SWINBURNE

CENTRE FOR ADVANCED INTERNET ARCHITECTURES

TNE20002/TNE70003

Topic 2: Routing Information Protocol (RIP)

Rev. 1.3

Outline

2.1 Distance Vector Protocols
- Characteristics

2.2 RIP
- RIP Characteristics
- RIP Message Format
- RIP commands

2.3 RIPv1 Auto-summarization
- Auto-summarization Example1
- Discontiguous Network Example2

2.4 RIPv2
- RIPv2 Characteristics
- RIPv2 Message Format
- RIPv2 commands

2.5 RIP Default Static Route
- RIP progagates Default Static Route

Types of Dynamic Routing Protocols

	Interior Gateway Protocols				Exterior Gateway Protocols
	Distance Vector		Link-State		Path Vector
IPv4	RIPv2	EIGRP	OSPFv2	IS-IS	BGP-4
IPv6	RIPng	EIGRP for IPv6	OSPFv3	IS-IS for IPv6	MBGP

Distance Vector protocols

The distance vector routing approach determines the direction (vector) & distance (such as link cost or number of hops) to any link in the network. The only information that a router knows about a remote network is the distance or metric to reach this network and which path or interface to use to get there. Distance vector routing protocols do not have an actual map of the network topology.

Link-State protocols

The link-state approach uses the Shortest Path First (SPF) algorithm to create an abstract of the exact topology of the entire network or at least within its area. A link-state routing protocol is like having a complete map of the network topology. The map is used to determine best path to a destination.

Path Vector protocols

Path information is used to determine the best paths and to prevent routing loops. Similar to distance vector protocols, path vector protocols do not have an abstract of the network topology. Path vector protocols indicate direction and distance, but also include additional information about the specific path of the destination.

Distance Vector Protocols

Distance + Vector

Distance + vector means that routes are advertised by providing two characteristics:

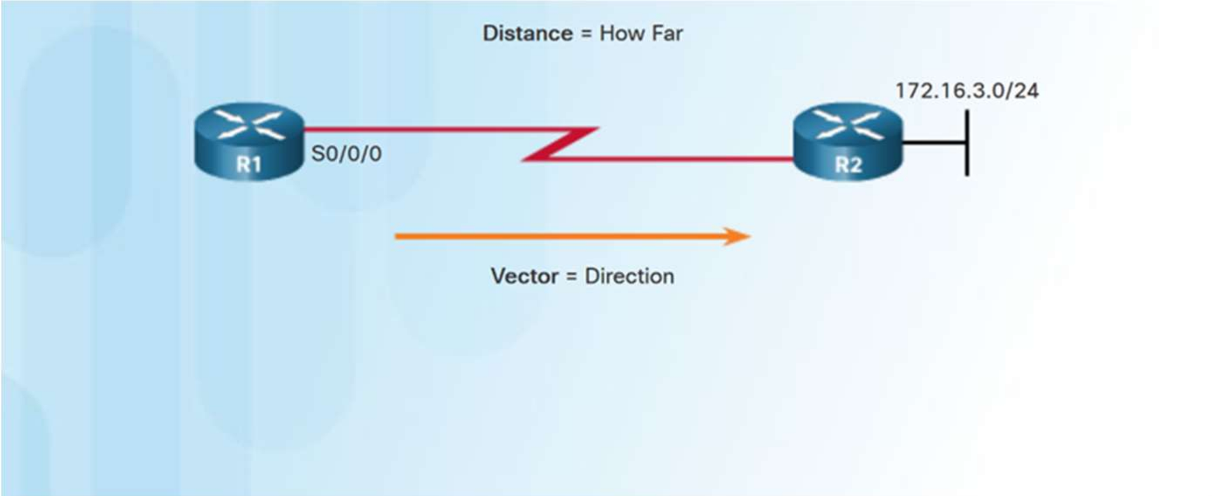
Distance - Identifies how far it is to the destination network based on a metric such as hop count, cost, bandwidth, delay.

Vector - Specifies the direction of the next-hop router or exit interface to reach the destination.

RIPv1 (legacy), RIPv2,

IGRP Cisco (obsolete),

EIGRP.



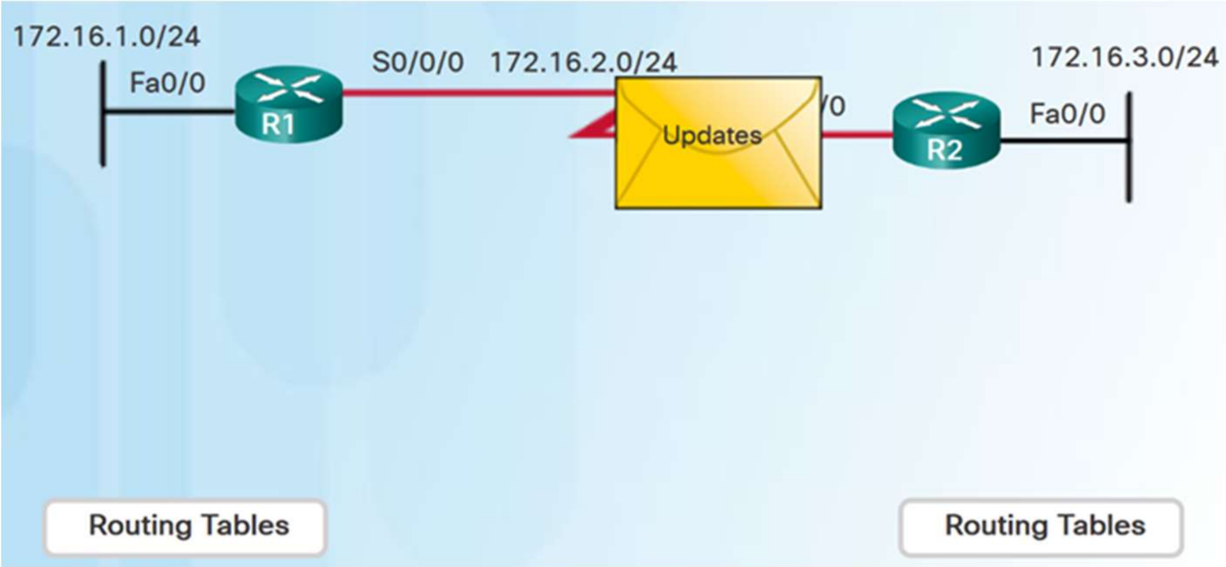
For R1, 172.16.3.0/24 is one hop away (distance). It can be reached through R2 (vector).

Distance Vector Protocols

Routing Protocol Updates

Operation of a dynamic routing protocol:

The router sends and receives routing messages on its interfaces.



The router shares routing messages &routing information with other routers using the same routing protocol.

Routers exchange routing information to learn about remote networks.

When a router detects a topology change, the routing protocol can advertise this change to other routers

Dynamic Routing Protocols

Main components of Dynamic Routing Protocols include:

- **Data structures** – A Routing Protocol uses **tables or databases** for their operations.
- These tables are stored in RAM.

- **Routing protocol message types**
  - To discover neighboring routers,
  - To exchange routing information,
  - To learn and maintain accurate information about the network.
- **Algorithm** - for least cost path determination.

Distance Vector Protocols

Distance Vector Algorithm

The ‘distance vector algorithm’ defines the following processes:

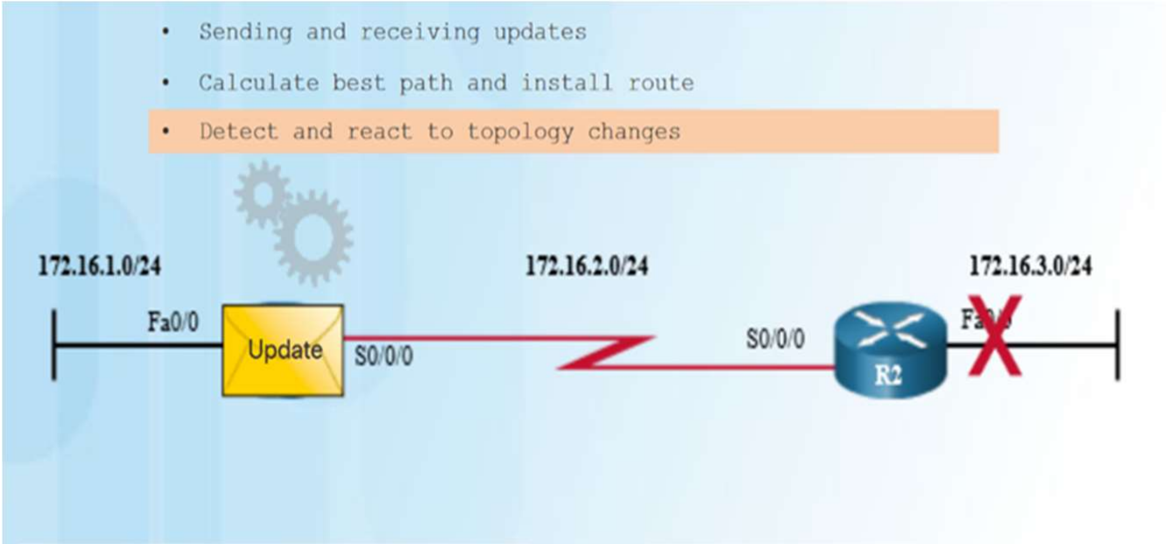
Mechanism for sending and receiving routing information

Mechanism for calculating the best paths and installing routes in the routing table

Mechanism for detecting and reacting to topology changes

RIP uses the Bellman-Ford routing algorithm.

