Securing the Network and Data Plane

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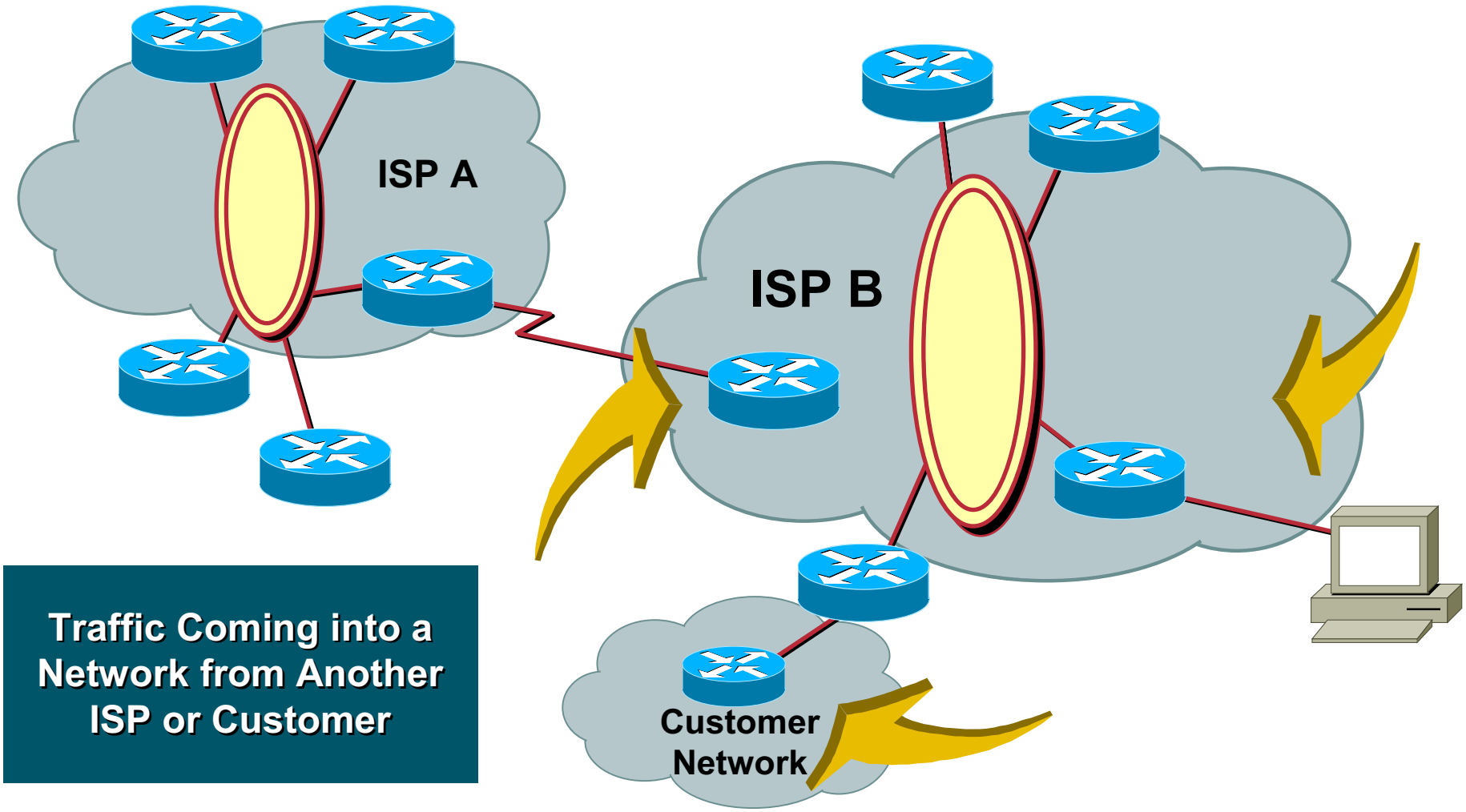
What is Ingress and Egress?

Securing the Network

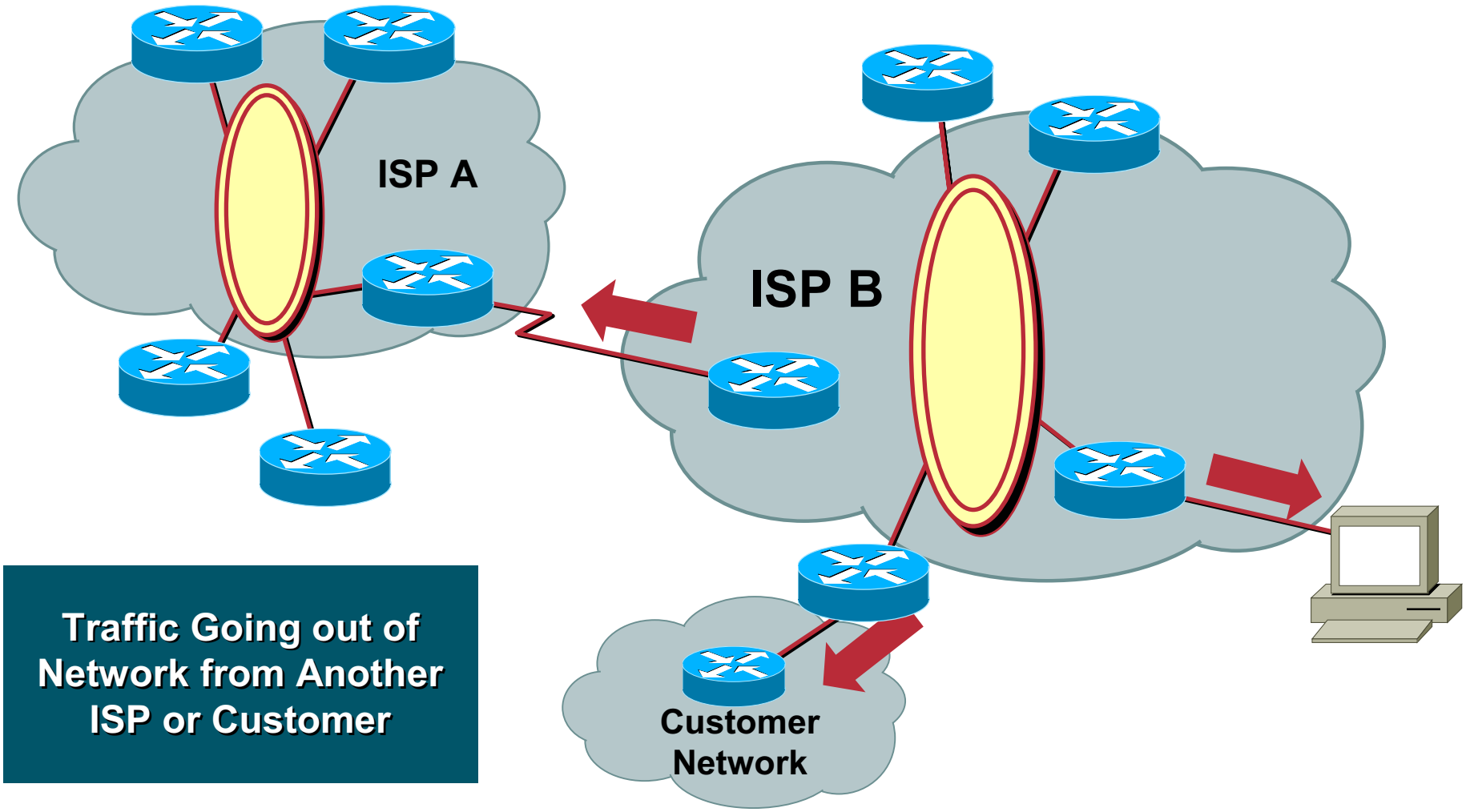
- Packet filtering - Dropping
- Traffic Rate limiting – Degrading

Ingress Filters—Inbound Traffic



Traffic Coming into a Network from Another ISP or Customer

Egress Filters—Outbound Traffic



Traffic Going out of Network from Another ISP or Customer

BCP 38 Ingress Packet Filtering

BCP 38 Ingress Packet Filtering

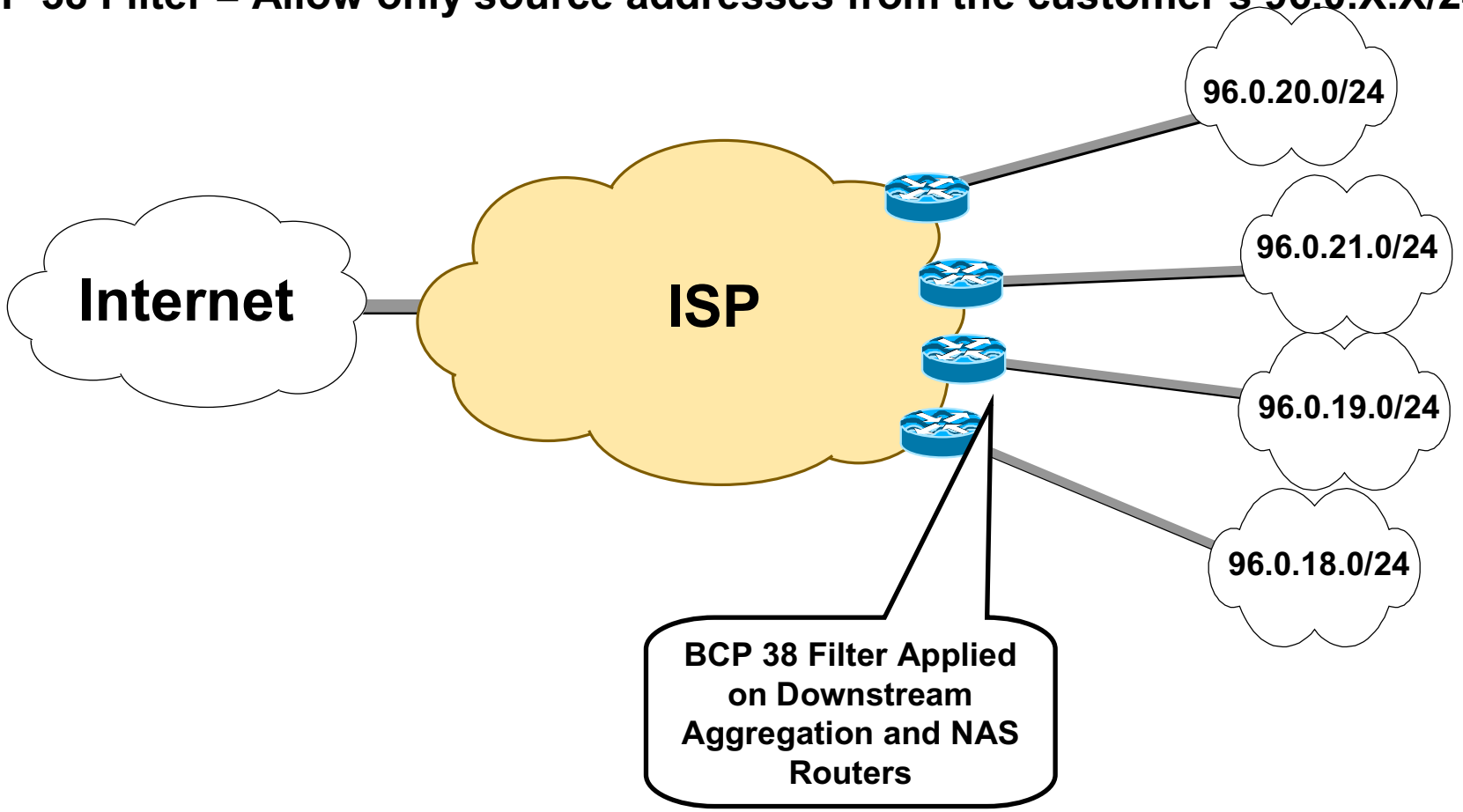
Your customers should not be sending any IP packets out to the Internet with a source address other then the address you have allocated to them!

