3	

DUAL Example (cont.)

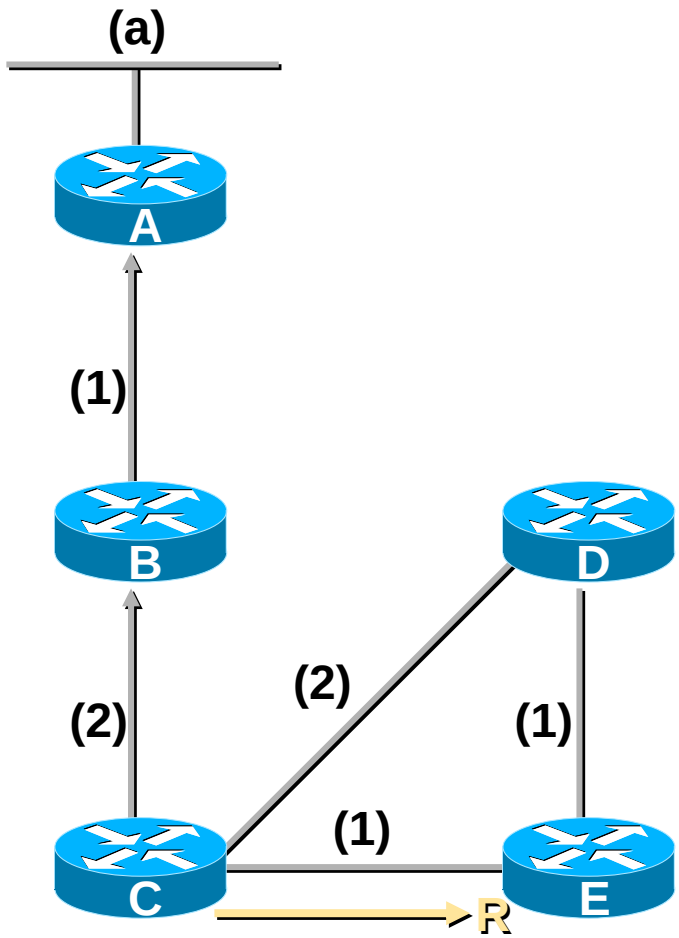


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E			

D	EIGRP	FD	AD	Topology
(a)	**ACTIVE**	-1		(fd)
	via E			(q)
	via C	5	3	

E	EIGRP	FD	AD	Topology
(a)	**ACTIVE**	-1		(fd)
	via D			
	via C	4	3	(q)

DUAL Example (cont.)

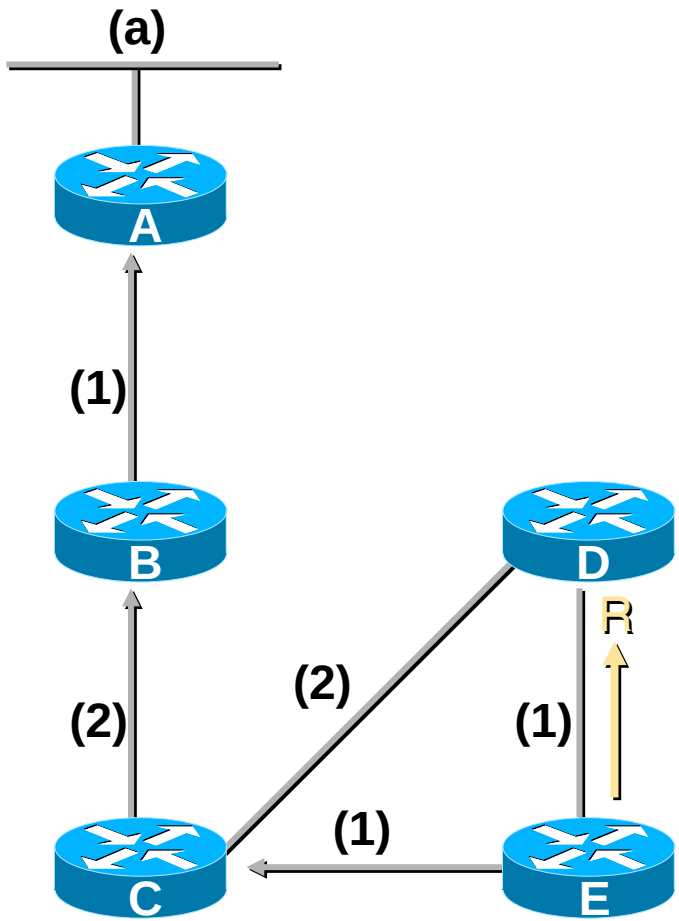


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E			

D	EIGRP	FD	AD	Topology
(a)	**ACTIVE**	-1		(fd)
	via E			(q)
	via C	5	3	

E	EIGRP	FD	AD	Topology
(a)		4		(fd)
	via C	4	3	(Successor)
	via D			

DUAL Example (cont.)

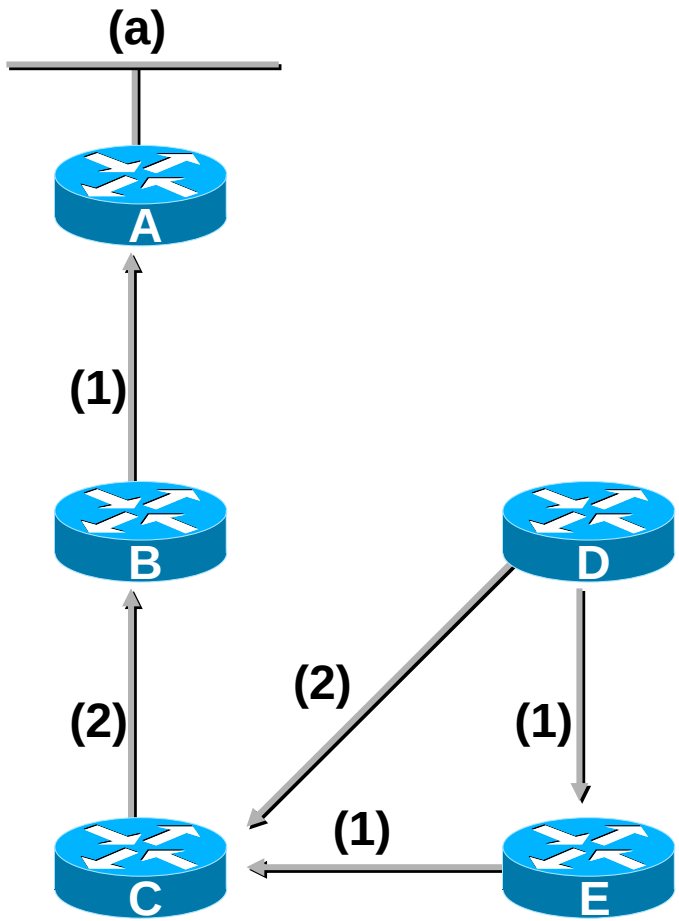


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E			

D	EIGRP	FD	AD	Topology
(a)		5		(fd)
	via C	5	3	(Successor)
	via E	5	4	(Successor)

E	EIGRP	FD	AD	Topology
(a)		4		(fd)
	via C	4	3	(Successor)
	via D			

DUAL Example (cont.)

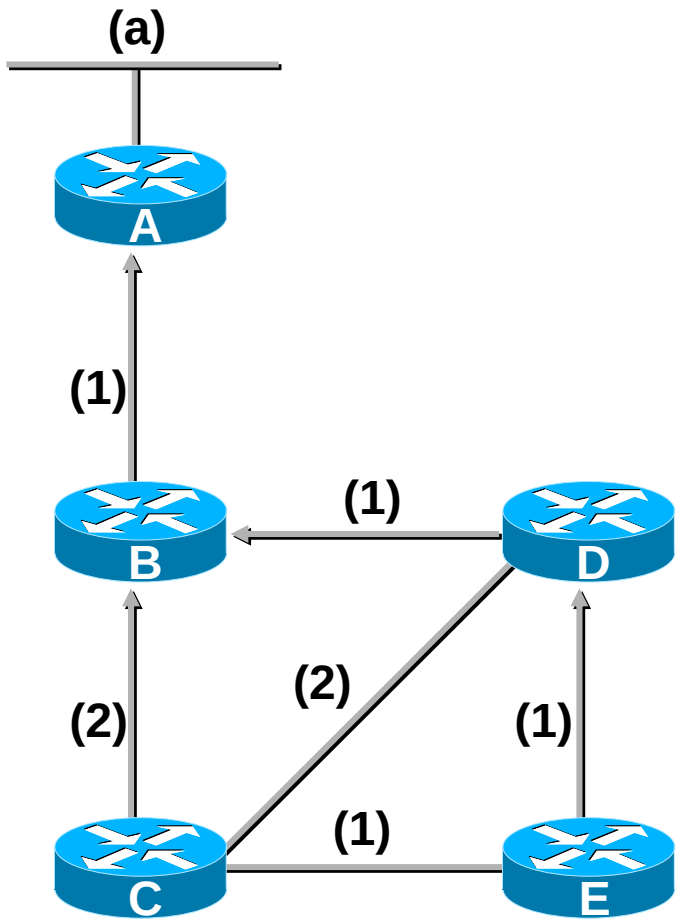


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E			

D	EIGRP	FD	AD	Topology
(a)		5		(fd)
	via C	5	3	(Successor)
	via E	5	4	(Successor)

E	EIGRP	FD	AD	Topology
(a)		4		(fd)
	via C	4	3	(Successor)
	via D			

DUAL Example (Start)