IGRP and EIGRP use the Diffusing Update Algorithm (DUAL) routing algorithm.



Network	Interface	Hop
172.16.1.0/24	Fa0/0	0
172.16.2.0/24	S0/0/0	0
172.16.3.0/24	S0/0/0	1

Network	Interface	Hop
172.16.2.0/24	S0/0/0	0
~~172.16.3.0/24~~	~~Fa0/0~~	~~0~~
172.16.1.0/24	S0/0/0	1

Classful Routing Protocols

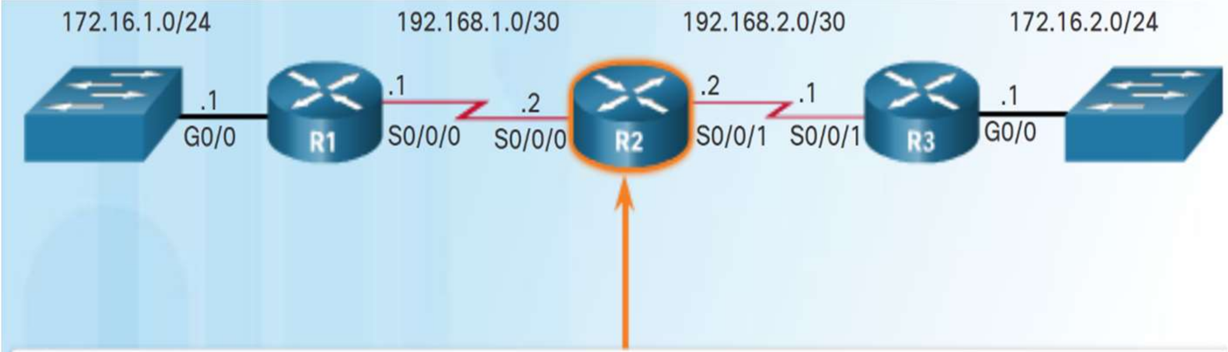
Classful Routing Protocols

Classful routing protocols do not send subnet mask information in routing updates.

Classful routing protocols cannot support variable-length subnet masks (VLSMs) and classless interdomain routing (CIDR).

Classful routing protocols create problems in discontiguous networks

Classless routing protocols include subnet mask information in the routing updates.




```
R2# ping 172.16.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 172.16.1.1, timeout is 2
seconds:
U.U.U
Success rate is 0 percent (0/5)
R2#
R2# traceroute 172.16.1.1
Type escape sequence to abort.
Tracing the route to 172.16.1.1
VRF info: (vrf in name/id, vrf out name/id)
  1 192.168.1.1 4 msec
    192.168.2.1 4 msec
    192.168.1.1 4 msec
R2#
```

Classless IPv4 routing protocols incl.
(RIPv2 , EIGRP, OSPF, and IS-IS)
These protocols include the subnet mask information in routing updates

Routing Protocols: Network Convergence

Network Convergence

- The network has converged when all routers have complete and accurate information (in their tables) about the network topology.

- Convergence process where routers notice change in the network, exchange information about the change, and perform necessary calculations to reevaluate the best routes.

- Convergence process is not Instantaneous

- It takes time for routers to
  - share information (collaborate with other routers),
  - determine least cost paths (independent of other routers),
  - update their tables

Topic 2.2

2.2 RIP

- RIP Characteristics
- RIP Message Format
- RIP commands

Routing Information Protocol RIP.

RIP Characteristics

- Classful Distance Vector protocol
- Periodically sends complete Routing Table to RIP Neighbour.
- Metric = Hop Count
- No. of Routers to reach the destination network.

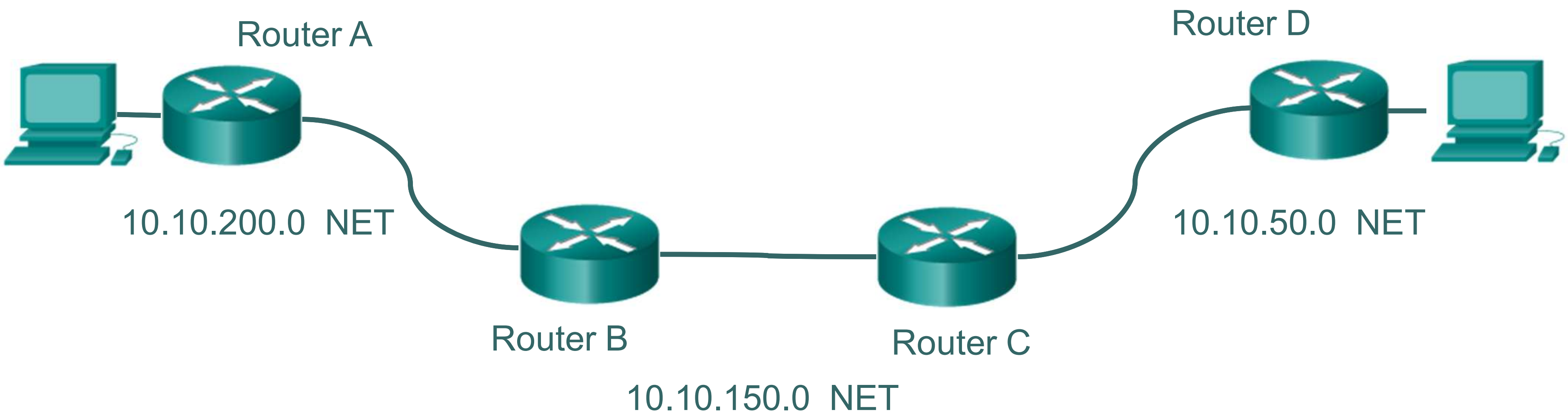
- Maximum Metric 15 Hops to prevent routing loops

- Default Administrative distance 120

- RIP Request Message
  - To request all RIP enabled devices to send Routing Table
- RIP Response Message
  - Response message containing Routing Table

Routing Protocols

Counting Hops on contiguous Network



Counting Hops

From	To	Hop Count
Router A	10.10.200.0	0
Router A	10.10.150.0	1
Router A	10.10. 50.0	2

RIPv1 – Message Format

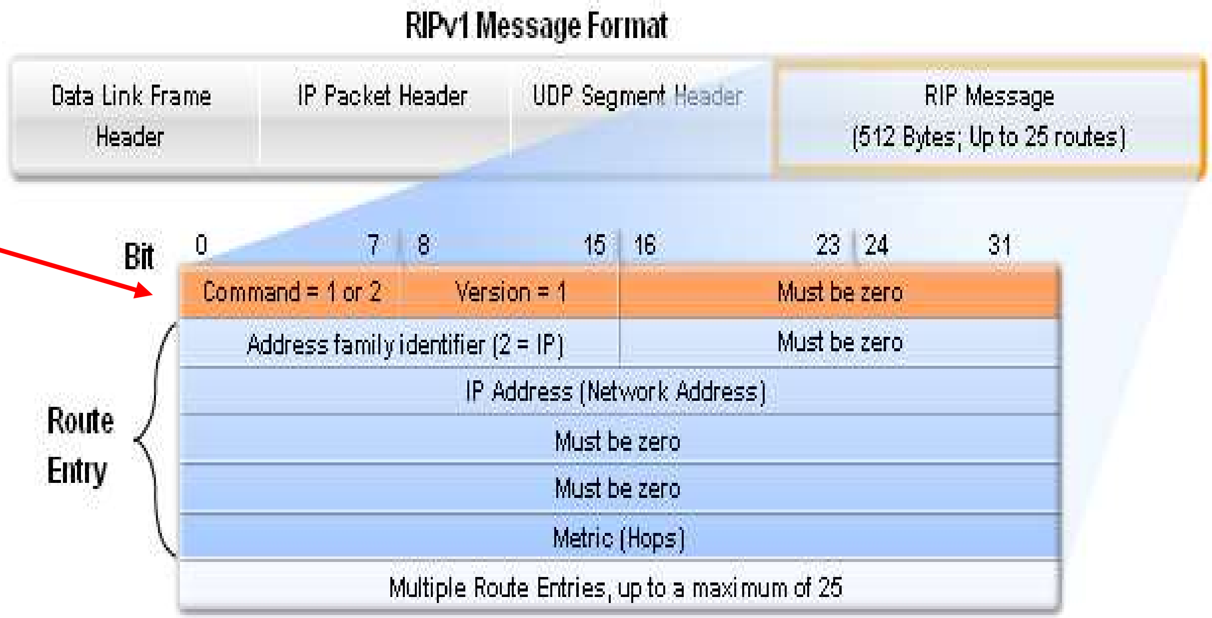
RIP header - fields:

Command field

- 1.Request 2.Response
- Version field
- ‘0x01 → RIPv1
- Must be zero

Route Entry - fields:

- Address family identifier
- 2. IP
- IP address
  Destination IP address
- Metric or Cost of route
- Hops



Command	1 for a Request or 2 for a Reply.
Version	1 for RIP v 1 or 2 for RIP v 2.
Address Family Identifier	2 for IP unless a Request is for the full routing table in which case, set to 0.
IP Address	The address of the destination route, which may be a network, subnet, or host address.
Metric	Hop count between 1 and 16. Sending router increases the metric before sending out message.

RIPv1 – Scenario A

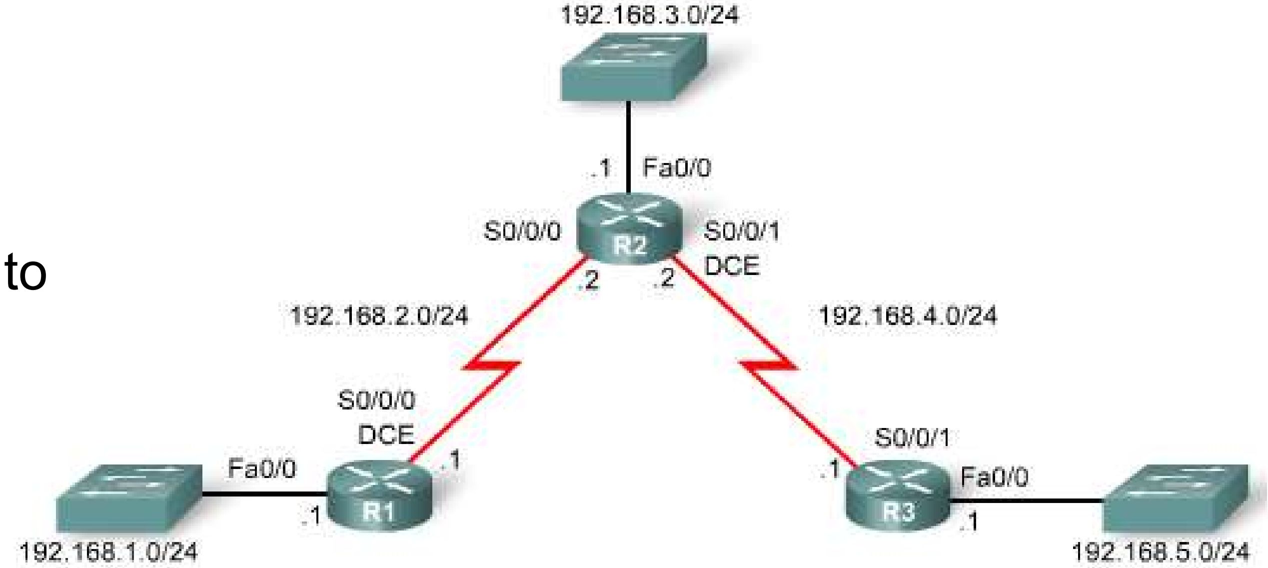
Topology includes:

- Three routers
- Use of 5 different IP subnets

- Need to tell the router which networks (subnets) to advertise to other routers
    - •Why don't we advertise all routes?

- Do not configure router with networks known by other routers
    - •We let those routers advertise those routes to us

RIP Topology: Scenario A



Addressing Table: Scenario A

Device	Interface	IP Address	Subnet Mask
R1	Fa0/0	192.168.1.1	255.255.255.0
	S0/0/0	192.168.2.1	255.255.255.0
R2	Fa0/0	192.168.3.1	255.255.255.0
	S0/0/0	192.168.2.2	255.255.255.0
	S0/0/1	192.168.4.2	255.255.255.0
R3	Fa0/0	192.168.5.1	255.255.255.0
	S0/0/1	192.168.4.1	255.255.255.0

RIPv1 – Scenario A

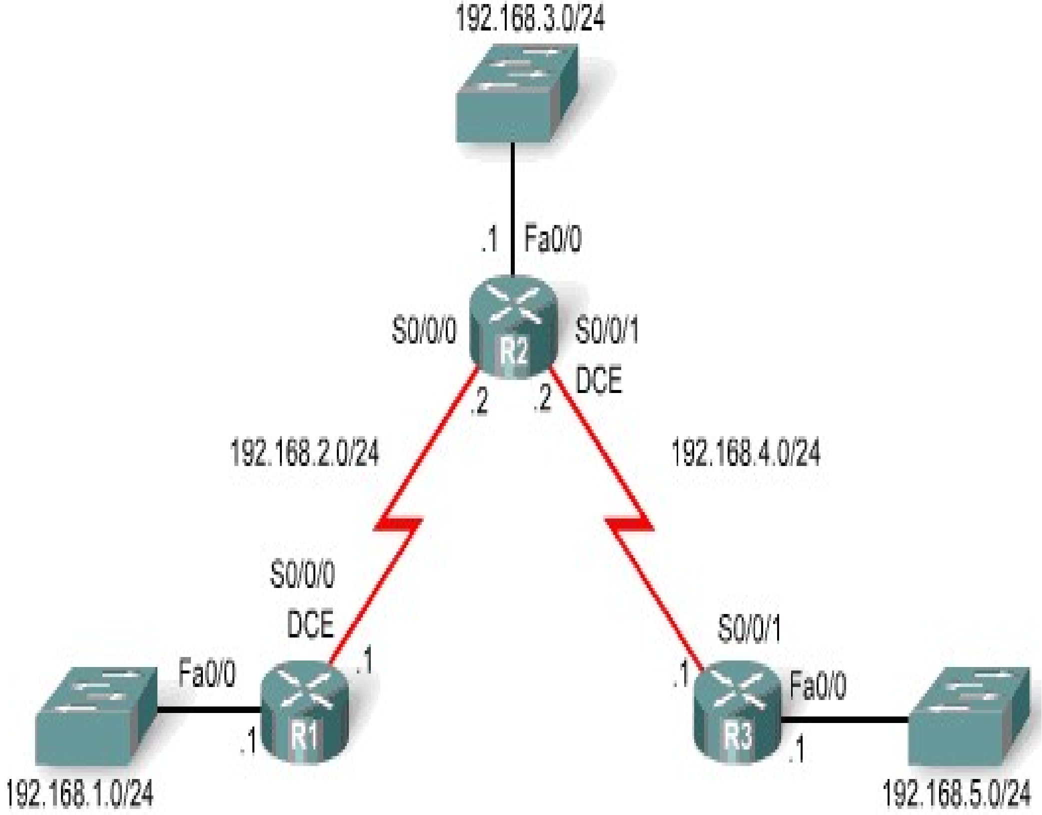
network Command:

- Specifying network(s)
- Enable RIP on all interfaces that belong to the network(s)
- Advertise connected network(s) in RIP updates

```
R1(config)#router rip
R1(config-router)#network 192.168.1.0
R1(config-router)#network 192.168.2.0
```

```
R2(config)#router rip
R2(config-router)#network 192.168.2.0
R2(config-router)#network 192.168.3.0
R2(config-router)#network 192.168.4.0
```

