RIP version 2
Access Control Lists

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RIP version 2

- Introduction
- RIPv1 Limitations
- Configuring RIPv2
- VLSM & CIDR
- Verifying & Troubleshooting RIPv2

Access Control Lists

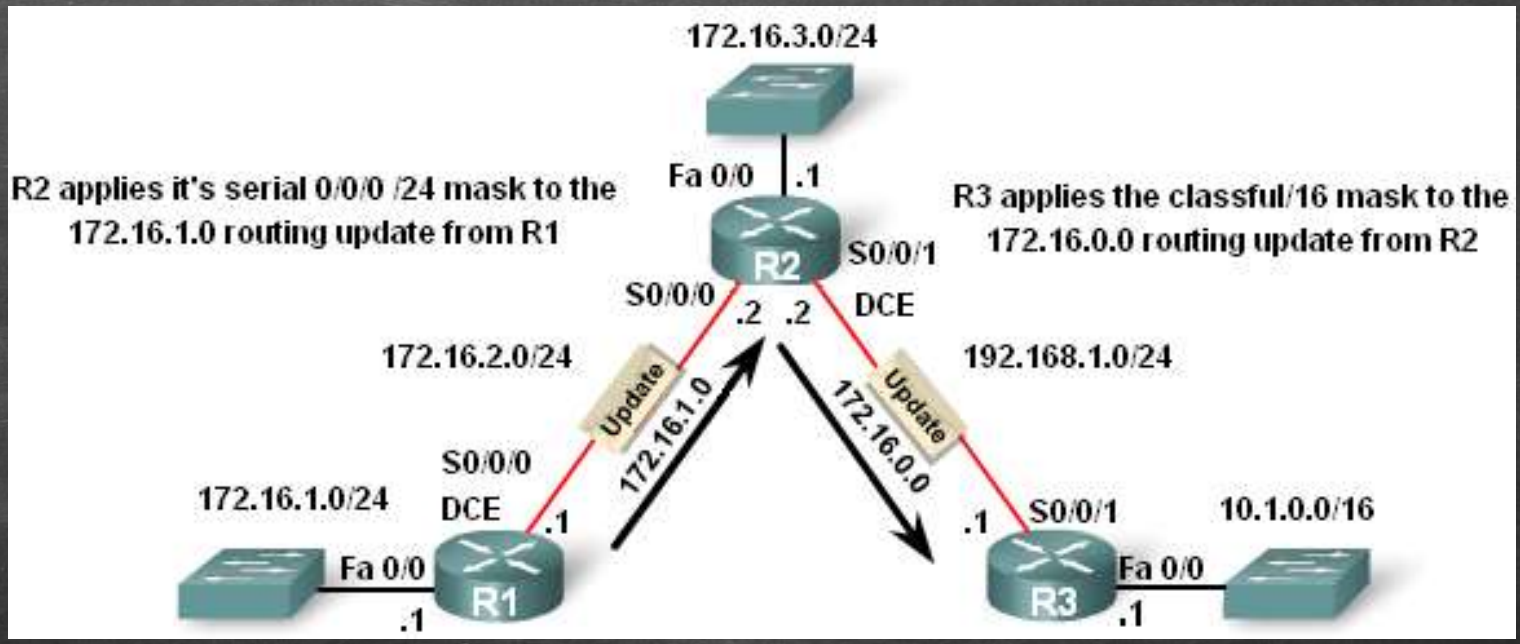
- Standard versus Extended IPv4 ACLs
- Wildcard Masks in ACLs
- Guidelines for ACL creation
- Configure Standard IPv4 ACLs
- Configure Extended IPv4 ACLs
- Limiting Debug / Processing Packets / Errors

Introduction

- Difference between RIPv1 & RIPv2
  - RIPv1
    - A classful distance vector routing protocol
    - Does not support discontiguous subnets
    - Does not support VLSM
    - Does not send subnet mask in routing update
    - Routing updates are broadcast
  - RIPv2
    - A classless distance vector routing protocol that is an enhancement of RIPv1's features.
    - Next hop address is included in updates
    - Routing updates are multicast
    - The use of authentication is an option

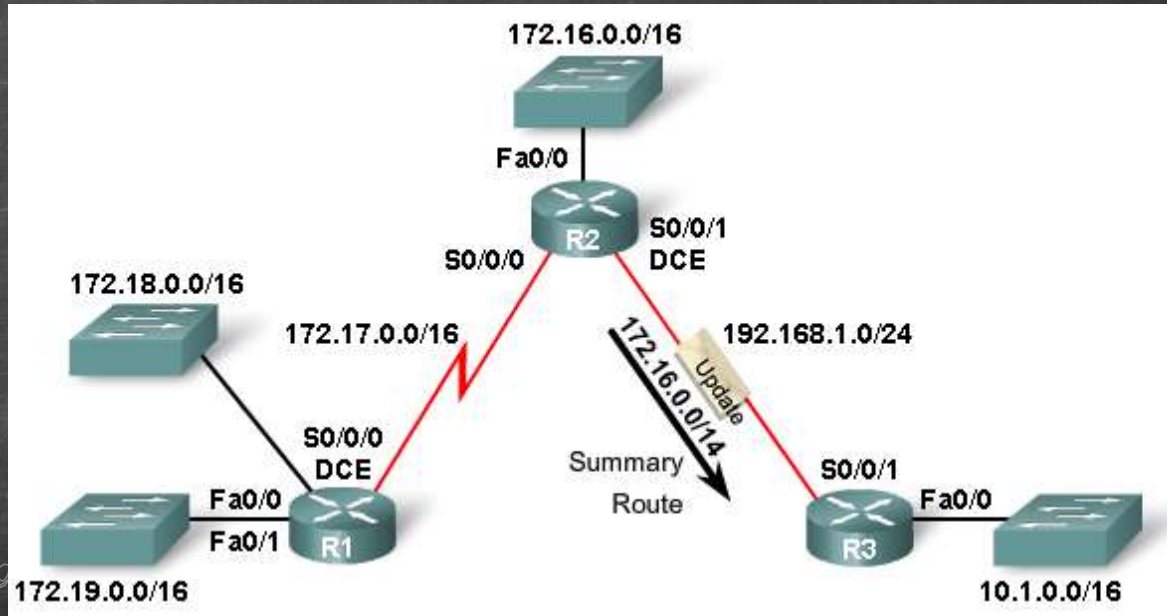
Introduction

- Classful Routing Updates
  - Recall that classful routing protocols (i.e. RIPv1) do not send subnet masks in their routing updates
    - The reason is that the Subnet mask is directly related to the network address



Introduction

- Classless Routing Protocol
  - Classless Inter-domain Routing (CIDR - RFC 1517)
- Characteristics of classless routing protocols:
  - Routing updates include the subnet mask
  - Supports Variable Length Subnet Masking (VLSM)
  - Supports Route Summarization (Prefix Aggregation)

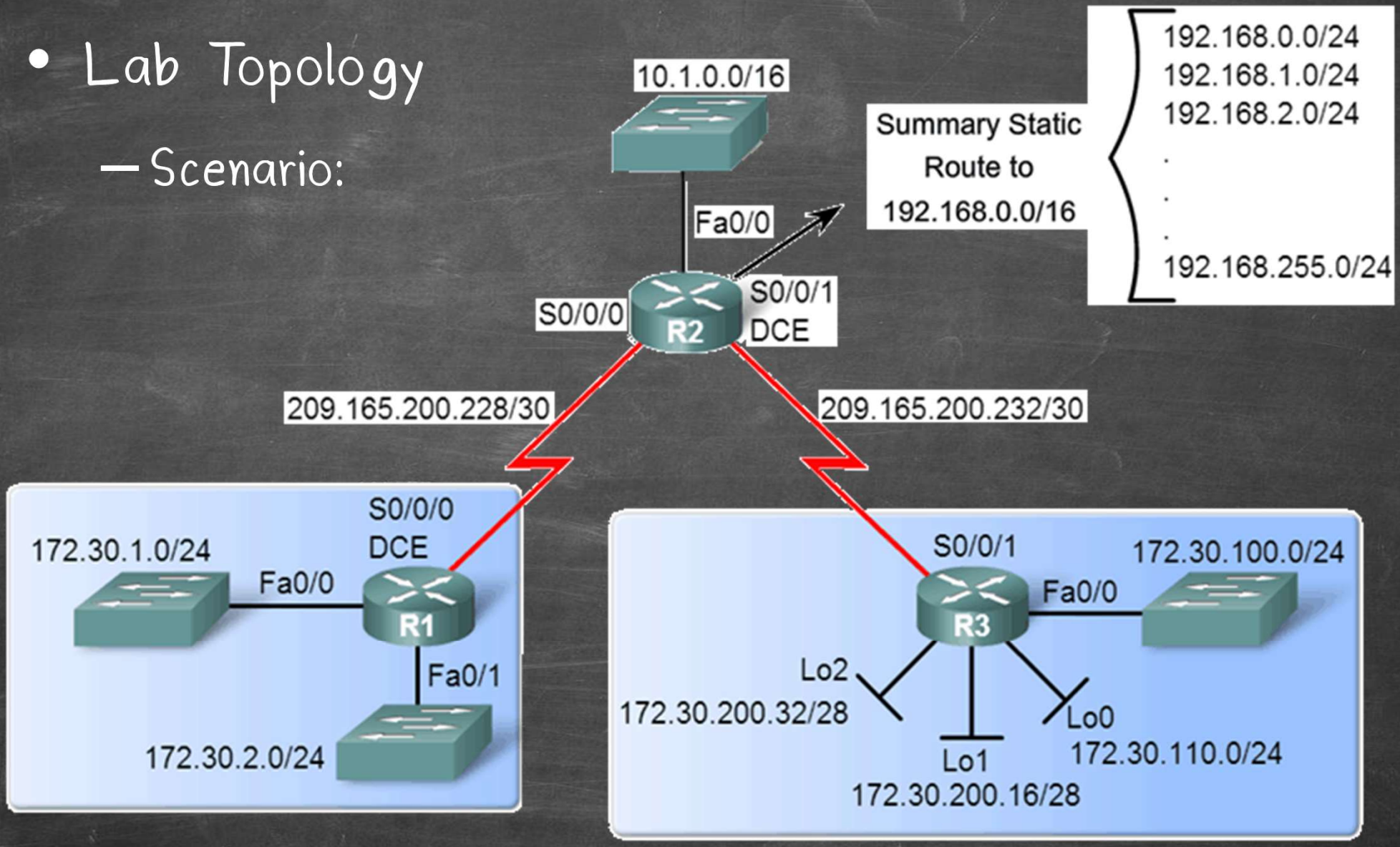


Introduction

- Similarities between RIPv1 & RIPv2
  - Use of timers to prevent routing loops
  - Use of split horizon or split horizon with poison reverse
  - Use of triggered updates
  - Maximum hop count of 15

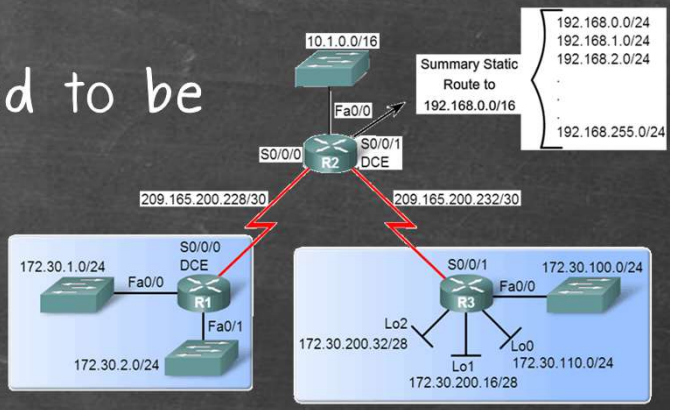
RIPv1 Limitations

- Lab Topology
  - Scenario:



RIPv1 Limitations

- Loopback interfaces
  - These are virtual interfaces that can be pinged and added to routing table
- Null Interfaces
  - This is a virtual interface that does not need to be created or configured
    - Traffic sent to a null interface is discarded
    - Null interfaces do not send or receive traffic

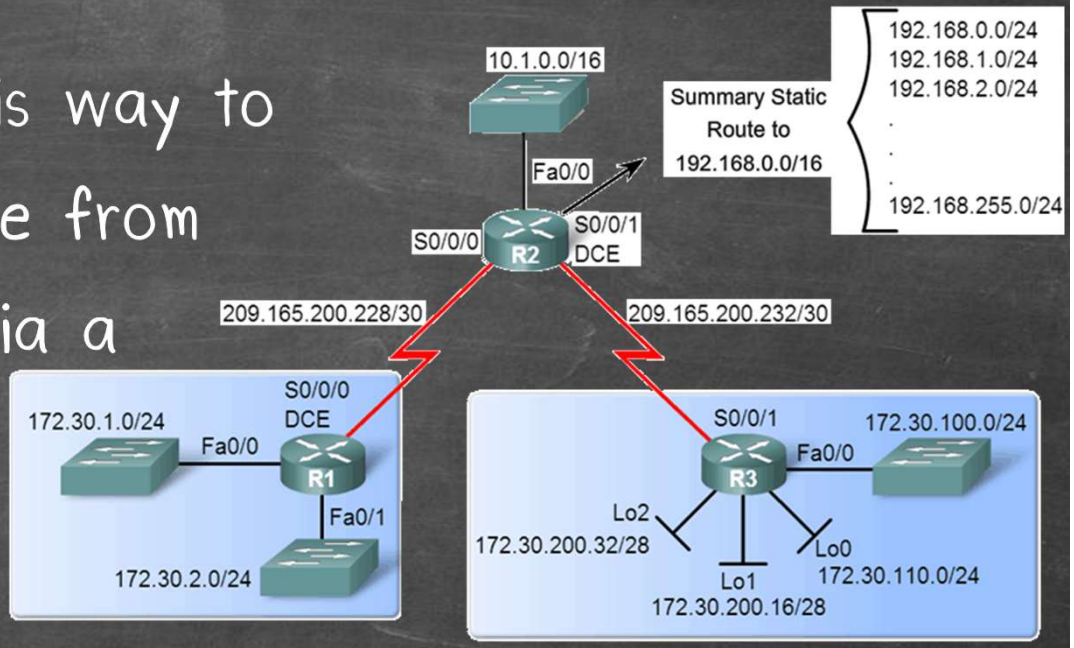


- Static routes and null interfaces
  - null interfaces will serve as the exit interface for static route
    - Example of configuring a static supernet route with a null interface

```
R2(config)#ip route 192.168.0.0 255.255.0.0 Null0
```

RIPv1 Limitations

- Route redistribution
  - Redistribution command is way to disseminate a static route from one router to another via a routing protocol
  - Example

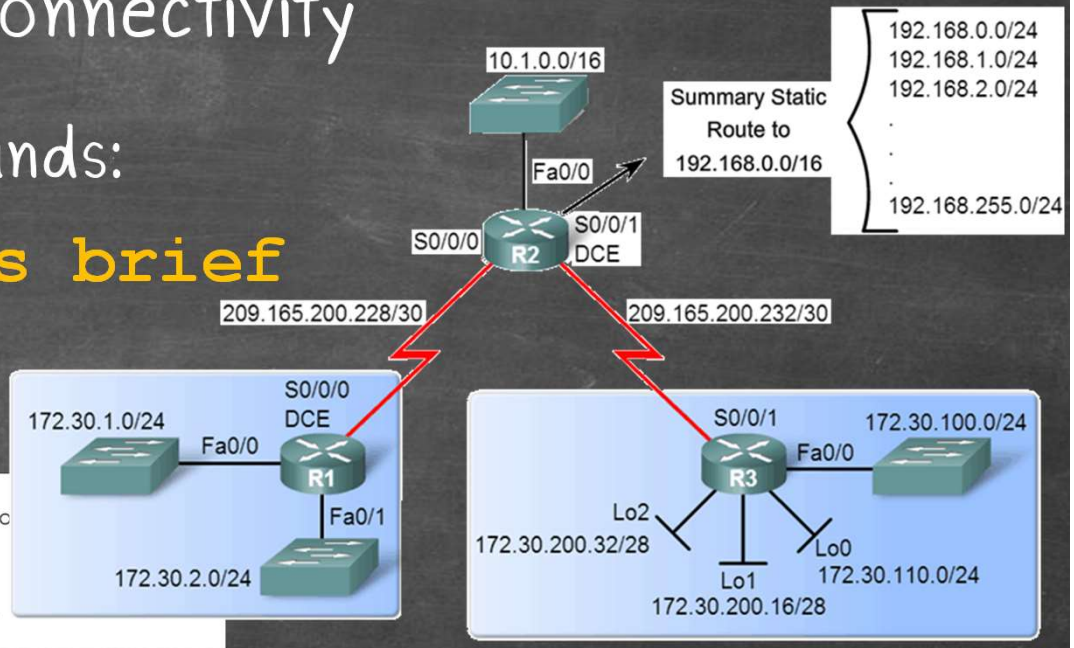



```
R2(config-router)#redistribute static
```

RIPv1 Limitations

- Verifying and Testing Connectivity
  - Use the following commands:

show ip interfaces brief
ping
traceroute




```
R2#show ip interface brief
Interface              IP-Address      OK? Method Status                Prcto
FastEthernet0/0        10.1.0.1        YES manual up                    up
Serial0/0/0            209.165.200.229 YES manual up                    up
FastEthernet0/1        unassigned      YES unset  administratively down down
Serial0/0/1            209.165.200.233 YES manual up                    up
```

```
R1#ping 10.1.0.1
Type escape sequence to abo
Sending 5, 100-byte ICMP Ec
!!!!!
Success rate is 100 percent

R1#ping 172.30.100.1
Type escape sequence to abo
Sending 5, 100-byte ICMP Ec
.....
Success rate is 0 percent
```

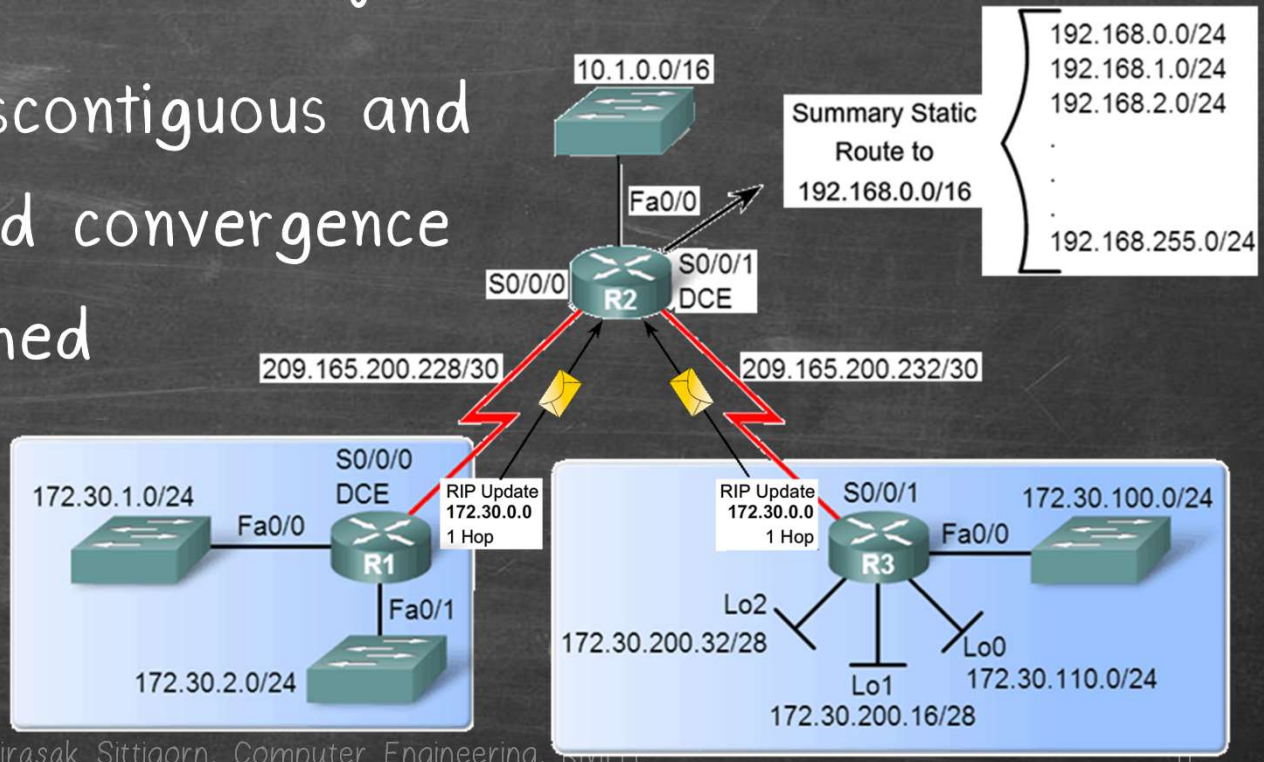
```
R2#ping 172.30.1.1
Type escape sequence to abort
Sending 5, 100-byte ICMP Echo
!U!.!
Success rate is 60 percent (

R2#ping 172.30.100.1
Type escape sequence to abort
Sending 5, 100-byte ICMP Echo
!U!.!
Success rate is 60 percent (
```

```
R3#ping 10.1.0.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos
!!!!!
Success rate is 100 percent (5

R3#ping 172.30.1.1
Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos
.....
Success rate is 0 percent (0/5
```