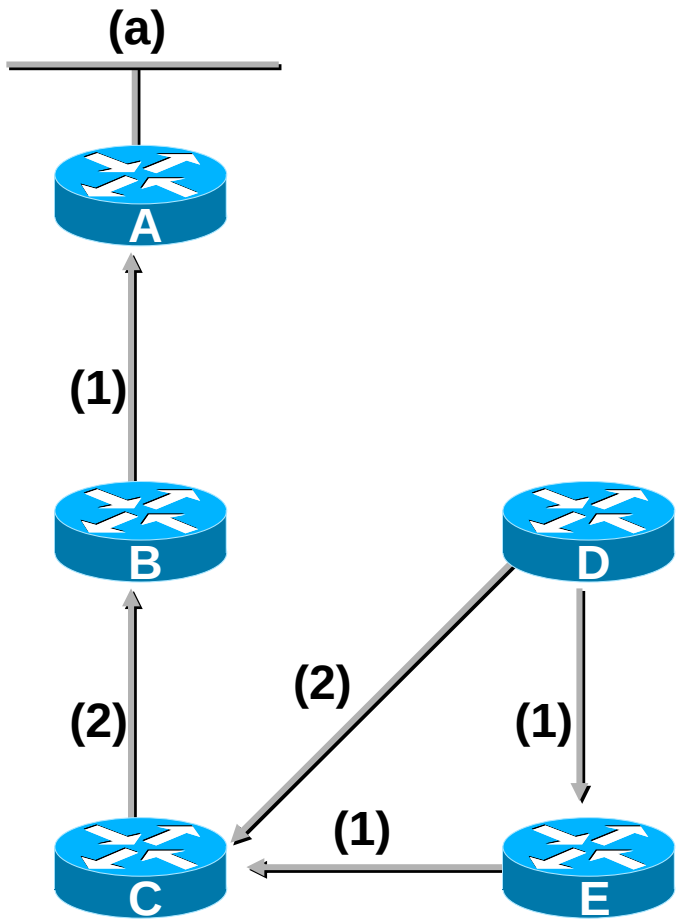


C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D	4	2	(fs)
	via E	4	3	

D	EIGRP	FD	AD	Topology
(a)		2		(fd)
	via B	2	1	(Successor)
	via C	5	3	

E	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via D	3	2	(Successor)
	via C	4	3	

DUAL Example (End)



C	EIGRP	FD	AD	Topology
(a)		3		(fd)
	via B	3	1	(Successor)
	via D			
	via E			

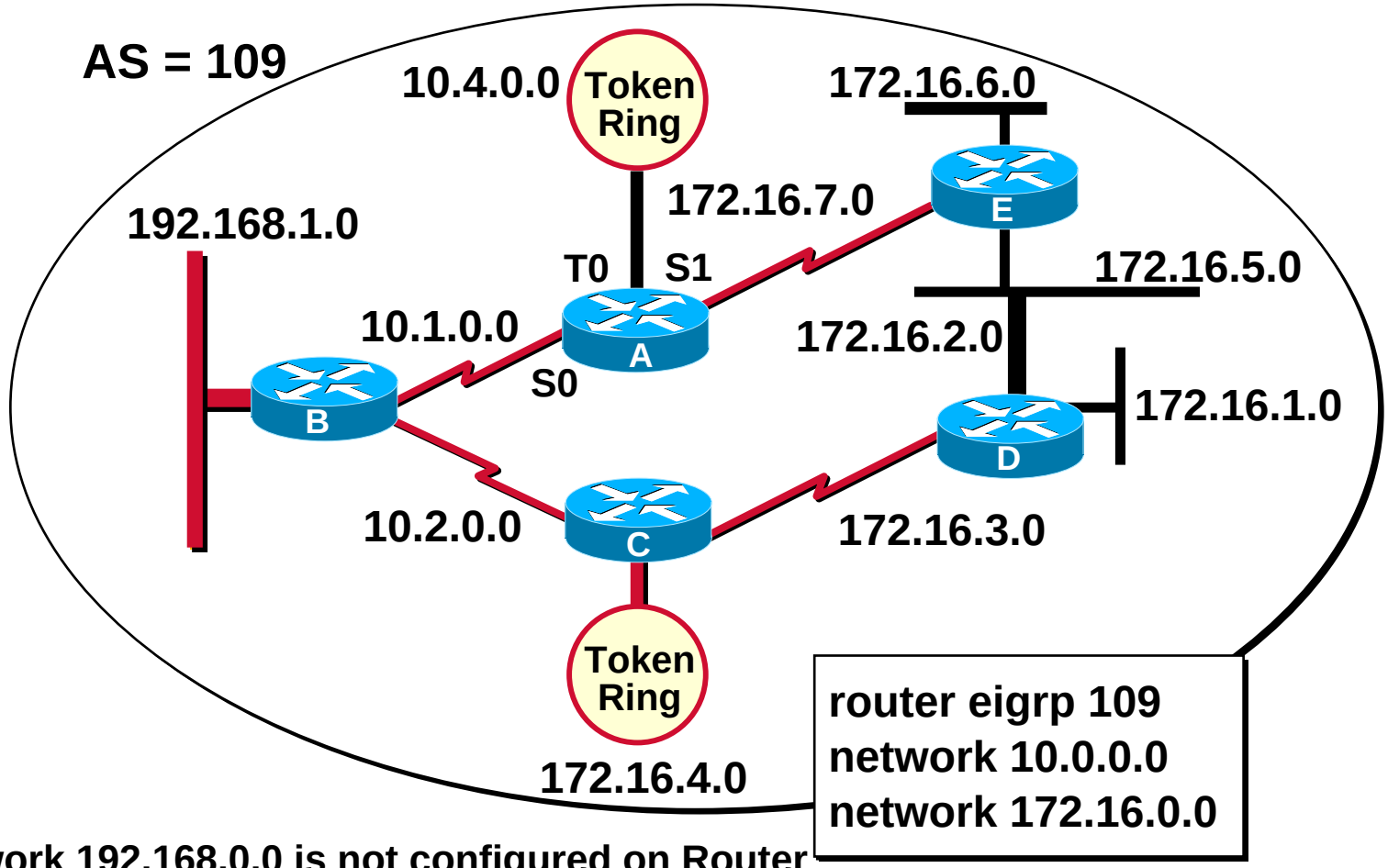
D	EIGRP	FD	AD	Topology
(a)		5		(fd)
	via C	5	3	(Successor)
	via E	5	4	(Successor)

E	EIGRP	FD	AD	Topology
(a)		4		(fd)
	via C	4	3	(Successor)
	via D			

Written Exercise

Configuring EIGRP

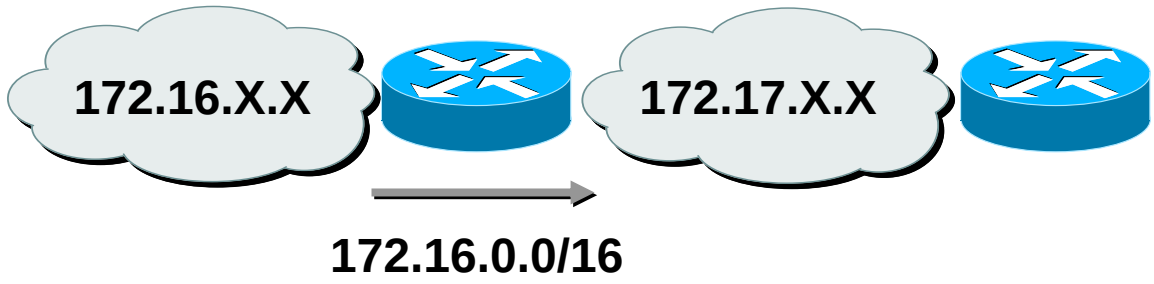
Configuring EIGRP for IP



- Network 192.168.0.0 is not configured on Router A because it is not directly connected to Router A

EIGRP Summarization—Automatic

- **Purpose: Smaller routing tables, smaller updates, query boundary**
- **Autosummarization:**
  - **On major network boundaries, subnetworks are summarized to a single classful (major) network**
  - **Autosummarization is turned on by default**



EIGRP Summarization—Manual

- Manual summarization
  - Configurable on a per-interface basis in any router within network
  - When summarization is configured on an interface, the router immediate creates a route pointing to null zero
    - Loop prevention mechanism
  - When the last specific route of the summary goes away, the summary is deleted
  - The minimum metric of the specific routes is used as the metric of the summary route

Configuring Summarization

```
(config-router)#
```

no auto-summary

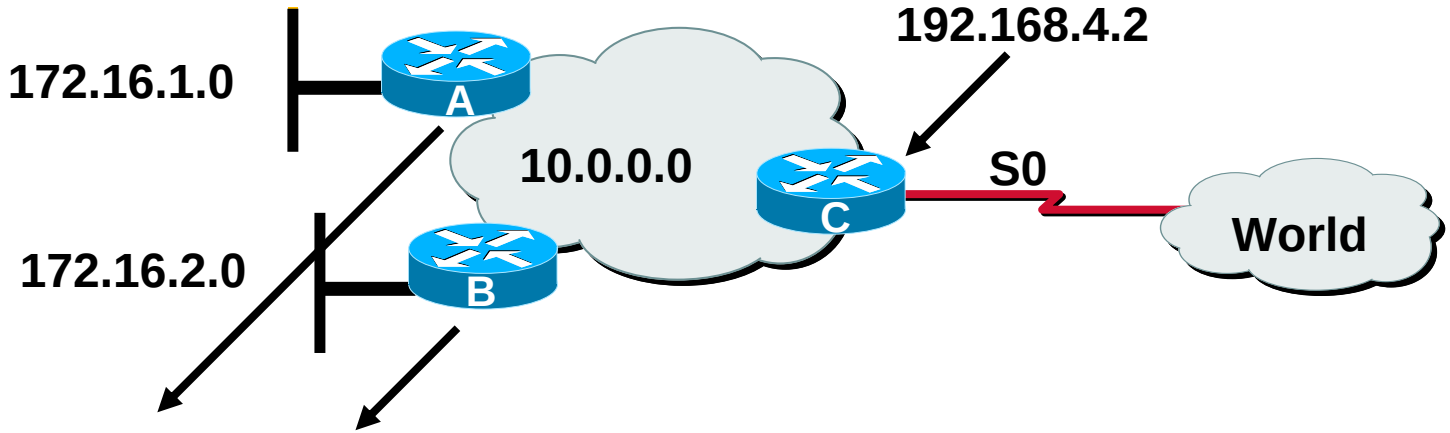
- **Turns off autosummarization for the EIGRP process**

```
(config-if)#
```

ip summary-address eigrp <*as-number*> <*address*> <*mask*>

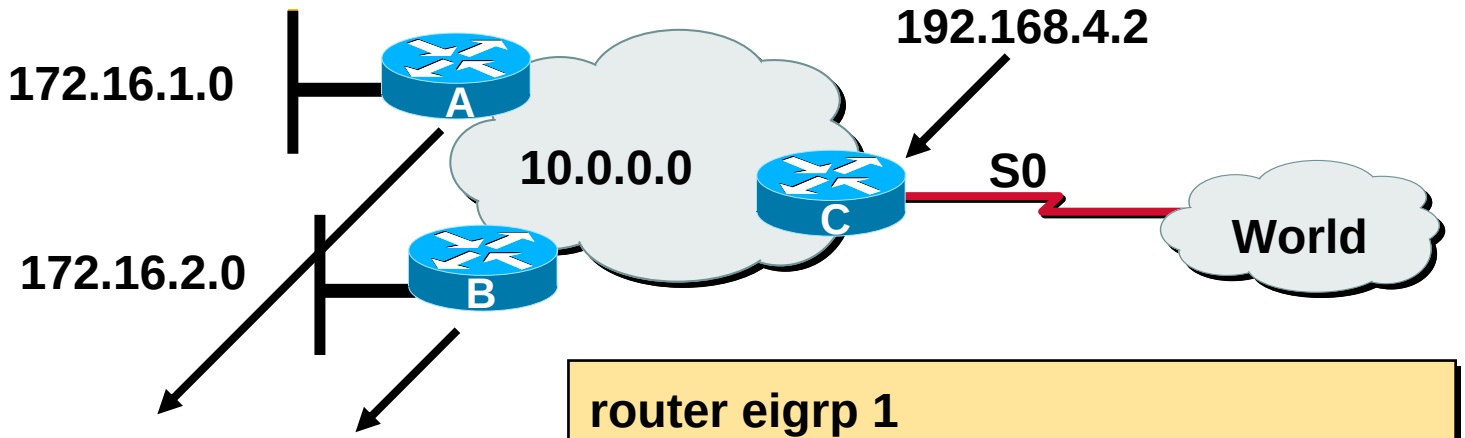
- **Creates a summary address to be generated by this interface**