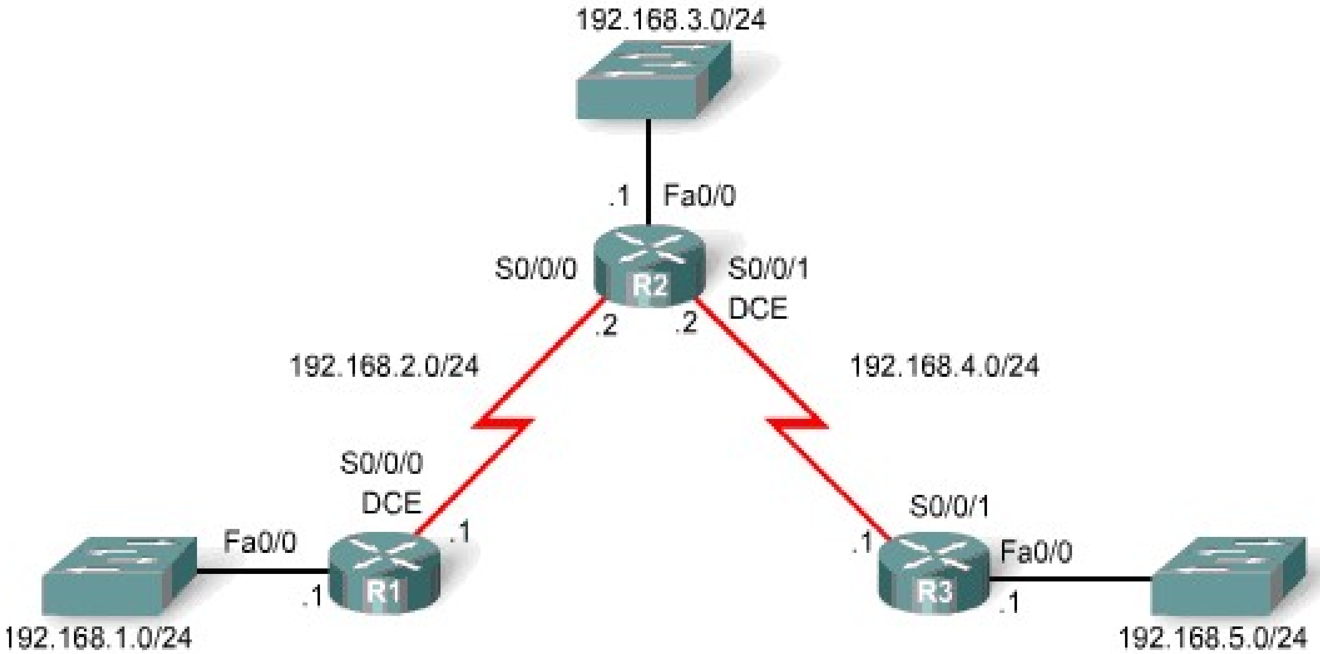
```
R3(config)#router rip
R3(config-router)#network 192.168.4.0
R3(config-router)#network 192.168.5.0
```



RIPv1 - Verification

RIP show commands:

- show ip route
- show ip protocols
- debug ip rip



RIP route

```
R 192.168.5.0/24 [120/2] via 192.168.2.2, 00:00:23, Serial 0/0/0
```

Interpreting a RIP Route in the Routing Table

R	Identifies the source of the route as RIP.
192.168.5.0	Indicates the address of the remote network.
/24	The subnet mask used for this network
[120/2]	The administrative distance (120) and the metric (2 hops)
via 192.168.2.2	Specifies the address of the next-hop router (R2) to send traffic to for the remote network.
00:00:23	Specifies the amount of time since the route was updated (here, 23 seconds). Another update is due in 7 seconds.
Serial0/0/0	192.168.2.1

RIPv1 - Verification

RIP commands:

- debug ip rip

Debug ip rip

R1#
R1#debug ip rip
RIP protocol debugging is on

RIP received update

RIP: received v1 update from 192.168.2.2 on Serial0/0/0
    192.168.3.0 in 1 hops
    192.168.4.0 in 1 hops
    192.168.5.0 in 2 hops

RIP sending update

RIP: sending v1 update to 255.255.255.255 via Serial0/0/0 (192.168.2.1)
RIP: build update entries
    network 192.168.1.0 metric 1

- undebug all

R1#undebug all
All possible debugging has been turned off
R1#

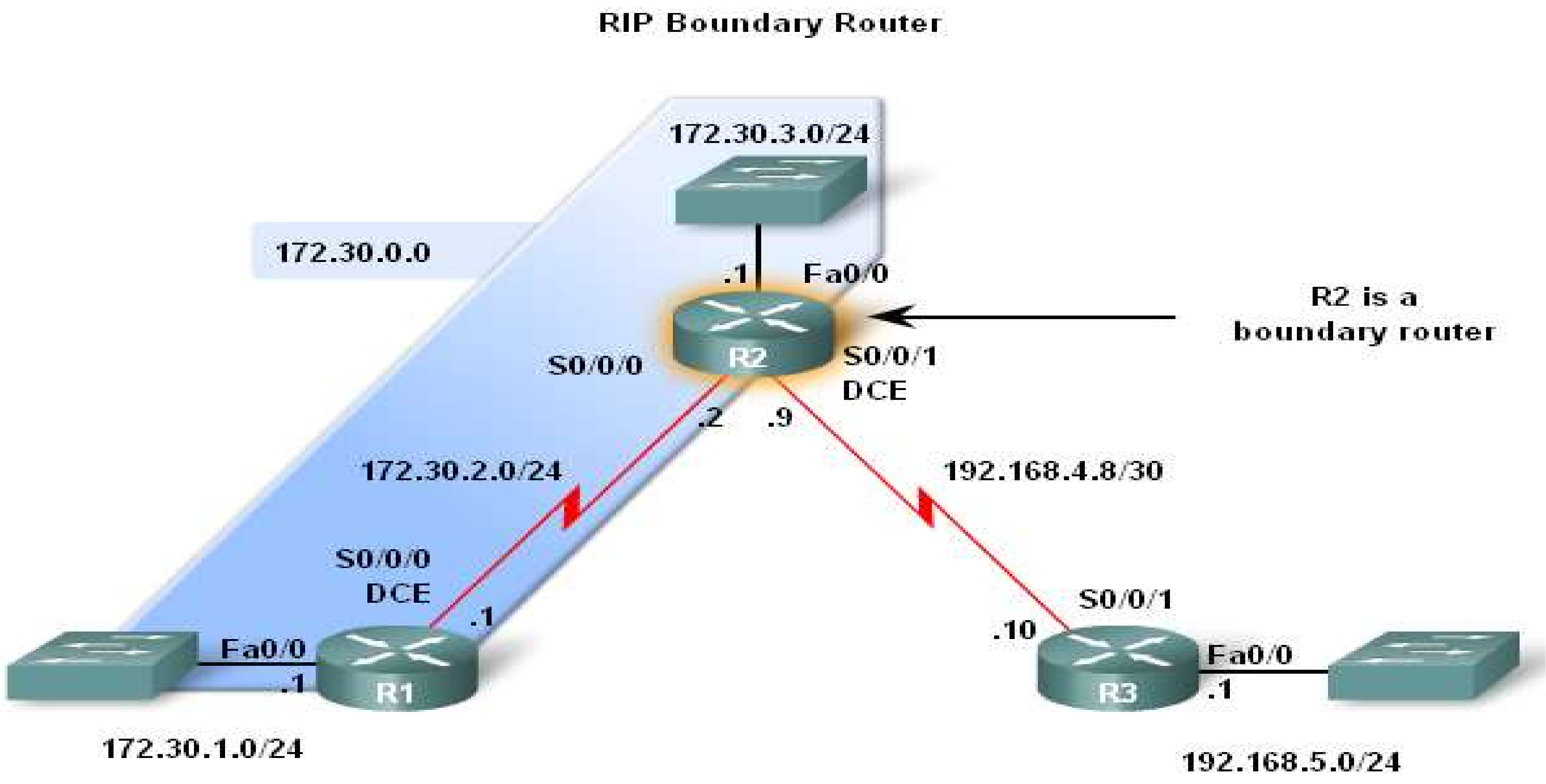
Topic 2.3

2.3 Auto-summarization

- Auto-summarization Example 1
- Discontiguous Network Example 2

RIPv1 - Automatic Summarization – Boundary Routers

- RIP automatically summarizes classful networks
- Boundary routers summarize RIP subnets from one major network to another.