BCP 38 Ingress Packet Filtering

- BCP 38/ RFC 2827
- Title: Network Ingress Filtering: Defeating Denial of Service Attacks which Employ IP Source Address Spoofing
- Author(s): P. Ferguson, D. Senie

BCP 38 Ingress Packet Filtering

ISP's Customer Allocation Block: 96.0.0.0/19
BCP 38 Filter = Allow only source addresses from the customer's 96.0.X.X/24



BCP 38 Packet Filtering: Principles

- Filter as close to the edge as possible
- Filter as precisely as possible
- Filter both source and destination where possible

Techniques for BCP 38 Ingress Packet Filtering

Three Techniques for BCP 38 Filtering

- Static access list on the edge of the network
- Dynamic access list with AAA profiles
- Unicast RPF

Techniques for BCP 38 Ingress Packet Filtering

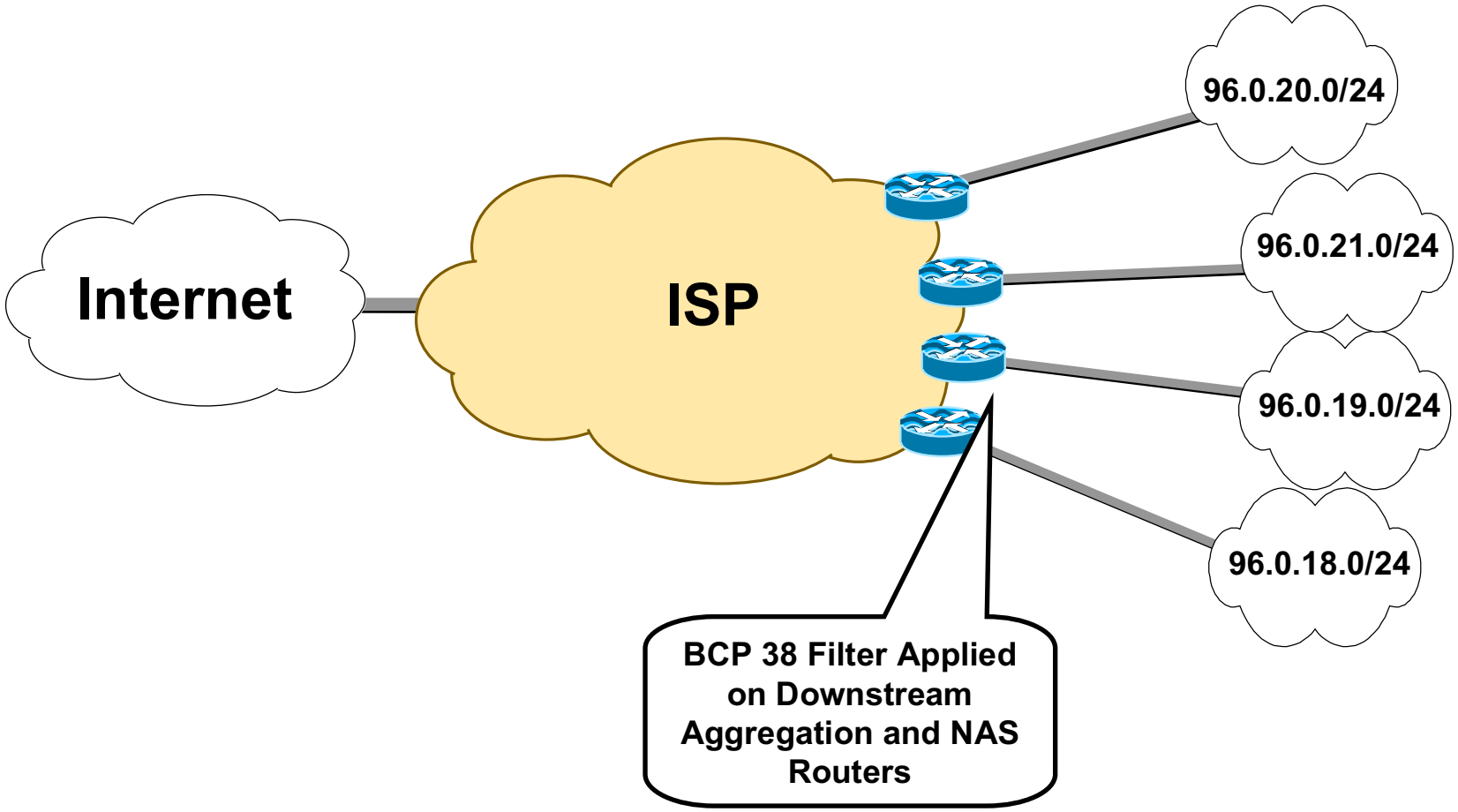
Static ACLs

Static BCP 38 ACLs on Customer Links

- **Static ACLs are the traditional mode of insuring the customer's source address matches their allocation block.**
  - ✓ **Permit All Traffic whose source address equals the allocation block.**
  - ✓ **Deny any other packet (might include logging).**

Static BCP 38 Ingress Packet Filtering

ISP's Customer Allocation Block: 96.0.0.0/19
BCP 38 Filter = Allow only source addresses from the customer's 96.0.X.X/24



Guidelines – Example

- **Access-list 100:**
  - ✓**Permit icmp**
  - ✓**Permit established tcp connections (ie block TCP-SYN)**
  - ✓**Permit SecureShell**
  - ✓**Allow WWW to Webserver**
  - ✓**Allow SMTP to Mailserver**
  - ✓**Allow DNS to Nameserver**
  - ✓**Allow NTP for time synchronisation**
  - ✓**Block NFS**
  - ✓**Permit only unprivileged UDP ports**
  - ✓**Block everything else, and log it**
- **Access-list 101:**
  - ✓**Permit only packets from my address block out**
  - ✓**Block everything else, and log it**

Guidelines – Example

Cisco.com

```
interface serial 0
 description Connection to Planet ISP
 ip unnumbered Ethernet 0
 ip access-group 100 in
 ip access-group 101 out
 no ip directed-broadcast
!
access-list 100 permit icmp any any
access-list 100 permit tcp any any established
access-list 100 permit tcp any any eq 22
access-list 100 permit tcp any host 221.4.0.1 eq www
access-list 100 permit tcp any host 221.4.0.2 eq smtp
access-list 100 permit udp any host 221.4.0.3 eq domain
access-list 100 permit tcp any host 221.4.0.3 eq domain
access-list 100 permit udp any any eq ntp
access-list 100 deny   udp any any eq 2049
access-list 100 permit udp any any gt 1023
access-list 100 deny   ip any any log
!
access-list 101 permit ip 221.4.0.0 0.0.3.255 any
access-list 101 deny   ip any any log
!
```

- **Lab Module 5 Exercise 1**

Techniques for BCP 38 Ingress Packet Filtering

Dynamic ACLs

Techniques for BCP 38 Ingress Packet Filtering

Strict Mode Unicast Reverse Path Forwarding (uRPF)

uRPF *Strict Mode*

- **What problems is it solving?**
  - ✓ **Scaling BCP 38!**
  - ✓ **How do you manage BCP 38 ACLs for over 10,000 lease line customers?**
  - ✓ **What is needed is a command that automatically executes BCP 38 filtering.**
  - ✓ **It would be really nice if the line engineer who first brings up the customer interface can configure this feature without needing to create ACLs or touch the routing protocols.**
  - ✓ **It would be nice if the *filter* could be automatically updated.**

uRPF *Strict Mode*

- **The answer is here …. uRPF Strict Mode.**
  - ✓ **One line config on the customer's interface.**
  - ✓ **Uses the CEF table as the certification authority for which packets pass and which are dropped – which means the the "drop table" is updated through routing.**
  - ✓ **Works on all single homed customers – which is 80% - 90% of your customers.**
  - ✓ **Works on most multi-homed customers – even with asymmetrical packet flows.**

Unicast RPF Details

Unicast Reverse Path Forwarding

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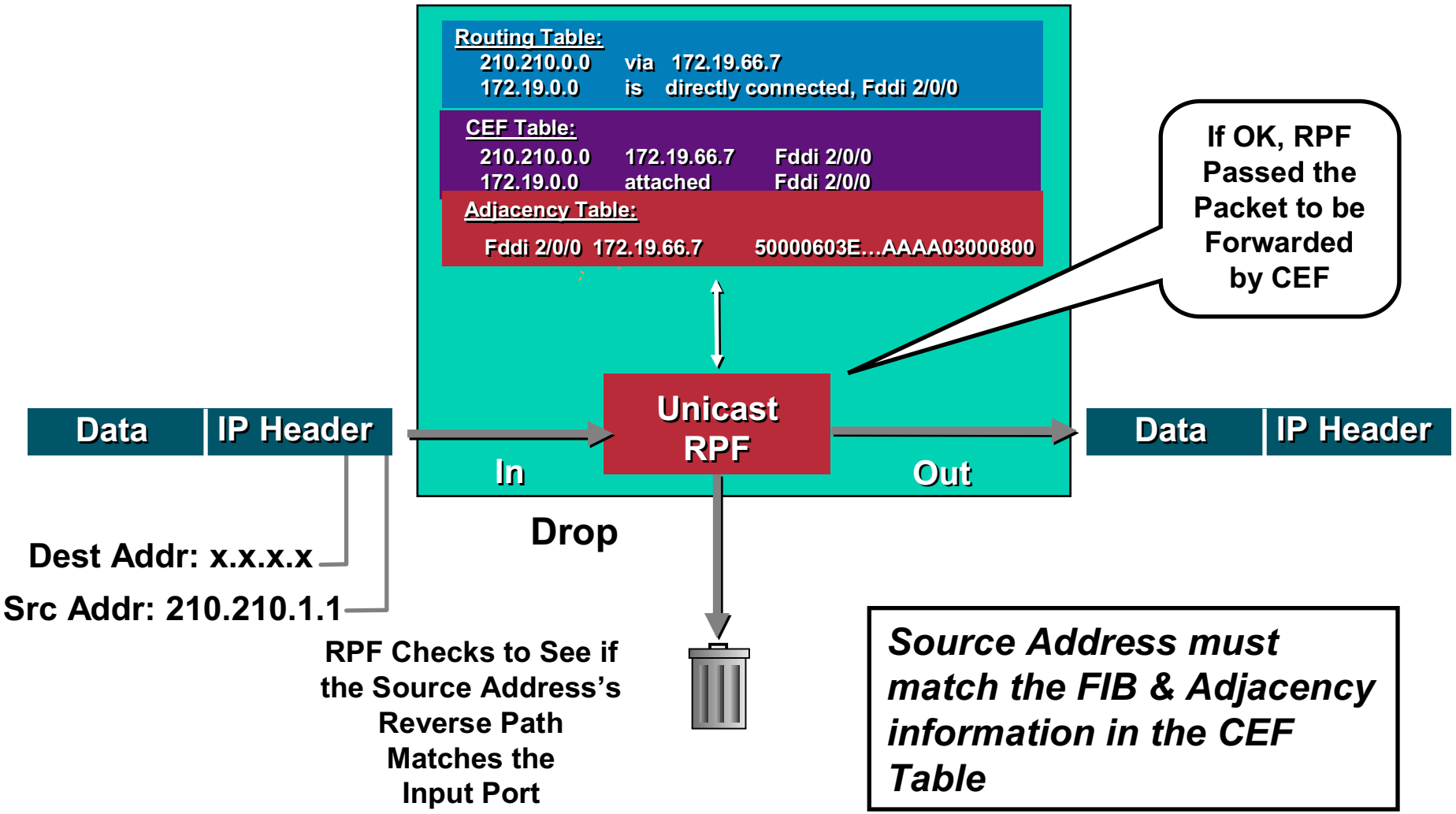
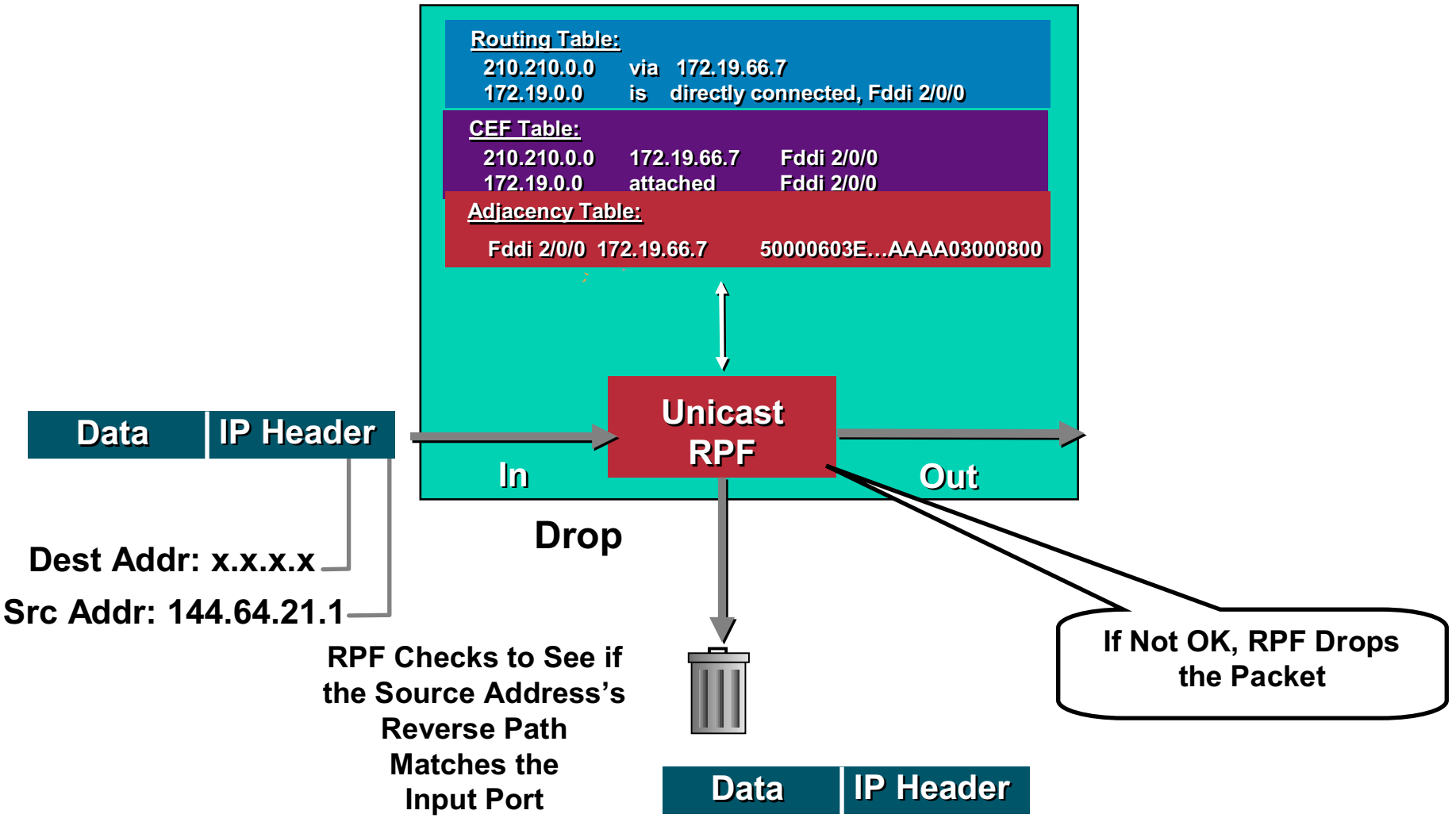
- Supported from 11.1(17)CC images
- CEF switching must be enabled
- Source IP packets are checked to ensure that the route back to the source uses the same interface
- Care required in multihoming situations
- Two Flavors of uRPF:
  - ✓ Strict Mode for BCP 38/ RFC 2827 Filters on Customer Ingress Edge
  - ✓ Loose Mode for ISP ISP Edge for Remote Triggered Black Hole Filtering