RIPv1 Limitations

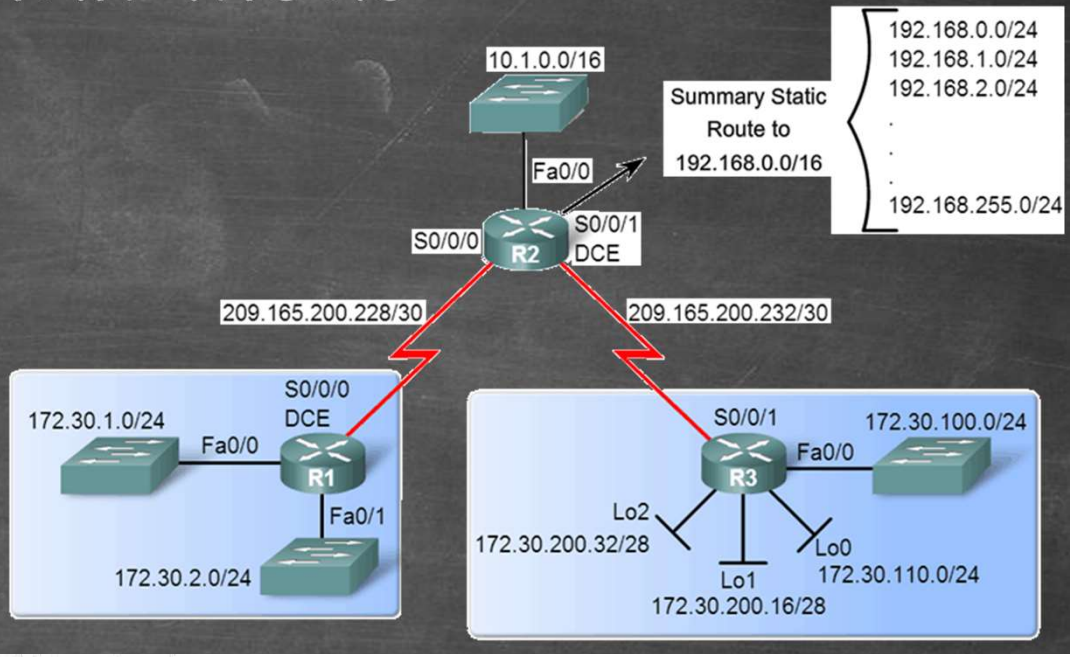
- RIPv1
  - a classful routing protocol
  - Subnet mask are not sent in updates
  - Summarizes networks at major network boundaries
  - if network is discontiguous and RIPv1 configured convergence will not be reached

```
Gateway of last resort is not set

R    172.30.0.0/16 [120/1] via 209.165.200.230, 00:00:09, Serial0/0/0
                   [120/1] via 209.165.200.234, 00:00:11, Serial0/0/1
     209.165.200.0/30 is subnetted, 2 subnets
C       209.165.200.232 is directly connected, Serial0/0/1
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
C       10.1.0.0 is directly connected, FastEthernet0/0
S    192.168.0.0/16 is directly connected, Null0
```



RIPv1 Limitations

- Examining the routing tables
  - To examine the contents of routing updates use the **debug ip rip** command
  - If RIPv1 is configured then Subnet masks will not be included with the network address

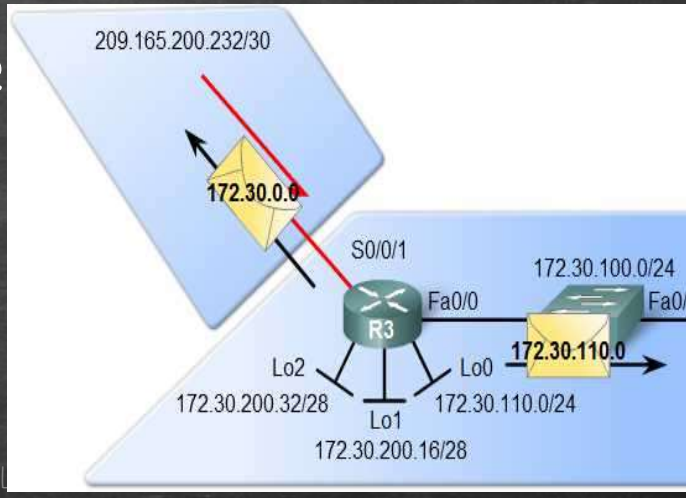



```
R2#debug ip rip
RIP protocol debugging is on

RIP: received v1 update from 209.165.200.230 on Serial0/0/0
     172.30.0.0 in 1 hops
RIP: received v1 update from 209.165.200.234 on Serial0/0/1
     172.30.0.0 in 1 hops
R2#
RIP: sending v1 update to 255.255.255.255 via Serial0/0/0 (209.165.200.229)
RIP: build update entries
        network 10.0.0.0 metric 1
        subnet 209.165.200.232 metric 1
RIP: sending v1 update to 255.255.255.255 via Serial0/0/1 (209.165.200.233)
RIP: build update entries
        network 10.0.0.0 metric 1
        subnet 209.165.200.228 metric 1
R2#
```

RIPv1 Limitations

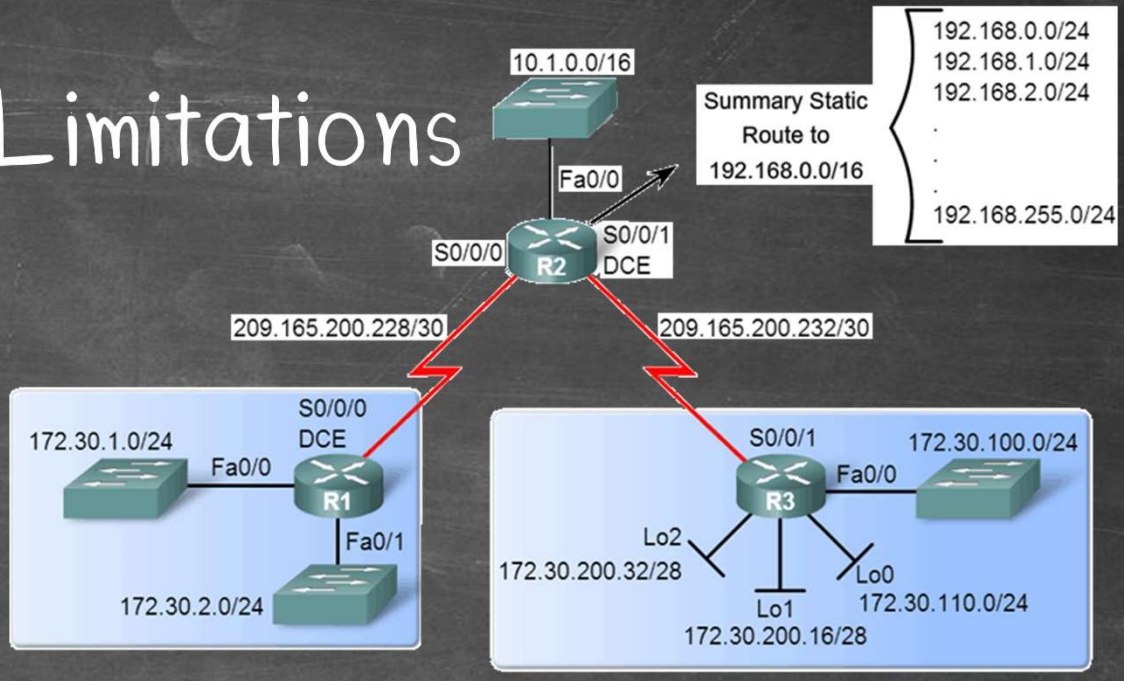
- RIPv1 does not support VLSM
  - Reason: RIPv1 does not send subnet mask in routing updates
- RIPv1 does summarize routes to the Classful boundary
  - Or uses the Subnet mask of the outgoing interface to determine which subnets to advertise

```
R3#debug ip rip
RIP protocol debugging is on
RIP: sending v1 update to 255.255.255.255 via FastEthernet0/0 (172.30.100.1)
RIP: build update entries
        network 10.0.0.0 metric 2
        subnet 172.30.110.0 metric 1
        network 209.165.200.0 metric 1
RIP: sending v1 update to 255.255.255.255 via Serial0/0/1 (209.165.200.234)
RIP: build update entries
        network 172.30.0.0 metric 1
```



RIPv1 Limitations

- No CIDR Support
- In the diagram R2 will not include the static route in its update
- Reason: Classful routing protocols do not support CIDR routes that are summarized with a smaller mask than the classful subnet mask



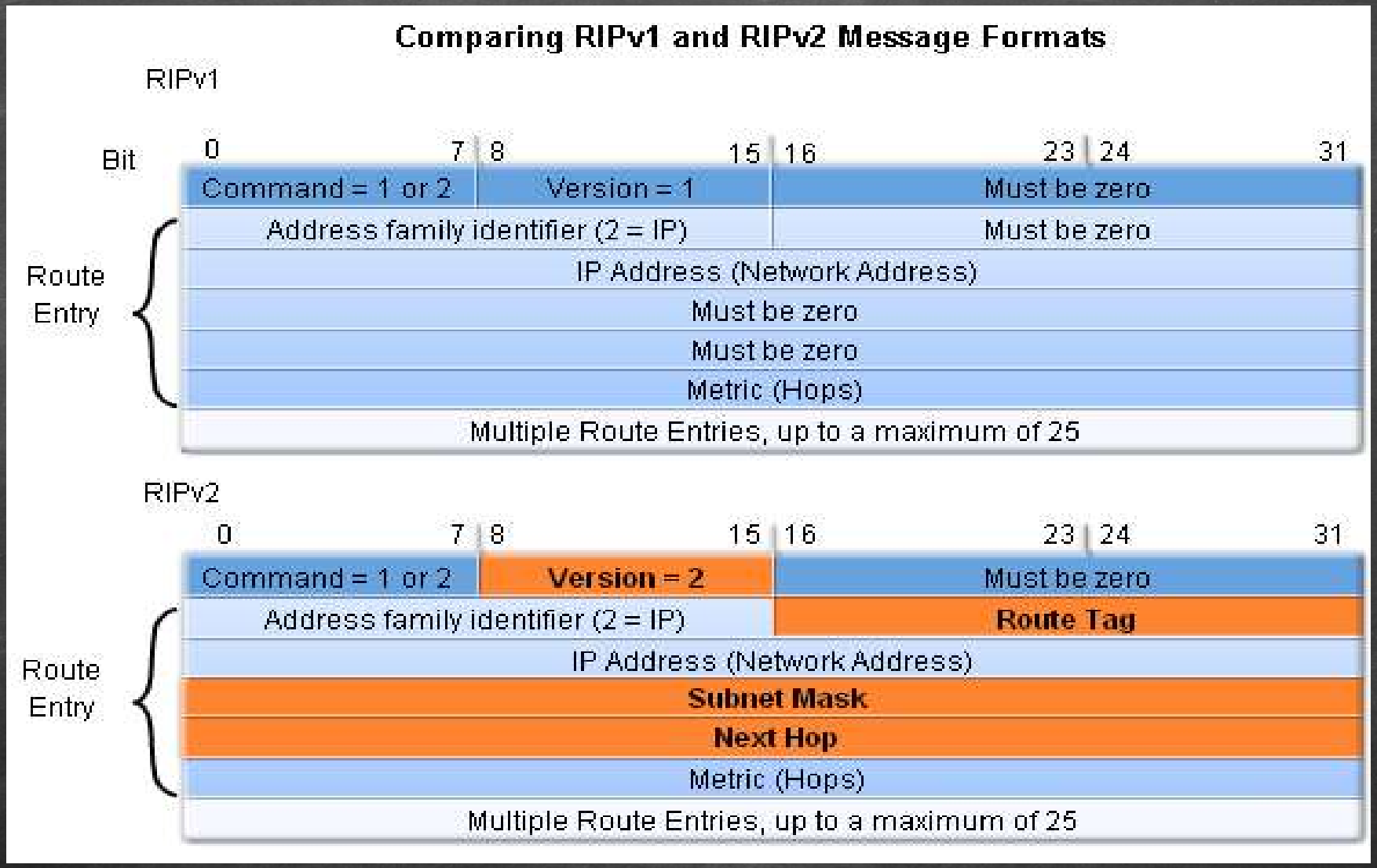

```
R2(config)#router rip
R2(config-router)#redistribute static
R2(config-router)#network 10.0.0.0
R2(config-router)#network 209.165.200.0
R2(config-router)#exit
R2(config)#ip route 192.168.0.0 255.255.0.0 null0
```

```
R2#show ip route
Codes: C - connected, S - static, I - IGRP, R - RIP, M - mobile, B - BG
(**output omitted**)
R    172.30.0.0/16 [120/1] via 209.165.200.230, 00:00:09, Serial0/0/0
                   [120/1] via 209.165.200.234, 00:00:11, Serial0/0/1
     209.165.200.0/30 is subnetted, 2 subnets
C       209.165.200.232 is directly connected, Serial0/0/1
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
C       10.1.0.0 is directly connected, FastEthernet0/0
S    192.168.0.0/16 is directly connected, Null0
```

```
RIP: sending v1 update to 255.255.255.255 via Serial0/0/0 (209.165.200.229)
RIP: build update entries
        network 10.0.0.0 metric 1
        subnet 209.165.200.232 metric 1
RIP: sending v1 update to 255.255.255.255 via Serial0/0/1 (209.165.200.233)
RIP: build update entries
        network 10.0.0.0 metric 1
        subnet 209.165.200.228 metric 1
R2#
```

Configuring RIPv2

- Comparing RIPv1 and RIPv2 Message Formats



Configuring RIPv2

- Enabling and Verifying RIPv2
- Configuring RIP on a Cisco router
  - By default it is running RIPv1

```
R2#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 1 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Redistributing: static, rip
  Default version control: send version 1, receive any version
    Interface             Send  Recv  Triggered RIP  Key-chain
    Serial0/0/0           1     1 2
    Serial0/0/1           1     1 2
  Automatic network summarization is in effect
  Routing for Networks:
    10.0.0.0
    209.165.200.0
  Passive Interface(s):
    FastEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    209.165.200.234      120      00:00:03
    209.165.200.230      120      00:00:17
  Distance: (default is 120)
```

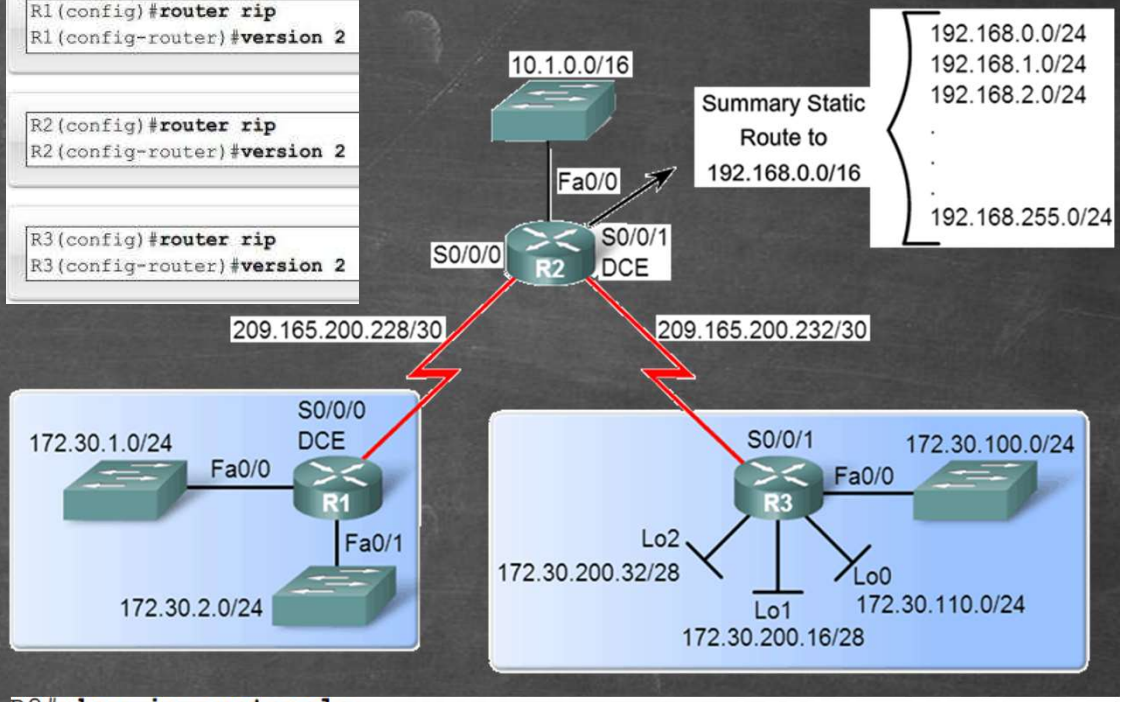
Configuring RIPv2

- Configuring RIPv2 on a Cisco router
  - Requires using the **version 2** command
  - RIPv2 ignores RIPv1 updates
- To verify RIPv2 is configured use the **show ip protocols** command

```
R1(config)#router rip
R1(config-router)#version 2
```

```
R2(config)#router rip
R2(config-router)#version 2
```

```
R3(config)#router rip
R3(config-router)#version 2
```



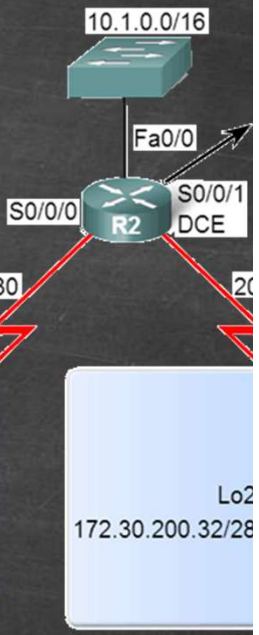

```
R2#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 1 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is
  Incoming update filter list for all interfaces is
  Redistributing: static, rip
  Default version control: send version 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    Serial0/0/0            2     2
    Serial0/0/1            2     2
  Automatic network summarization is in effect
  Routing for Networks:
    10.0.0.0
    209.165.200.0
  Passive Interface(s):
    FastEthernet0/0
  Routing Information Sources:
    Gateway         Distance      Last Update
    209.165.200.234         120         00:00:03
    209.165.200.230         120         00:00:17
  Distance: (default is 120)
```

Configuring RIPv2

- Auto-Summary & RIPv2
- RIPv2 will automatically summarize routes at major network boundaries and can also summarize routes with a subnet mask that is smaller than the classful subnet mask

```
R    172.30.0.0/16 [120/1] via 209.165.200.230, 00:00:28, Serial0/0/0
                   [120/1] via 209.165.200.234, 00:00:18, Serial0/0/1
     209.165.200.0/30 is subnetted, 2 subnets
C       209.165.200.232 is directly connected, Serial0/0/1
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
C       10.1.0.0 is directly connected, FastEthernet0/0
S    192.168.0.0/16 is directly connected, Null0
```

```
R1#debug ip rip
RIP protocol debugging is on
R1#
RIP: sending v2 update to 224.0.0.9 via Serial0/1/0 (209.165.200.230)
RIP: build update entries
        172.30.0.0/16 via 0.0.0.0, metric 1, tag 0
R1#
<Output omitted for brevity>
RIP: received v2 update from 209.165.200.229 on Serial0/1/0
     10.0.0.0/8 via 0.0.0.0 in 1 hops
     192.168.0.0/16 via 0.0.0.0 in 1 hops
     209.165.200.232/30 via 0.0.0.0 in 1 hops
(**output omitted**)
R1#
```



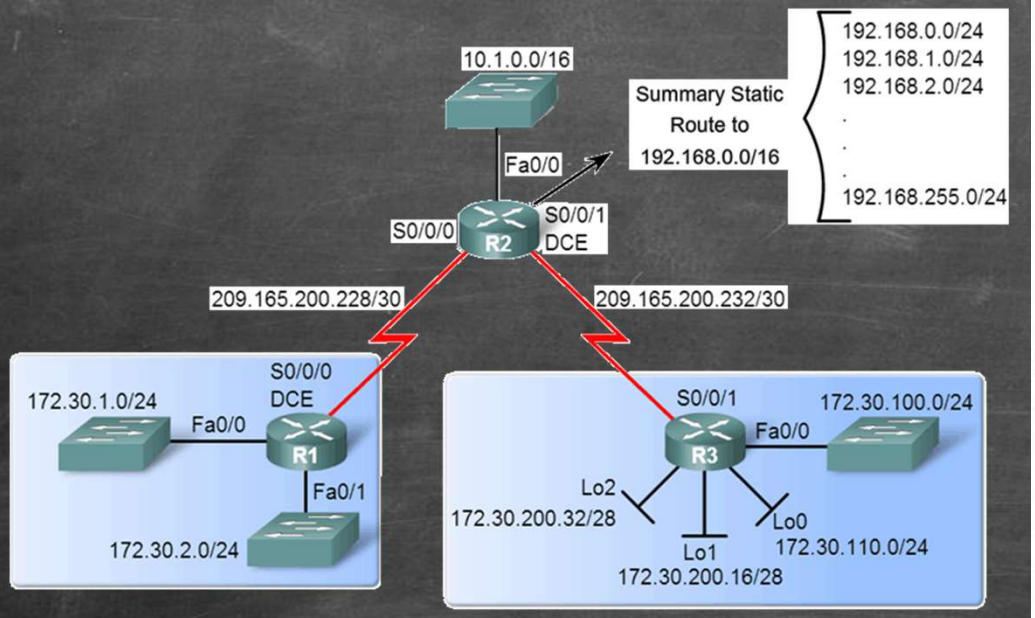

```
R1#debug ip rip
RIP protocol debugging is on
R1#
RIP: sending v2 update to 224.0.0.9 via Serial0/0/0 (209.165.200.230)
RIP: build update entries
        172.30.0.0/16 via 0.0.0.0, metric 1, tag 0
R1#
(**output omitted**)
RIP: received v2 update from 209.165.200.229 on Serial0/0/0
     10.0.0.0/8 via 0.0.0.0 in 1 hops
     192.168.0.0/16 via 0.0.0.0 in 1 hops
     209.165.200.232/30 via 0.0.0.0 in 1 hops
(**output omitted**)
R1#
```

```
     172.30.0.0/24 is subnetted, 2 subnets
C       172.30.1.0 is directly connected, FastEthernet0/0
C       172.30.2.0 is directly connected, FastEthernet0/1
     209.165.200.0/30 is subnetted, 2 subnets
R       209.165.200.232 [120/1] via 209.165.200.229, 00:00:04, Serial0/0/0
C       209.165.200.228 is directly connected, Serial0/0/0
R    10.0.0.0/8 [120/1] via 209.165.200.229, 00:00:04, Serial0/0/0
R    192.168.0.0/16 [120/1] via 209.165.200.229, 00:00:04, Serial0/0/0
```

```
R1#show ip protocols
Routing Protocol is "rip"
  Sending updates every 30 seconds, next due in 20 seconds
  Invalid after 180 seconds, hold down 180, flushed after 240
  Outgoing update filter list for all interfaces is not set
  Incoming update filter list for all interfaces is not set
  Redistributing: rip
  Default version control: send version 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0        2     2
    FastEthernet0/1        2     2
    Serial0/1/0            2     2
  Automatic network summarization is in effect
  Maximum path: 4
```