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RIPv1 - Automatic Summarization – Sending RIP Updates

RIP uses automatic summarization to reduce the size of a routing table.

```
R1#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       <remaining codes omitted>

Gateway of last resort is not set

     172.30.0.0/24 is subnetted, 3 subnets
C       172.30.1.0 is directly connected, FastEthernet0/0
C       172.30.2.0 is directly connected, Serial0/0/0
R       172.30.3.0 [120/1] via 172.30.2.2, 00:00:17, Serial0/0/0
R    192.168.4.0/24 [120/1] via 172.30.2.2, 00:00:17, Serial0/0/0
R    192.168.5.0/24 [120/2] via 172.30.2.2, 00:00:17, Serial0/0/0
```

```
R2#debug ip rip
RIP protocol debugging is on
RIP: sending  v1 update to 255.255.255.255 via Serial0/0/0 (172.30.2.2)
RIP: build update entries
      network 172.30.3.0 metric 1
      network 192.168.4.0 metric 1
      network 192.168.5.0 metric 2
RIP: sending  v1 update to 255.255.255.255 via Serial0/0/1 (192.168.4.9)
RIP: build update entries
      network 172.30.0.0 metric 1
R2#undebug all
All possible debugging has been turned off
R2#
```

Routes sent to R1.

```
R3#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BGP
       <remaining codes omitted>

Gateway of last resort is not set

R    172.30.0.0/16 [120/1] via 192.168.4.9, 00:00:15, Serial0/0/1
     192.168.4.0/30 is subnetted, 1 subnets
C       192.168.4.8 is directly connected, Serial0/0/1
C    192.168.5.0/24 is directly connected, FastEthernet0/0
```

Compare R1 and R3 Routes for Network 172.30.0.0

No Summary

RIP Updates

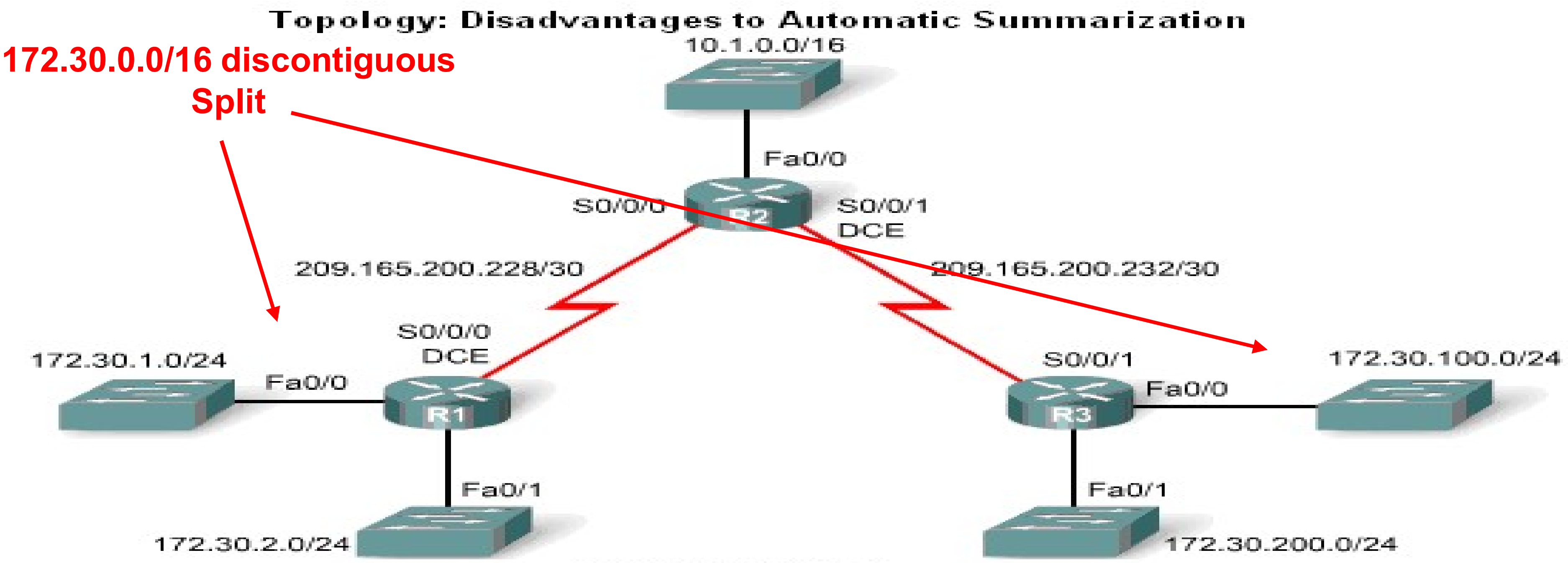
Summary

A SINGLE Summarized route

.

RIPv1 - Automatic Summarization - Disadvantage

RIPv1 does not support discontiguous (split) networks



Addressing Table

Subnet Mask	Subnet Mask	Subnet Mask	Subnet Mask
R1	Fa0/0	172.30.1.1	255.255.255.0
	Fa0/1	172.30.2.1	255.255.255.0
	S0/0/0	209.165.200.229	255.255.255.252
R2	Fa0/0	10.1.0.1	255.255.255.0
	S0/0/0	209.165.200.230	255.255.255.252
	S0/0/1	209.165.200.233	255.255.255.252
R3	Fa0/0	172.30.100.1	255.255.255.0
	Fa0/0	172.30.200.1	255.255.255.0
	S0/0/1	209.165.200.234	255.255.255.252

RIPv1 – Auto-Summarization

R1 Routing Table

R1 show ip route

RIP

RIP

```
R1#
R1#sh ip route
Codes: L - local, C - connected, S - static, R - RIP, M - mobile, B - BGP
       D - EIGRP, EX - EIGRP external, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2, E - EGP
       i - IS-IS, 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
------------
R     10.0.0.0/8 [120/1] via 209.165.200.230, 00:00:14, Serial0/0/0
     172.30.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.30.1.0/24 is directly connected, FastEthernet0/0
L       172.30.1.1/32 is directly connected, FastEthernet0/0
C       172.30.2.0/24 is directly connected, FastEthernet0/1
L       172.30.2.1/32 is directly connected, FastEthernet0/1
     209.165.200.0/24 is variably subnetted, 3 subnets, 2 masks
C       209.165.200.228/30 is directly connected, Serial0/0/0
L       209.165.200.229/32 is directly connected, Serial0/0/0
R       209.165.200.232/30 [120/1] via 209.165.200.230, 00:00:14, Serial0/0/0
------------
```

RIPv1 – Auto-Summarization

R1 Debug ip rip

R1.

- debug ip rip

R1#
R1#debug ip rip
RIP protocol debugging is on

RIP received update

R1#RIP: received v1 update from 209.165.200.230 on Serial0/0/0
 10.0.0.0 in 1 hops
 209.165.200.232 in 1 hops

RIP sending update

R1#RIP: sending v1 update to 255.255.255.255 via Serial0/0/0 (209.165.200.229)
RIP: build update entries
 network 172.30.0.0 metric 1

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RIPv1 – Auto-Summarization

R2 show ip route

RIP

R2 Routing Table

```
R2#
R2#sh ip route
------------

Gateway of last resort is not set
------------
 10.0.0.0/8 is variably subnetted, 2 subnets, 2 masks
C       10.1.0.0/16 is directly connected, FastEthernet0/0
L       10.1.0.1/32 is directly connected, FastEthernet0/0
R    172.30.0.0/16 [120/1] via 209.165.200.229, 00:00:23, Serial0/0/0
                   [120/1] via 209.165.200.234, 00:00:08, Serial0/0/1
     209.165.200.0/24 is variably subnetted, 4 subnets, 2 masks
C       209.165.200.228/30 is directly connected, Serial0/0/0
L       209.165.200.230/32 is directly connected, Serial0/0/0
C       209.165.200.232/30 is directly connected, Serial0/0/1
L       209.165.200.233/32 is directly connected, Serial0/0/1

R2#
------------
```

RIPv1 – Auto-Summarization

R3 show ip route

R3 Routing Table

RIP

RIP

```
R3#
R3#sh ip route
------------

Gateway of last resort is not set
------------
R    10.0.0.0/8 [120/1] via 209.165.200.233, 00:00:24, Serial0/0/1
     172.30.0.0/16 is variably subnetted, 4 subnets, 2 masks
C       172.30.100.0/24 is directly connected, FastEthernet0/0
L       172.30.100.1/32 is directly connected, FastEthernet0/0
C       172.30.200.0/24 is directly connected, FastEthernet0/1
L       172.30.200.1/32 is directly connected, FastEthernet0/1
     209.165.200.0/24 is variably subnetted, 3 subnets, 2 masks
R       209.165.200.228/30 [120/1] via 209.165.200.233, 00:00:24, Serial0/0/1
C       209.165.200.232/30 is directly connected, Serial0/0/1
L       209.165.200.234/32 is directly connected, Serial0/0/1

R3#
------------
```