Summarizing EIGRP Routes




```
router eigrp 1
network 10.0.0.0
network
no auto-summary
```

Summarizing EIGRP Routes




```
router eigrp 1
network
network 172.16.0.0
no auto-summary
```

```
router eigrp 1
network 10.0.0.0
network 192.168.4.0
!
int s0
ip address 192.168.4.2 255.255.255.0
ip summary-address eigrp 1
172.16.0.0 255.255.0.0
```

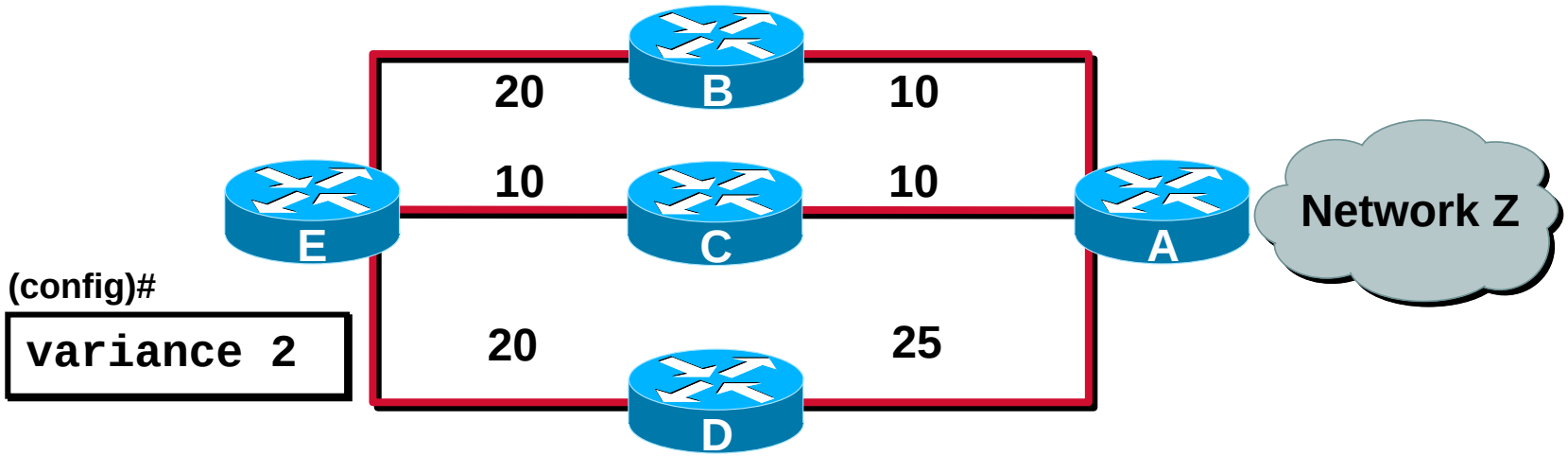
EIGRP Load Balancing

- Routes with metric equal to the minimum metric will be installed in the routing table (equal-cost load balancing)
- Up to six entries in the routing table for the same destination
  - Number of entries is configurable
  - Default is four

EIGRP Unequal-Cost Load Balancing

- **EIGRP offers unequal-cost load balancing**
  - ***variance* command**
- **Variance allows the router to include routes with a metric smaller than multiplier times the minimum metric route to that destination**
  - **Multiplier is the number specified by the *variance* command**

Variance Example



- Router E will choose Router C to get to Network Z because FD = 20
- With variance of 2, Router E will also choose Router B to get to Network Z (20 + 10) < (2 x [FD])
- Router D will not be used to get to Network Z (45 > 40)

Configuring WAN Links

- EIGRP supports different WAN links
  - Point-to-point
  - NBMA
    - Multipoint
    - Point-to-point
- EIGRP configurations must address
  - Bandwidth utilization
  - Overhead traffic associated with router operation

EIGRP Bandwidth Utilization

(config-if)#

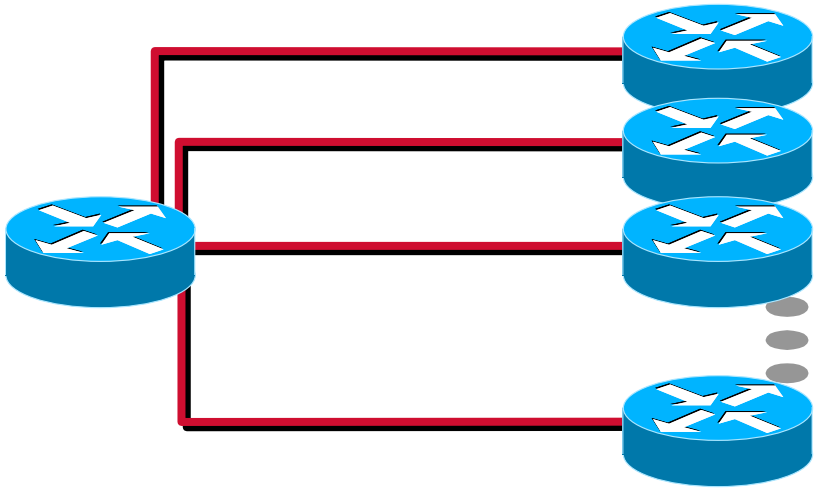
ip bandwidth-percent eigrp as-number <*nnn*>

- **Specifies what percentage of bandwidth EIGRP packets will be able to utilize on this interface**
- **Uses up to 50% of the link bandwidth for EIGRP packets, by default**
  - **Used for greater EIGRP load control**

Bandwidth over WAN Interfaces

- **Bandwidth utilization over point-to-point subinterfaces using Frame Relay**
  - **Treats bandwidth as T1, by default**
  - **Best practice is to manually configure bandwidth as the CIR of the PVC**

Bandwidth over WAN Interfaces (cont.)

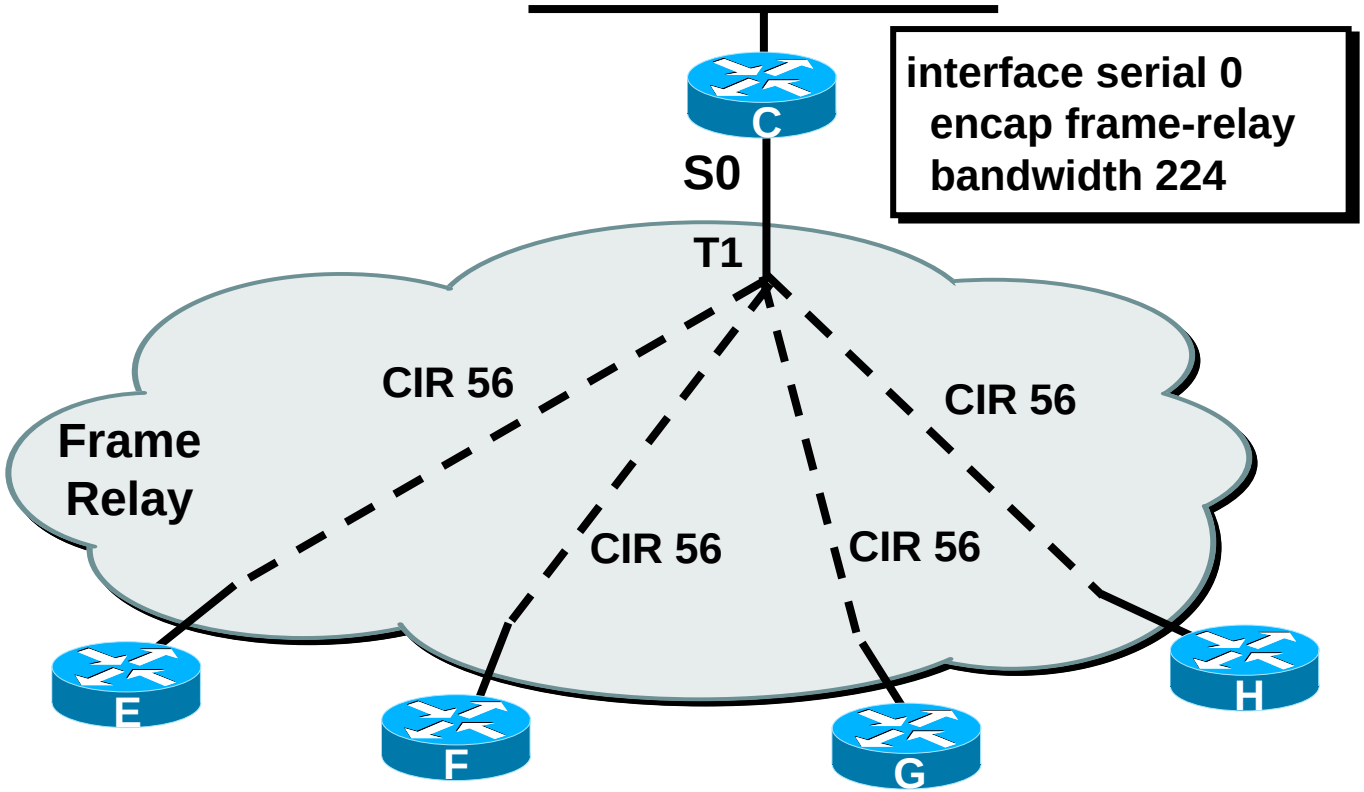


- **Bandwidth over multipoint Frame Relay, ATM, SMDS, and ISDN PRI:**
  - **EIGRP uses the bandwidth on the main interface divided by the number of neighbors on that interface to get the bandwidth information per neighbor**

Bandwidth over WAN Interfaces (cont.)