Configuring RIPv2

- Disabling Auto-Summary in RIPv2
- To disable automatic summarization issue the **no auto-summary** command




```
R1(config)#router rip
R1(config-router)#no auto-summary
R1(config-router)#end
R1#show ip protocols
Routing Protocol is "rip"
<output omitted for brevity>
  Default version control: send version 2, receive version 2
    Interface              Send  Recv  Triggered RIP  Key-chain
    FastEthernet0/0        2     2
    FastEthernet0/1        2     2
    Serial0/1/0            2     2
  Automatic network summarization is not in effect
  <output omitted for brevity>
```

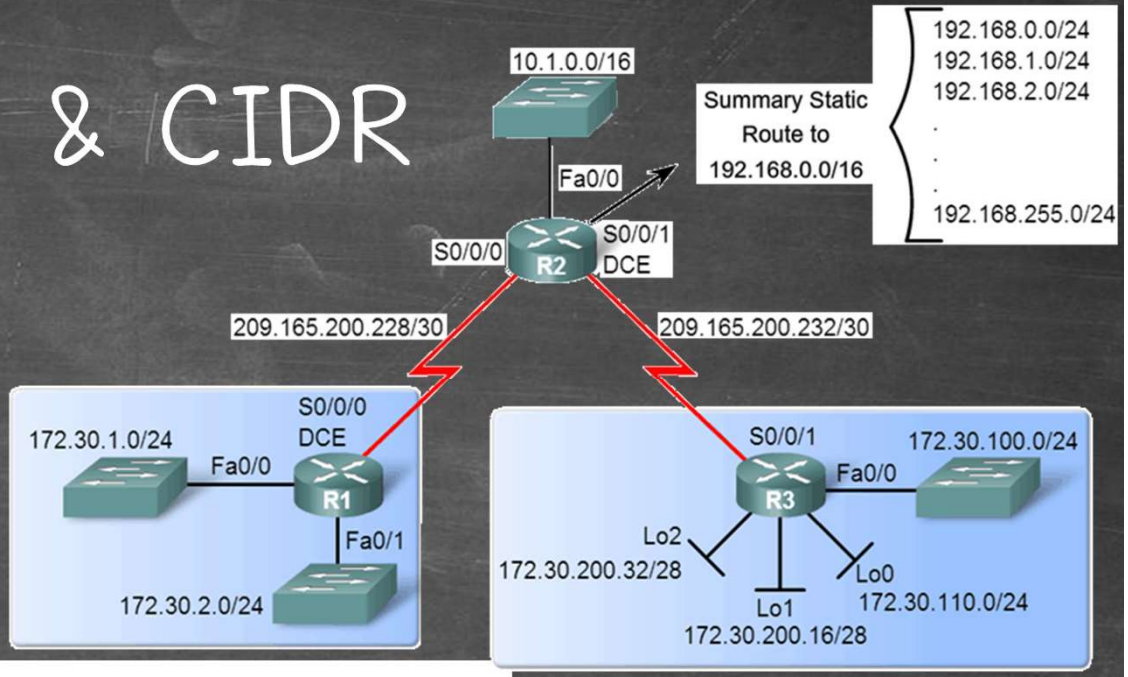
```
R2(config)#router rip
R2(config-router)# no auto-summary
```

```
R3(config)#router rip
R3(config-router)#no auto-summary
```

VLSM & CIDR

- Verifying RIPv2 Updates
- When using RIPv2 with automatic summarization turned off
  - Each subnet and mask has its own specific entry, along with the exit interface and next-hop address to reach that subnet.
- To verify information being sent by RIPv2 use the **debug ip rip** command

VLSM & CIDR




```
R2#show ip route
 (**output omitted**)

Gateway of last resort is not set

     172.30.0.0/16 is variably subnetted, 6 subnets, 2 masks
R       172.30.200.32/28 [120/1] via 209.165.200.234, 00:00:09, Serial0/0/1
R       172.30.200.16/28 [120/1] via 209.165.200.234, 00:00:09, Serial0/0/1
R       172.30.2.0/24 [120/1] via 209.165.200.230, 00:00:03, Serial0/0/0
R       172.30.1.0/24 [120/1] via 209.165.200.230, 00:00:03, Serial0/0/0
R       172.30.100.0/24 [120/1] via 209.165.200.234, 00:00:09, Serial0/0/1
R       172.30.110.0/24 [120/1] via 209.165.200.234, 00:00:09, Serial0/0/1
     209.165.200.0/30 is subnetted, 2 subnets
C       209.165.200.232 is directly connected, Serial0/0/1
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
C       10.1.0.0 is directly connected, FastEthernet0/0
S    192.168.0.0/16 is directly connected, Null0
```

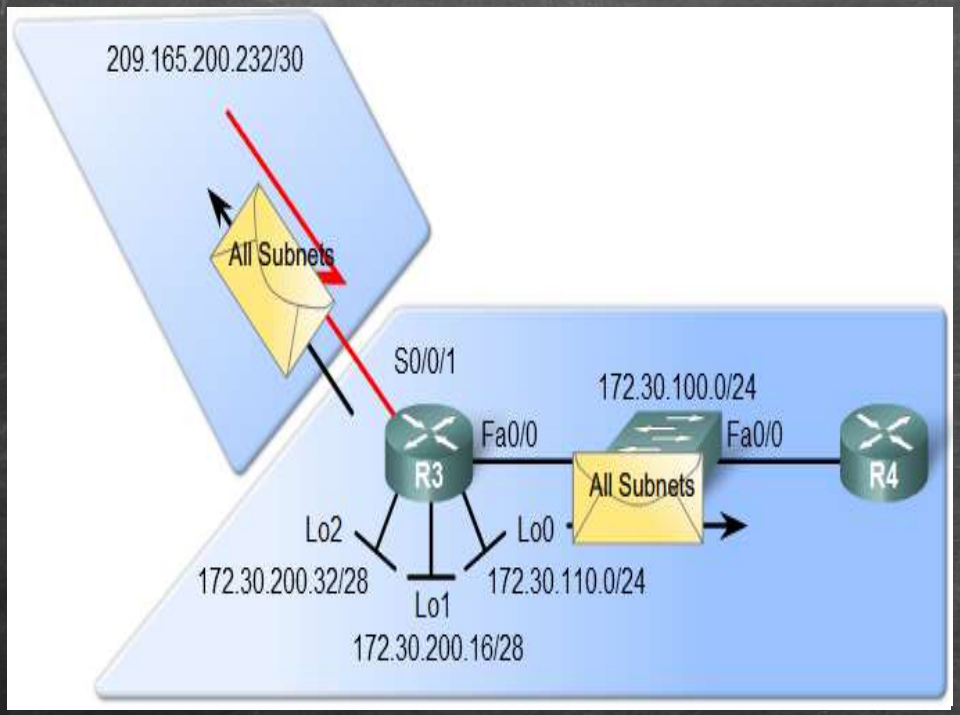
```
R2#debug ip rip
RIP protocol debugging is on
 (**output omitted**)

R2#
RIP: received v2 update from 209.165.200.234 on Serial0/0/1
     172.30.100.0/24 via 0.0.0.0 in 1 hops
     172.30.110.0/24 via 0.0.0.0 in 1 hops
     172.30.200.16/28 via 0.0.0.0 in 1 hops
     172.30.200.32/28 via 0.0.0.0 in 1 hops
R2#
RIP: sending v2 update to 224.0.0.9 via Serial0/0/0 (209.165.200.229)
RIP: build update entries
         10.1.0.0/16 via 0.0.0.0, metric 1, tag 0
         172.30.100.0/24 via 0.0.0.0, metric 2, tag 0
         172.30.110.0/24 via 0.0.0.0, metric 2, tag 0
         172.30.200.16/28 via 0.0.0.0, metric 2, tag 0
         172.30.200.32/28 via 0.0.0.0, metric 2, tag 0
         192.168.0.0/16 via 0.0.0.0, metric 1, tag 0
         209.165.200.232/30 via 0.0.0.0, metric 1, tag 0
R2#
```

```
R1#show ip route
 (**output omitted**)

Gateway of last resort is not set

     172.30.0.0/16 is variably subnetted, 6 subnets, 2 masks
R       172.30.200.32/28 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
R       172.30.200.16/28 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
C       172.30.1.0/24 is directly connected, FastEthernet0/0
C       172.30.2.0/24 is directly connected, FastEthernet0/1
R       172.30.100.0/24 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
R       172.30.110.0/24 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
     209.165.200.0/30 is subnetted, 2 subnets
R       209.165.200.232 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
R       10.1.0.0 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
R    192.168.0.0/16 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
```

```
R3#show ip route
 (**output omitted**)

Gateway of last resort is not set

     172.30.0.0/16 is variably subnetted, 6 subnets, 2 masks
C       172.30.200.32/28 is directly connected, Loopback2
C       172.30.200.16/28 is directly connected, Loopback1
R       172.30.2.0/24 [120/2] via 209.165.200.233, 00:00:01, Serial0/0/1
R       172.30.1.0/24 [120/2] via 209.165.200.233, 00:00:01, Serial0/0/1
C       172.30.100.0/24 is directly connected, FastEthernet0/0
C       172.30.110.0/24 is directly connected, Loopback0
     209.165.200.0/30 is subnetted, 2 subnets
C       209.165.200.232 is directly connected, Serial0/0/1
R       209.165.200.228 [120/1] via 209.165.200.233, 00:00:02, Serial0/0/1
     10.0.0.0/16 is subnetted, 1 subnets
R       10.1.0.0 [120/1] via 209.165.200.233, 00:00:02, Serial0/0/1
R    192.168.0.0/16 [120/1] via 209.165.200.233, 00:00:02, Serial0/0/1
```

VLSM & CIDR

- RIPv2 and VLSM
- Networks using a VLSM IP addressing scheme
  - Use classless routing protocols (i.e. RIPv2) to disseminate network addresses and their subnet masks

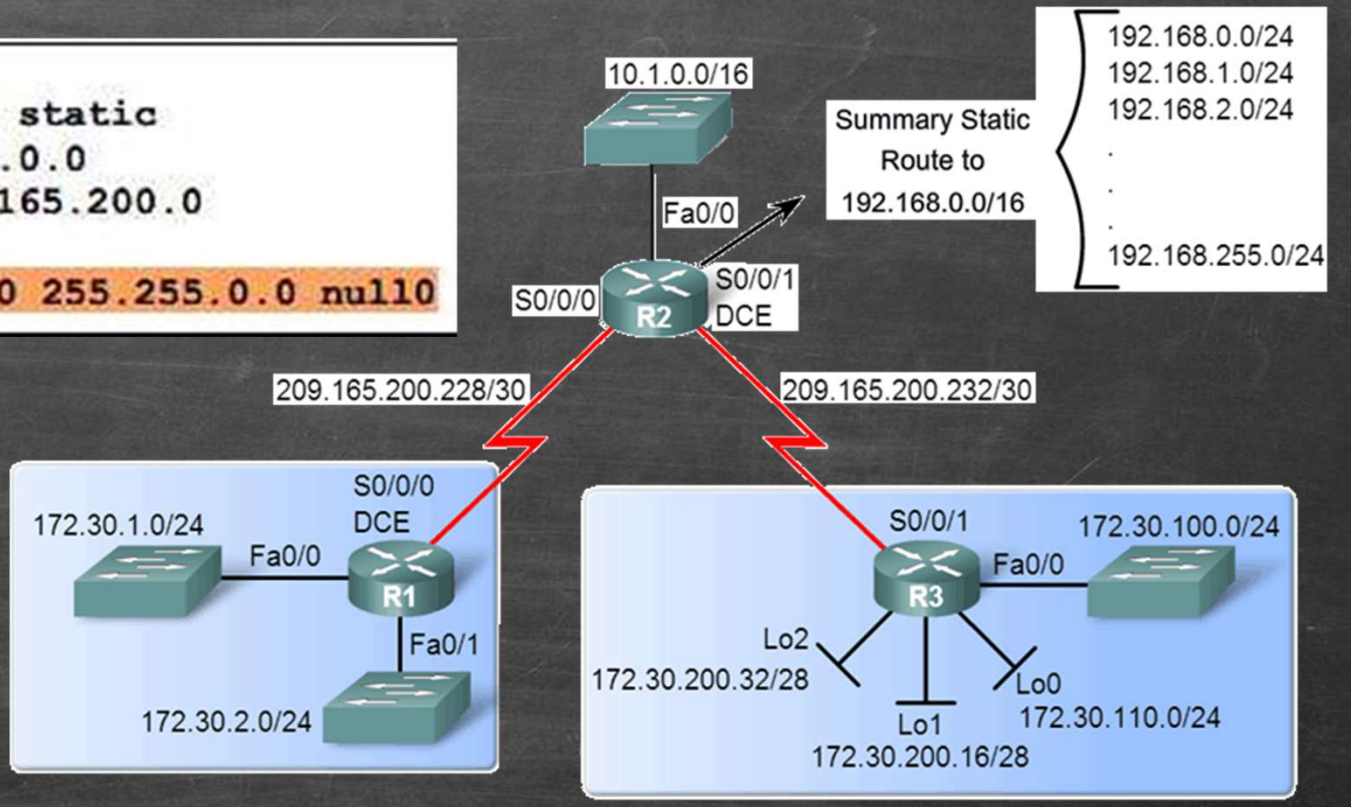



```
R3#debug ip rip
RIP protocol debugging is on
R3#
RIP: received v2 update from 209.165.200.233 on Serial0/0/1
     10.1.0.0/16 via 0.0.0.0 in 1 hops
     172.30.1.0/24 via 0.0.0.0 in 2 hops
     172.30.2.0/24 via 0.0.0.0 in 2 hops
     192.168.0.0/16 via 0.0.0.0 in 1 hops
     209.165.200.228/30 via 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 update to 224.0.0.9 via 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
```

VLSM & CIDR

- CIDR uses Supernetting
  - Supernetting is a bunch of contiguous classful networks that is addressed as a single network.

```
R2(config)#router rip
R2(config-router)#redistribute static
R2(config-router)#network 10.0.0.0
R2(config-router)#network 209.165.200.0
R2(config-router)#exit
R2(config)#ip route 192.168.0.0 255.255.0.0 null0
```



VLSM & CIDR

- To verify that supernets are being sent and received use the following commands

show ip route

debug ip rip

```
R2#debug ip rip
RIP protocol debugging is on
R2#
RIP: sending v2 update to 224.0.0.9 via Serial0/0/0 (209.165.200.229)
RIP: build update entries
        10.1.0.0/16 via 0.0.0.0, metric 1, tag 0
        172.30.100.0/24 via 0.0.0.0, metric 2, tag 0
        172.30.110.0/24 via 0.0.0.0, metric 2, tag 0
        172.30.200.16/28 via 0.0.0.0, metric 2, tag 0
        172.30.200.32/28 via 0.0.0.0, metric 2, tag 0
        192.168.0.0/16 via 0.0.0.0, metric 1, tag 0
        209.165.200.232/30 via 0.0.0.0, metric 1, tag 0
<output omitted for brevity>
R2#
```

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

Gateway of last resort is not set

     172.30.0.0/16 is variably subnetted, 6 subnets, 2 masks
R       172.30.200.32/28 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
R       172.30.200.16/28 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
C       172.30.1.0/24 is directly connected, FastEthernet0/0
C       172.30.2.0/24 is directly connected, FastEthernet0/1
R       172.30.100.0/24 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
R       172.30.110.0/24 [120/2] via 209.165.200.229, 00:00:01, Serial0/0/0
     209.165.200.0/30 is subnetted, 2 subnets
R       209.165.200.232 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
C       209.165.200.228 is directly connected, Serial0/0/0
     10.0.0.0/16 is subnetted, 1 subnets
R       10.1.0.0 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
R    192.168.0.0/16 [120/1] via 209.165.200.229, 00:00:02, Serial0/0/0
```

Verifying & Troubleshooting RIPv2

- Basic Troubleshooting steps
  - Check the status of all links
  - Check cabling
  - Check IP address & subnet mask configuration
  - Remove any unneeded configuration commands
- Commands used to verify proper operation of RIPv2