2.4 RIP v2

- RIPv2 Characteristics
- RIPv2 Message Format
- RIPv2 commands

RIPv2 Characteristics

- Classless Distance Vector Protocol
- RFC 1723 – 1994, RFC 2453 - 1998

- Uses well known port 520
- Administrative distance 120
- Metric Hop Count
- Maximum Hop Limit 15

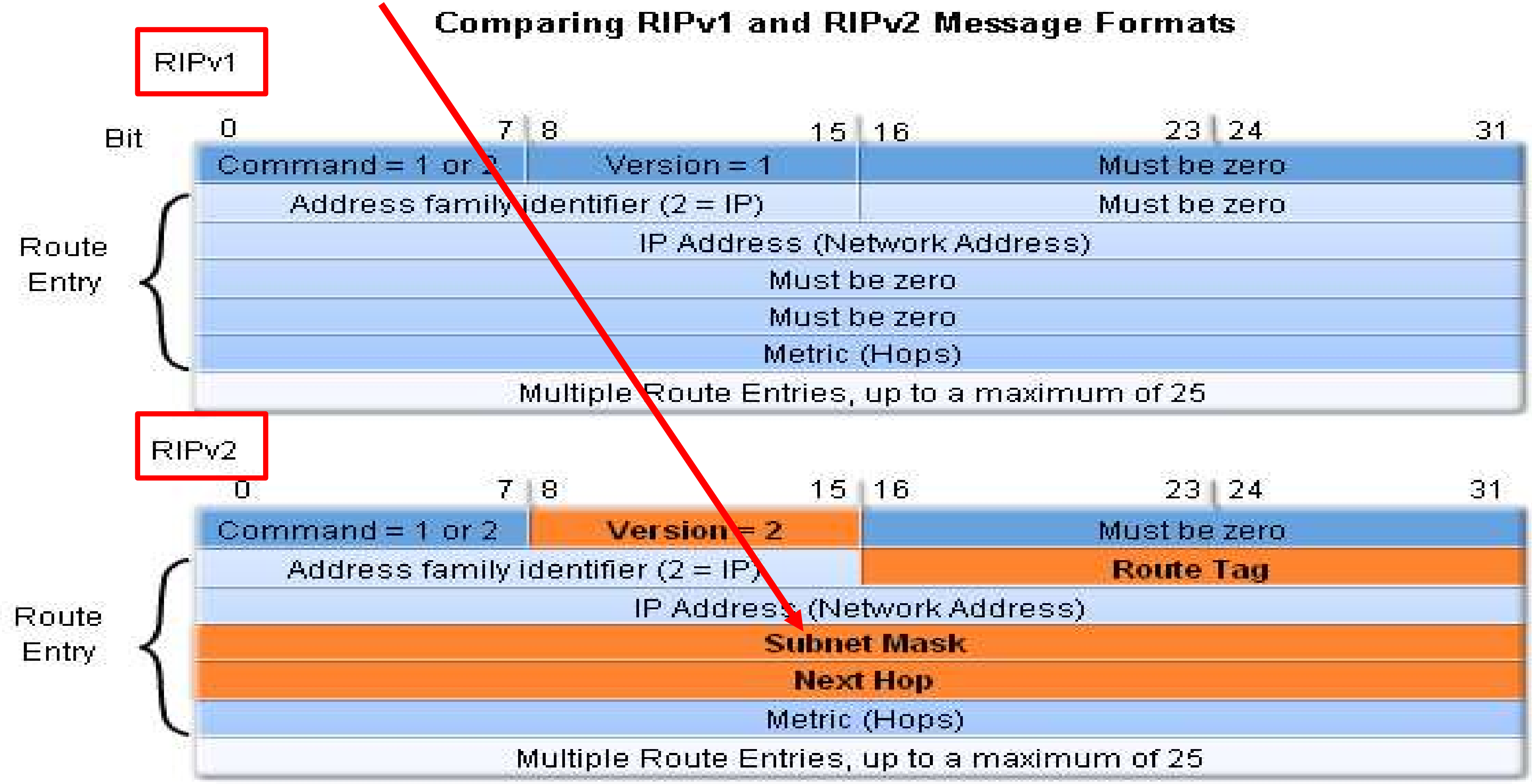
Characteristics and Features	RIPv1	RIPv2
Metric	Both use hop count as a simple metric. The maximum number of hops is 15.	
Updates Forwarded to Address	255.255.255.255	224.0.0.9
Supports VLSM	✗	✓
Supports CIDR	✗	✓
Supports Summarization	✗	✓
Supports Authentication	✗	✓

- Supports VLSM, includes subnet mask in RIP update
- Next hop address is included in update
- Periodic updates every 30 secs
- Triggered updates on link failure

- Routing updates are multicast, 224.0.0.9
- Use debug ip rip to view multicasting of updates
- authentication is an option

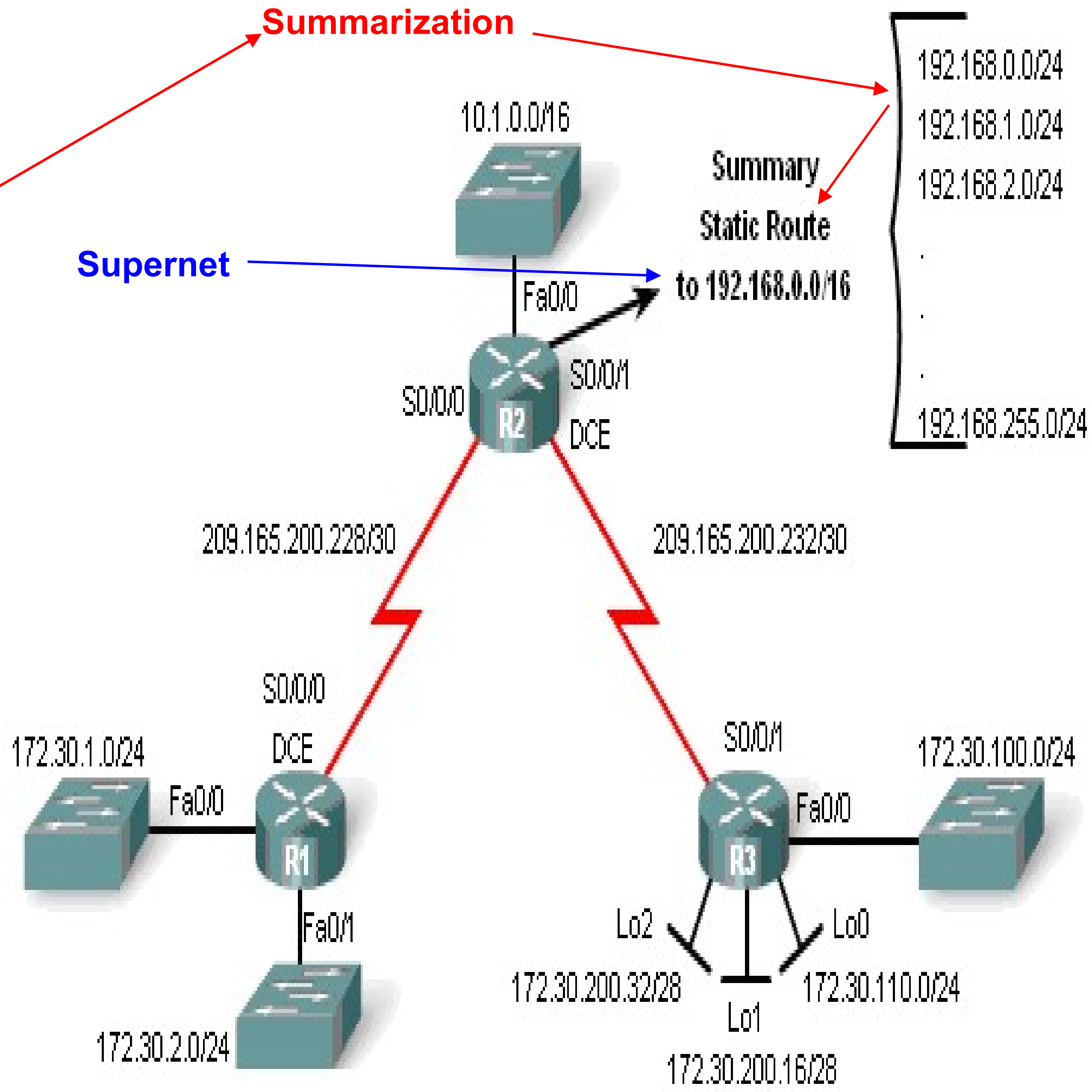
Comparing RIPv2 & RIPv1 Message Formats

- RIPv2 Message format has extensions:
  - A subnet mask field
  - The addition of next hop address