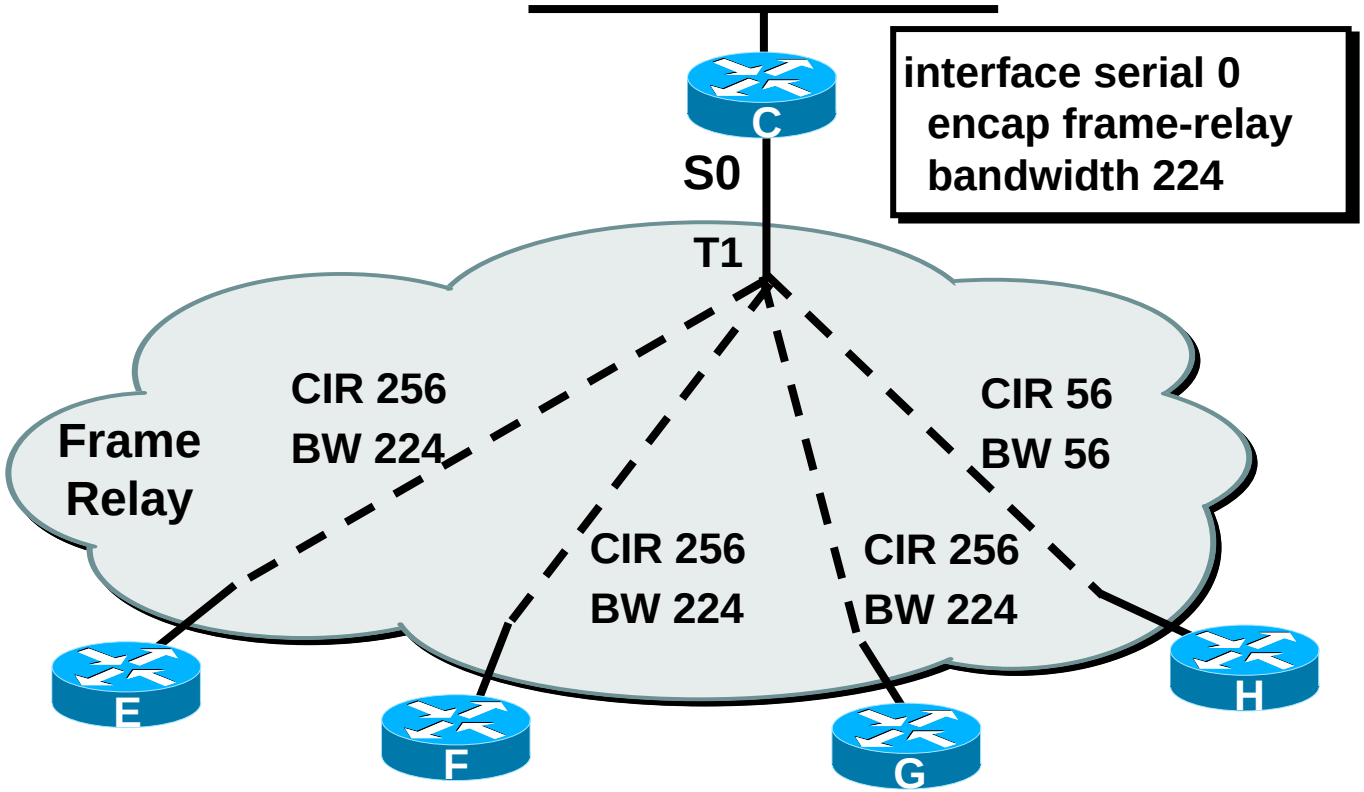
- Each PVC might have a different CIR, this might create an EIGRP packet pacing problem
  - Multipoint interfaces:
    - Convert to point-to-point configuration, or
    - Manually configure bandwidth = (lowest CIR x number of PVCs)

EIGRP WAN Configuration—Pure Multipoint



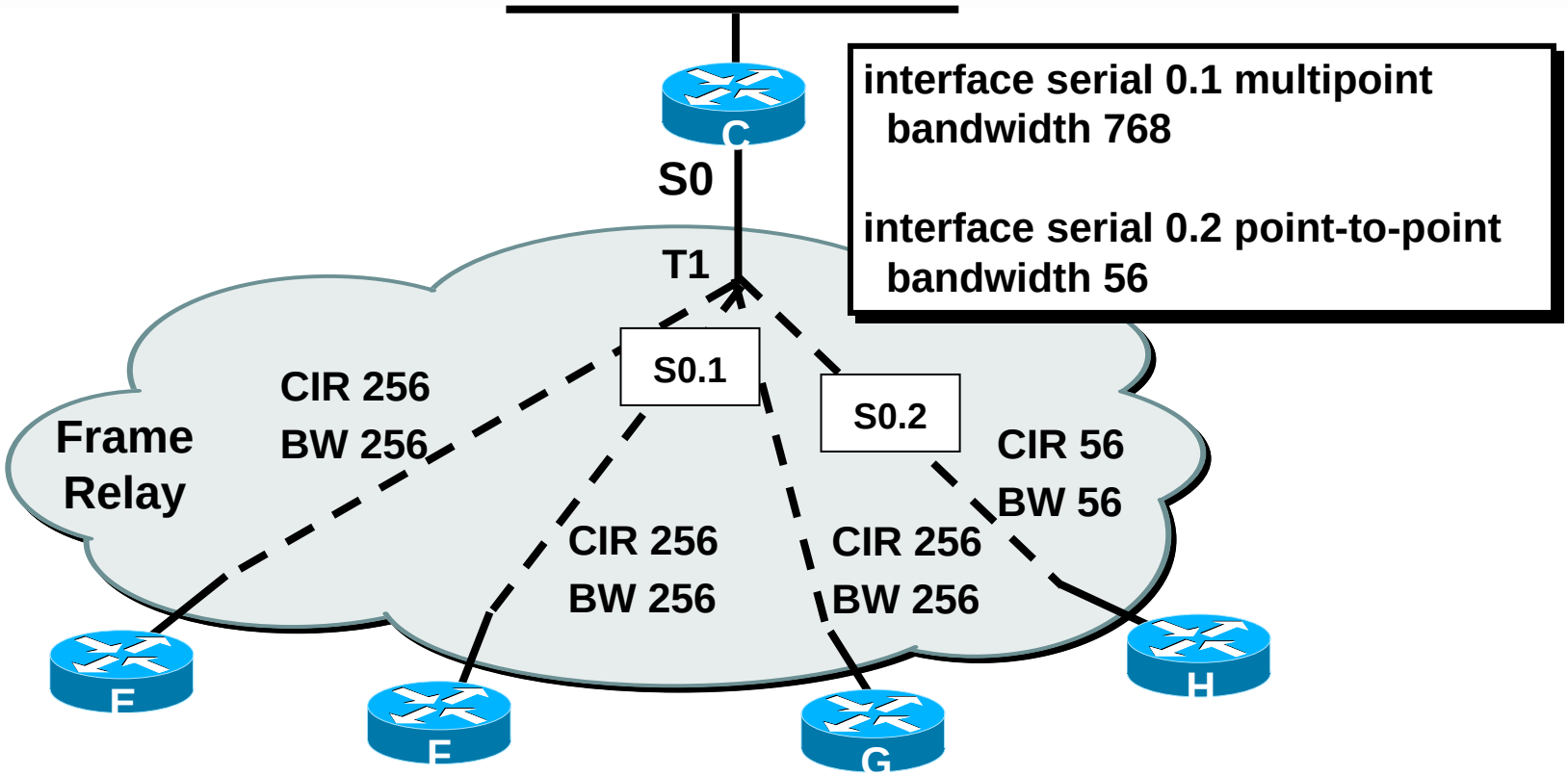
- All VCs share bandwidth evenly: 4 x 56 = 224

EIGRP WAN Configuration—Hybrid Multipoint



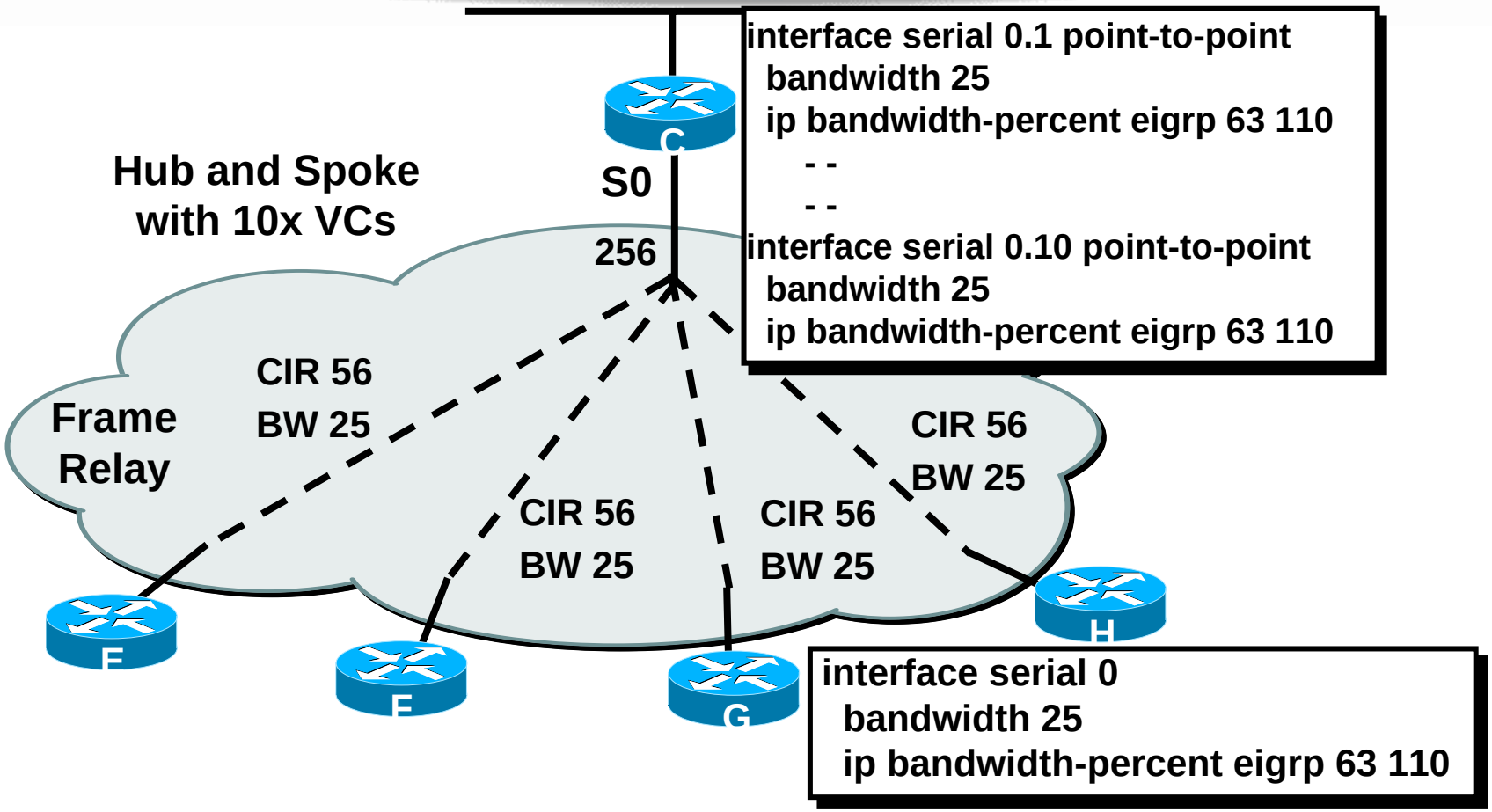
- Lowest CIR x # of VC: 56 x 4 = 224

EIGRP WAN Configuration—Hybrid Multipoint (Preferred)