```
show ip interfaces brief
show ip protocols
debug ip rip
show ip route
```

Verifying & Troubleshooting RIPv2

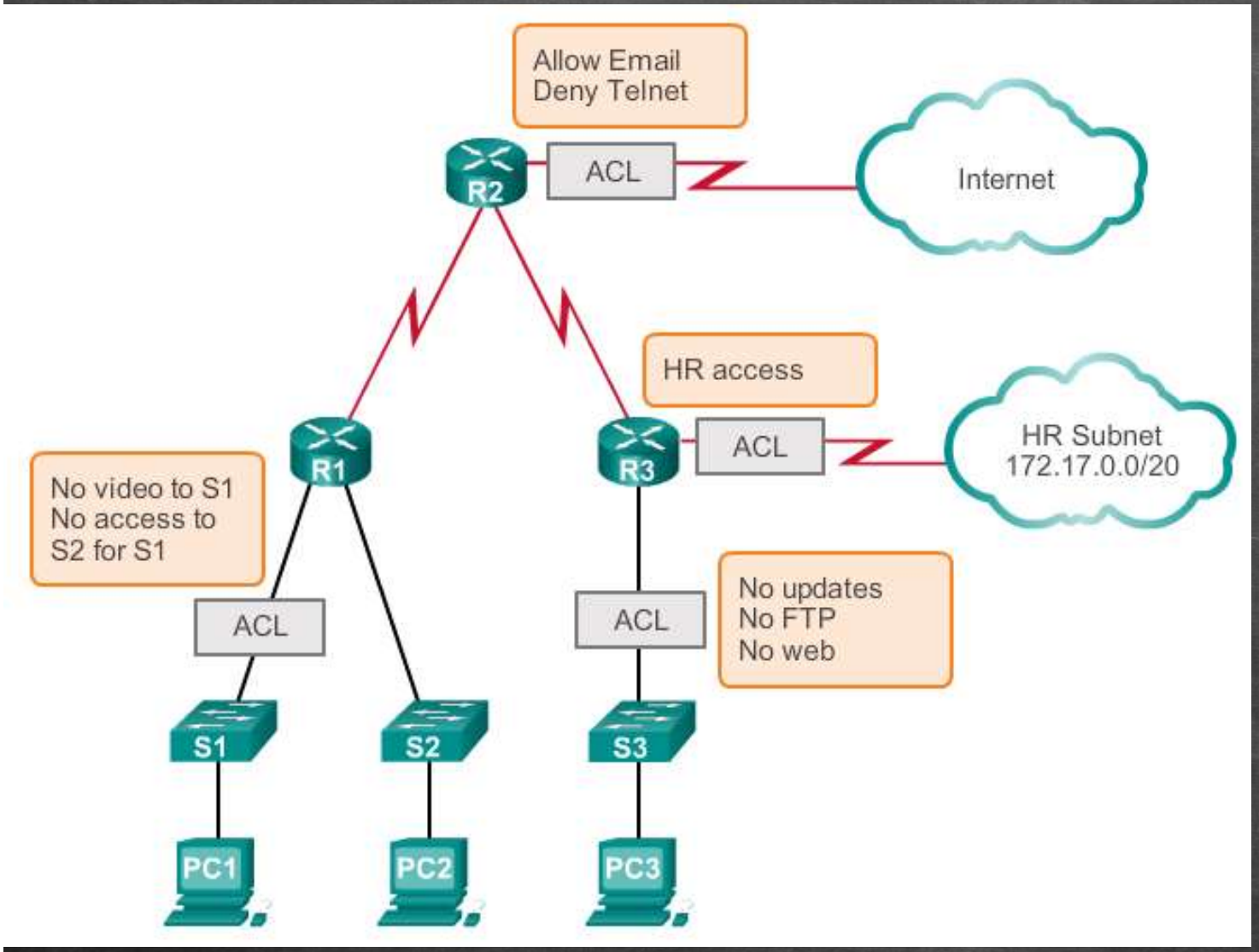
- Common RIPv2 Issues
- When trouble shooting RIPv2 examine the following issues:
  - Version
    - Check to make sure you are using version 2
  - Network statements
    - Network statements may be incorrectly typed or missing
  - Automatic summarization
    - If summarized routes are not needed then disable automatic summarization

Verifying & Troubleshooting RIPv2

- Reasons why it's good to authenticate routing information
  - Prevent the possibility of accepting invalid routing updates
  - Contents of routing updates are encrypted
- Types of routing protocols that can use authentication
  - RIPv2
  - EIGRP
  - OSPF
  - IS-IS
  - BGP

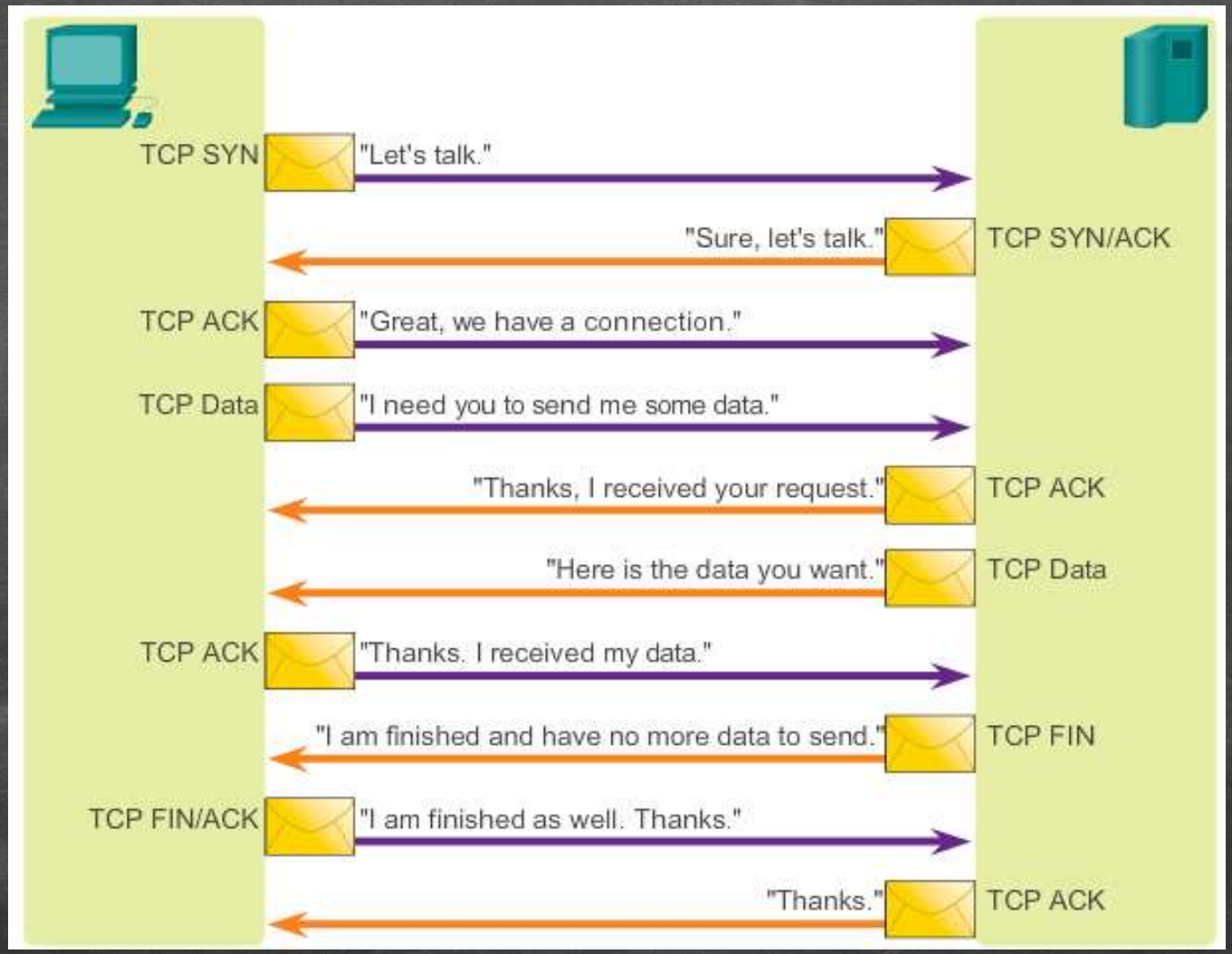
Access Control Lists

- What is an ACL?



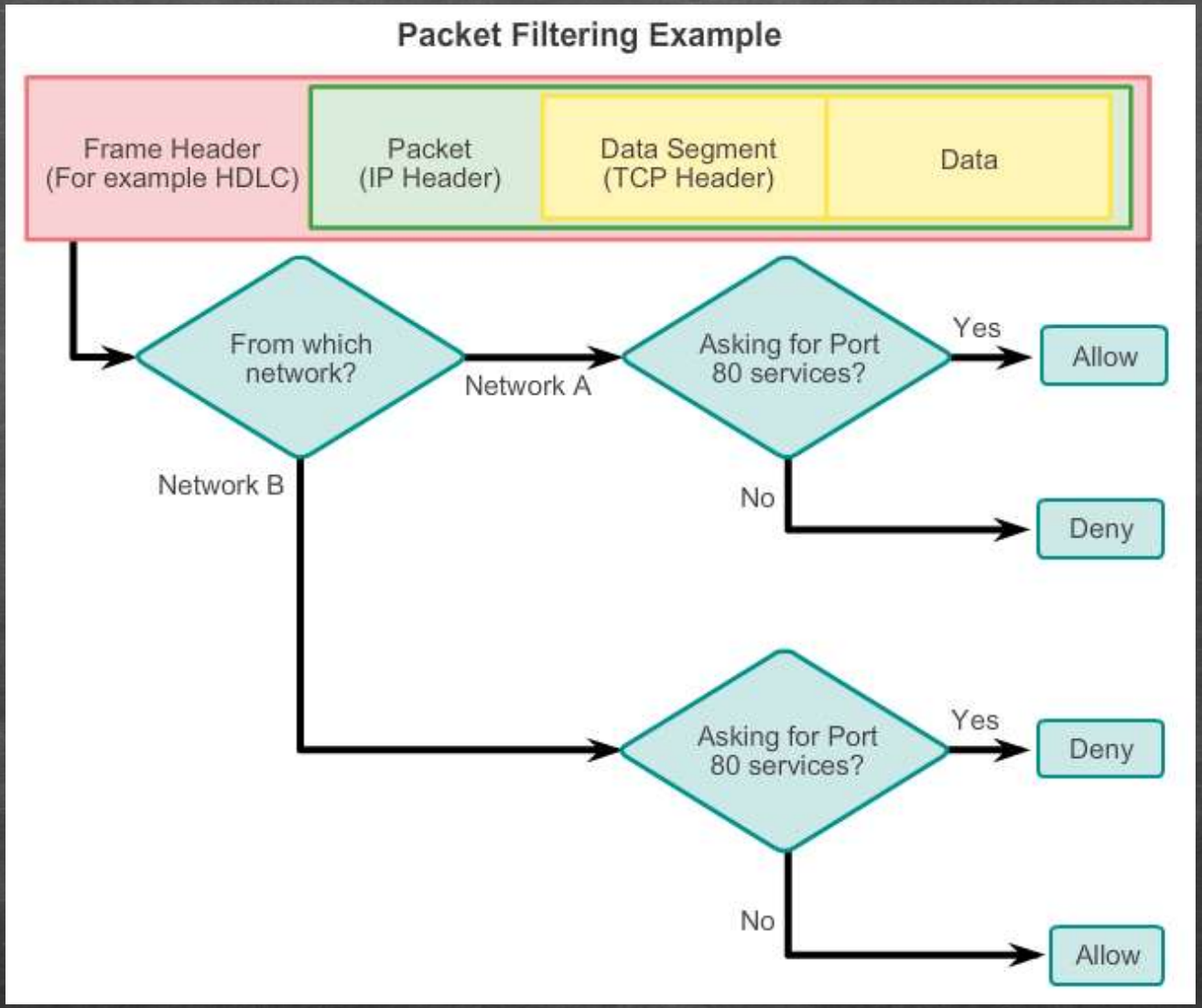
Access Control Lists

- A TCP Conversation



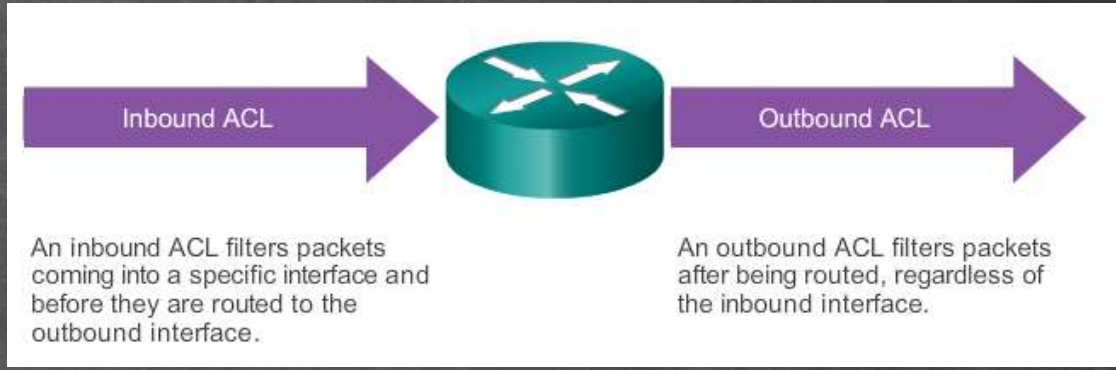
Access Control Lists

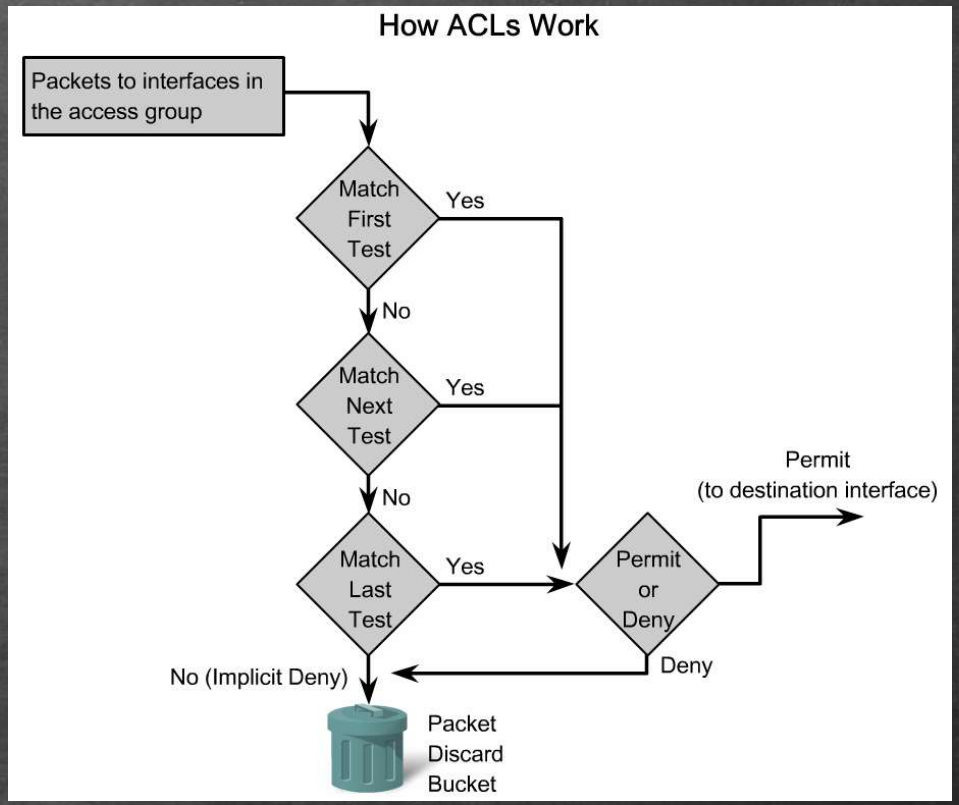
- Packet Filtering



Access Control Lists

- ACL Operation
  - The last statement of an ACL is always an implicit deny. This statement is automatically inserted at the end of each ACL even though it is not physically present. The implicit deny blocks all traffic. Because of this implicit deny, an ACL that does not have at least one permit statement will block all traffic.





Standard versus Extended IPv4 ACLs

- Standard ACLs
  - Checks source address
  - Generally permits or denies entire protocol suite

```
access-list 10 permit 192.168.30.0 0.0.0.255
```

Standard ACLs filter IP packets based on the source address only.

- Extended ACLs
  - Checks source and destination address
  - Generally permits or denies specific protocols

```
access-list 103 permit tcp 192.168.30.0 0.0.0.255 any eq 80
```

Extended ACLs filter IP packets based on several attributes, including the following:

- Source and destination IP addresses
- Source and destination TCP and UDP ports
- Protocol type/ Protocol number (example: IP, ICP, UDP, TCP, etc.)

Standard versus Extended IPv4 ACLs

- Numbering and Naming ACLs

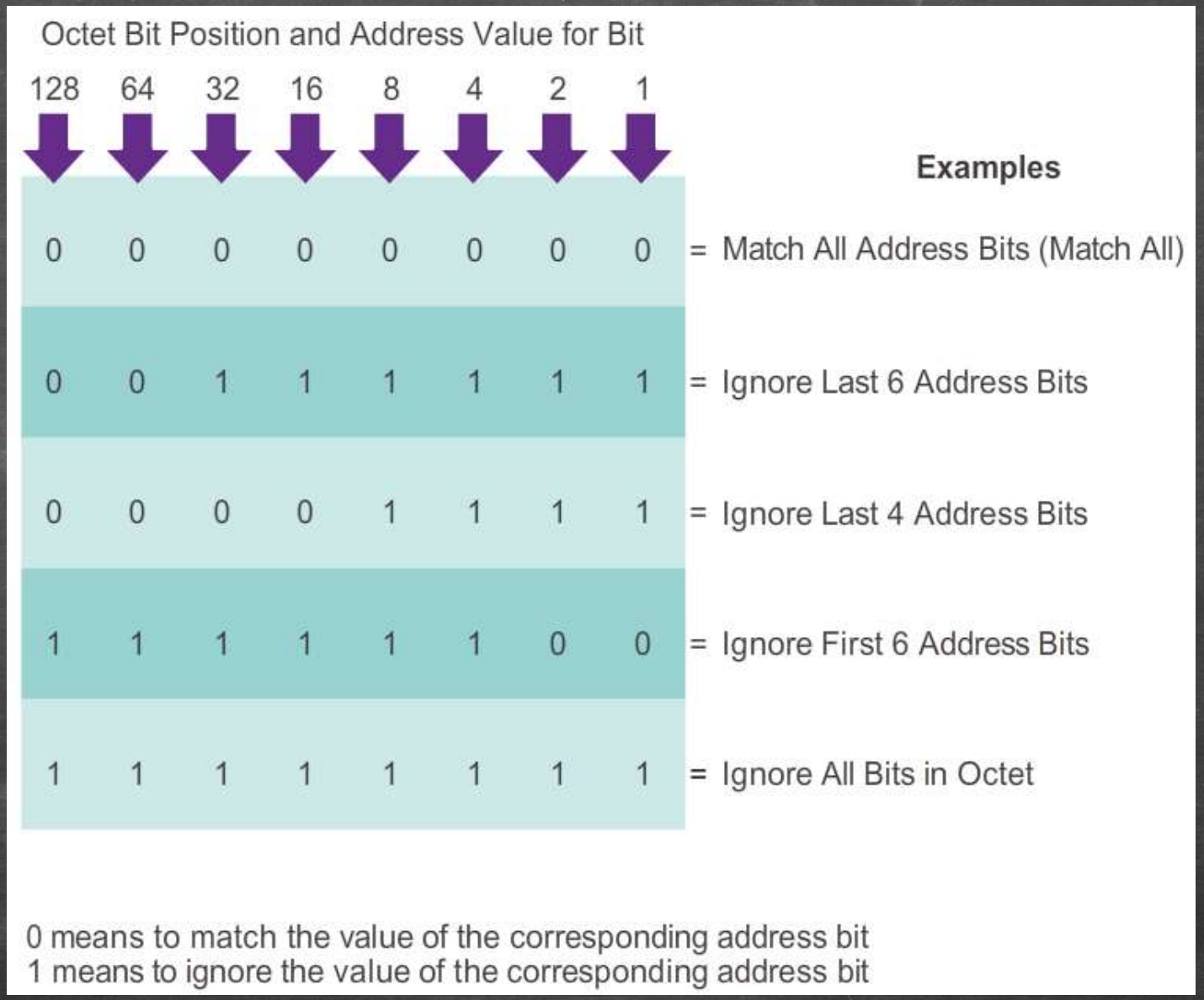
Numbered ACL:

You assign a number based on which protocol you want filtered:
- (1 to 99) and (1300 and 1999): Standard IP ACL
- (100 to 199) and (2000 to 2699): Extended IP ACL

Named ACL:

You assign a name by providing the name of the ACL:
- Names can contain alphanumeric characters.
- It is suggested that the name be written in CAPITAL LETTERS.
- Names cannot contain spaces or punctuation.
- You can add or delete entries within the ACL.

Wildcard Masks in ACLs



Wildcard Masks in ACLs

- Wildcard Mask Examples: Hosts / Subnets

Example 1

	Decimal	Binary
IP Address	192.168.1.1	11000000.10101000.00000001.00000001
Wildcard Mask	0.0.0.0.	00000000.00000000.00000000.00000000
Result	192.168.1.1	11000000.10101000.00000001.00000001

Example 2

	Decimal	Binary
IP Address	192.168.1.1	11000000.10101000.00000001.00000001
Wildcard Mask	255.255.255.255	11111111.11111111.11111111.11111111
Result	0.0.0.0	00000000.00000000.00000000.00000000

Example 3

	Decimal	Binary
IP Address	192.168.1.1	11000000.10101000.00000001.00000001
Wildcard Mask	0.0.0.255	00000000.00000000.00000000.11111111
Result	192.168.1.0	11000000.10101000.00000001.00000000

Wildcard Masks in ACLs

- Wildcard Mask Examples: Match Ranges

Example 1

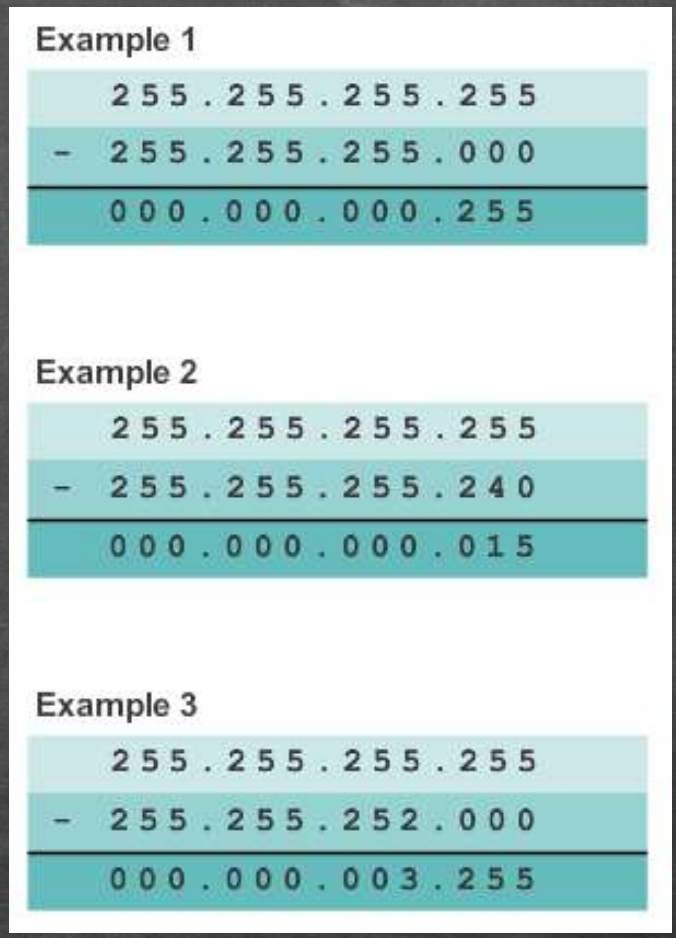
	Decimal	Binary
IP Address	192.168.16.0	11000000.10101000.00010000.00000000
Wildcard Mask	0.0.15.255	00000000.00000000.00001111.11111111
Result Range	192.168.16.0 to 192.168.31.255	11000000.10101000.00010000.00000000 to 11000000.10101000.00011111.11111111

Example 2

	Decimal	Binary
IP Address	192.168.1.0	11000000.10101000.00000001.00000000
Wildcard Mask	0.0.254.255	00000000.00000000.11111110.11111111
Result	192.168.1.0	11000000.10101000.00000001.00000000
	All odd numbered subnets in the 192.168.0.0 major network	

Wildcard Masks in ACLs

- Calculating wildcard masks can be challenging. One shortcut method is to subtract the subnet mask from 255.255.255.255.

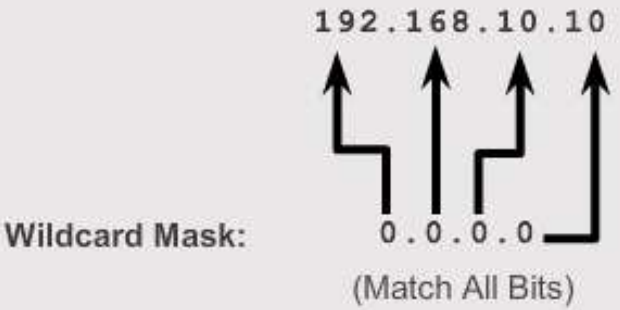


Wildcard Masks in ACLs

- Wildcard Mask Keywords

Example 1

- 192.168.10.10 0.0.0.0 matches all of the address bits
- Abbreviate this wildcard mask using the IP address preceded by the keyword **host** (**host 192.168.10.10**)



Example 2

- 0.0.0.0 255.255.255.255 ignores all address bits
- Abbreviate expression with the keyword **any**

Wildcard Masks in ACLs

- Examples Wildcard Mask Keywords

Example 1:

```
R1(config)#access-list 1 permit 0.0.0.0 255.255.255.255
R1(config)#access-list 1 permit any
```

Example 2:

```
R1(config)#access-list 1 permit 192.168.10.10 0.0.0.0
R1(config)#access-list 1 permit host 192.168.10.10
```

Guidelines for ACL creation

- Use ACLs in firewall routers positioned between your internal network and an external network such as the Internet.
- Use ACLs on a router positioned between two parts of your network to control traffic entering or exiting a specific part of your internal network.
- Configure ACLs on border routers, that is routers situated at the edges of your networks.
- Configure ACLs for each network protocol configured on the border router interfaces.

Guidelines for ACL creation

- The Three Ps
- One ACL per protocol - To control traffic flow on an interface, an ACL must be defined for each protocol enabled on the interface.
- One ACL per direction - ACLs control traffic in one direction at a time on an interface. Two separate ACLs must be created to control inbound and outbound traffic.
- One ACL per interface - ACLs control traffic for an interface, for example, GigabitEthernet 0/0.

Guidelines for ACL creation

- ACL Best Practices

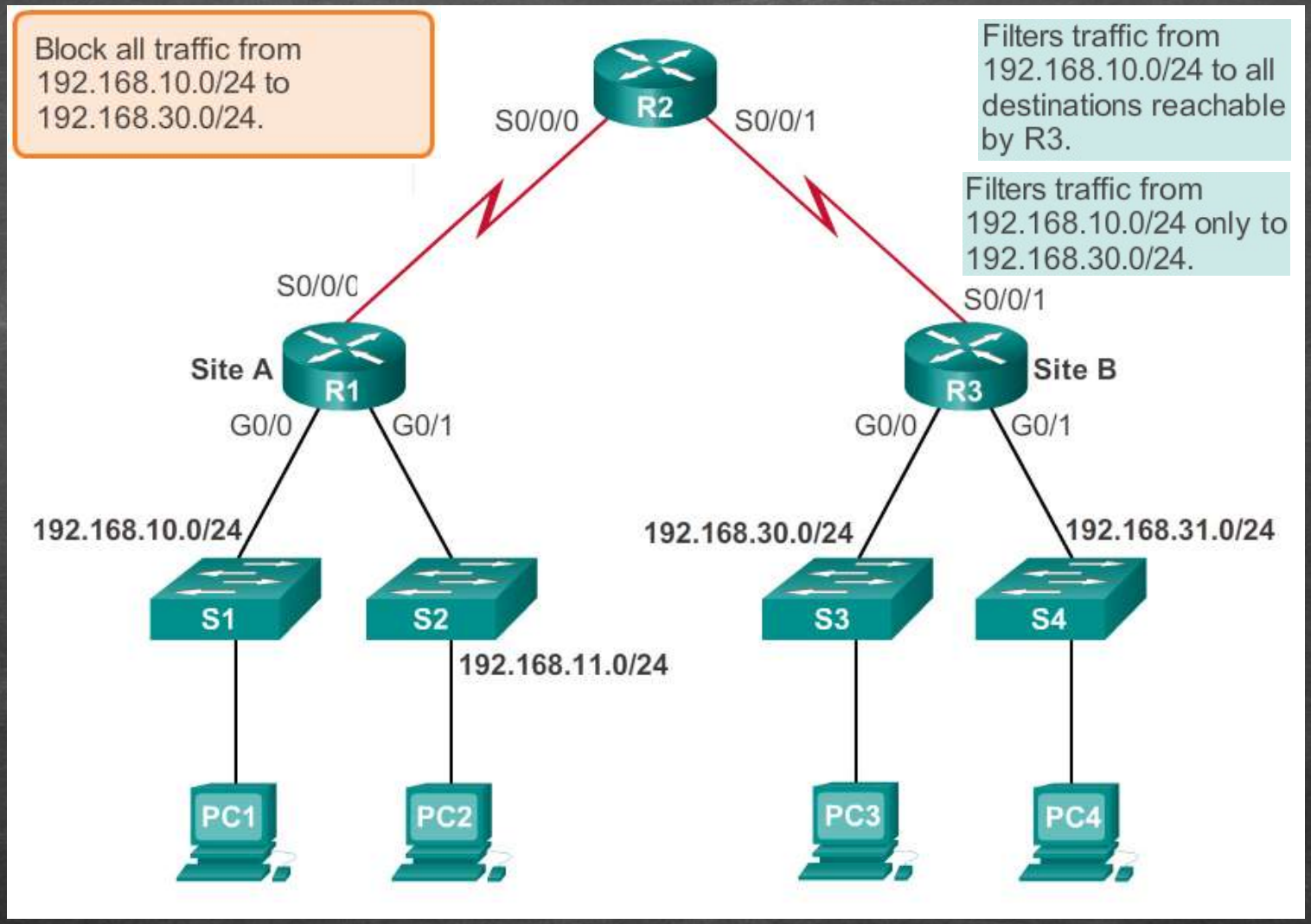
Guideline	Benefit
Base your ACLs on the security policy of the organization.	This will ensure you implement organizational security guidelines.
Prepare a description of what you want your ACLs to do.	This will help you avoid inadvertently creating potential access problems.
Use a text editor to create, edit and save ACLs.	This will help you create a library of reusable ACLs.
Test your ACLs on a development network before implementing them on a production network.	This will help you avoid costly errors.

Guidelines for ACL creation

- Where to Place ACLs
  - Every ACL should be placed where it has the greatest impact on efficiency. The basic rules are:
    - Extended ACLs: Locate extended ACLs as close as possible to the source of the traffic to be filtered.
    - Standard ACLs: Because standard ACLs do not specify destination addresses, place them as close to the destination as possible.
  - Placement of the ACL and therefore the type of ACL used may also depend on: the extent of the network administrator's control, bandwidth of the networks involved, and ease of configuration.

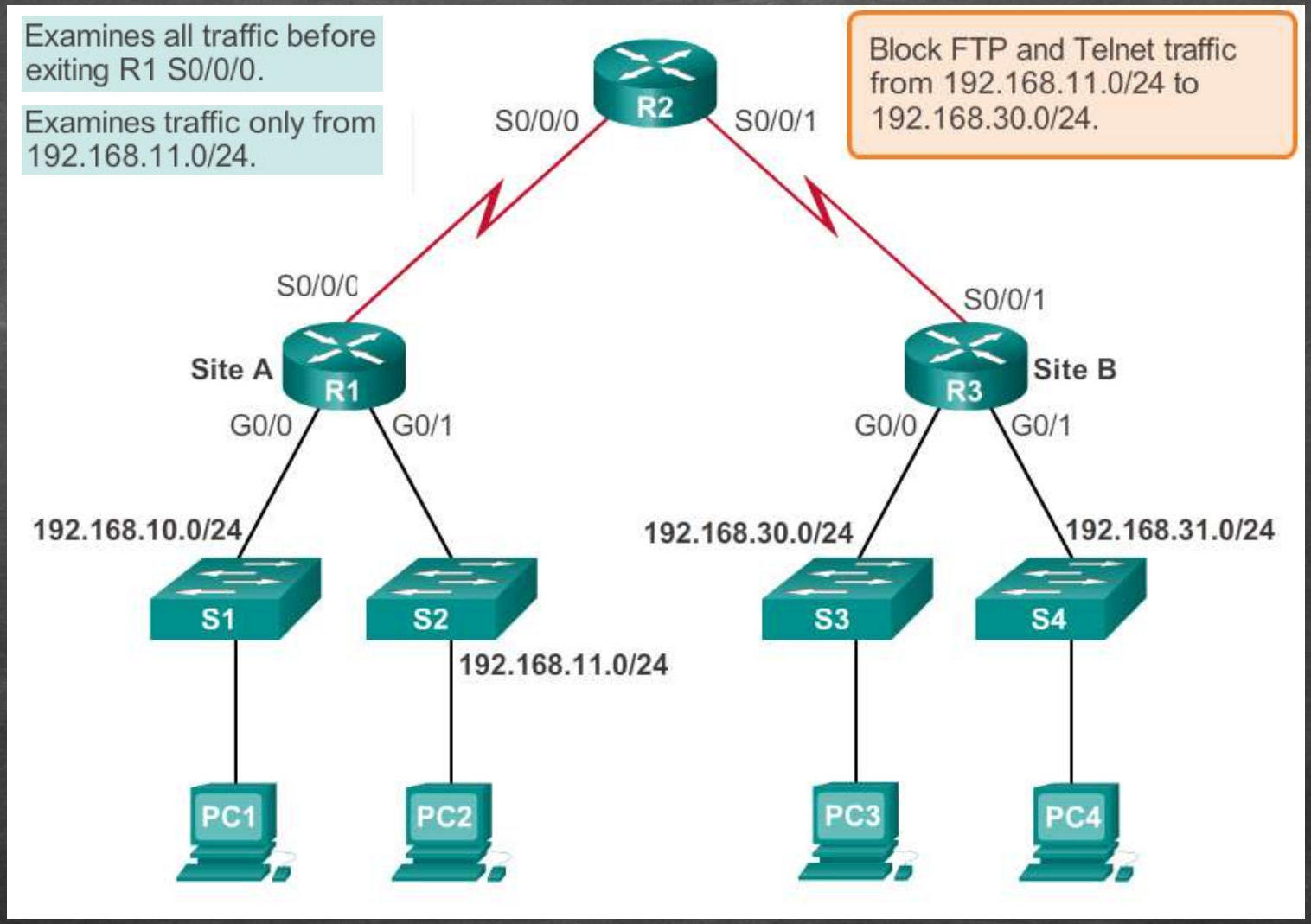
Guidelines for ACL creation

- Standard ACL Placement



Guidelines for ACL creation

- Extended ACL Placement



Configure ACLs

- Creating ACLs Statements (Standard | Extended)

- Applying Standard ACLs to Interfaces

Configure Standard IPv4 ACLs

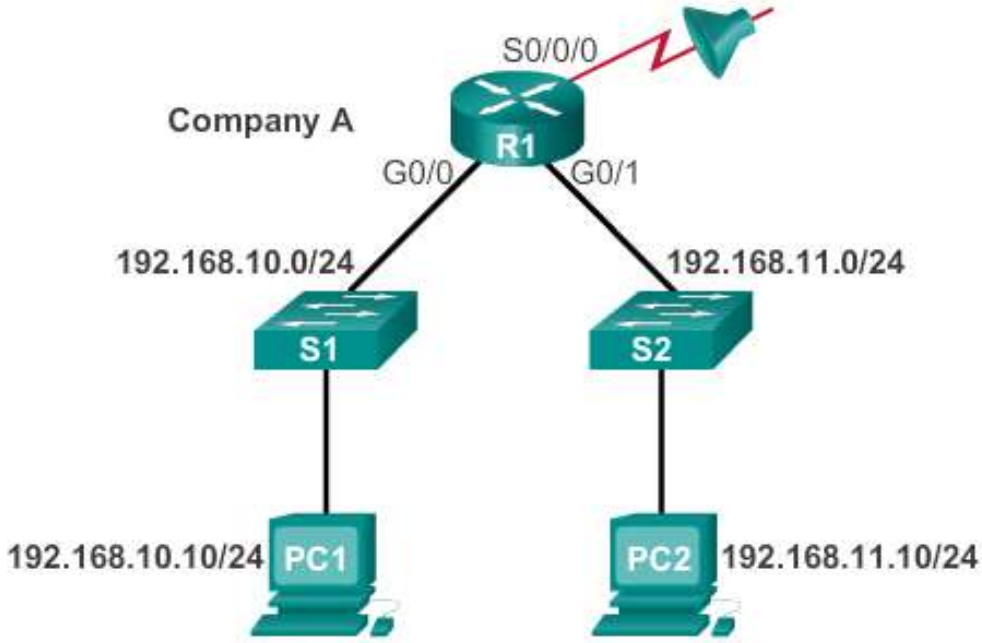
- The full syntax of the standard ACL command is as follows:

```
Router(config)# access-list access-list-number
    deny | permit | remark
    source [ source-wildcard ] [ log ]
```

- To remove the ACL, the global configuration **no access-list** command is used.
- The **remark** keyword is used for documentation and makes access lists a great deal easier to understand.

Configure Standard IPv4 ACLs

- Entering Criteria Statements



ACL 1

```
R1(config)#access-list 1 permit ip 192.168.10.0 0.0.0.255
```

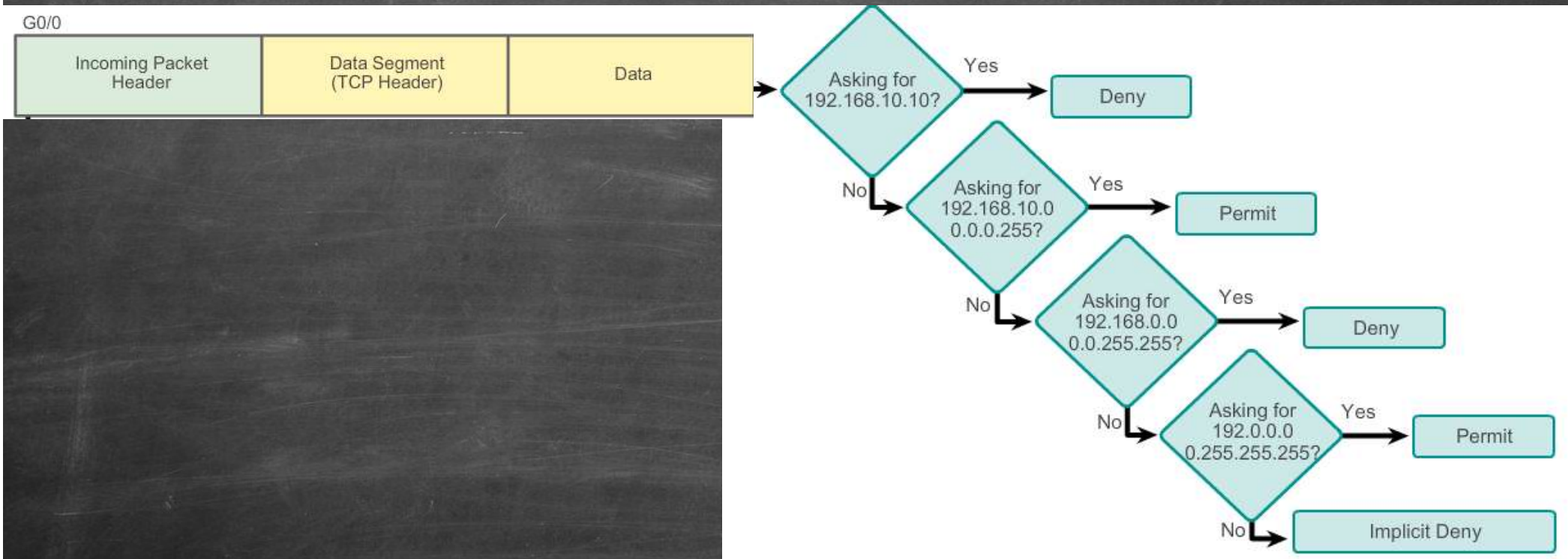
ACL 2

```
R1(config)#access-list 2 permit ip 192.168.10.0 0.0.0.255
R1(config)#access-list 2 deny any
```

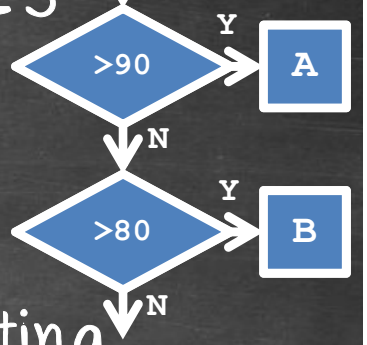
Configure Standard IPv4 ACLs

- Example ACL

```
access-list 2 deny host 192.168.10.10
access-list 2 permit 192.168.10.0 0.0.0.255
access-list 2 deny 192.168.0.0 0.0.255.255
access-list 2 permit 192.0.0.0 0.255.255.255
```



Configure Standard IPv4 ACLs



- Internal Logic
  - Cisco IOS applies an internal logic when accepting and processing standard access list statements. As discussed previously, access list statements are processed sequentially. Therefore, the order in which statements are entered is important.

```
R1(config)#access-list 3 deny 192.168.10.0 0.0.0.255
R1(config)#access-list 3 permit host 192.168.10.10
% Access rule can't be configured at higher sequence num as
it is part of the existing rule at sequence num 10
R1(config)#
```

ACL 3: Host statement conflicts with previous range statement.

Configure Standard IPv4 ACLs

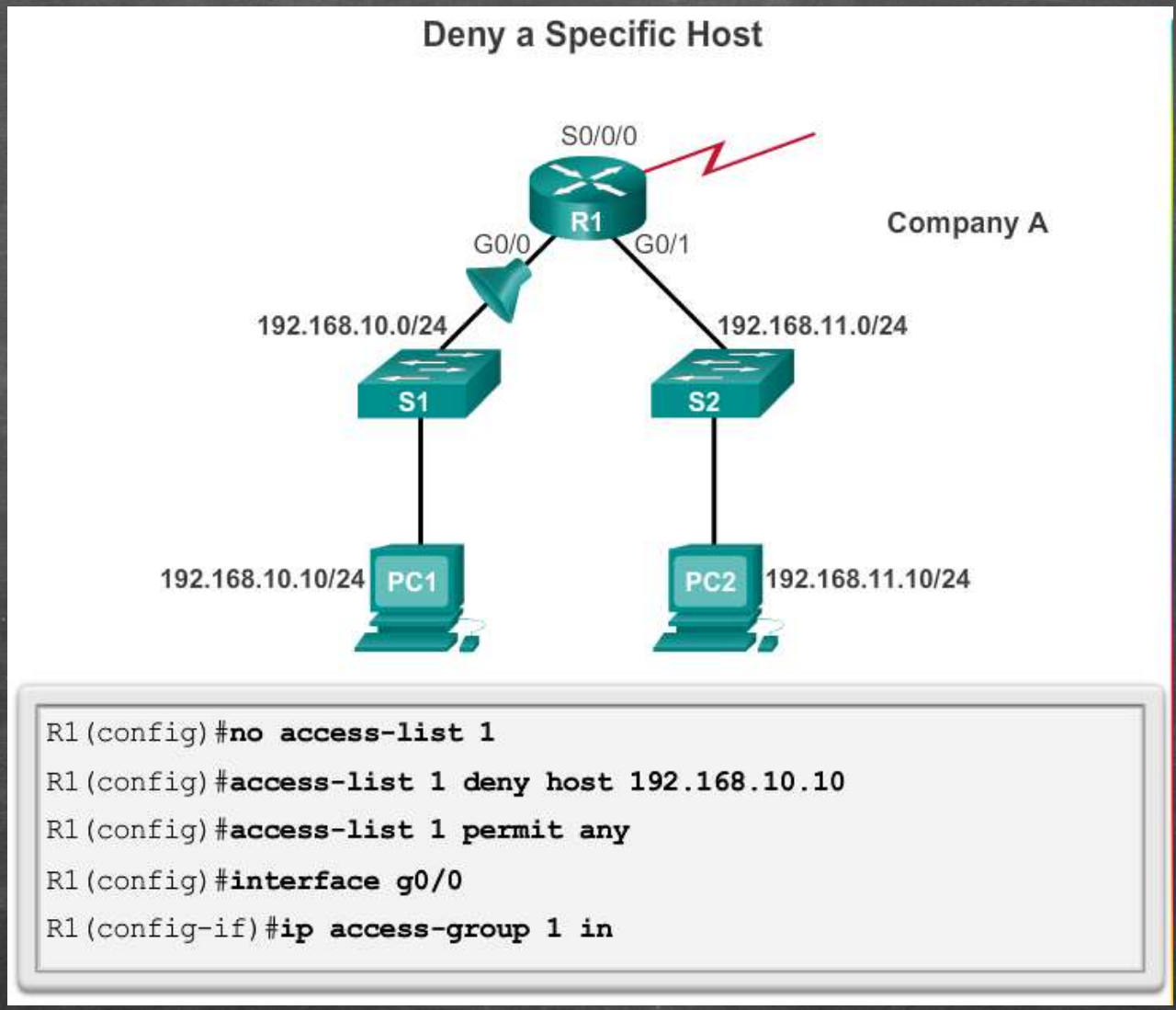
- Applying Standard ACLs to Interfaces
  - After a standard ACL is configured, it is linked to an interface using the **ip access-group** command in interface configuration mode:

```
Router(config-if)# ip access-group
  { access-list-number | access-list-name }
  { in | out }
```

  - To remove an ACL from an interface, first enter the **no ip access-group** command on the interface, and then enter the global **no access-list** command to remove the entire ACL.

Configure Standard IPv4 ACLs

- Applying Standard ACLs to Interfaces (Cont.)



Configure Standard IPv4 ACLs

- Creating Named Standard ACLs

```
Router(config)#ip access-list [standard | extended ] name
```

Alphanumeric name string must be unique and cannot begin with a number.