CEF Unicast RPF (Strict Mode)



CEF Unicast RPF (Strict Mode)



CEF Unicast RPF (Loose Check Mode)

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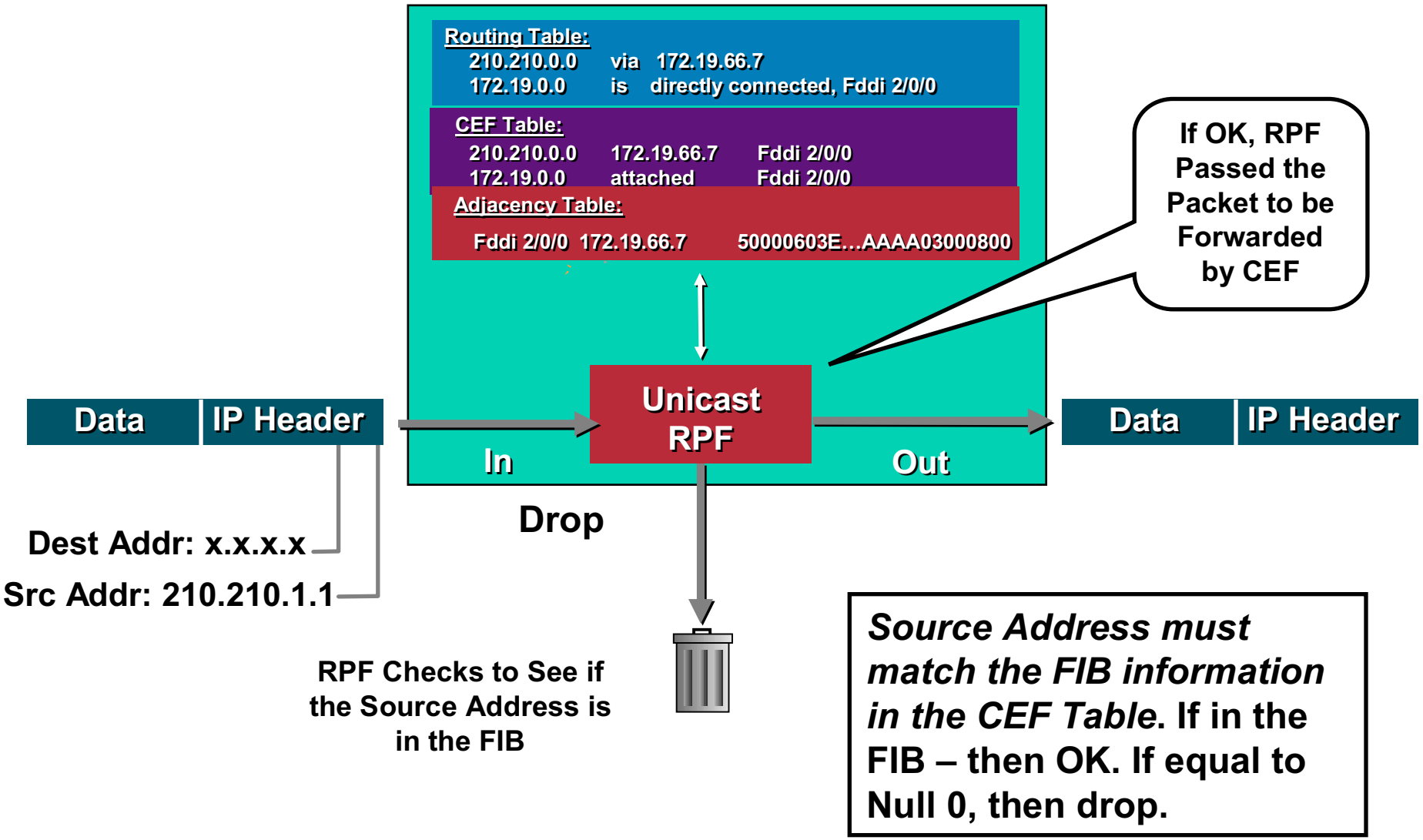
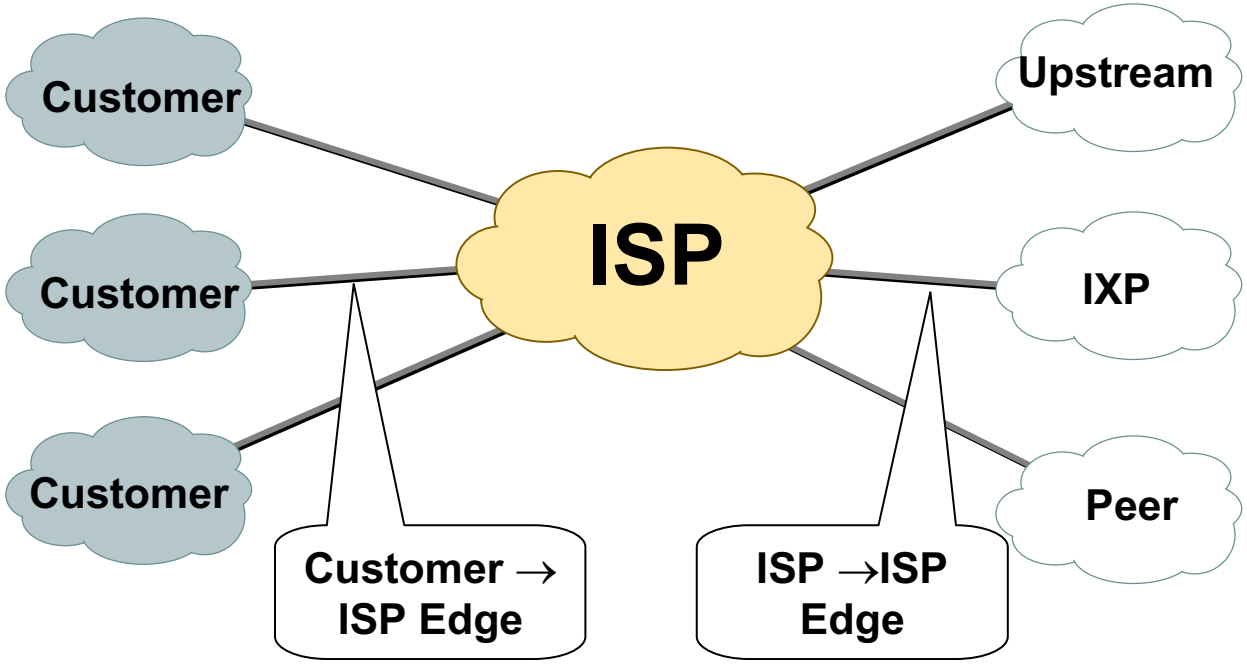


uRPF Originally Designed for the Customer→ISP Edge

- Unicast RPF was originally designed for deployment on the customer→ISP edge
- New enhancements allow it to work on the ISP→ISP edge



Unicast RPF Commands (Strict Mode)

Cisco.com

- **Configure RPF on the interface using the following interface command syntax:**

```
[no] ip verify unicast reverse-path [<ACL>]
```

- **For example on a leased line aggregation router:**

```
ip cef ! or "ip cef distributed" for an RSP+VIP based
  box
!
interface serial 5/0/0
  ip verify unicast reverse-path
```

- ***Interface group-async* command for dial-up ports:**

```
ip cef
!
interface Group-Async1
  ip verify unicast reverse-path
```

Unicast RPF Drop Logic (Strict Mode)