RIPv2 - Summarization

- Automatically summarizes routes at major network boundaries
- Can also summarize routes with a subnet mask that is smaller than the classful subnet mask
- To disable automatic summarization issue the *no auto-summary* command



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RIPv2 – Updates include (VLSM) Subnet Masks

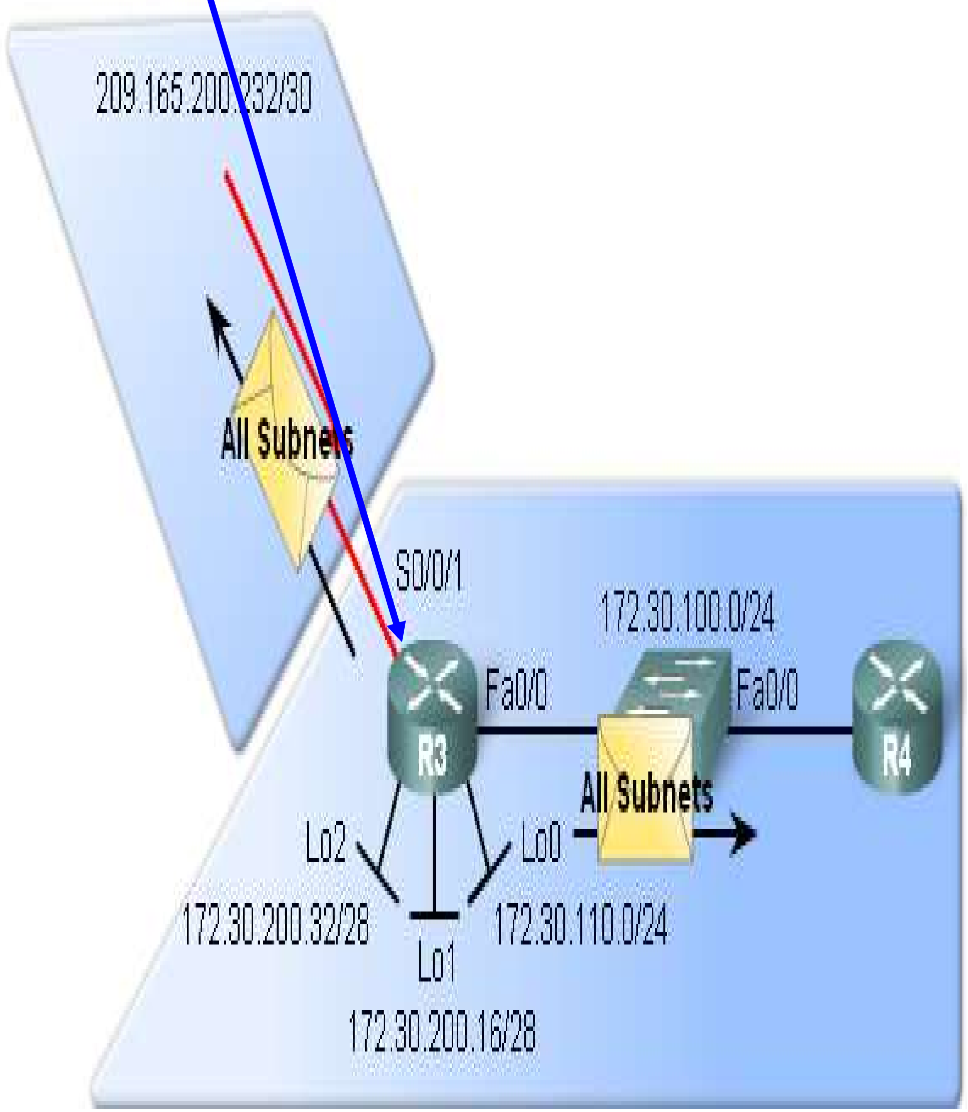
Use the *debug ip rip*

R3 Debug Output

```
R3#debug ip rip
RIP protocol debugging is on
R3#
RIP: received v2 update from 209.165.200.233 on Serial0/0/1
     10.1.0.0/16 via 0.0.0.0 in 1 hops
     172.30.1.0/24 via 0.0.0.0 in 2 hops
     172.30.2.0/24 via 0.0.0.0 in 2 hops
     192.168.0.0/16 via 0.0.0.0 in 1 hops
     209.165.200.228/30 via 0.0.0.0 in 1 hops
R3#
RIP: sending v2 update to 224.0.0.9 via FastEthernet0/0 (172.30.100.1)
RIP: build update entries
        10.1.0.0/16 via 0.0.0.0, metric 2, tag 0
        172.30.1.0/24 via 0.0.0.0, metric 3, tag 0
        172.30.2.0/24 via 0.0.0.0, metric 3, tag 0
        172.30.110.0/24 via 0.0.0.0, metric 1, tag 0
        172.30.200.16/28 via 0.0.0.0, metric 1, tag 0
        172.30.200.32/28 via 0.0.0.0, metric 1, tag 0
        192.168.0.0/16 via 0.0.0.0, metric 2, tag 0
        209.165.200.228/30 via 0.0.0.0, metric 2, tag 0
        209.165.200.232/30 via 0.0.0.0, metric 1, tag 0
RIP: sending v2 upda 209.165.200.233  Serial0/0/1 (209.165.200.234)
RIP: build update entries
        172.30.100.0/24 via 0.0.0.0, metric 1, tag 0
        172.30.110.0/24 via 0.0.0.0, metric 1, tag 0
        172.30.200.16/28 via 0.0.0.0, metric 1, tag 0
        172.30.200.32/28 via 0.0.0.0, metric 1, tag 0
```

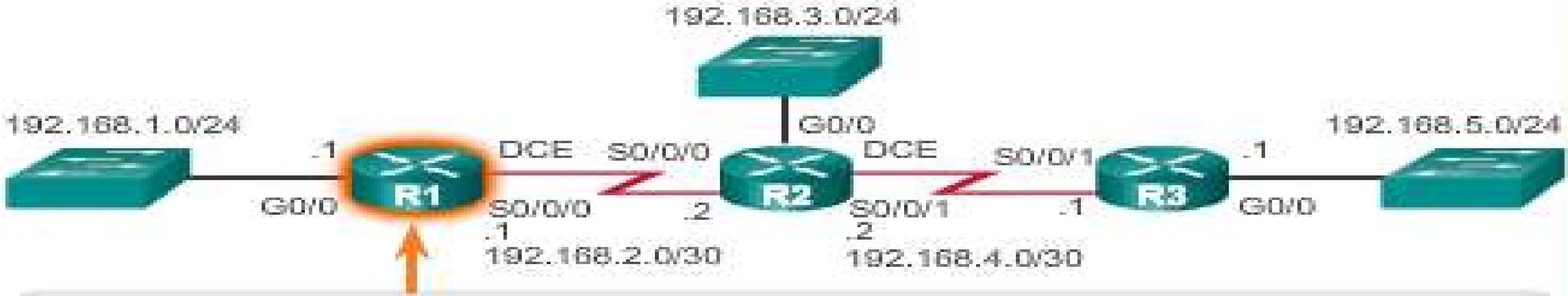
RIPv2 supports VLSM

R3 Debug Output



Enabling RIPv2

Enable and Verify RIPv2 on R1




```
R1(config)# router rip
R1(config-router)# version 2
R1(config-router)# ^Z
R1#
R1# show ip protocols | section Default
  Default version control: send version 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    GigabitEthernet0/0     2     2
    Serial0/0/0            2     2
R1#
```