```
Router(config-std-nacl)#[permit | deny | remark] {source
[source- wildcard]} [log]
```

```
Router(config-if)#ip access-group name [in | out]
```

Activates the named IP ACL on an inteface.

Configure Standard IPv4 ACLs

- Commenting ACLs

Example 1: Commenting a numbered ACL

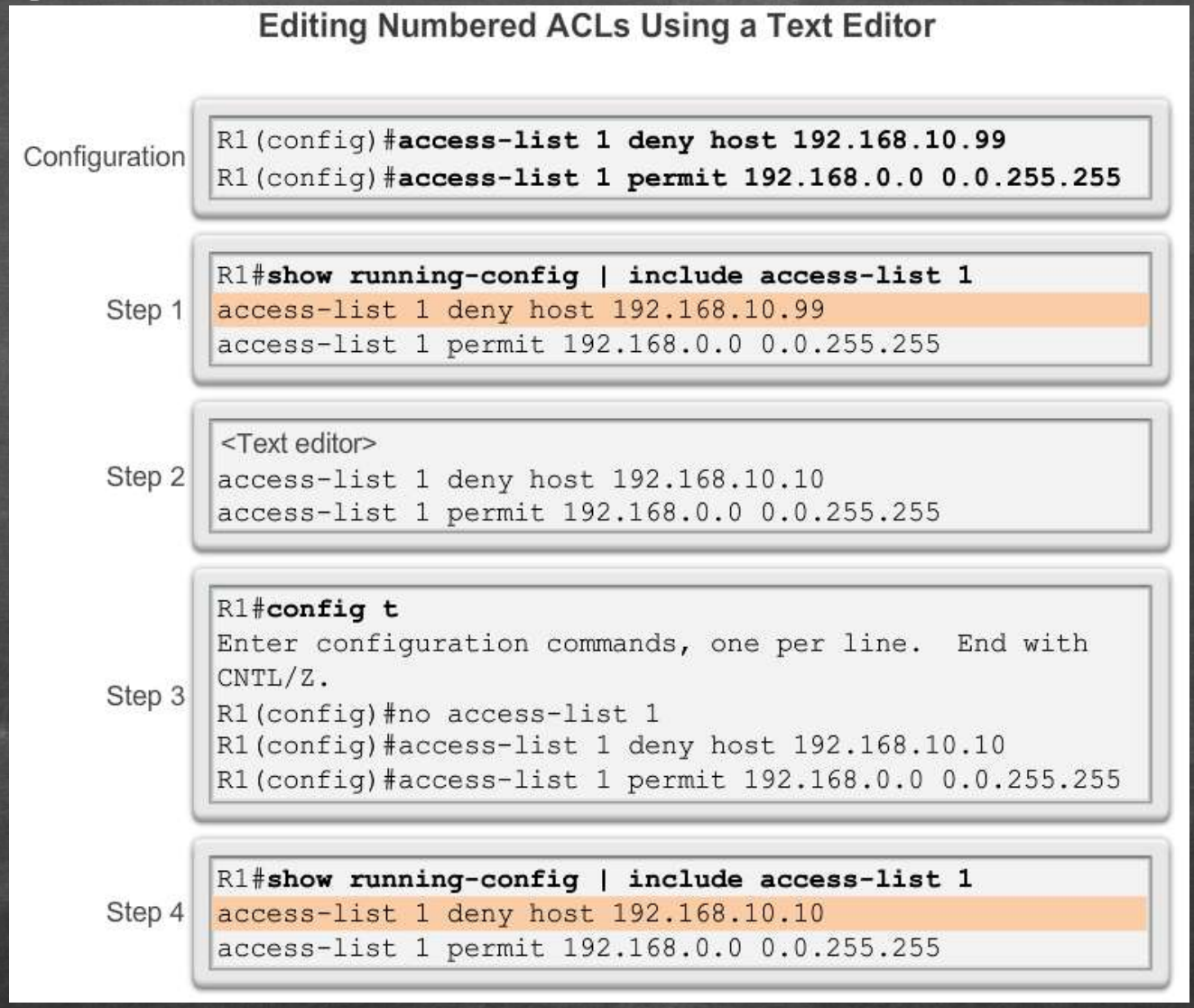
```
R1(config)#access-list 1 remark Do not allow Guest workstation
through
R1(config)#access-list 1 deny host 192.168.10.10
R1(config)#access-list 1 remark Allow devices from all other
192.168.x.x subnets
R1(config)#access-list 1 permit 192.168.0.0 0.0.255.255
R1(config)#interface s0/0/0
R1(config-if)#ip access-group 1 out
R1(config-if)#
```

Example 2: Commenting a named ACL

```
R1(config)#ip access-list standard NO_ACCESS
R1(config-std-nacl)#remark Do not allow access from Lab
workstation
R1(config-std-nacl)#deny host 192.168.11.10
R1(config-std-nacl)#remark Allow access from all other networks
R1(config-std-nacl)#permit any
R1(config-std-nacl)#interface G0/0
R1(config-if)#ip access-group NO_ACCESS out
R1(config-if)#
```

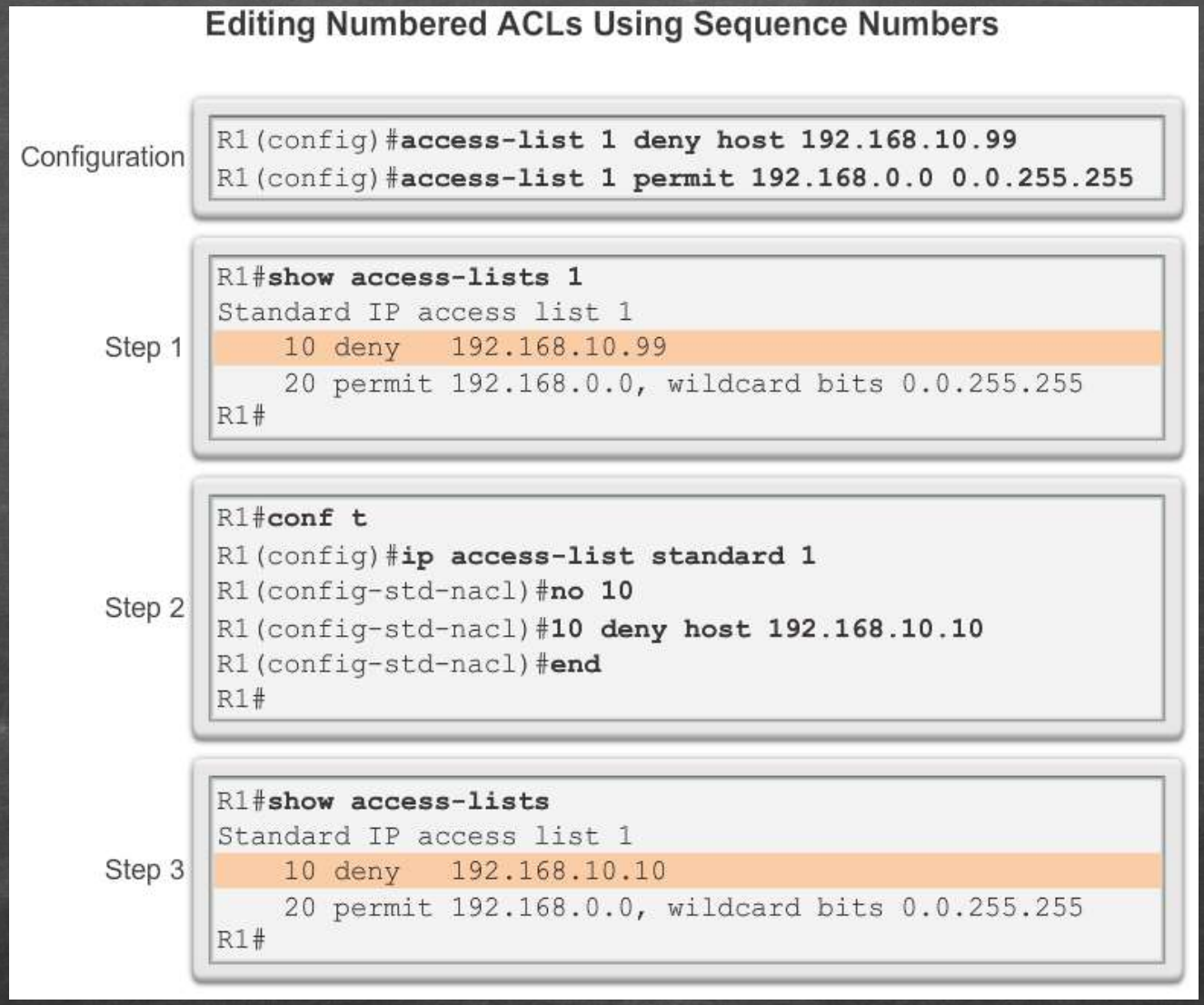
Modify IPv4 ACLs

- Editing Standard Numbered ACLs



Modify IPv4 ACLs

- Editing Standard Numbered ACLs (Cont.)



Modify IPv4 ACLs

- Editing Standard Named ACLs

Adding a Line to a Named ACL

```
R1#show access-lists
Standard IP access list NO_ACCESS
    10 deny   192.168.11.10
    20 permit 192.168.11.0, wildcard bits 0.0.0.255
R1#conf t
Enter configuration commands, one per line.  End with
CNTL/Z.
R1(config)#ip access-list standard NO_ACCESS
R1(config-std-nacl)#15 deny host 192.168.11.11
R1(config-std-nacl)#end
R1#show access-lists
Standard IP access list NO_ACCESS
    10 deny   192.168.11.10
    15 deny   192.168.11.11
    20 permit 192.168.11.0, wildcard bits 0.0.0.255
R1#
```

Note: The **no sequence-number** named-ACL command is used to delete individual statements.

Modify IPv4 ACLs

- Verifying ACLs

```
R1# show ip interface s0/0/0
Serial0/0/0 is up, line protocol is up
  Internet address is 10.1.1.1/30
<output omitted>
  Outgoing access list is 1
  Inbound  access list is not set
<output omitted>

R1# show ip interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 192.168.10.1/24
<output omitted>
  Outgoing access list is NO_ACCESS
  Inbo
<output
```

```
R1# show access-lists
Standard IP access list 1
    10 deny   192.168.10.10
    20 permit 192.168.0.0, wildcard bits 0.0.255.255
Standard IP access list NO_ACCESS
    15 deny   192.168.11.11
    10 deny   192.168.11.10
    20 permit 192.168.11.0, wildcard bits 0.0.0.255
R1#
```

Modify IPv4 ACLs

- ACL Statistics

```
R1#show access-lists
Standard IP access list 1
    10 deny   192.168.10.10 (4 match(es))
    20 permit 192.168.0.0, wildcard bits 0.0.255.255
Standard IP access list NO_ACCESS
    15 deny   192.168.11.11
    10 deny   192.168.11.10 (4 match(es))
    20 permit 192.168.11.0, wildcard bits 0.0.0.255
R1#
```

Output after pinging PC3 from PC1.

Matches have been incremented.

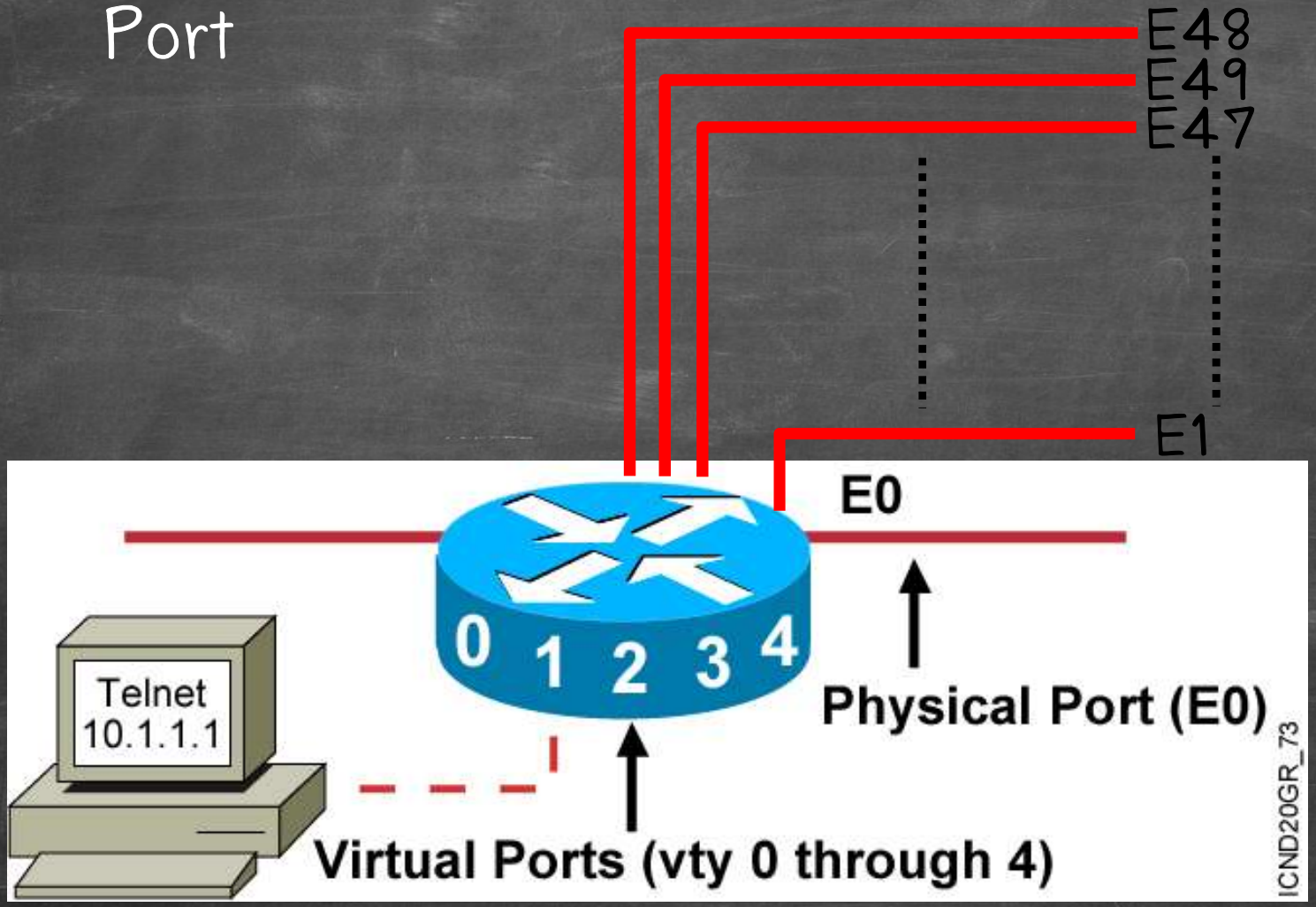
```
R1#show access-lists
Standard IP access list 1
    10 deny   192.168.10.10 (8 match(es))
    20 permit 192.168.0.0, wildcard bits 0.0.255.255
Standard IP access list NO_ACCESS
    15 deny   192.168.11.11
    10 deny   192.168.11.10 (4 match(es))
    20 permit 192.168.11.0, wildcard bits 0.0.0.255
R1#
```

Modify IPv4 ACLs

- Standard ACL Sequence Numbers
  - Another part of the IOS internal logic involves the internal sequencing of standard ACL statements. Range statements that deny three networks are configured first followed by five host statements. The host statements are all valid statements because their host IP addresses are not part of the previously entered range statements.
  - The host statements are listed first by the show command, but not necessarily in the order that they were entered. The IOS puts host statements in an order using a special hashing function. The resulting order optimizes the search for a host ACL entry.

Securing VTY ports with a Standard IPv4 ACL

- Configuring a Standard ACL to Secure a VTY Port



Securing VTY ports with a Standard IPv4 ACL

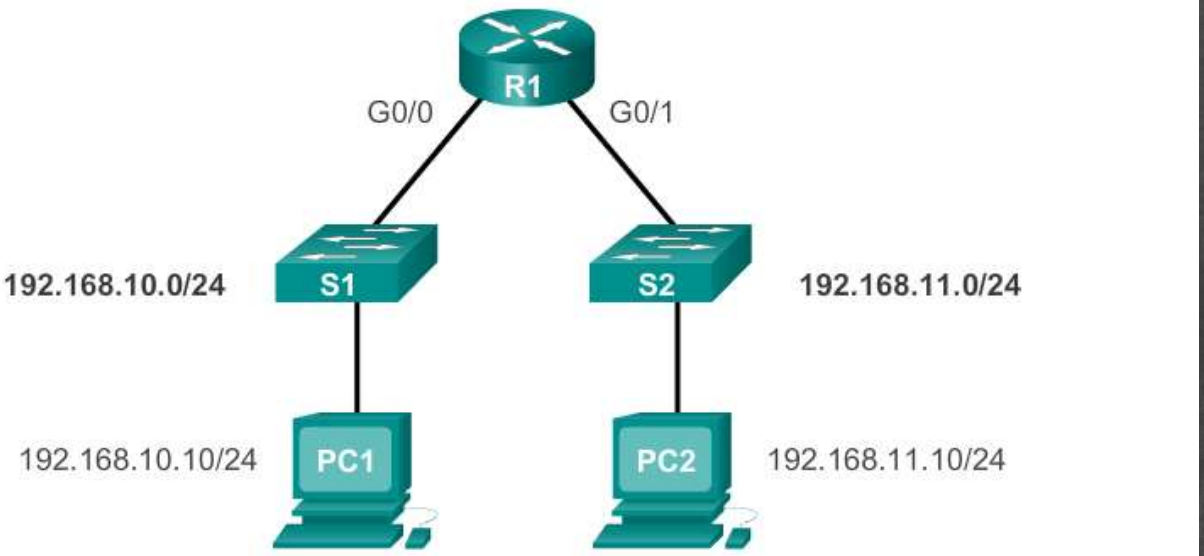
- Configuring a Standard ACL to Secure a VTY Port
  - Filtering Telnet or SSH traffic is typically considered an extended IP ACL function because it filters a higher level protocol. However, because the **access-class** command is used to filter incoming or outgoing Telnet/SSH sessions by source address, a standard ACL can be used.

```
Router(config-line)# access-class access-
  list-number { in [ vrf-also ] | out }
```

Securing VTY ports with a Standard IPv4 ACL

- Verifying a Standard ACL used to Secure a VTY Port

```
R1#show access-lists
Standard IP access list 21
    10 permit 192.168.10.0, wildcard bits 0.0.0.255 (2 matches)
    20 deny   any (1 match)
R1#
```

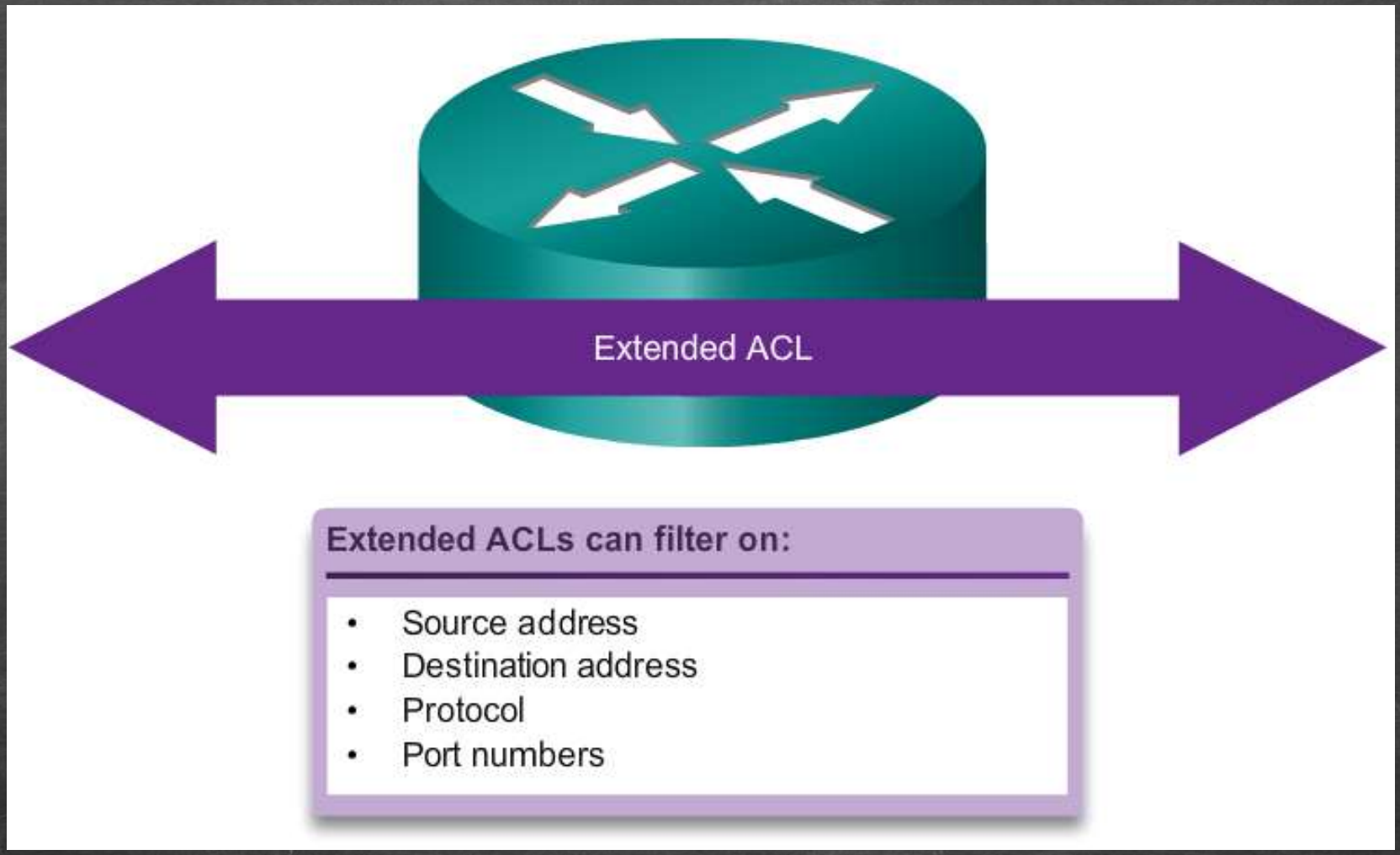



```
PC1>ssh 192.168.10.1

Login as: admin
Password: *****
R1>
```

```
PC2>ssh 192.168.11.1
ssh connect to host 192.168.11.1 port
22: Connection refused

PC2>
```

Structure of an Extended IPv4 ACL

- Extended ACLs



Structure of an Extended IPv4 ACL

- Extended ACLs (Cont.)

Using Port Numbers