- Configure lowest CIR VC as point-to-point, specify BW = CIR
- Configure higher CIR VCs as multipoint, combine CIRs

EIGRP WAN Configuration—Pure Point-to-Point



- Configure each VC as point-to-point, specify BW = 1/10 of link capacity
- Increase EIGRP utilization to 50% of actual VC capacity

Using EIGRP in Scalable Internetworks

Factors that Influence EIGRP Scalability

- EIGRP is not plug-and-play for large networks
- Limit EIGRP query range!
- Quantity of routing information exchanged between peers
  - Advertise major network or default route to regions or remotes

EIGRP Query Process

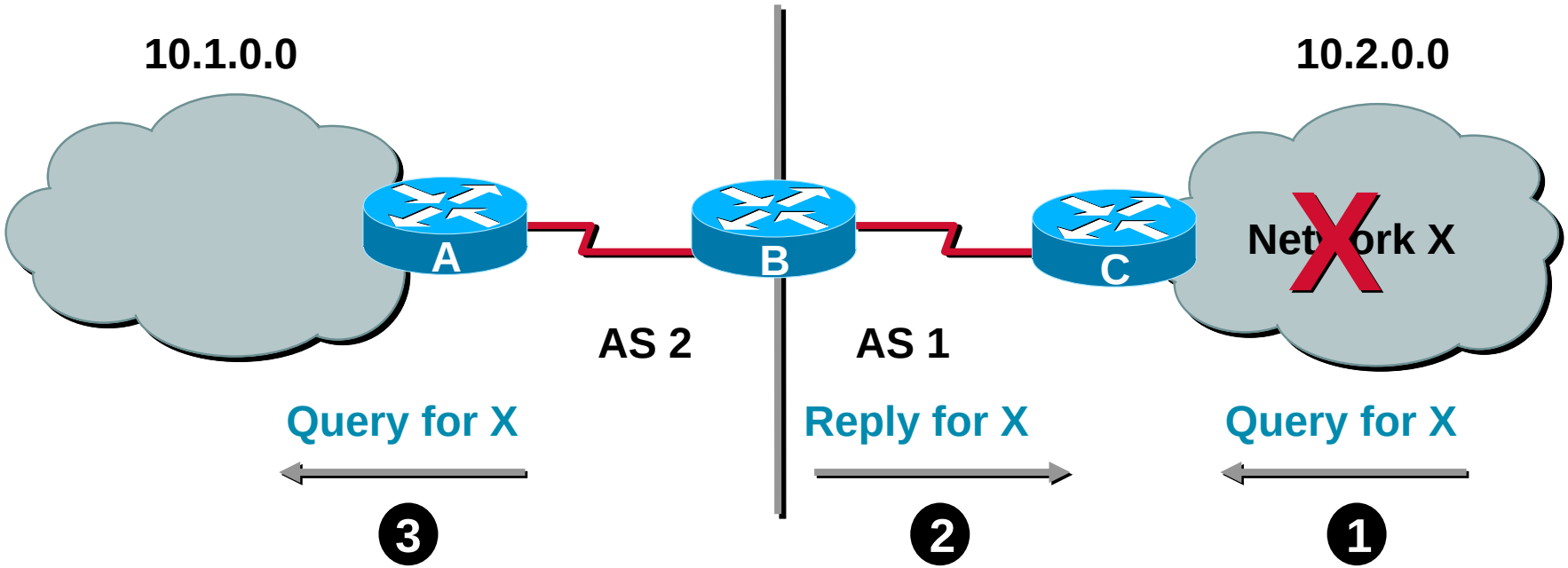
- Queries are sent out when a route is lost and no feasible successor is available
- The lost route is now in active state
- Queries are sent out to all of its neighbors on all interfaces except the interface to the successor
- If the neighbor does not have the lost route information, queries are sent out to their neighbors

EIGRP Query Process (cont.)

- The router will have to get ALL of the replies from the neighbors before the router calculates the successor information
- If any neighbor fails to reply the query in 3 minutes, this route is stuck in active and the router resets the neighbor that fails to reply
- Solution for stuck in active is to limit the query range, also known as *query scoping*

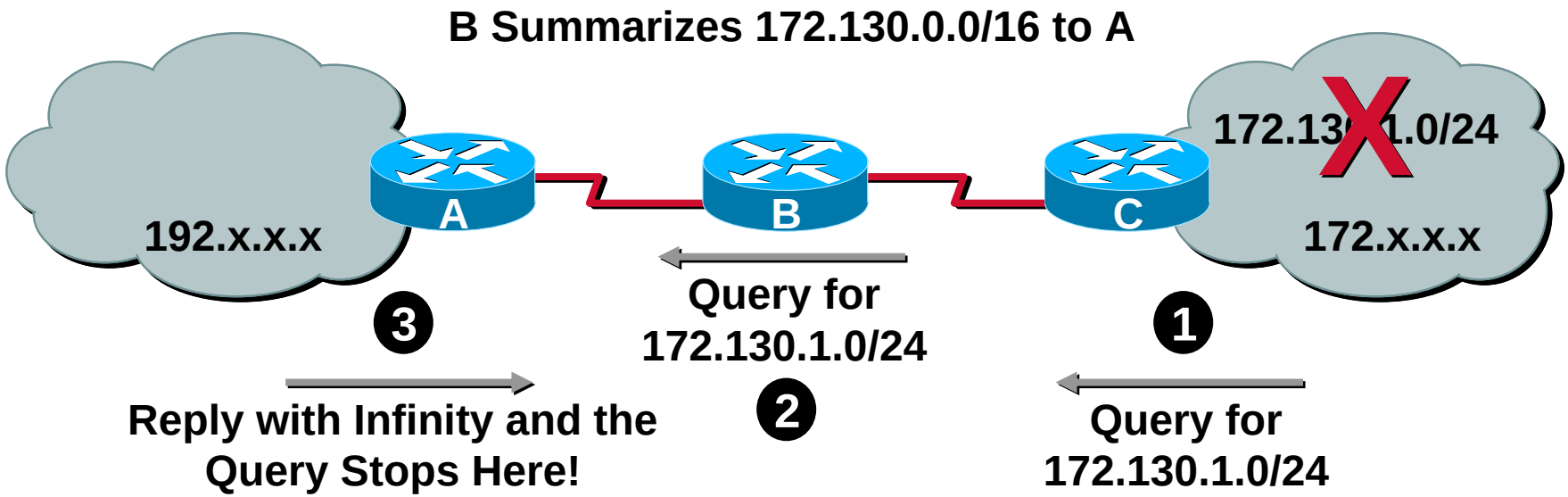
EIGRP Query Range

- Autonomous system boundaries
  - Contrary to popular belief, queries are not bounded by AS boundaries. Queries from AS 1 will be propagated to AS 2.



EIGRP Query Range (cont.)

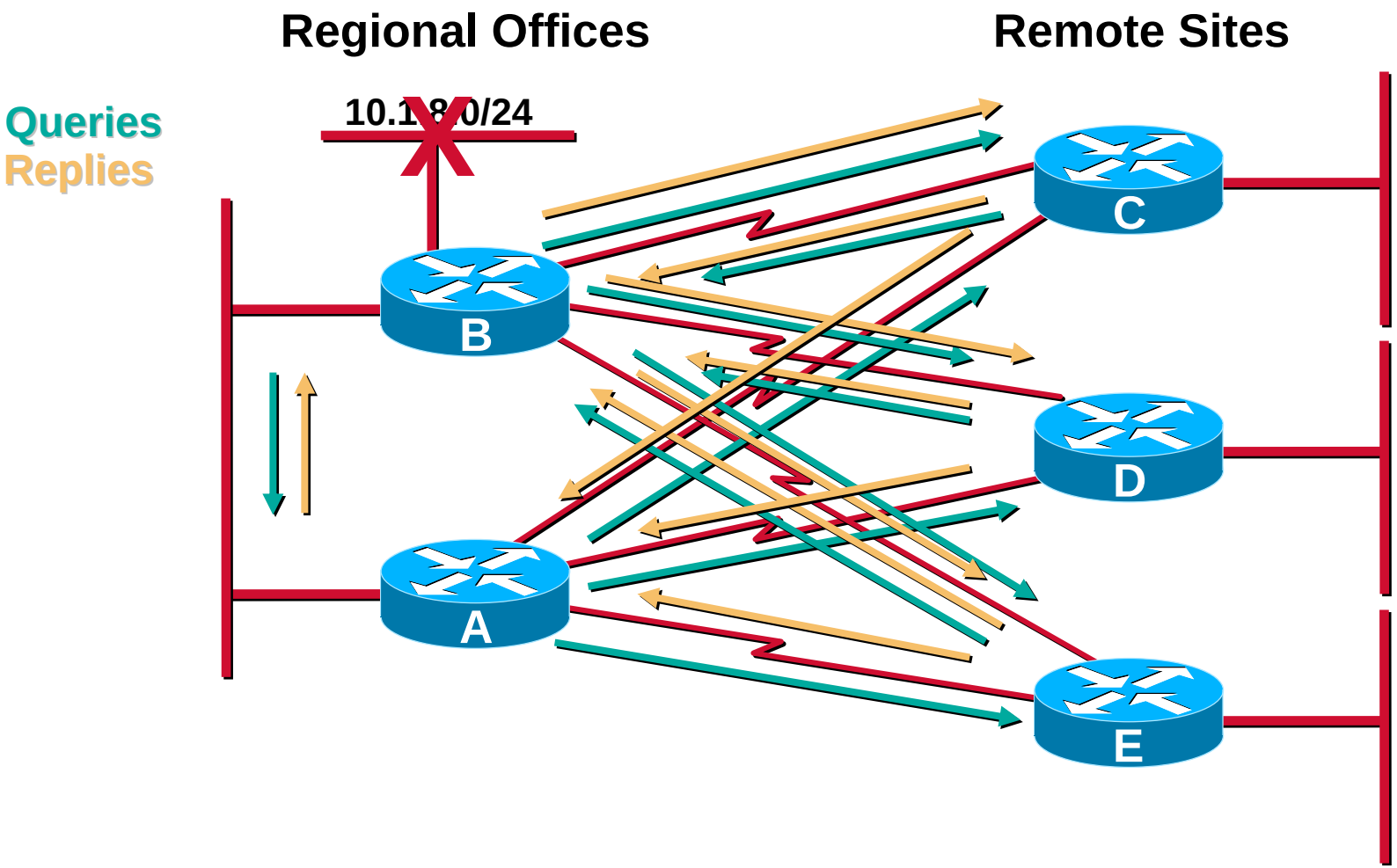
- **Summarization point**
  - **Auto or manual summarization is the best way to bound queries**
  - **Requires a good address allocation scheme**