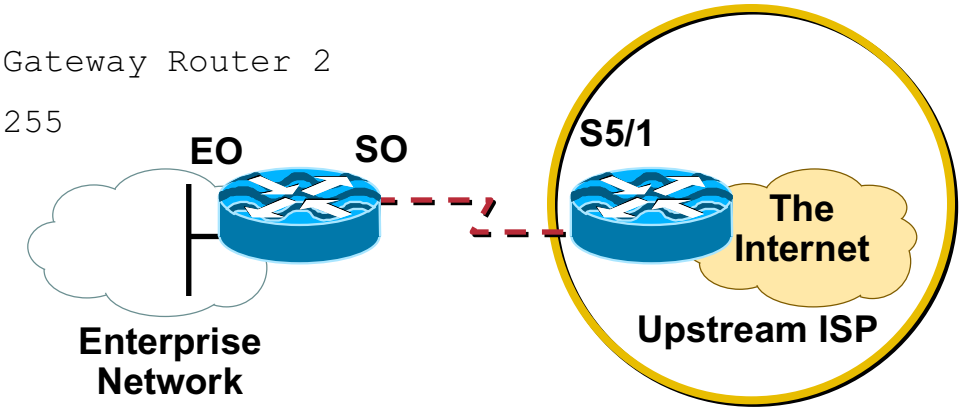
- **Exceptions to RPF**

```
lookup source address in forwarding database
 if the source address is reachable via the source
  interface
       pass the packet
    else
 if the source is 0.0.0.0 and destination is a
  255.255.255.255
       /* BOOTP and DHCP */
          pass the packet
       else if destination is multicast
          pass the packet
       else
          drop the packet
```

Unicast RPF (Strict Mode) —Simple Single Homed Customer Example

Cisco.com

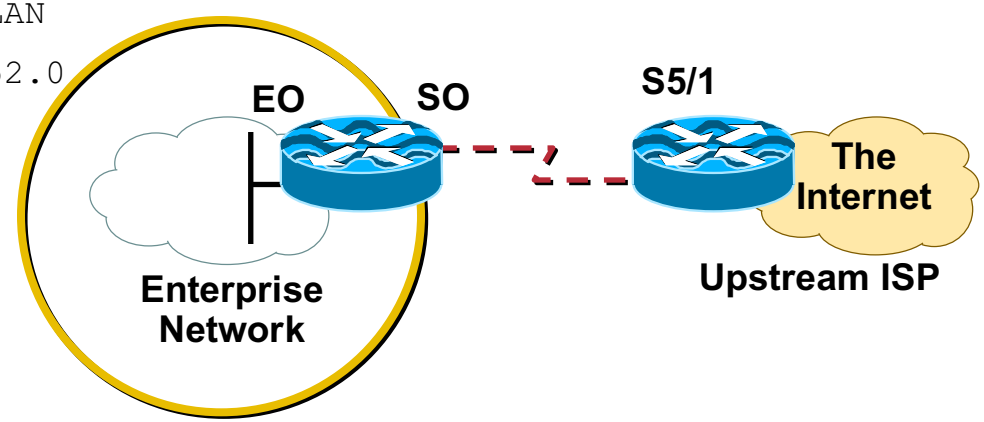
```
interface loopback 0
  description Loopback interface on Gateway Router 2
  ip address 215.17.3.1 255.255.255.255
  no ip redirects
  no ip directed-broadcast
  no ip proxy-arp
!
interface Serial 5/0
  description 128K HDLC link to Galaxy Publications Ltd [galpub1]  R5-0
  bandwidth 128
  ip unnumbered loopback 0
  ip verify unicast reverse-path  ! Unicast RPF activated here
  no ip redirects
  no ip directed-broadcast
  no ip proxy-arp
!
ip route 215.34.10.0 255.255.252.0 Serial 5/0
```



Unicast RPF (Strict Mode) —Simple Single Homed Customer Example

Cisco.com

```
interface Ethernet 0
  description Galaxy Publications LAN
  ip address 215.34.10.1 255.255.252.0
  no ip redirects
  no ip directed-broadcast
  no ip proxy-arp
!
interface Serial 0
  description 128K HDLC link to Galaxy Internet Inc WT50314E  C0
  bandwidth 128
  ip unnumbered ethernet 0
  ip verify unicast reverse-path  ! Unicast RPF activated here
  no ip redirects
  no ip directed-broadcast
  no ip proxy-arp
!
ip route 0.0.0.0 0.0.0.0 Serial 0
```



CEF Unicast RPF (Strict Mode)

- **Unicast RPF provides**
  - ✓ **Automatic Ingress filtering based on routing information**
  - ✓ **Can be part of the default configuration**
  - ✓ **Packet drops at CEF—Before the router processes spoofed packets**
- **If this feature is so great, why is it not used?**

Why Is Unicast RPF (Strict Mode) Not Widely Deployed?

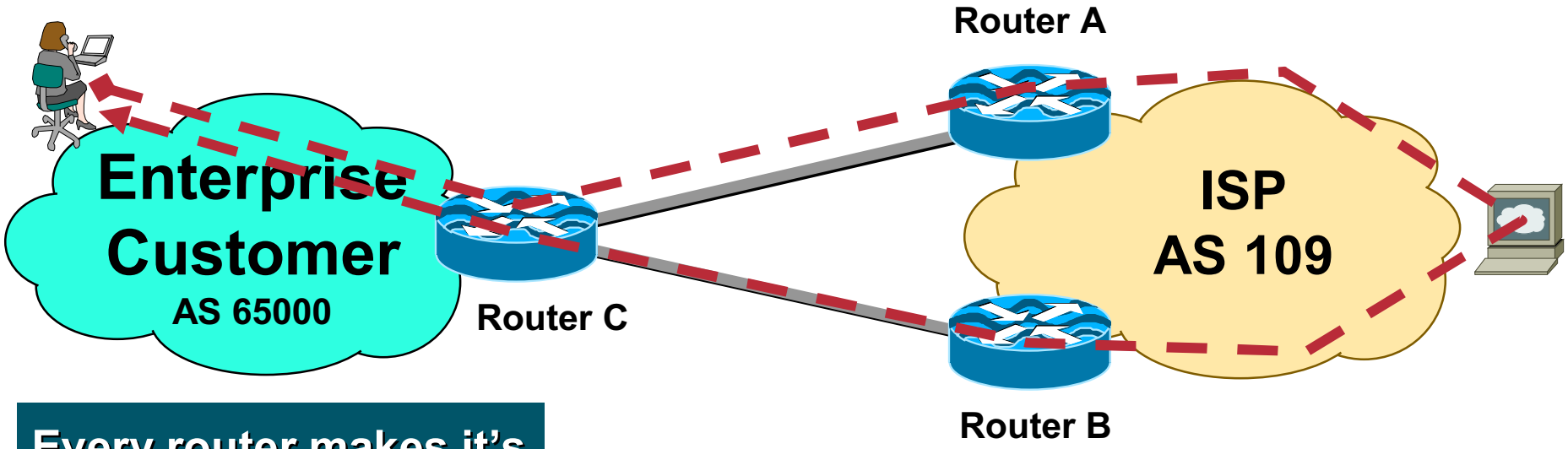
- The myth
  - ✓ What people say:

    Unicast RPF will not work with asymmetrical routing; since the Internet has a lot of asymmetrical routing, it will not work

  - ✓ The real reason:

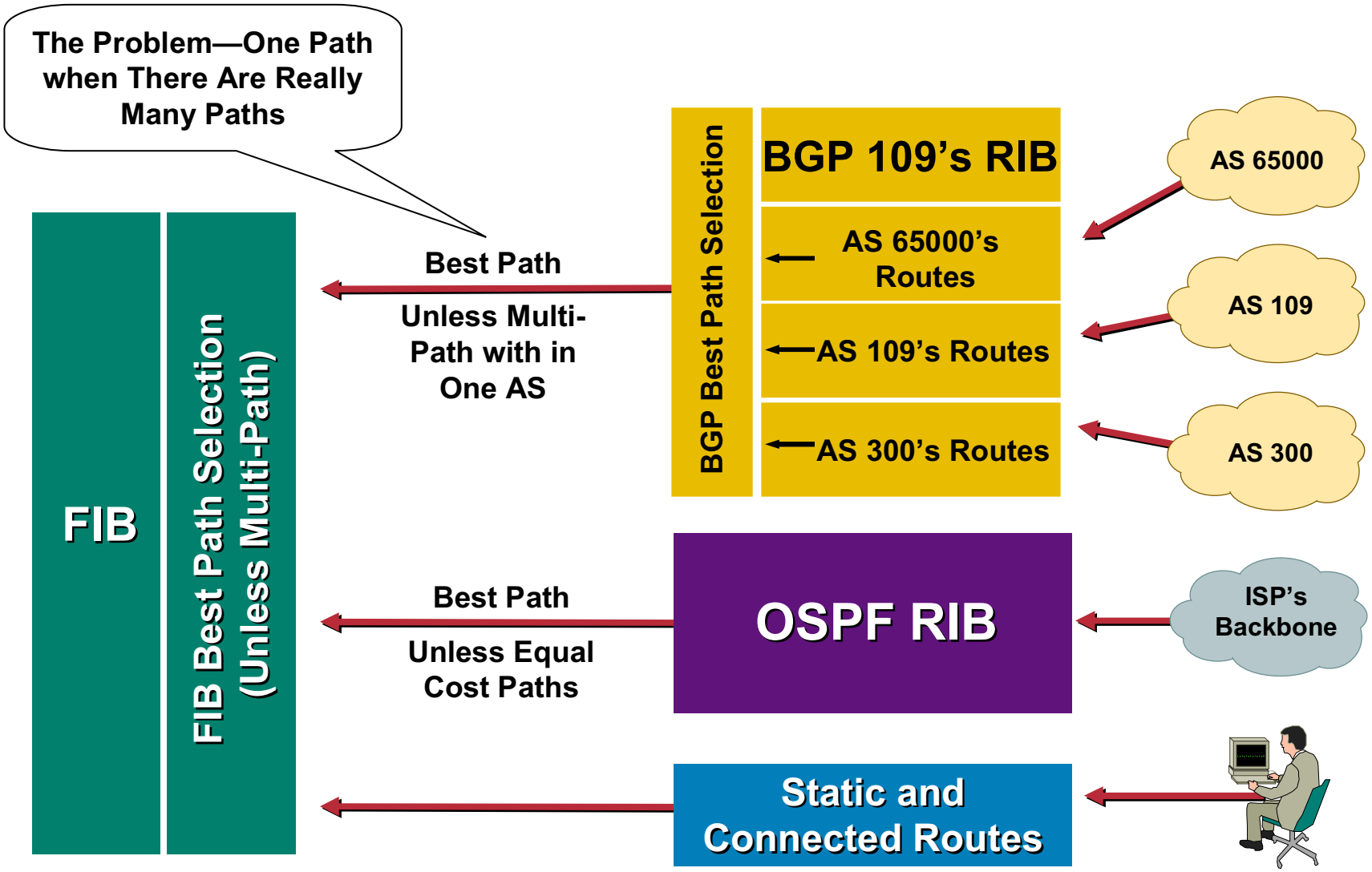
    ISP network engineers have not given the feature enough thought!

What is Asymmetrical Routing?