```
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq 23
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq 21
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq 20
```

Using Keywords

```
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq telnet
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq ftp
access-list 114 permit tcp 192.168.20.0 0.0.0.255 any eq ftp-data
```

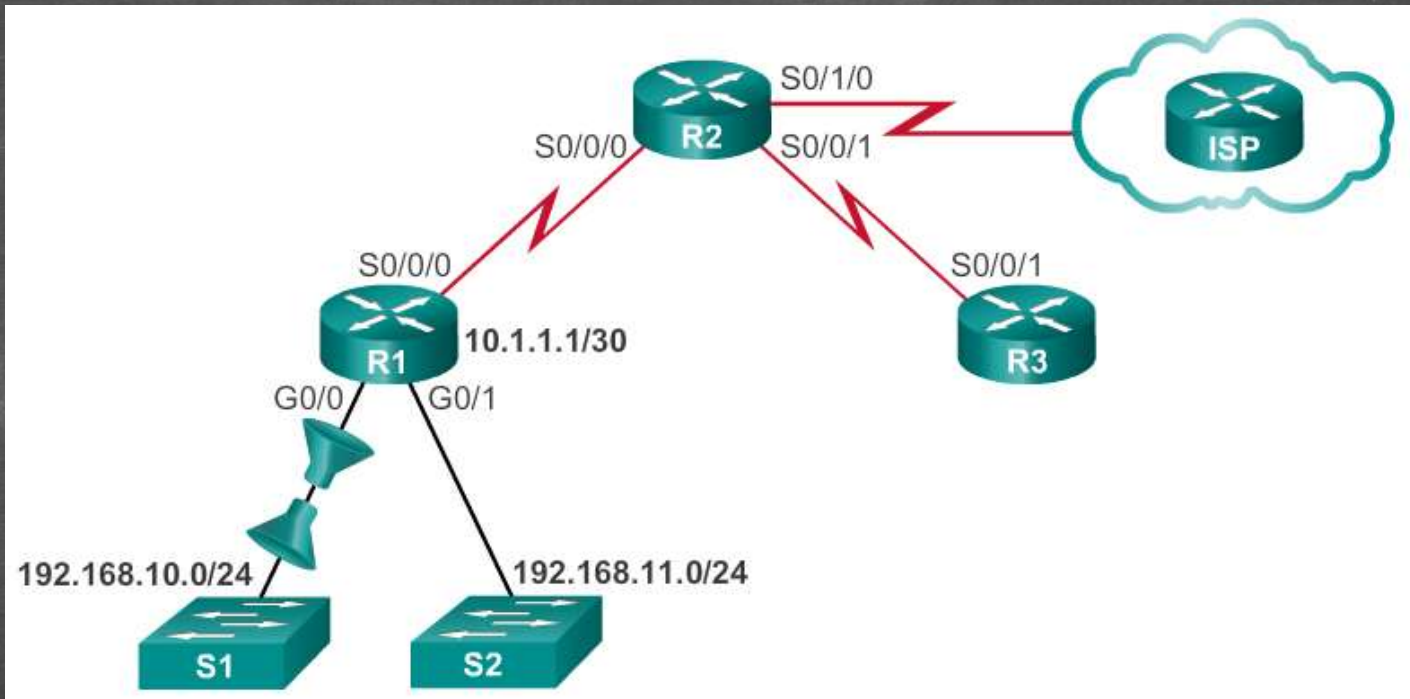
Configure Extended IPv4 ACLs

- The procedural steps for configuring extended ACLs are the same as for standard ACLs. The extended ACL is first configured, and then it is activated on an interface. However, the command syntax and parameters are more complex to support the additional features provided by extended ACLs.

```
access-list access-list-number {deny | permit | remark}
protocol source [source-wildcard] [operator operand]
[port port-number or name] destination [destination-wildcard]
[operator operand] [port port-number or name][established]
```

Configure Extended IPv4 ACLs

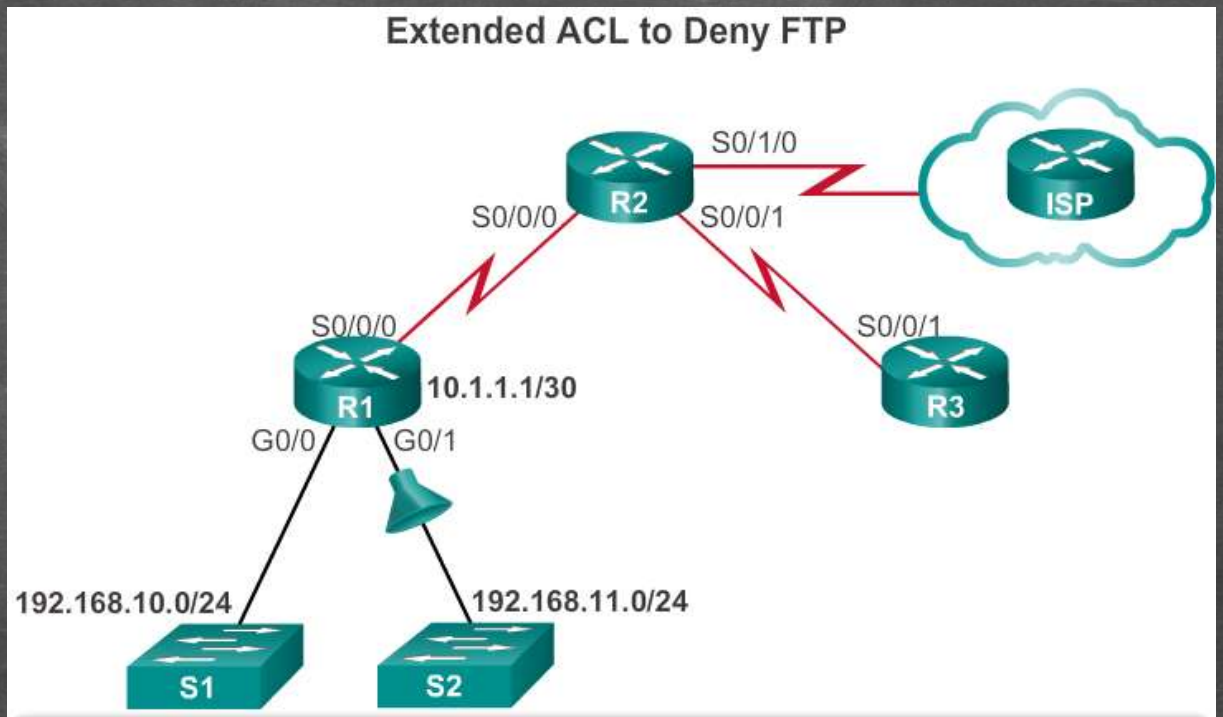
- Applying Extended ACLs to Interfaces




```
R1(config)#access-list 103 permit tcp 192.168.10.0 0.0.0.255 any eq 80
R1(config)#access-list 103 permit tcp 192.168.10.0 0.0.0.255 any eq 443
R1(config)#access-list 104 permit tcp any 192.168.10.0 0.0.0.255 established
R1(config)#interface g0/0
R1(config-if)#ip access-group 103 in
R1(config-if)#ip access-group 104 out
```

Configure Extended IPv4 ACLs

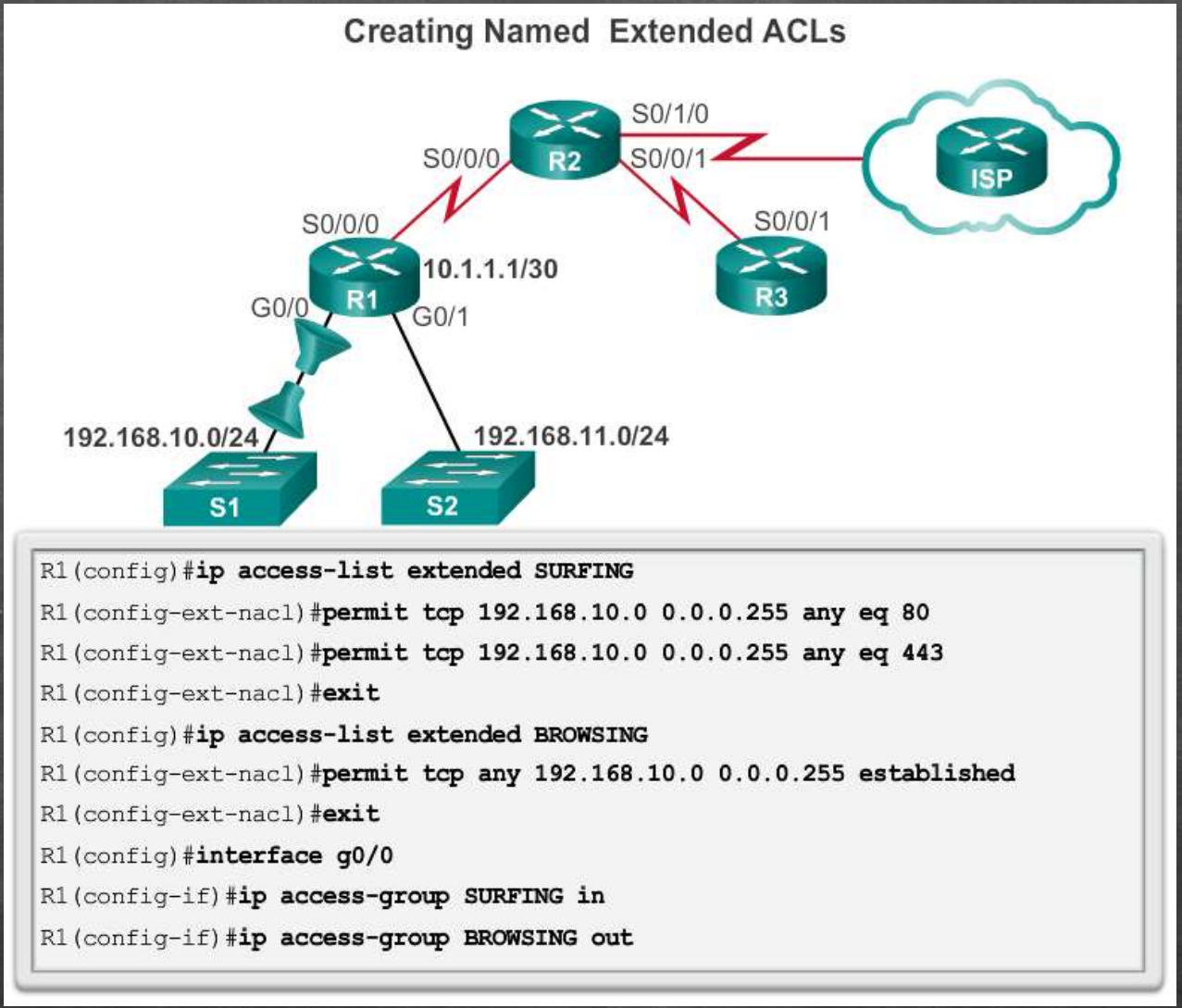
- Filtering Traffic with Extended ACLs




```
R1(config)#access-list 101 deny tcp 192.168.11.0 0.0.0.255 192.168.10.0
0.0.0.255 eq ftp
R1(config)#access-list 101 deny tcp 192.168.11.0 0.0.0.255 192.168.10.0
0.0.0.255 eq ftp-data
R1(config)#access-list 101 permit ip any any
R1(config)#interface g0/1
R1(config-if)#ip access-group 101 in
```

Configure Extended IPv4 ACLs

- Creating Named Extended ACLs



Configure Extended IPv4 ACLs

- Verifying Extended ACLs

```
R1#show access-lists
Extended IP access list BROWSING
    10 permit tcp any 192.168.10.0 0.0.0.255 established
Extended IP access list SURFING
    10 permit tcp 192.168.10.0 0.0.0.255 any eq www
    20 permit tcp 192.168.10.0 0.0.0.255 any eq 443
R1#
R1#show ip interface g0/0
GigabitEthernet0/0 is up, line protocol is up
  Internet address is 192.168.10.1/24
<output omitted for brevity>
  Outgoing access list is BROWSING
  Inbound  access list is SURFING
<output omitted for brevity>
```

Configure Extended IPv4 ACLs

- Editing Extended ACLs
  - Editing an extended ACL can be accomplished using the same process as editing a standard. An extended ACL can be modified using:
    - Method 1 - Text editor
    - Method 2 - Sequence numbers

Limiting Debug Output

- Purpose of Limiting debug Output with ACLs
  - Debug commands are tools used to help verify and troubleshoot network operations.
  - When using some debug options, the output may display much more information than is needed or can be easily viewed.
  - In a production network, the amount of information provided by debug commands can be overwhelming and can cause network interruptions.
  - Some debug commands can be combined with an access list to limit output so that only the information needed for verification or troubleshooting a specific issue is displayed.

Limiting Debug Output

- Configuring ACLs to Limit debug Output
  - The administrator for R2 wants to verify that traffic is being routed correctly using debug ip packet. To limit the debug output to include only the ICMP traffic between R1 and R3, ACL 101 will be applied.


```
R2(config)#ip access-list extended 101
R2(config-ext-nacl)#permit icmp host 10.1.1.1 host 10.1.2.2
R2(config-ext-nacl)#permit icmp host 10.1.2.2 host 10.1.1.1
R2(config-ext-nacl)#exit
R2(config)#interface s0/0/0
R2(config-if)#no ip route-cache
R2(config-if)#exit
R2(config)#interface s0/0/1
R2(config-if)#no ip route-cache
R2(config-if)#end
R2#
R2#debug ip packet 101
IP packet debugging is on for access list 101
R2#
```

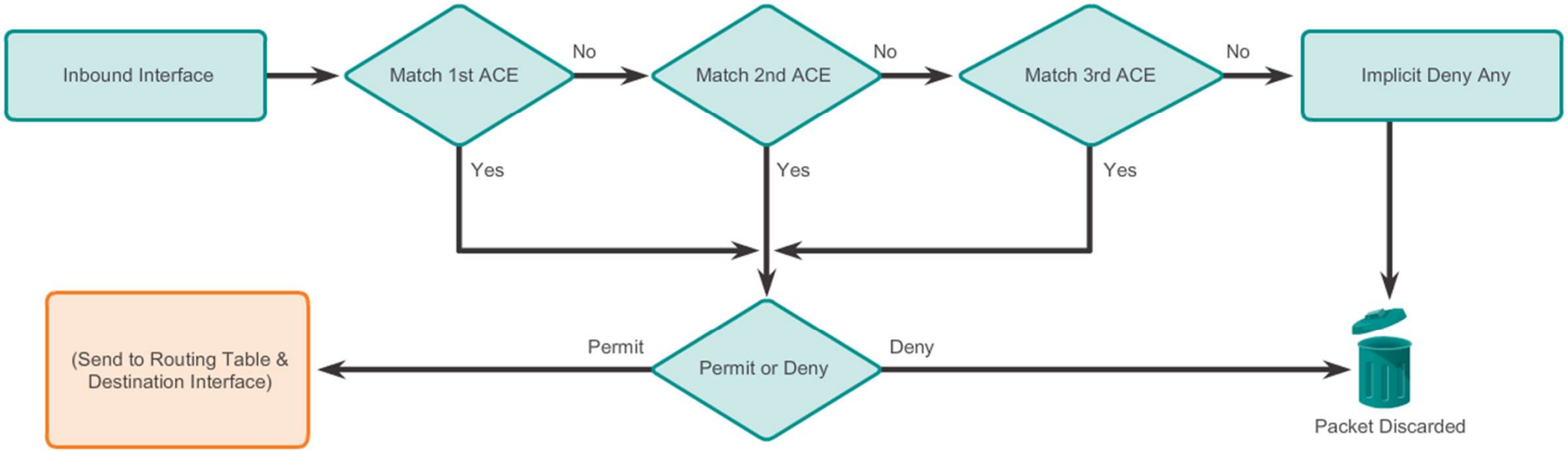
Limiting Debug Output

- Verifying ACLs that Limit debug Output


```
R2# debug ip packet 101
IP packet debugging is on for access list 101
R2#

<ping 10.1.2.2 command entered on R1>

*Jan 25 20:49:26.910: IP: s=10.1.1.1 (Serial0/0/0), d=10.1.2.2
(Serial0/0/1), g=10.1.2.2, len 100, forward
*Jan 25 20:49:26.910: IP: s=10.1.1.1 (Serial0/0/0), d=10.1.2.2
(Serial0/0/1), len 100, sending full packet
*Jan 25 20:49:26.938: IP: s=10.1.2.2 (Serial0/0/1), d=10.1.1.1
(Serial0/0/0), g=10.1.1.1, len 100, forward
*Jan 25 20:49:26.938: IP: s=10.1.2.2 (Serial0/0/1), d=10.1.1.1
(Serial0/0/0), len 100, sending full packet