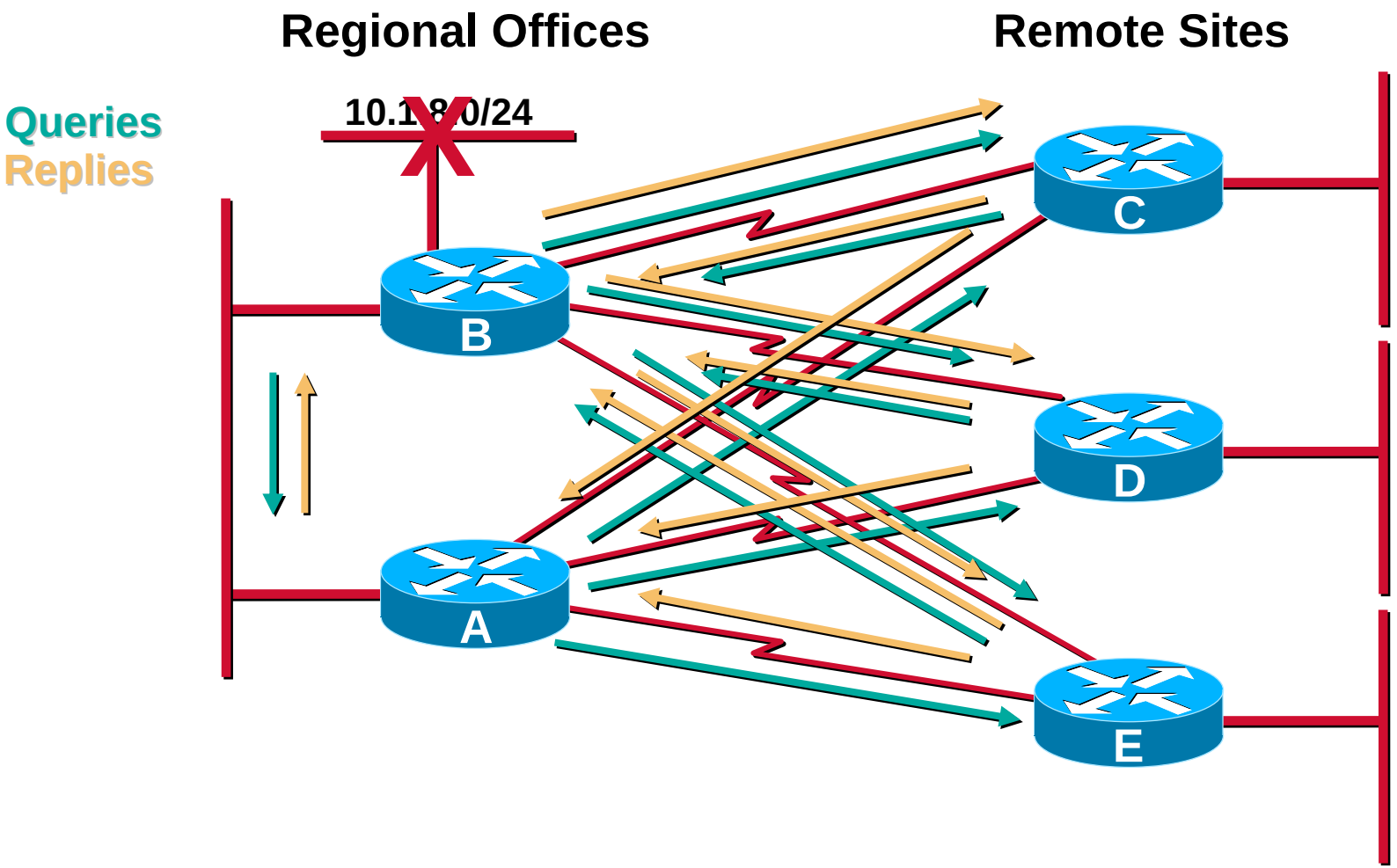
Limiting Size/Scope of Updates/Queries

- **Evaluate routing requirements**
  - **What routes are needed where?**
- **Once needs are determined:**
  - **Use summary address**
  - **Use filters**