Every router makes it's own best path forwarding decision – resulting in asymmetrical routing

Best Path Routing in the Internet



BGP Weight aligns the FIB for uRPF

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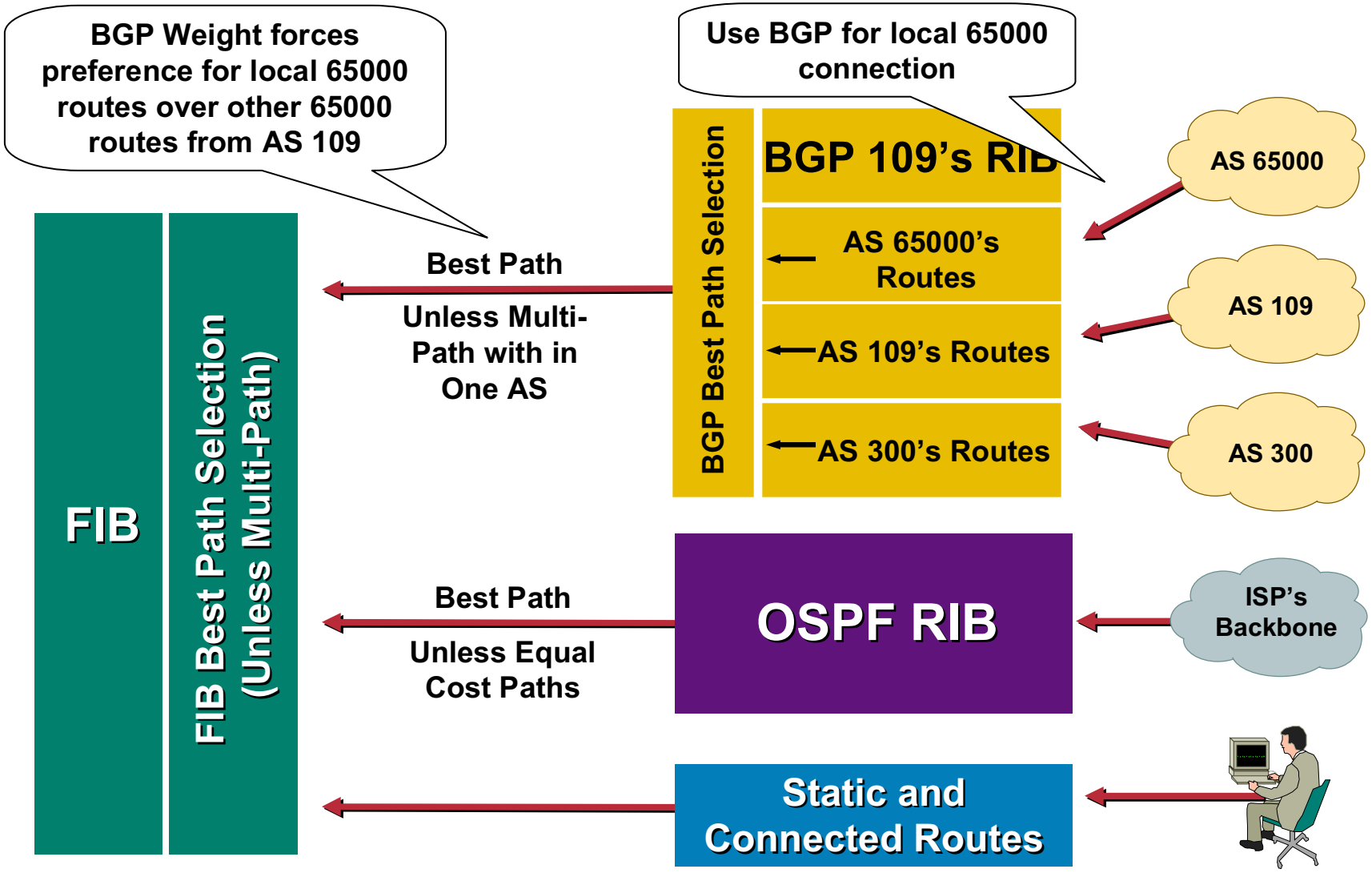
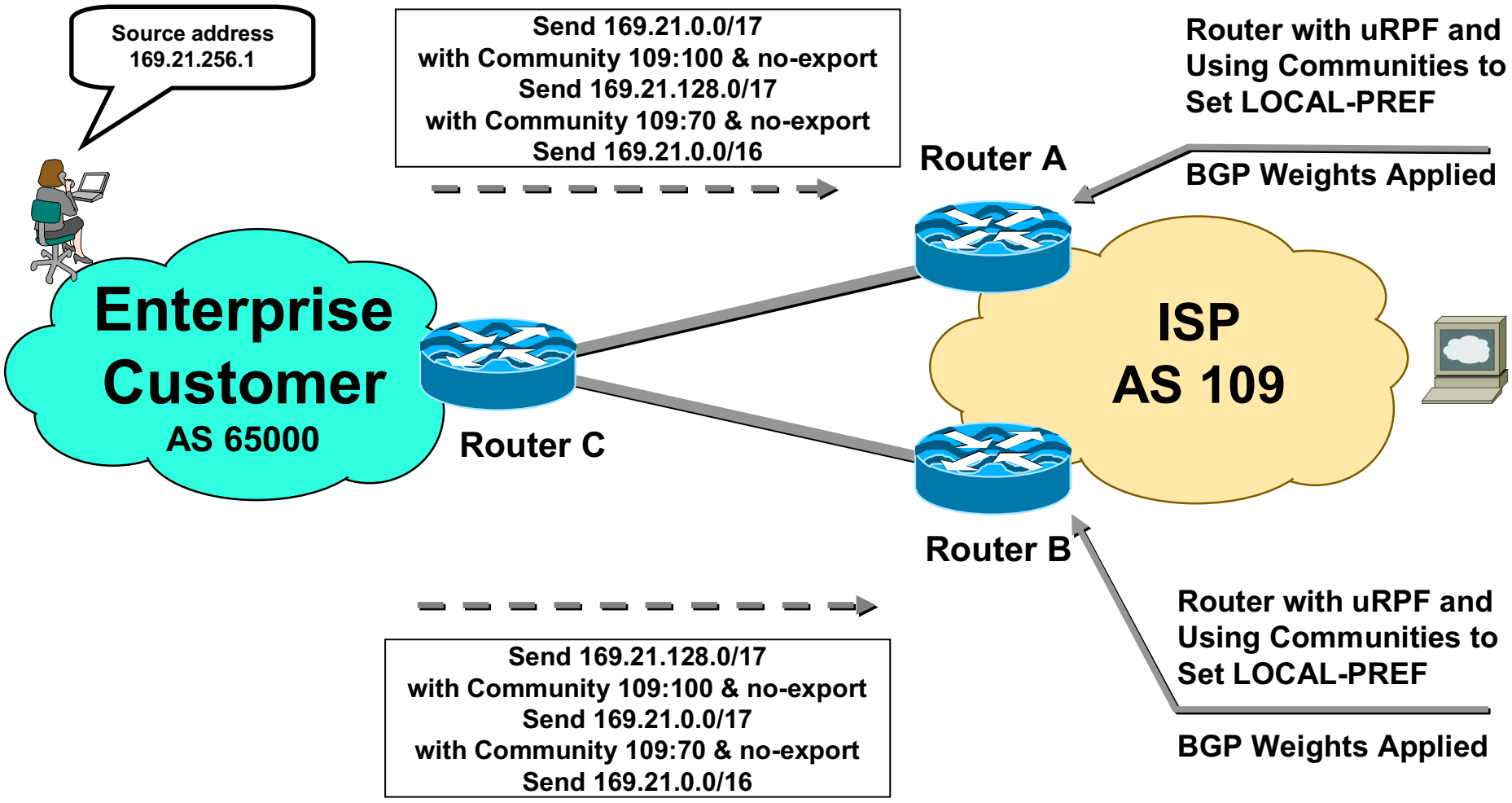
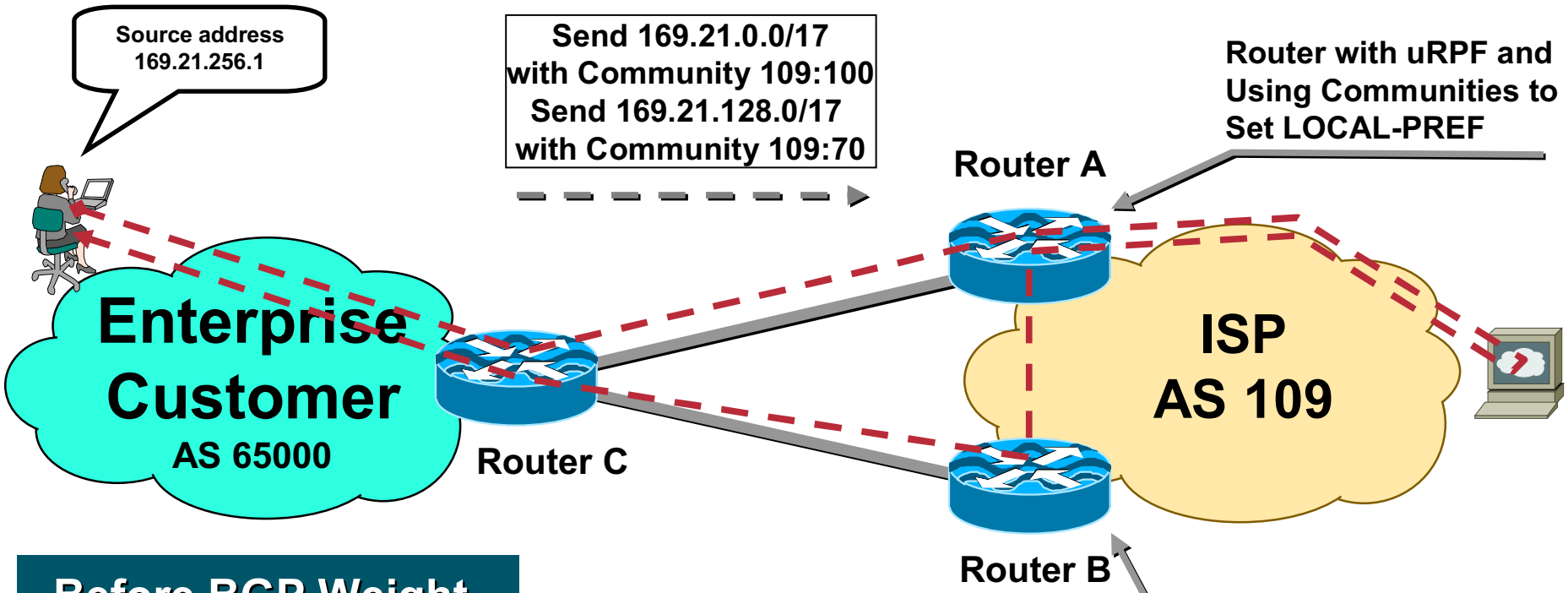


Unicast RPF (Strict Mode) — Dual Homed Customer

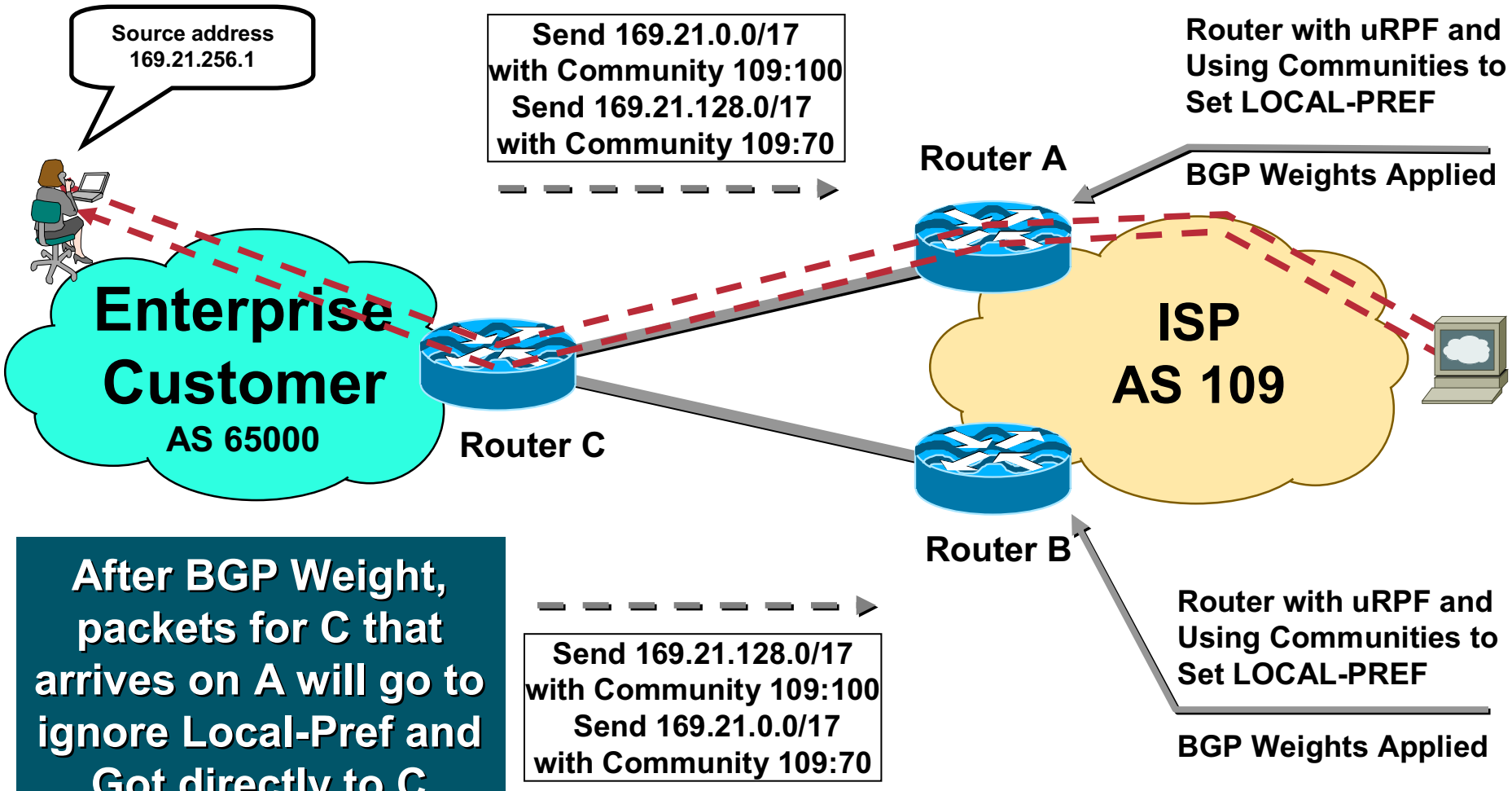


Unicast RPF (Strict Mode) — Before BGP Weight



Before BGP Weight, Local Preference would force a packet on A to go to B then C.