RIPv2 – Advertising Directly Connected Networks

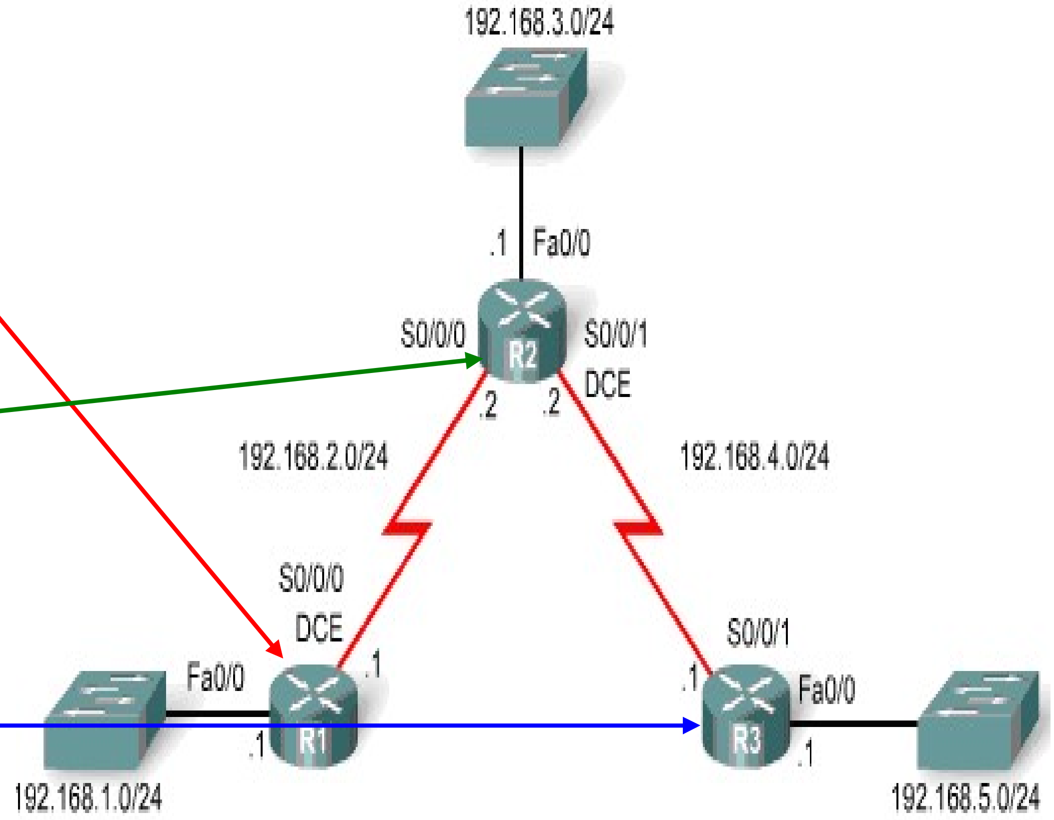
The network Command:

- Specifies network to be advertised
- Enables RIP on all interfaces that belong to the networks
- You advertise, only the directly connected networks, on any given router

```
R1(config)# router rip
R1(config-router) version 2
R1(config-router) network 192.168.1.0
R1(config-router) network 192.168.2.0

R2(config)# router rip
R2(config-router) version 2
R2(config-router) network 192.168.2.0
R2(config-router) network 192.168.3.0
R2(config-router) network 192.168.4.0

R3(config)# router rip
R3(config-router) version 2
R3(config-router) network 192.168.4.0
R3(config-router) network 192.168.5.0
```

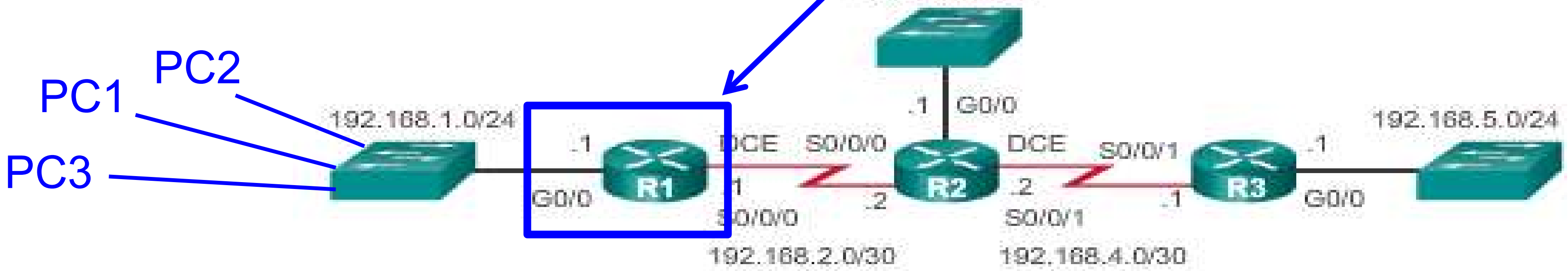


Configuring Passive Interfaces R1

Sending out unneeded updates to LANs impacts the network:

- Wasted Bandwidth on Link
- Wasted CPU Resources on PCs
- Security Risk, routing tables reveal network topology

Configuring Passive Interfaces on R1




```
R1(config)# router rip
R1(config-router)# passive-interface g0/0
R1(config-router)# end
R1#
R1# show ip protocols | begin Default
  Default version control: send version 2, receive version 2
    Interface             Send  Recv  Triggered RIP  Key-chain
    Serial0/0/0           2     2
  Automatic network summarization is not in effect
  Maximum path: 4
  Routing for Networks:
    192.168.1.0
    192.168.2.0
  Passive Interface(s):
    GigabitEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    192.168.2.2          120      00:00:06
  Distance: (default is 120)

R1#
```

2.5 RIP Default Static Route

- RIP propagates Default Static Route

Default Static Routes

Static routes are manually configured and define an explicit path between two networking devices.

- There are two main types of static routes in the routing table:

Static route to a specific network

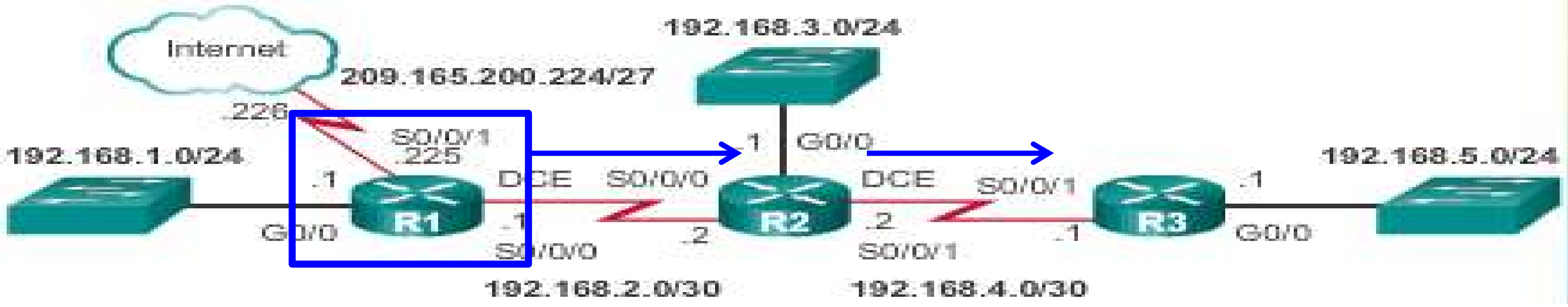
- IPv4 static routes are configured using the following command:
  - **ip route** network-address subnet-mask { *next-hop-ip* | *exit-intf* }
- A static route appears in the routing table with the code ‘S’.

Default Static route

- A “default static route” is similar to a default gateway on a PC or host.
- The “default route” specifies exit point to use when the routing table does not have a path for the destination network. Use the command:
  - **ip route** 0.0.0.0 0.0.0.0 { exit-intf | next-hop-ip }
  - Candidate “default route” appears in routing table with the code ‘S * ’.

R1 Gateway Propagating a Default Route to R2,R3

Propagating a Default Route on R1




```
R1(config)# ip route 0.0.0.0 0.0.0.0 S0/0/1 209.165.200.226
R1(config)# router rip
R1(config-router)# default-information originate
R1(config-router)# ^Z
R1#
*Mar 10 23:33:51.801: %SYS-5-CONFIG_I: Configured from
console by console
R1# show ip route | begin Gateway
Gateway of last resort is 209.165.200.226 to network
0.0.0.0

S*     0.0.0.0/0 [1/0] via 209.165.200.226, Serial0/0/1
       192.168.1.0/24 is variably subnetted, 2 subnets, 2
masks
C         192.168.1.0/24 is directly connected,
GigabitEthernet0/0
L         192.168.1.1/32 is directly connected,
GigabitEthernet0/0
       192.168.2.0/24 is variably subnetted, 2 subnets, 2
masks
C         192.168.2.0/24 is directly connected, Serial0/0/0
L         192.168.2.1/32 is directly connected, Serial0/0/0
R      192.168.3.0/24 [120/1] via 192.168.2.2, 00:00:08,
```

Review

2.1 Distance Vector Protocols

- Characteristics

2.2 RIP

- RIP Characteristics
- RIP Message Format
- RIP commands

2.3 RIPv1 Auto-summarization

- Auto-summarization Example1
- Discontiguous Network Example2

2.4 RIPv2

- RIPv2 Characteristics
- RIPv2 Message Format
- RIPv2 commands

2.5 RIP Default Static Route

- RIP propagates Default Static Route