Limiting Updates/Queries—Example



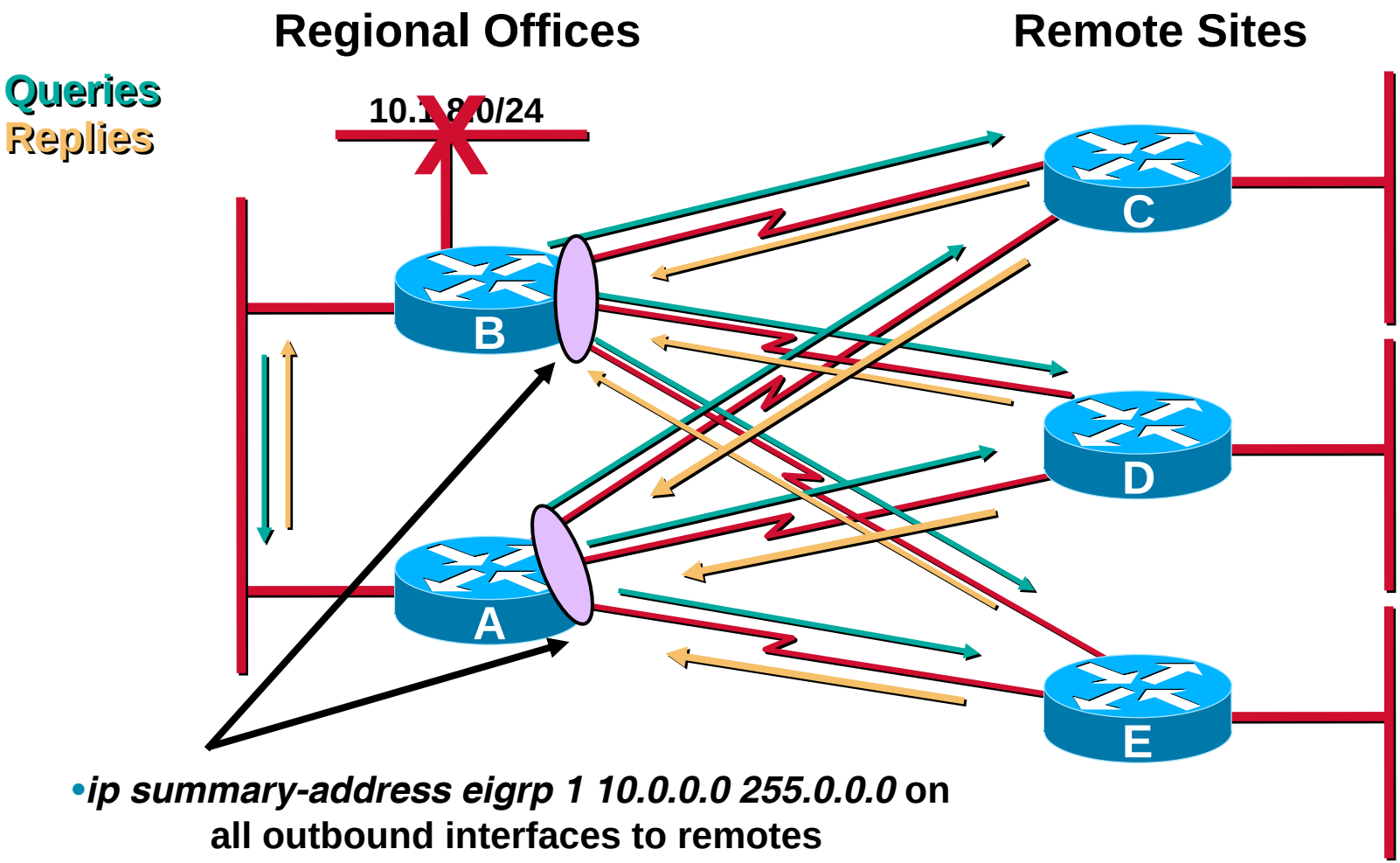
Limiting Updates/Queries—Example



LimitingUpdates/Queries—Reality

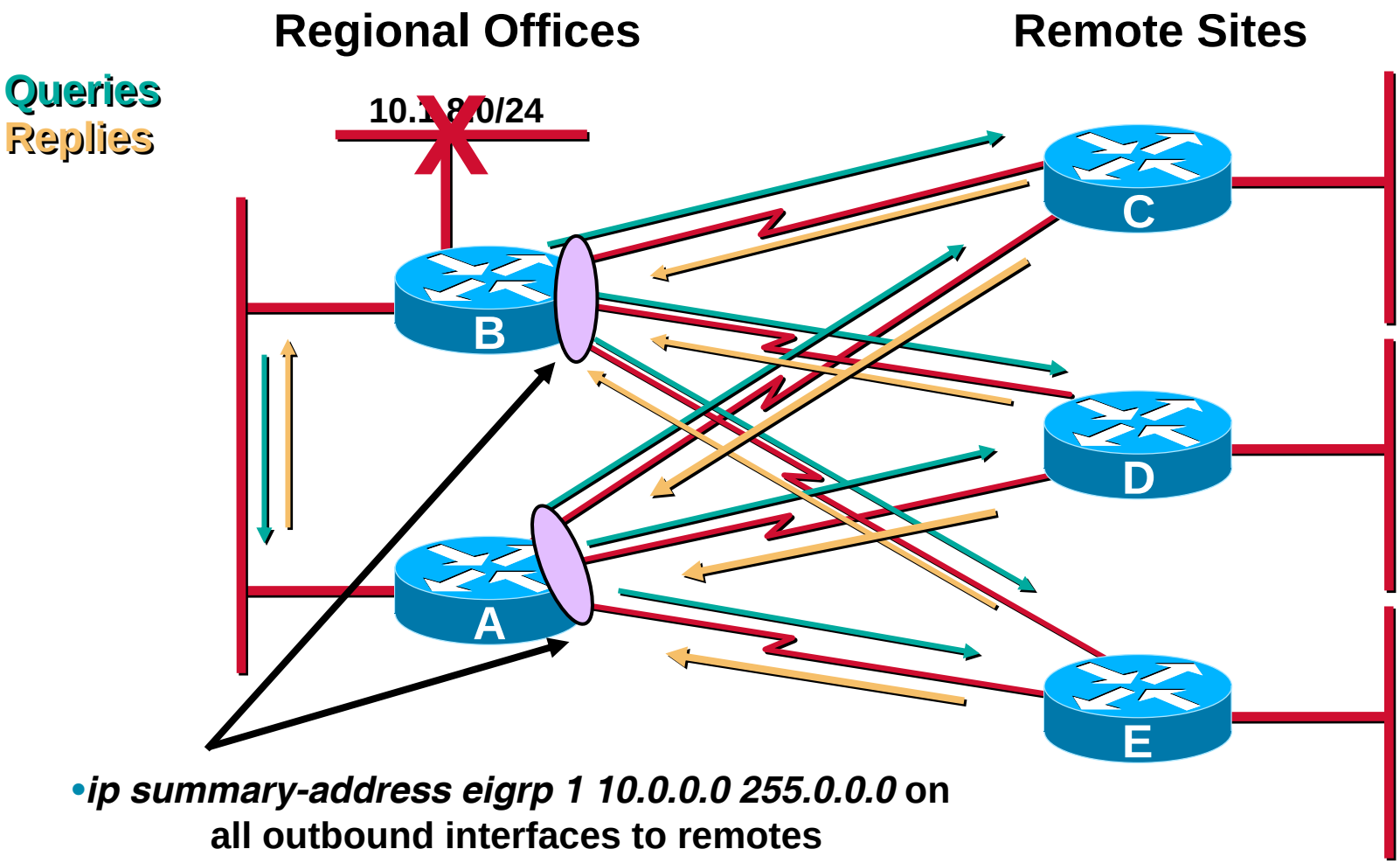
- Remote routers are fully involved in convergence
  - Most remote routers are never intended to be transit
  - Convergence complicated through lack of information hiding

Limiting Updates/Queries—Better



- *ip summary-address eigrp 1 10.0.0.0 255.0.0.0* on all outbound interfaces to remotes

Limiting Updates/Queries—Better



- *ip summary-address eigrp 1 10.0.0.0 255.0.0.0* on all outbound interfaces to remotes

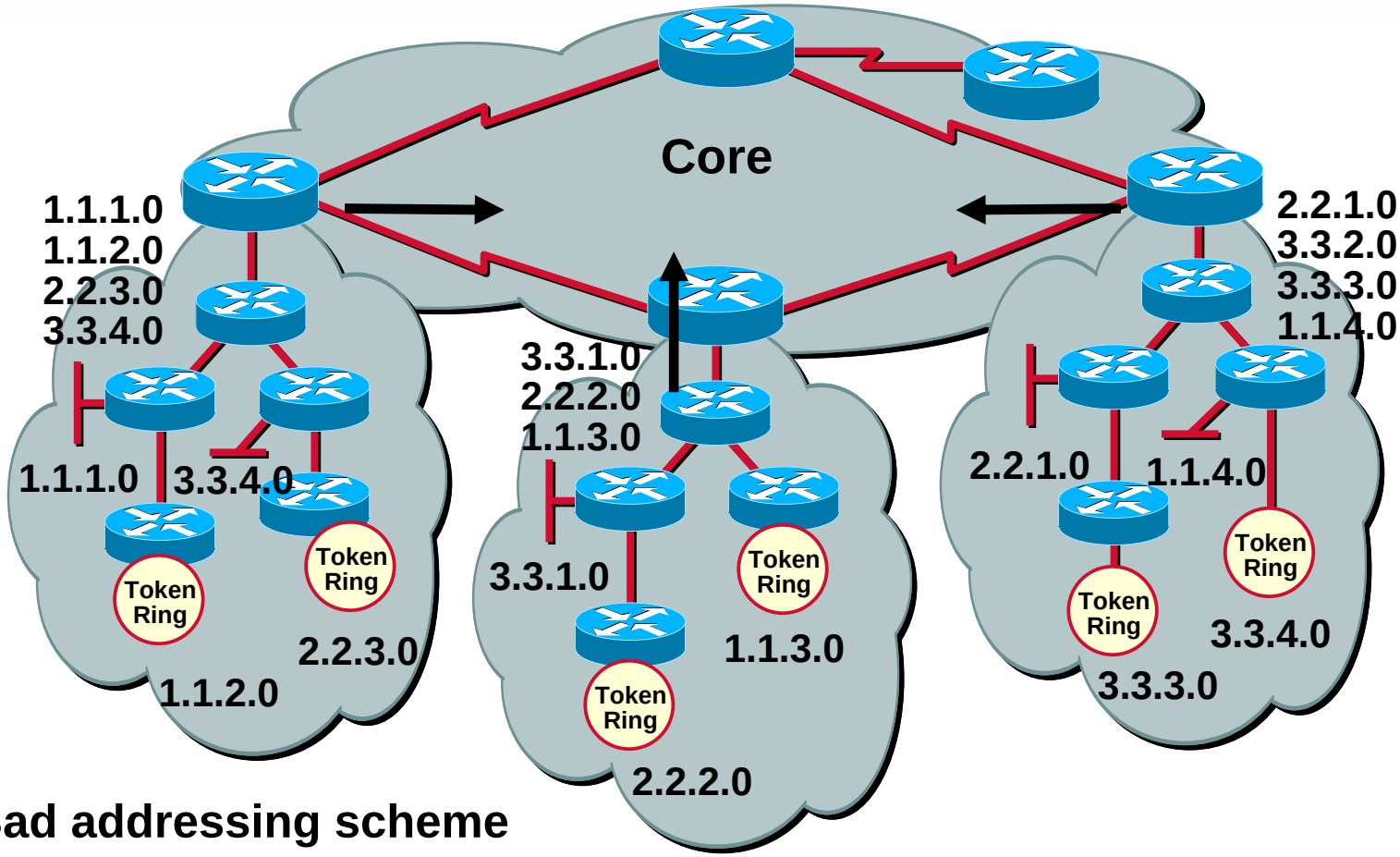
Limiting Updates/Queries—Summary

- **Convergence simplified by adding the summary-address statements**
  - **Remote routers just reply when queried, do not forward queries**

EIGRP Scalability Rules

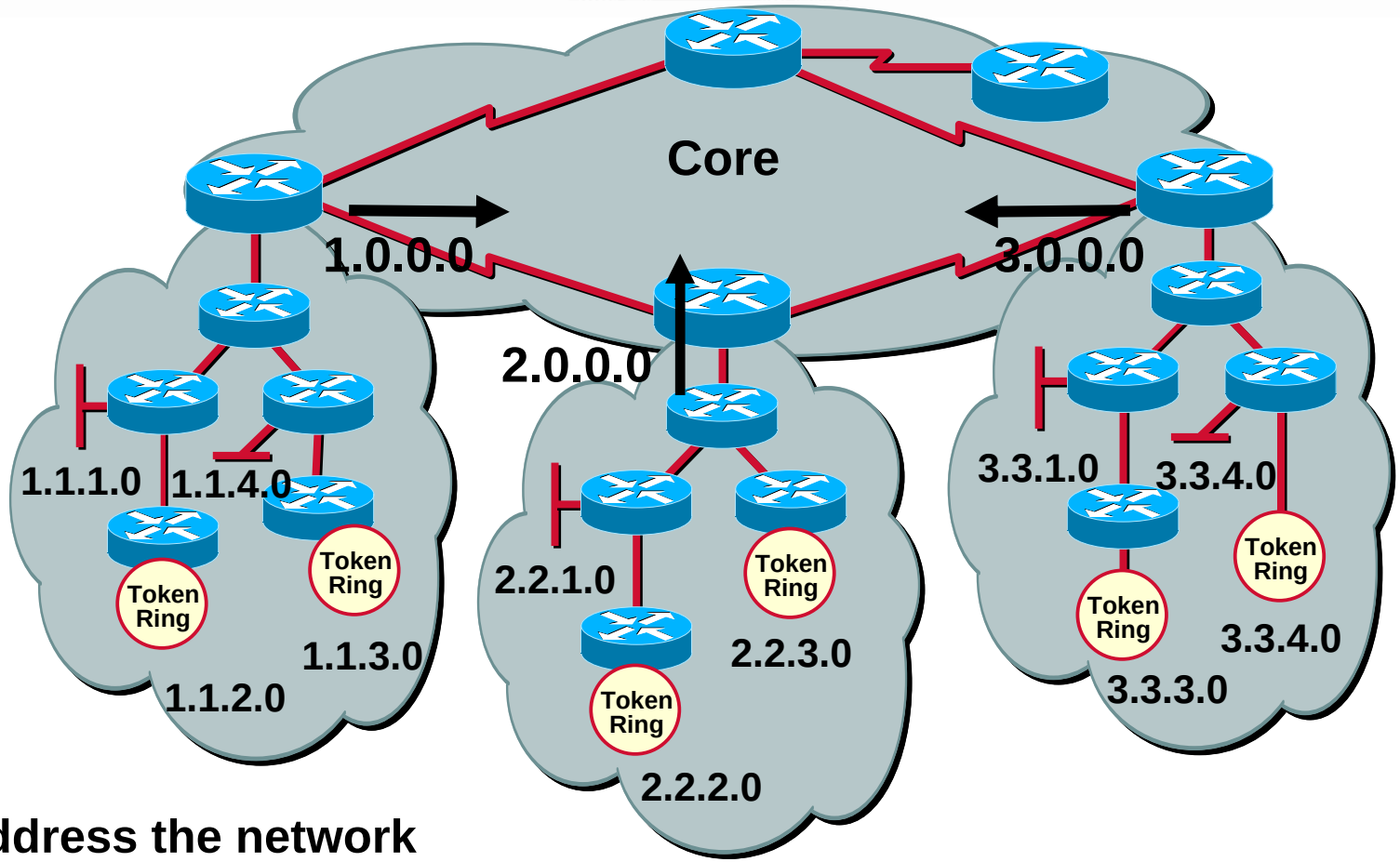
- **EIGRP is a very scalable routing protocol if proper design methods are used:**
  - **Good allocation of address space**
    - **Each region should have a contiguous address space so route summarization is possible**
  - **Have a tiered network design model**