Unicast RPF (Strict Mode) — After BGP Weight



After BGP Weight, packets for C that arrives on A will go to ignore Local-Pref and Got directly to C

Unicast RPF (Strict Mode) — Dual Homed Customer

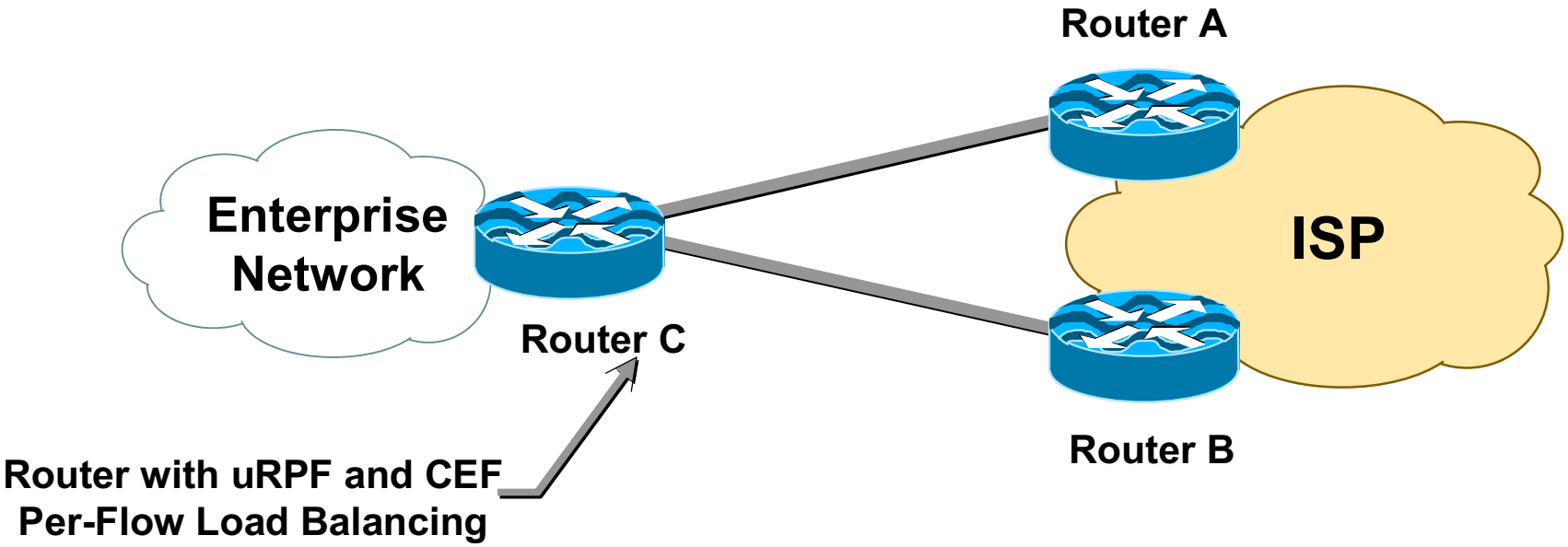

```
ISP Router A - Link to Customer Router C
interface serial 1/0/1
 description Link to Acme Computer's Router C
 ip address 192.168.3.2 255.255.255.252
 ip verify unicast reverse-path
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
 ip route-cache distributed
```

Unicast RPF (Strict Mode) — Dual Homed Customer

ISP Router A - Link to Customer Router C (Cont)

```
router bgp 109
 neighbor 192.168.10.3 remote-as 65000
 neighbor 192.168.10.3 description Multihomed Customer – Acme
Computers
 neighbor 192.168.10.3 update-source Loopback0
 neighbor 192.168.10.3 send-community
 neighbor 192.168.10.3 soft-reconfiguration inbound
 neighbor 192.168.10.3 route-map set-customer-local-pref in
 neighbor 192.168.10.3 weight 255
 .
ip route 192.168.10.3 255.255.255.255 serial 1/0/1
ip bgp-community new-format
```

Unicast RPF (Strict Mode) — Dual Homed Enterprise to One ISP



- Used to protect against spoof attacks
- Some attacks get around the RFC1918 filters by using un-allocated IP address space

Unicast RPF (Strict Mode) — Dual Homed Enterprise to One ISP

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```
router bgp 65000
 no synchronization
 network 169.21.0.0
 network 169.21.0.0 mask 255.255.128.0
 network 169.21.128.0 mask 255.255.128.0
 neighbor 171.70.18.100 remote-as 109
 neighbor 171.70.18.100 description Upstream Connection #1
 neighbor 171.70.18.100 update-source Loopback0
 neighbor 171.70.10.100 send-community
 neighbor 171.70.18.100 soft-reconfiguration inbound
 neighbor 171.70.18.100 route-map Router-A-Community out
 neighbor 171.70.18.200 remote-as 109
 neighbor 171.70.18.200 description Upstream Connection #2
 neighbor 171.70.18.200 update-source Loopback0
 neighbor 171.70.18.200 send-community
 neighbor 171.70.18.200 soft-reconfiguration inbound
 neighbor 171.70.18.200 route-map Router-B-Community out
 maximum-paths 2
 no auto-summary
```

```
route-map Router-A-Community permit 10
 match ip address 51
 set community 109:70
!
route-map Router-A-Community permit 20
 match ip address 50
 set community 109:100
!
route-map Router-B-Community permit 10
 match ip address 50
 set community 109:70
!
route-map Router-B-Community permit 20
 match ip address 51
 set community 109:100
!
access-list 50 permit 169.21.0.0 0.0.127.255
access-list 51 permit 169.21.128.0 0.0.127.255
```

Unicast RPF (Strict Mode) — Dual Homed Enterprise to One ISP

Cisco.com

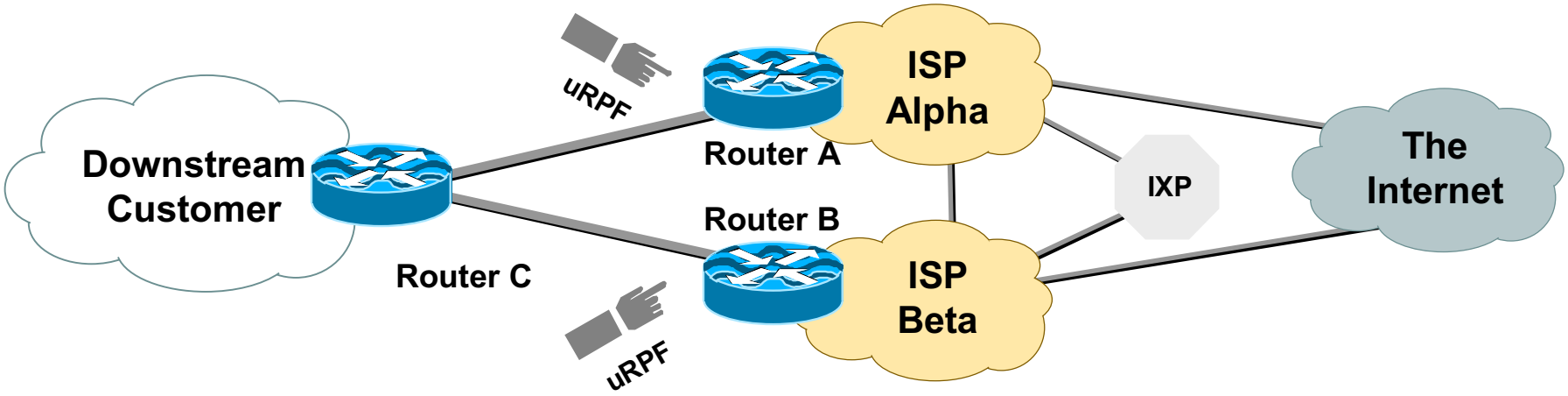
```
ip route 169.21.0.0 0.0.255.255 Null 0
ip route 169.21.0.0 0.0.127.255 Null 0
ip route 169.21.128.0 0.0.127.255 Null 0
ip route 171.70.18.100 255.255.255.255 S 1/0
ip route 171.70.18.200 255.255.255.255 S 1/1
ip bgp-community new-format
!
```