<output omitted>
```

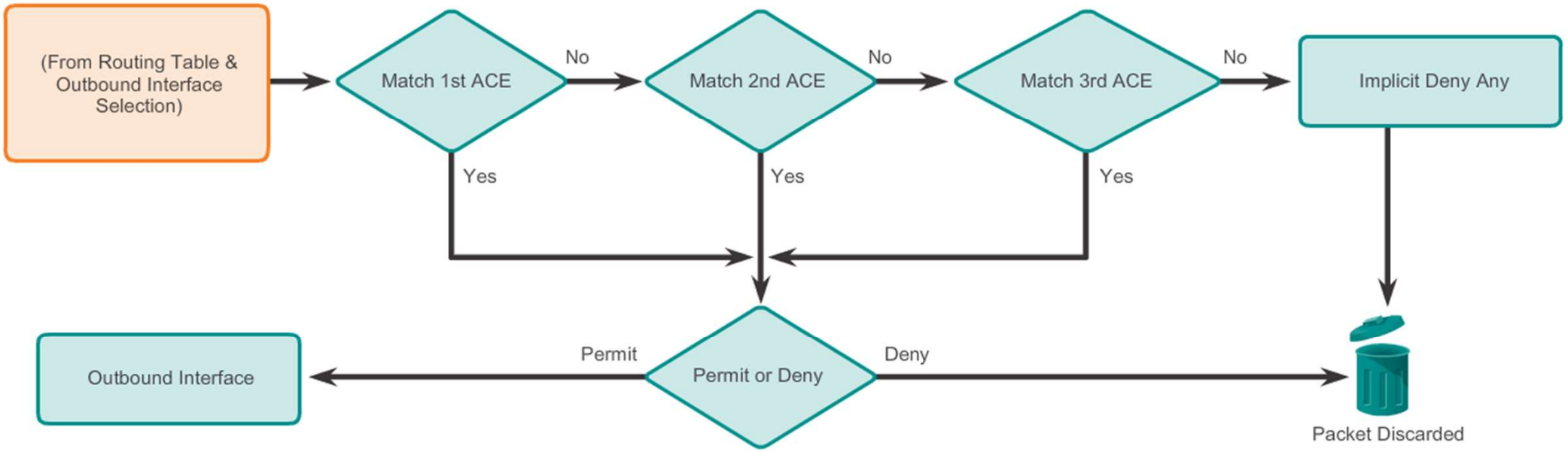
Processing Packets with ACLs

- Inbound ACL Logic

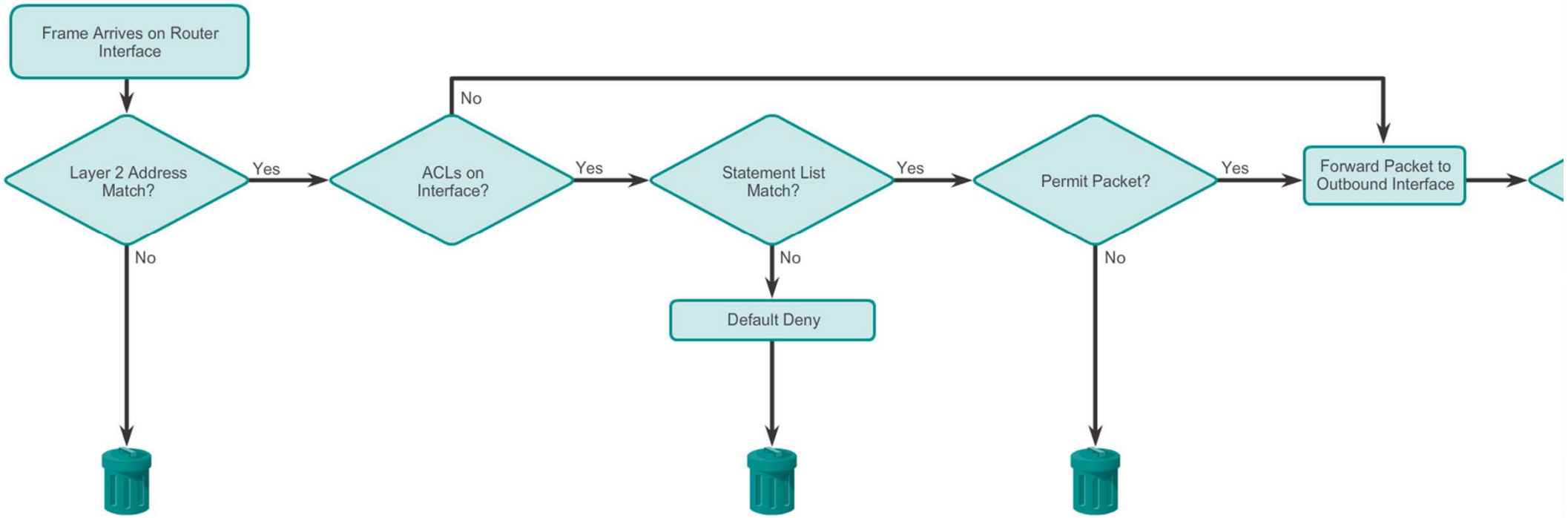


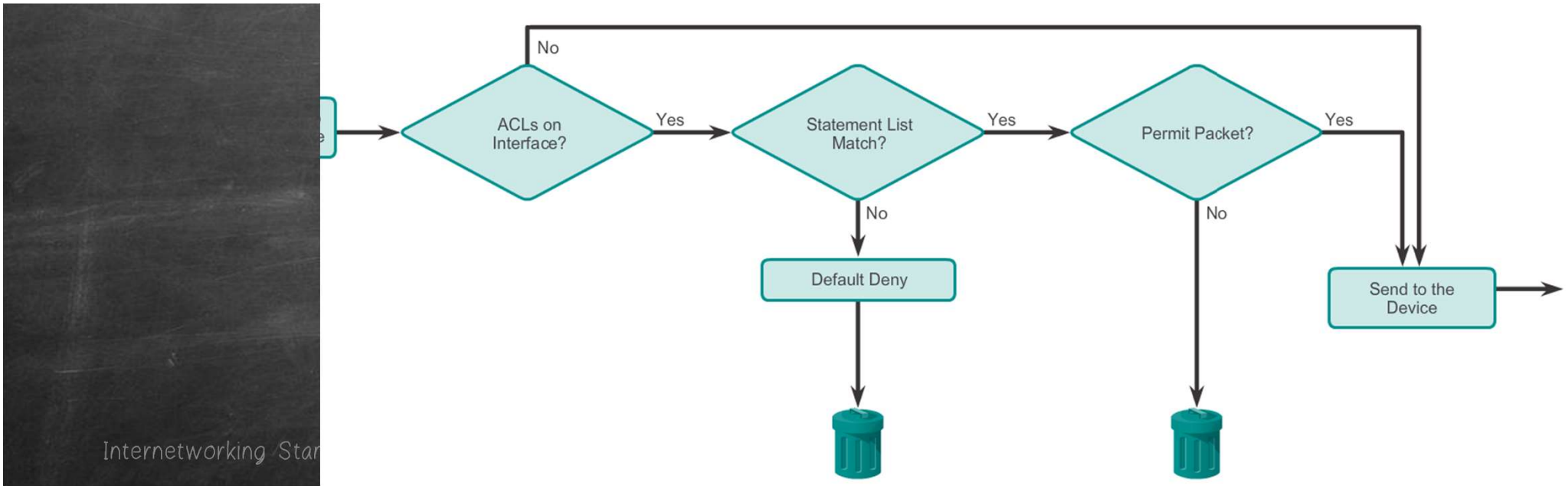
Processing Packets with ACLs

- Outbound ACL Logic



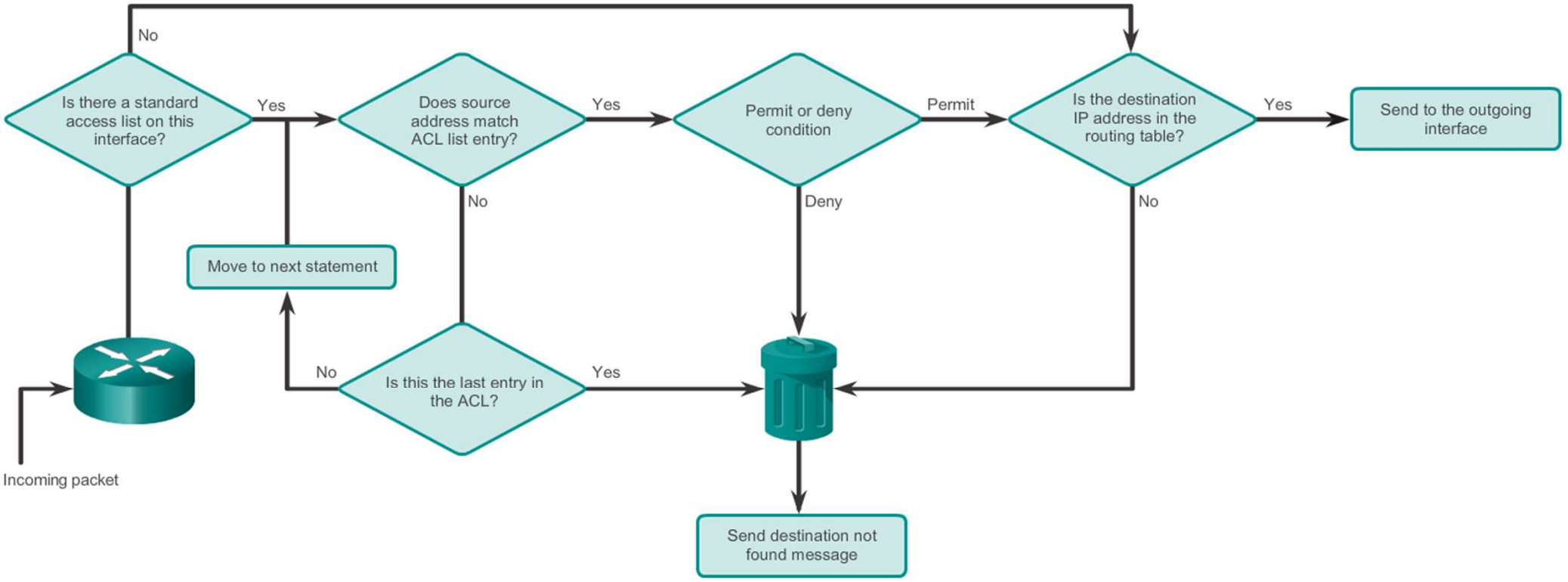
Processing Packets with ACLs





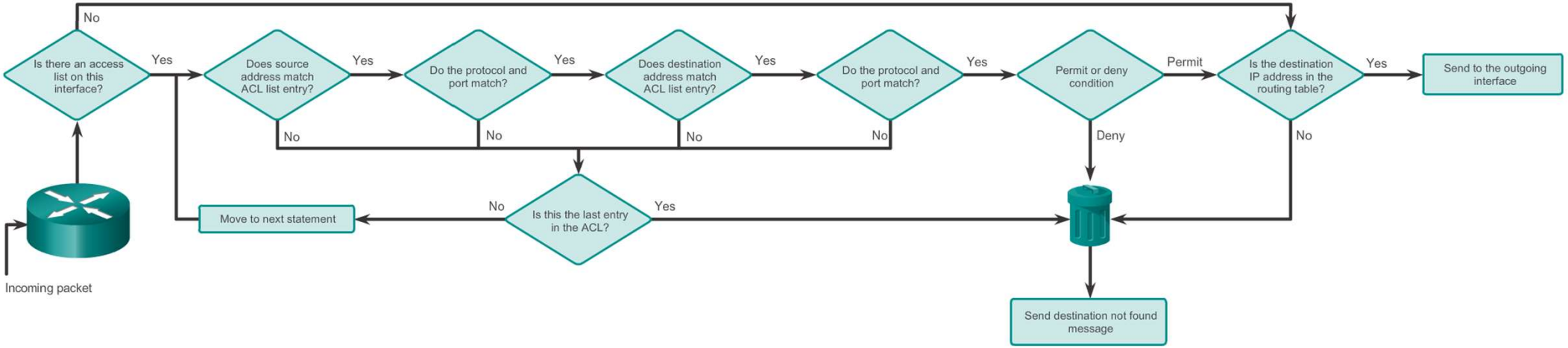
Processing Packets with ACLs

- Standard ACL Decision Process



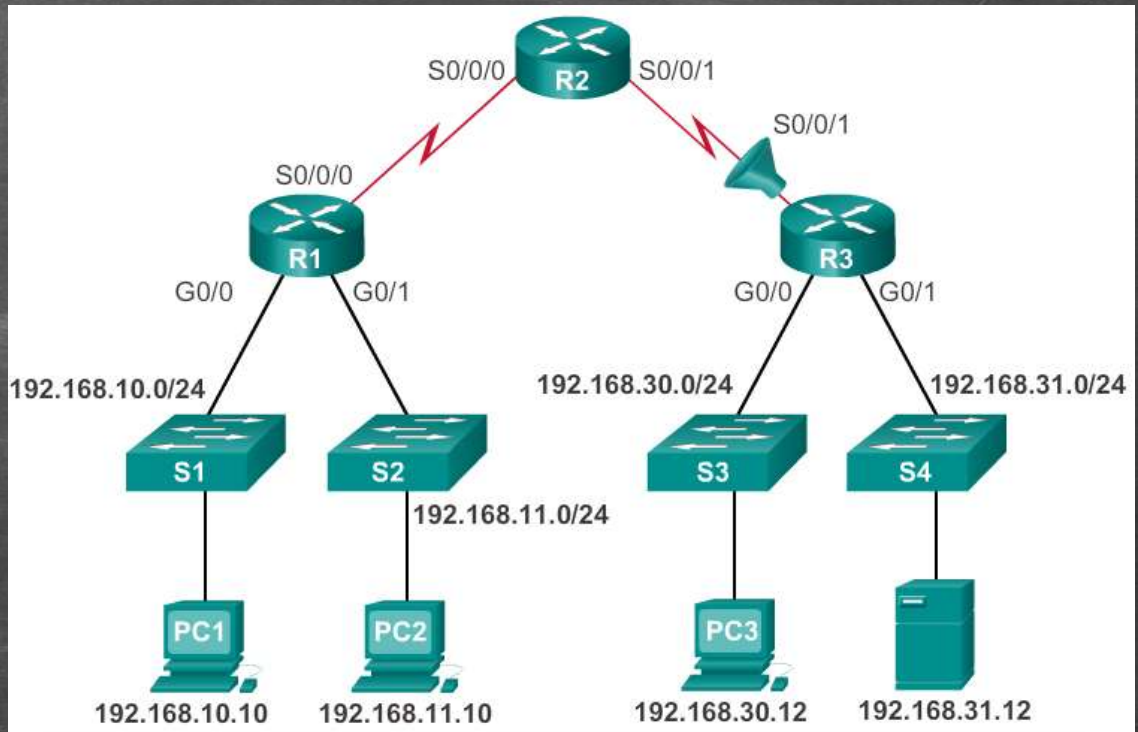
Processing Packets with ACLs

- Extended ACL Decision Process



Common ACLs Errors

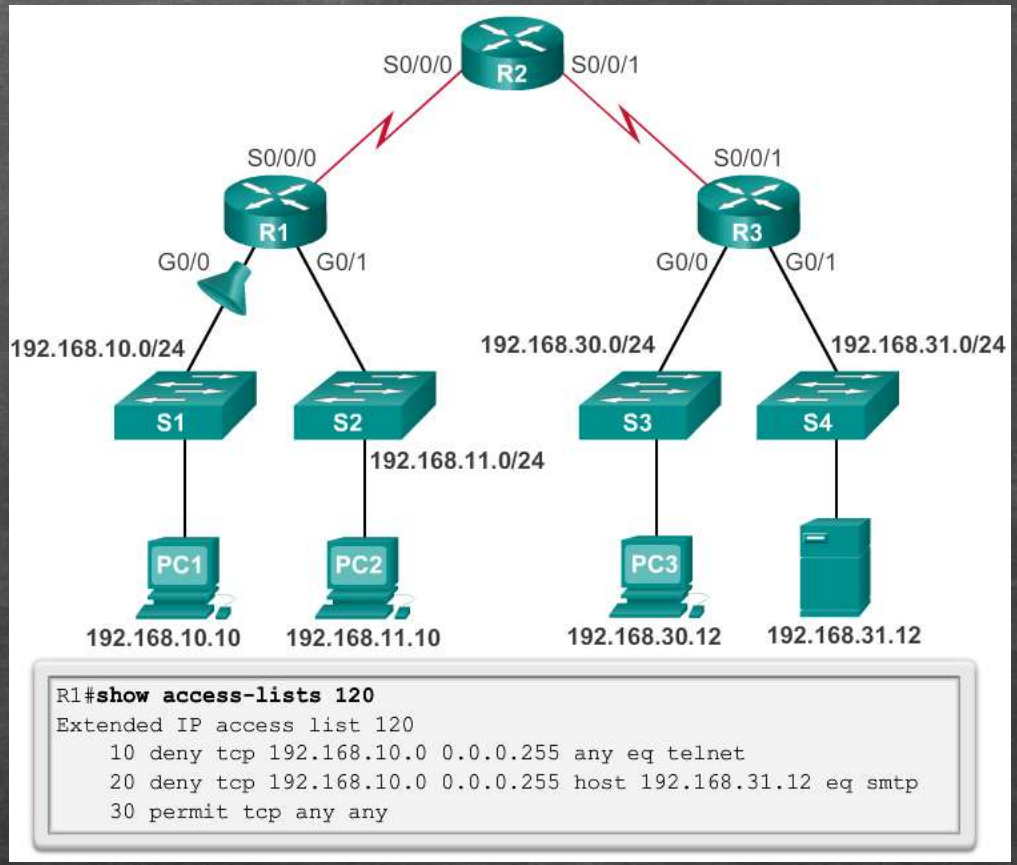
- Troubleshooting Common ACL Errors - Example 1
  - Host 192.168.10.10 has no connectivity with 192.168.30.12.




```
R3#show access-lists
Extended IP access list 110
    10 deny tcp 192.168.10.0 0.0.0.255 any (12 match(es))
    20 permit tcp 192.168.10.0 0.0.0.255 any eq telnet
    30 permit ip any any
```

Common ACLs Errors

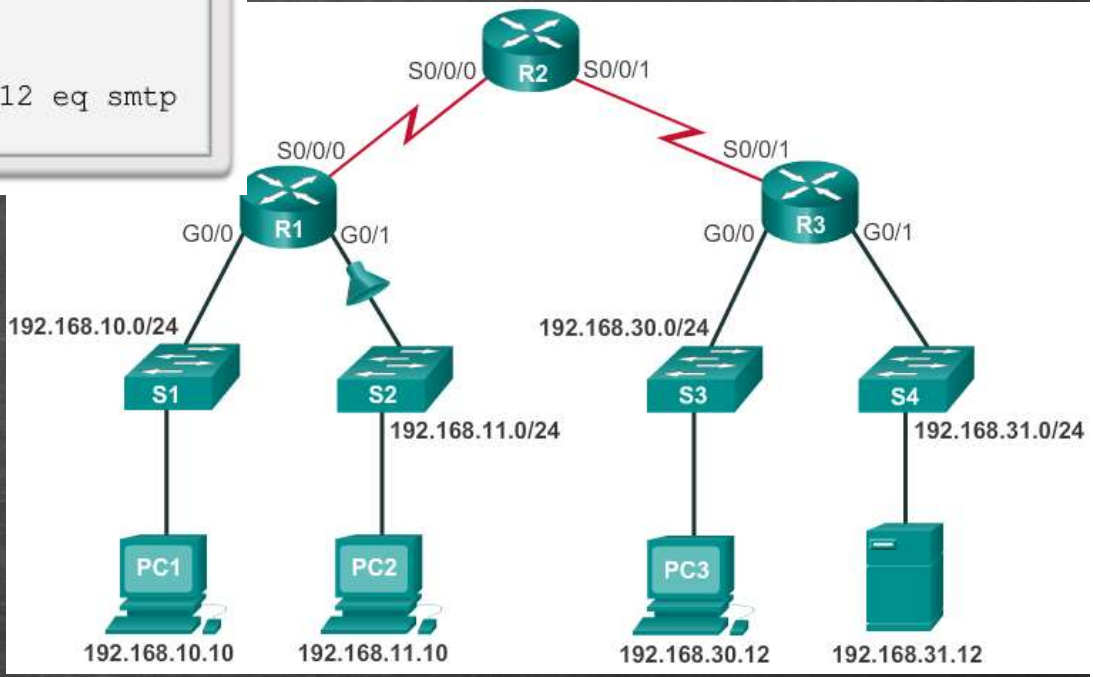
- Troubleshooting Common ACL Errors - Example 2
  - The 192.168.10.0 /24 network cannot use TFTP to connect to the 192.168.30.0 /24 network.



Common ACLs Errors

- Troubleshooting Common ACL Errors - Example 3
  - The 192.168.11.0 /24 network can use Telnet to connect to 192.168.30.0 /24, but according to company policy, this connection should not be allowed.

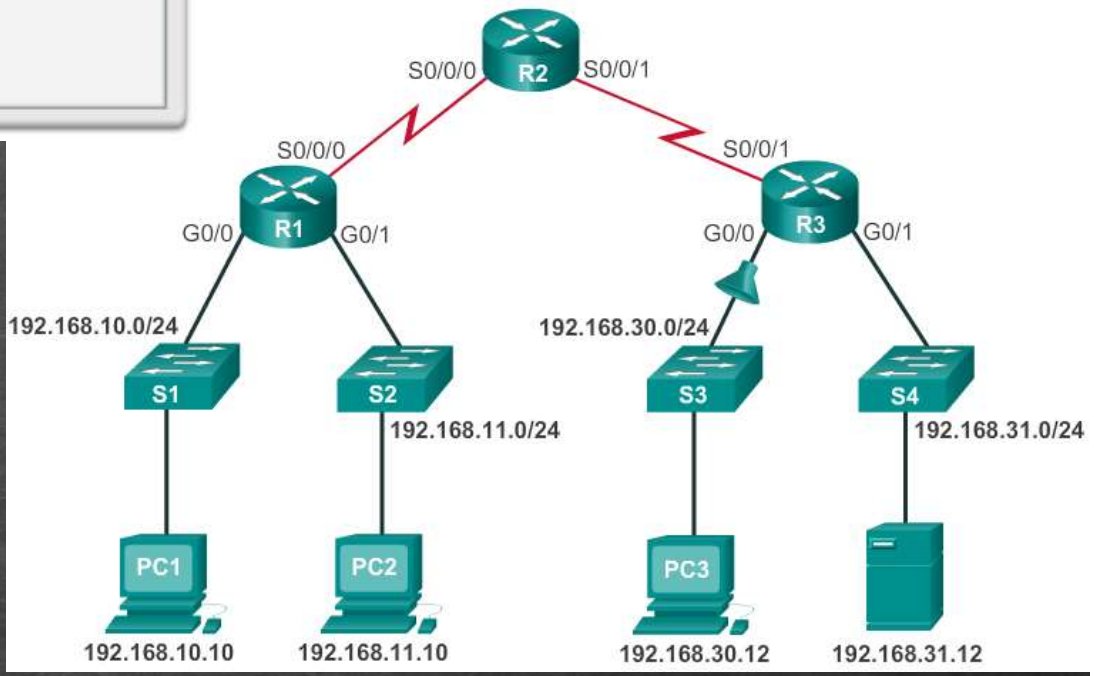
```
R1#show access-lists 130
Extended IP access list 130
    10 deny tcp any eq telnet any
    20 deny tcp 192.168.11.0 0.0.0.255 host 192.168.31.12 eq smtp
    30 permit tcp any any (12 match(es))
```



Common ACLs Errors

- Troubleshooting Common ACL Errors - Example 4
  - Host 192.168.30.12 is able to Telnet to connect to 192.168.31.12, but company policy states that this connection should not be allowed.

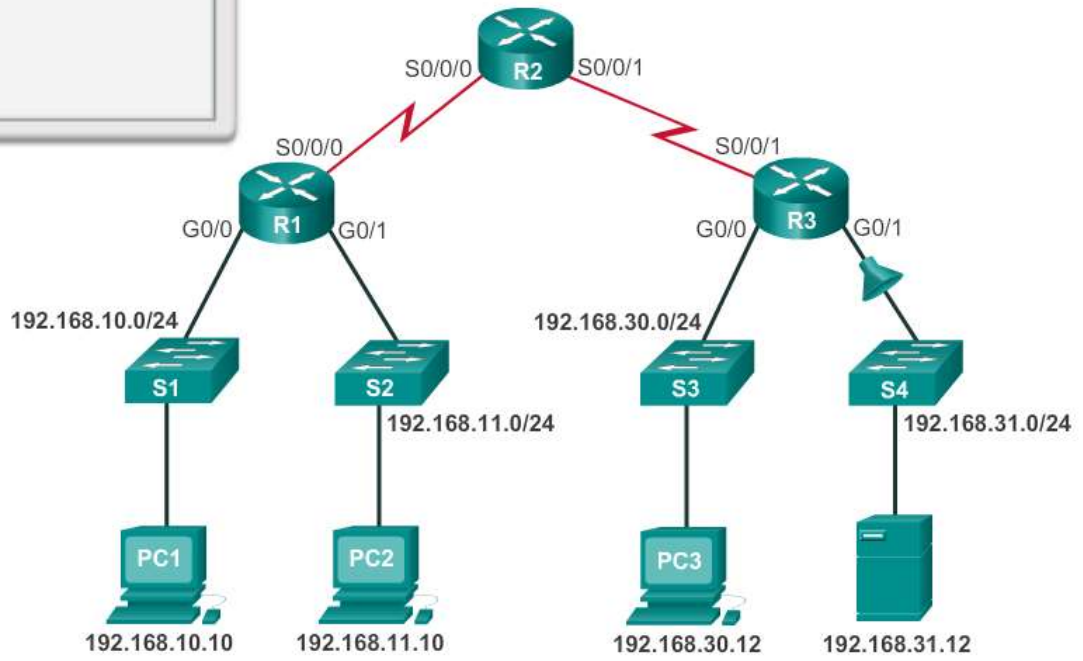
```
R3#show access-lists 140
Extended IP access list 140
    10 deny tcp host 192.168.30.1 any eq telnet
    20 permit ip any any (5 match(es))
```



Common ACLs Errors

- Troubleshooting Common ACL Errors - Example 5
  - Host 192.168.30.12 can use Telnet to connect to 192.168.31.12, but according to the security policy, this connection should not be allowed.

```
R2#show access-lists 150
Extended IP access list 150
    10 deny tcp any host 192.168.31.12 eq telnet
    20 permit ip any any
```



Questions and Answers