Nonscalable Network—Example



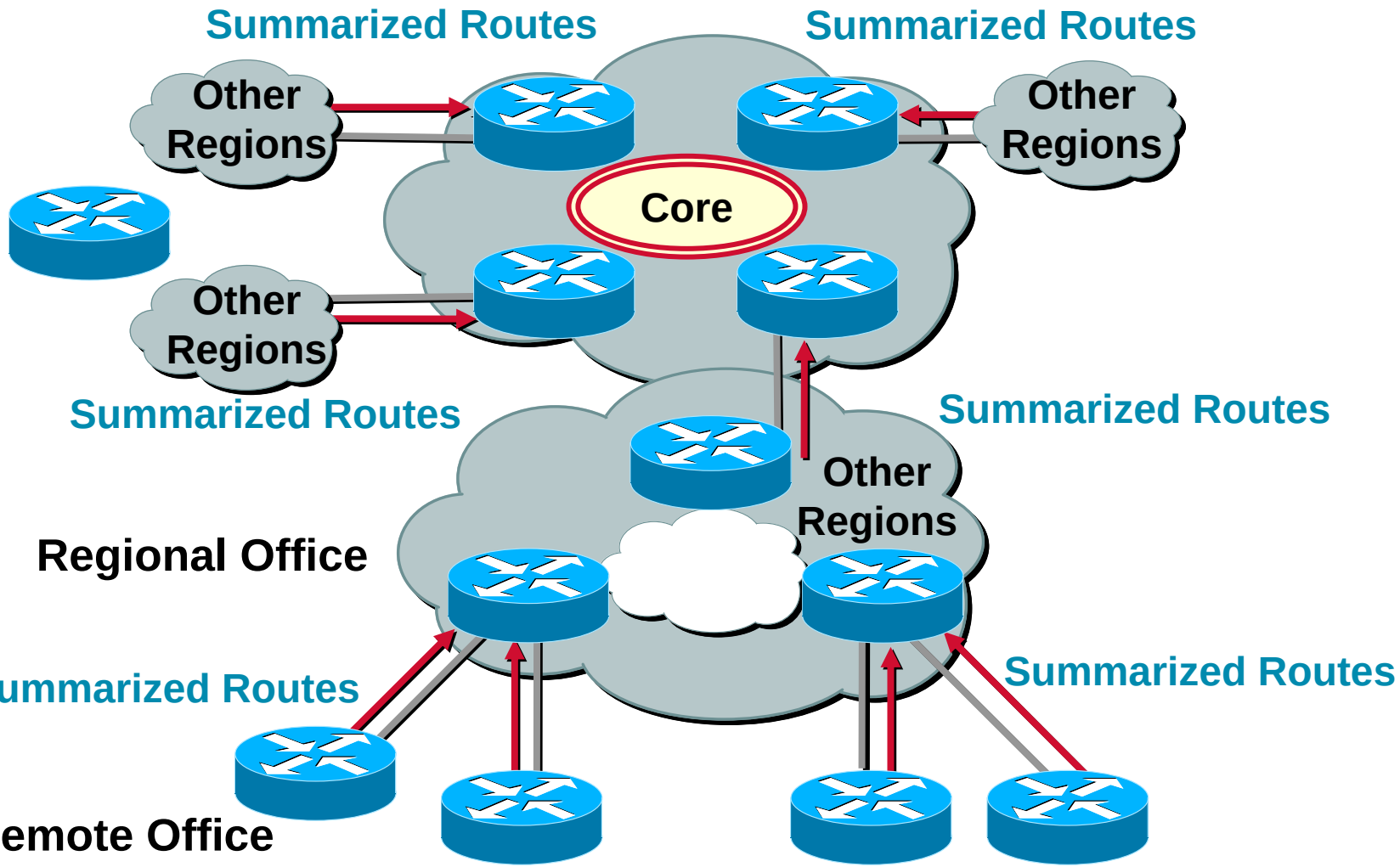
- **Bad addressing scheme**
  - **Subnets are everywhere throughout entire network**
- **Queries not bounded**

Scalable Network—Example



- **Readdress the network**
  - **Each region has its own block of addresses**
- **Queries bounded by using *ip summary-address eigrp* command**

Tiered Network Design



More EIGRP Scalability Rules

- Proper network resources
  - Sufficient memory on the router
  - Sufficient bandwidth on WAN interfaces
- Proper configuration of the bandwidth statement over WAN interfaces, especially over Frame Relay

Verifying EIGRP Operation

Verifying EIGRP Operation

Router#
```
show ip eigrp neighbors
```

Router#
```
show ip eigrp topology
```

Router#
```
show ip route eigrp
```

Router#
```
show ip protocols
```

Router#
```
show ip eigrp traffic
```

- Displays the neighbors discovered by IP EIGRP
- Displays the IP EIGRP topology table
- Displays current EIGRP entries in the routing table
- Displays the parameters and current state of the active routing protocol process
- Displays the number of IP EIGRP packets sent and received

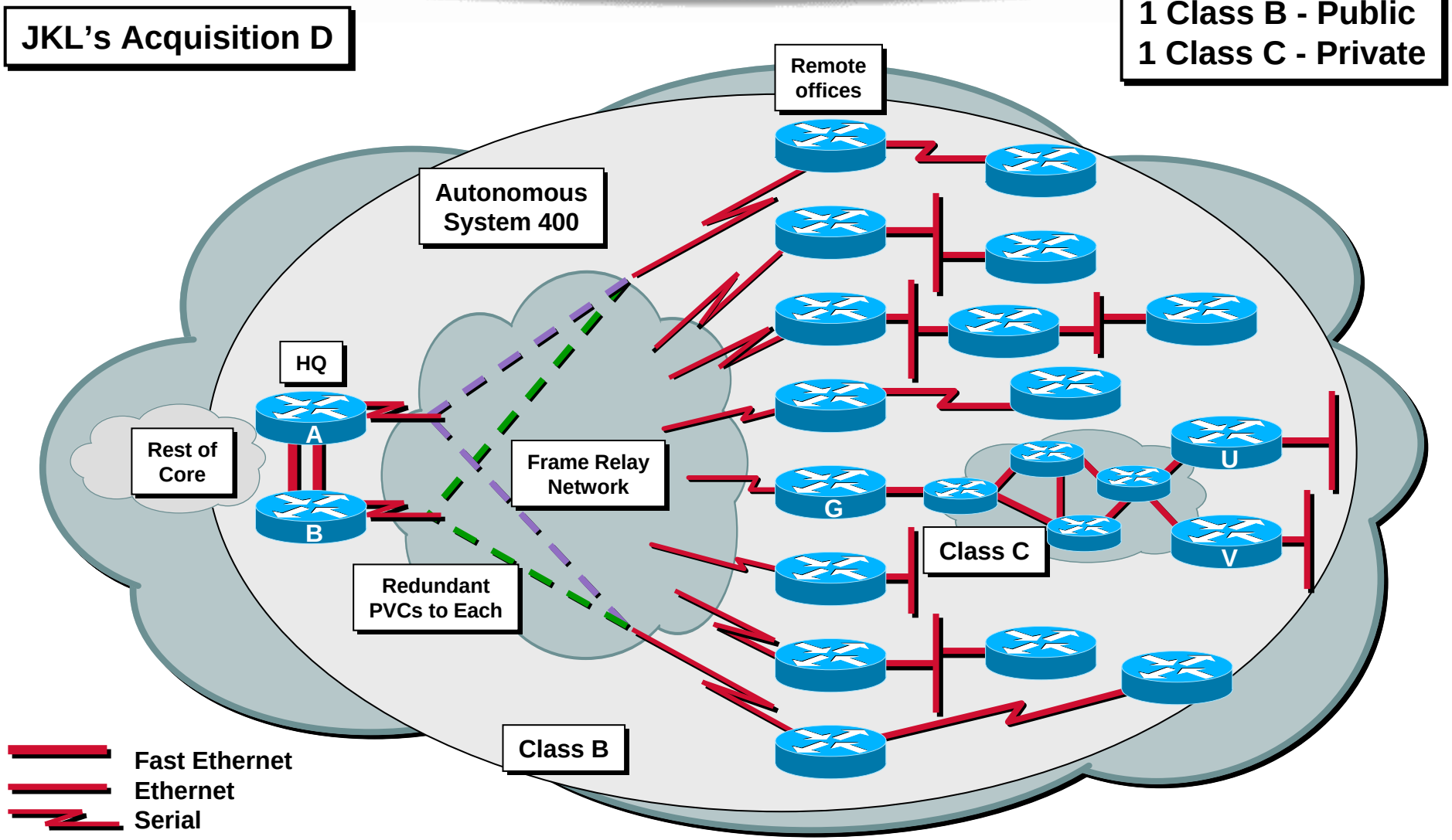
Verifying EIGRP Operation (cont.)

```
Router#
debug eigrp packet

Router#
debug eigrp neighbor

Router#
debug ip eigrp route

Router#
debug ip eigrp summary

Router#
show ip eigrp events
```

- Displays all types of EIGRP packets, both sent and received
- Displays the EIGRP neighbor interaction
- Displays advertisements and changes EIGRP makes to the routing table
- Displays a brief report of the EIGRP routing activity
- Displays the different categories of EIGRP activity, including route calculations

Case Study

Case Study—EIGRP



Lab Exercise

Summary

After completing this chapter, you should be able to perform the following tasks:

- **Describe EIGRP features and operation**
- **Explain how EIGRP discovers, chooses, and maintains routes**
- **Explain how EIGRP supports the use of VLSM**
- **Explain how EIGRP operates in an NBMA environment**
- **Explain how EIGRP supports the use of route summarization**

Summary (cont.)

- Describe how EIGRP supports large networks
- Configure EIGRP
- Verify EIGRP operation
- Given a set of network requirements, configure an EIGRP environment and verify proper operation (within described guidelines) of your routers
- Given a set of network requirements, configure EIGRP in an NBMA environment and verify proper operation (within described guidelines) of your routers

Review Questions

1. How are IGRP and EIGRP different in their metric calculation?
2. Why are EIGRP routing updates described as “reliable?”
3. What does it mean when a route is marked as a feasible successor?
4. What is the recommended practice for configuring bandwidth on a Frame Relay point-to-point subinterface?