```
interface serial 1/0/
 description Link to Upstream Router A
 ip address 192.168.3.1 255.255.255.252
 ip verify unicast reverse-path
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
 ip load-sharing per-destination
 ip route-cache distributed
!
interface serial 1/0
 description Link to Upstream ISP Router B
 ip address 192.168.3.5 255.255.255.252
 ip verify unicast reverse-path
 no ip redirects
 no ip directed-broadcast
 no ip proxy-arp
 ip load-sharing per-destination
 ip route-cache distributed
```

Unicast RPF (Strict Mode) — Dual Homed Enterprise to One ISP

- **The results:**
  - ✓ **The customer has a multihomed connection to the Internet with Unicast RPF protecting source spoofing**
  - ✓ **The ISP provides a multihomed solution with Unicast RPF turned on**

Unicast RPF (Strict Mode) — Dual Homed Enterprise to Two ISPs



- **ISP Configuration for both ISPs are similar to a dual homed customer.**
  - ✓ **BGP weight is used to over ride AS path prepends**

Unicast RPF (Strict Mode) — Dual Homed Enterprise to Two ISPs

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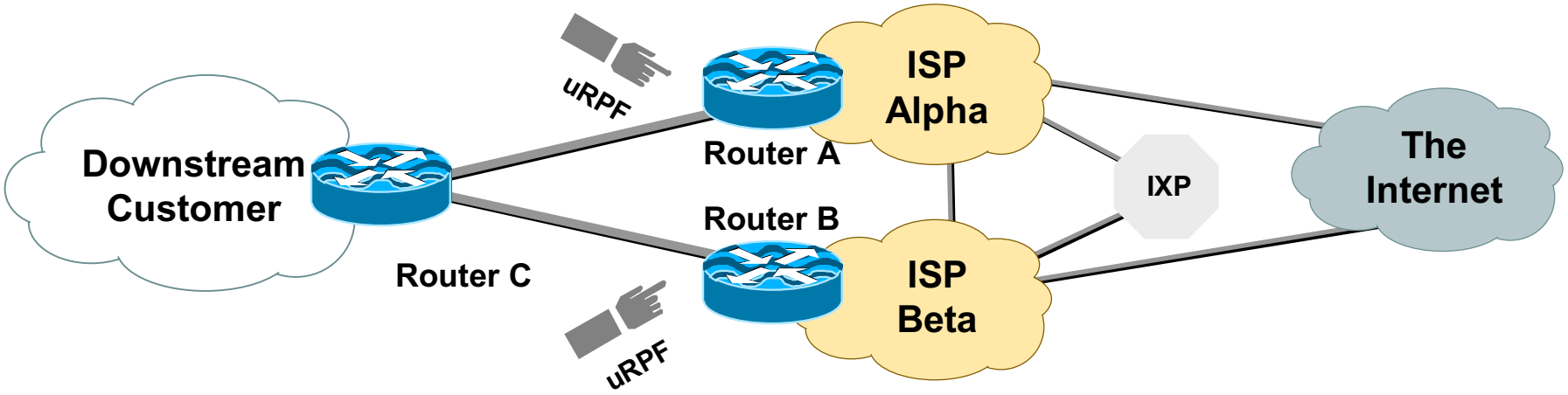
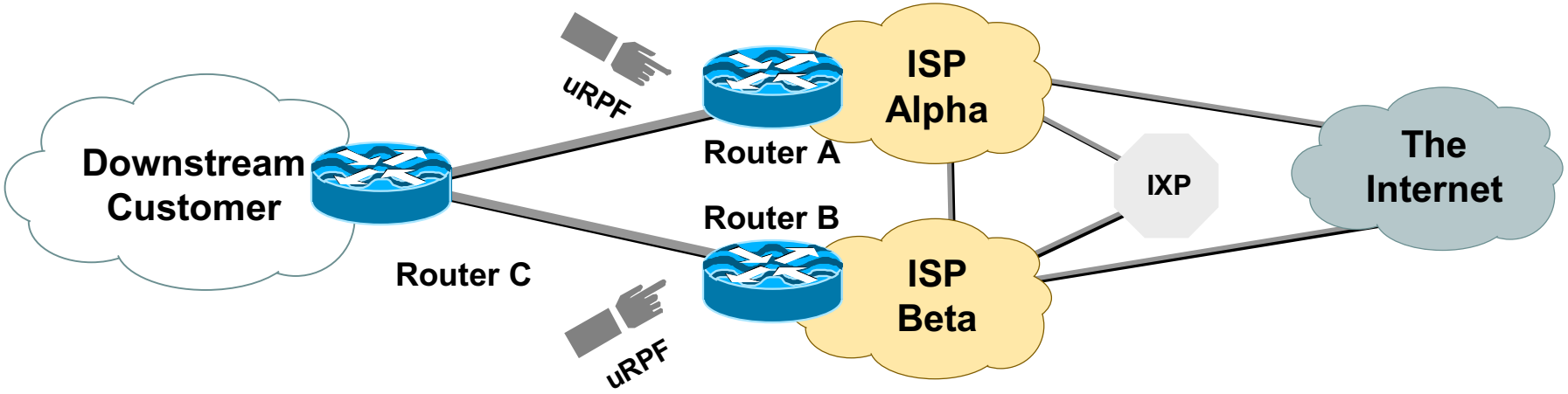


- **BGP weight override an AS path prepend**
  - ✓ **BGP weight on Router A will keep the preferred path for packets on that router to be C↔A**
  - ✓ **BGP weight on Router B will keep the preferred path for packets on that router to be C↔B**

Unicast RPF (Strict Mode) — Dual Homed Enterprise to Two ISPs



- **Enterprise configuration cannot use maximum-paths**
  - ✓ **Need equal AS paths for maximum-paths to work**

Unicast RPF (Strict Mode) — The ACL Bypass Option

- **ACLs can now be used with Unicast RPF (Strict Mode):**

  ip verify unicast reverse-path 171

- **uRPF ACLs are used to:**
  - ✓ **Allow exceptions to the Unicast RPF check**
  - ✓ **Identify characteristics of spoofed packets being dropped by Unicast RPF**
- **Software Forwarding Only! Not Supported on uRPF in the Forwarding ASICs (i.e. Engine 2, Engine 4, etc.)**

Unicast RPF (Strict Mode) — The ACL Bypass Option

- **Cisco 7206 with bypass ACL**

```
interface ethernet 1/1
 ip address 192.168.200.1 255.255.255.0
 ip verify unicast reverse-path 197
!
access-list 197 permit ip 192.168.201.0 0.0.0.255 any log-input

show ip interface ethernet 1/1 | include RPF
 Unicast RPF ACL 197
 1 unicast RPF drop
 1 unicast RPF suppressed drop
```

Unicast RPF (Strict Mode) — The ACL Bypass Option

- **Show the "log-input" results:**
  - ✓ **7200—logging done in the RP**

    show logging
  - ✓ **7500—logging done on the VIP**

Excalabur#sh controllers vip 4 logging

show logging from Slot 4:

.

4d00h: %SEC-6-IPACCESSLOGNP: list 171 denied 0 20.1.1.1 -> 255.255.255.255, 1 packet

.

Unicast RPF (Strict Mode) — The ACL Bypass Option

- NOTE – ACL Bypass option will not be in the ASIC implementations of uRPF.
  - ✓ Cisco 12XXX Engine 2
  - ✓ Cisco 12XXX Engine 3
  - ✓ Cisco 12XXX Engine 4+
  - ✓ Cisco 7600 Sup 2

Unicast RPF (Strict Mode) — Operations Tools


```
Excalabur#sh cef inter serial 2/0/0
Serial2/0/0 is up (if_number 8)
  Internet address is 169.223.10.2/30
  ICMP redirects are never sent
  Per packet loadbalancing is disabled
  IP unicast RPF check is enabled
  Inbound access list is not set
```

Unicast RPF (Strict Mode) — Operations Tools

- **Other commands:**
  - ✓ **show ip traffic | include RPF**
  - ✓ **show ip interface ethernet 0/1/1 | include RPF**
  - ✓ **debug ip cef drops rpf <ACL>**

Unicast RPF (Strict Mode) — Bottom Line

- Unicast RFP Strict Mode is designed to help scale BCP 38 filtering.
- It is just another tool to help defend the Internet
- It is not a perfect tool.
- Deploying it will easily cover 80% of your customers (those who are single homed).
- Can can be deployed on the last 20% that are multihomed customers.

- **Module 5 Exercise 5**

Unicast RPF Enhancements
Loose Check

New Unicast RPF Enhancements

- **Objectives—Allow Unicast RPF to work on an ISP-ISP Edge or ISP-Complex multihomed enterprise customer edge**
  - ✓ **Phase 1—Original uRPF (BCP 38/ RFC 2827)**
  - ✓ **Phase 2—Loose check — if exist in FIB**
  - ✓ **Phase 3—Dedicated VRF table per interface**

New Unicast RPF Enhancements

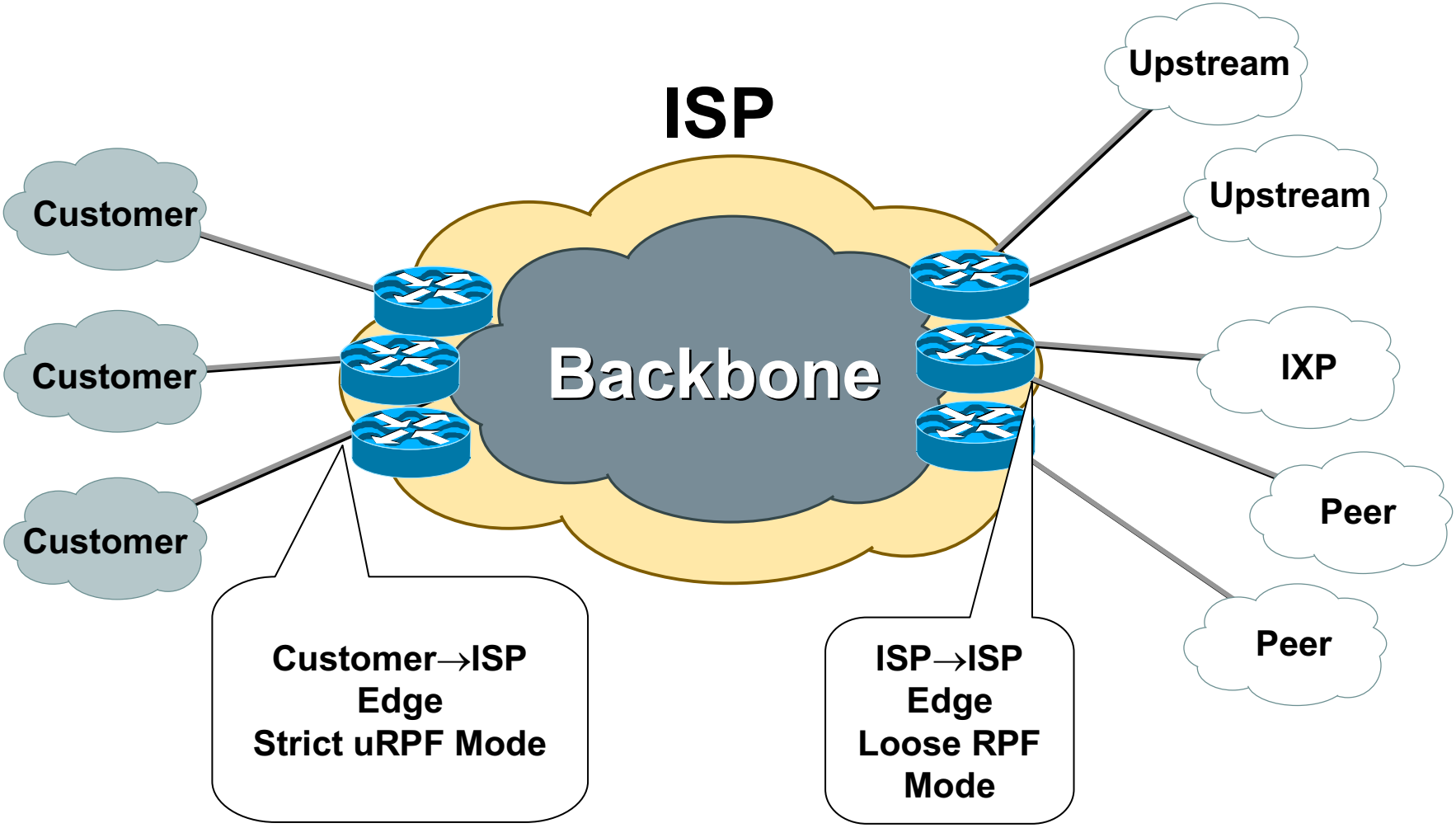
- **Phase 2—Loose check (if exist)**
  - ✓ **DDTS CSCdr93424**
  - ✓ **12.0(14)S for 7200, 7500, and GSR Engine 0 and 1**
  - ✓ **12.0(19)S for GSR Engine 2**

    In ASIC with 1.6 Mpps performance
  - ✓ **Scheduled 12.1(8)E for CAT6K**

    In ASIC at line rate
  - ✓ **Cisco 12XXX Engine 3 – 12.0(22)S**

    In ASIC at line rate

uRPF Originally Designed for the Customer→ISP Edge



CEF Unicast RPF (Loose Check Mode)

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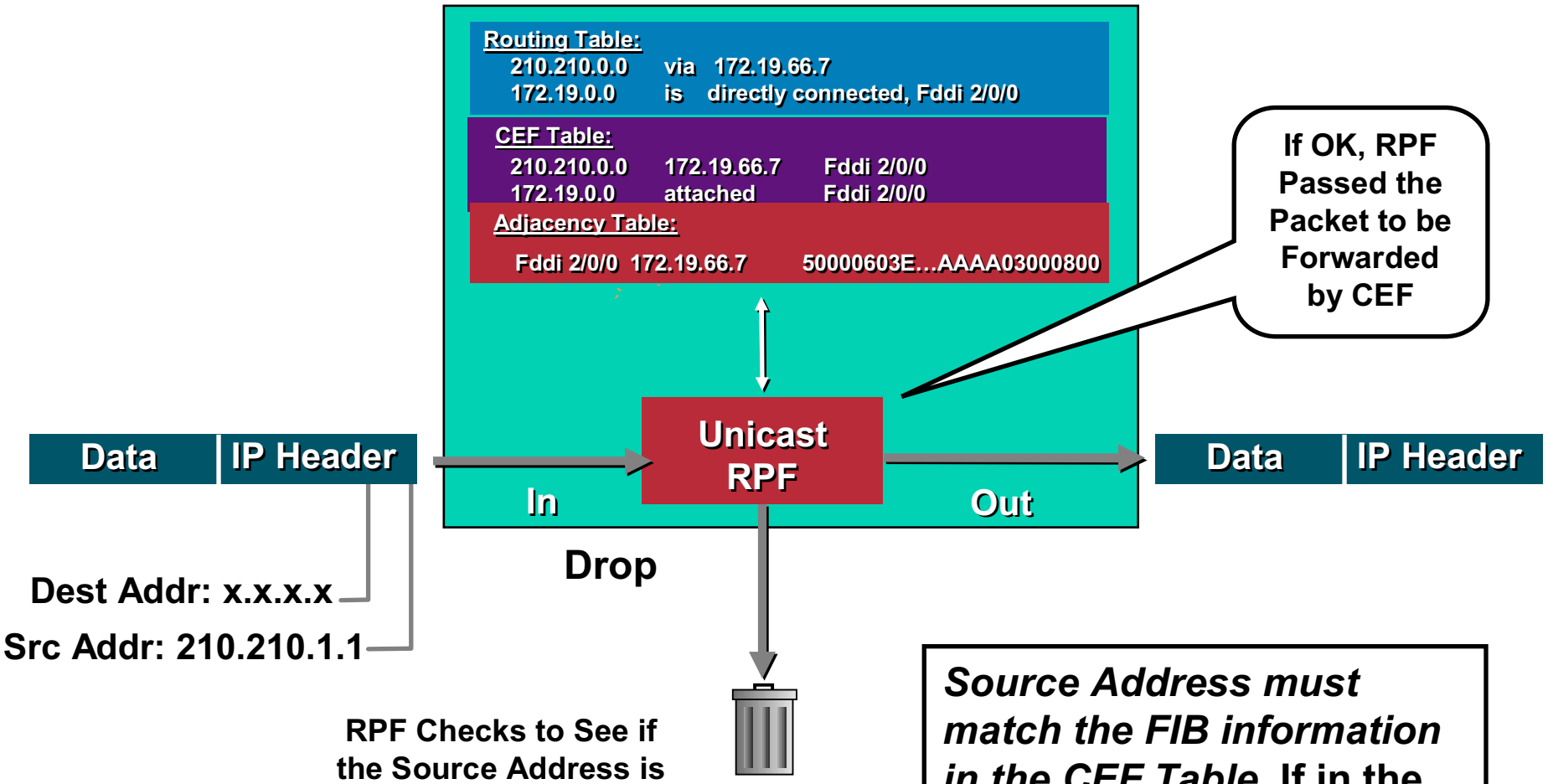

New Unicast RPF Enhancements

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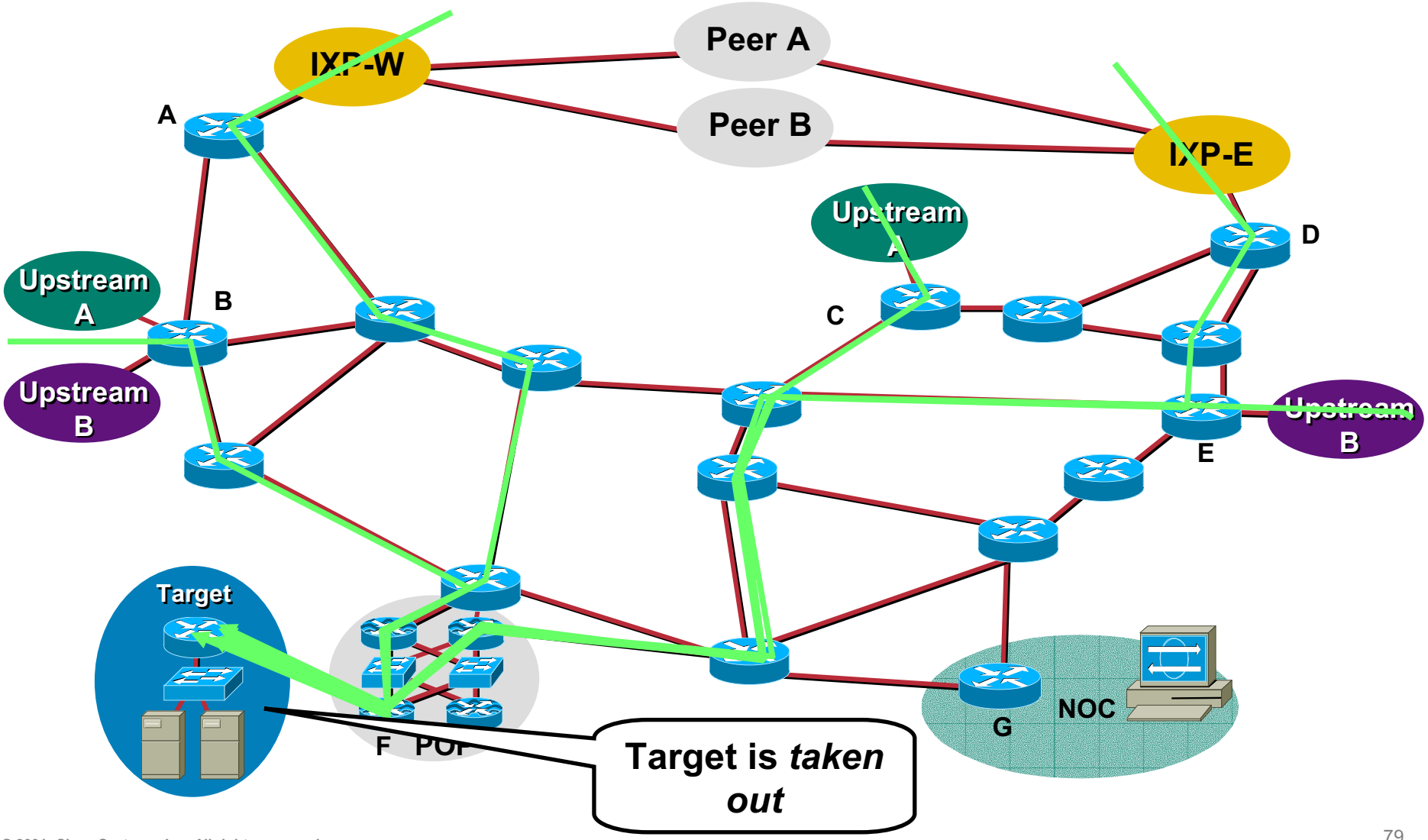
- **Objectives in phase 2:**
  - ✓ **Allow for uRPF to work on the ISP ISP edge of the network**
  - ✓ **Source Based – Remote Triggered Black Hole Filtering. Create a new tool to drop DOS/DDOS attacks on the edge of an ISP's network**

Network Wide Black Hole of an Attack Flow - Before



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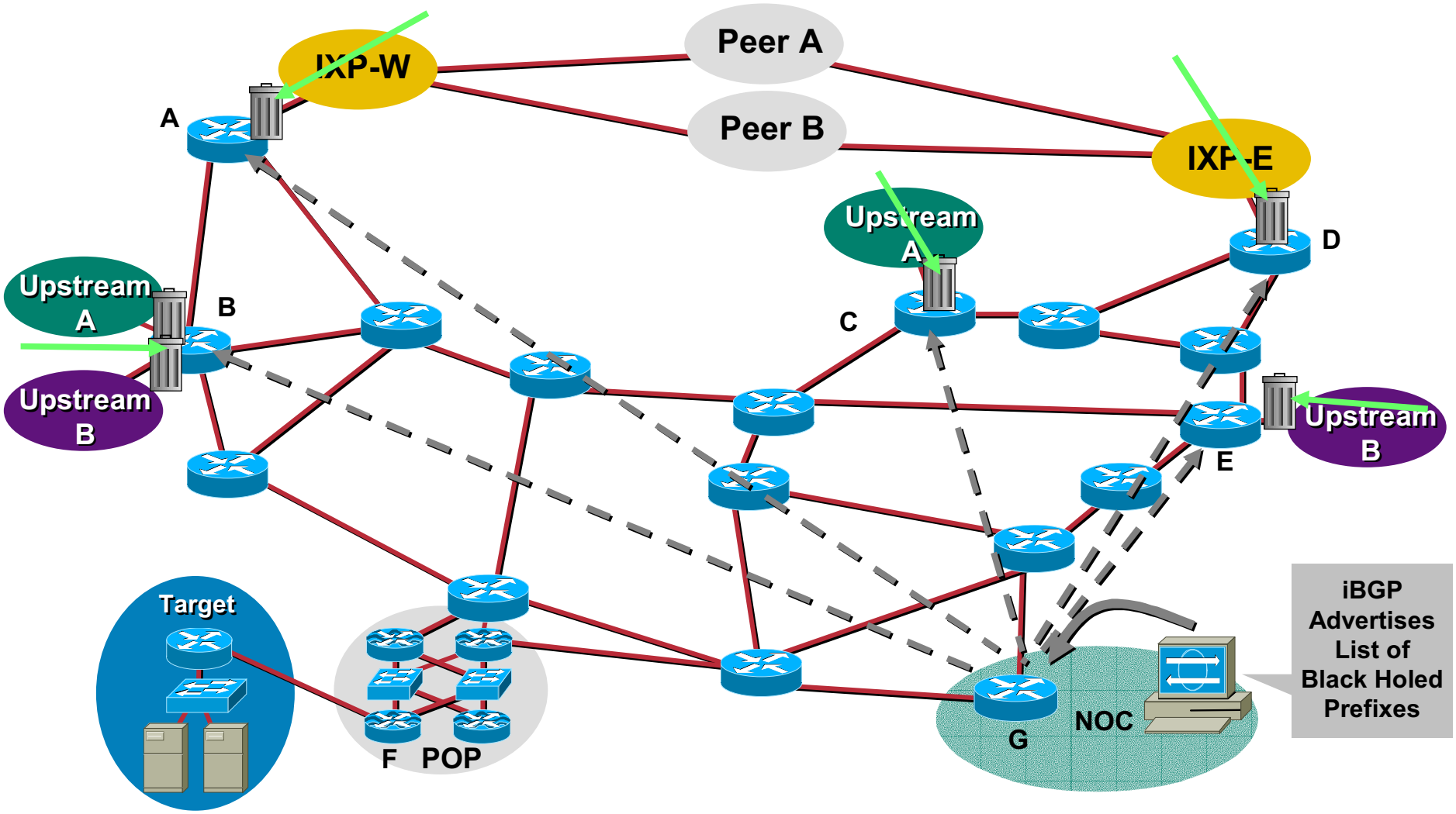

New Unicast RPF Enhancements

- **New commands from DDTS CSCdr93424:**

```
ip verify unicast reverse-path [allow-self-
ping] [<list>]

ip verify unicast source reachable-via
(rx|any) [allow-default] [allow-self-ping]
[<list>]
```

Data Plane Security

Deployment Considerations

Deployment Considerations

- **#1 Consideration …… will data plane security cause an adverse impact on the service?**
  - ✓ **PPS Rates**
  - ✓ **Stability**
  - ✓ **Complexity**

Deployment Considerations

Cisco.com

- Two modes of network gear:
  - ✓CPU Based forwarding/feature processing
  - ✓ASIC Based forwarding/feature processing
- Cisco does both.
- ASICs – especially today's 2nd ASICs – are mission specific.
  - ✓Which means they are designed for a specific niche in the network.

Data Plane Security Summary