BGP Best Practices for ISPs

Prefix List, AS PATH filters, Bogon Filters, Anycast, Mailing Lists, INOC DBA

....

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What are Best Practices

- Established or known good ways of doing things.
- Being a good Internet citizen.
- Trying TO restrict damage to your network and FROM you network
- A lot of RFCs devoted on different BCP, but here we'll just cover a few topics here

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BGP Security

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Protocols are vulnerable

- Routing protocols, like BGP, OSPF can be attacked and weakness exploited
  - False Information
  - Man-in-middle situation
  - Denial of service
  - Routing Conditions

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BGP Security Issues

- Prefix Lists
  - Why, How and Where
- Prefix Lists
  - Customers
  - Peers
  - Upstream
- Protocol Authentication
  - MD5
- BGP BCP
  - Bogons

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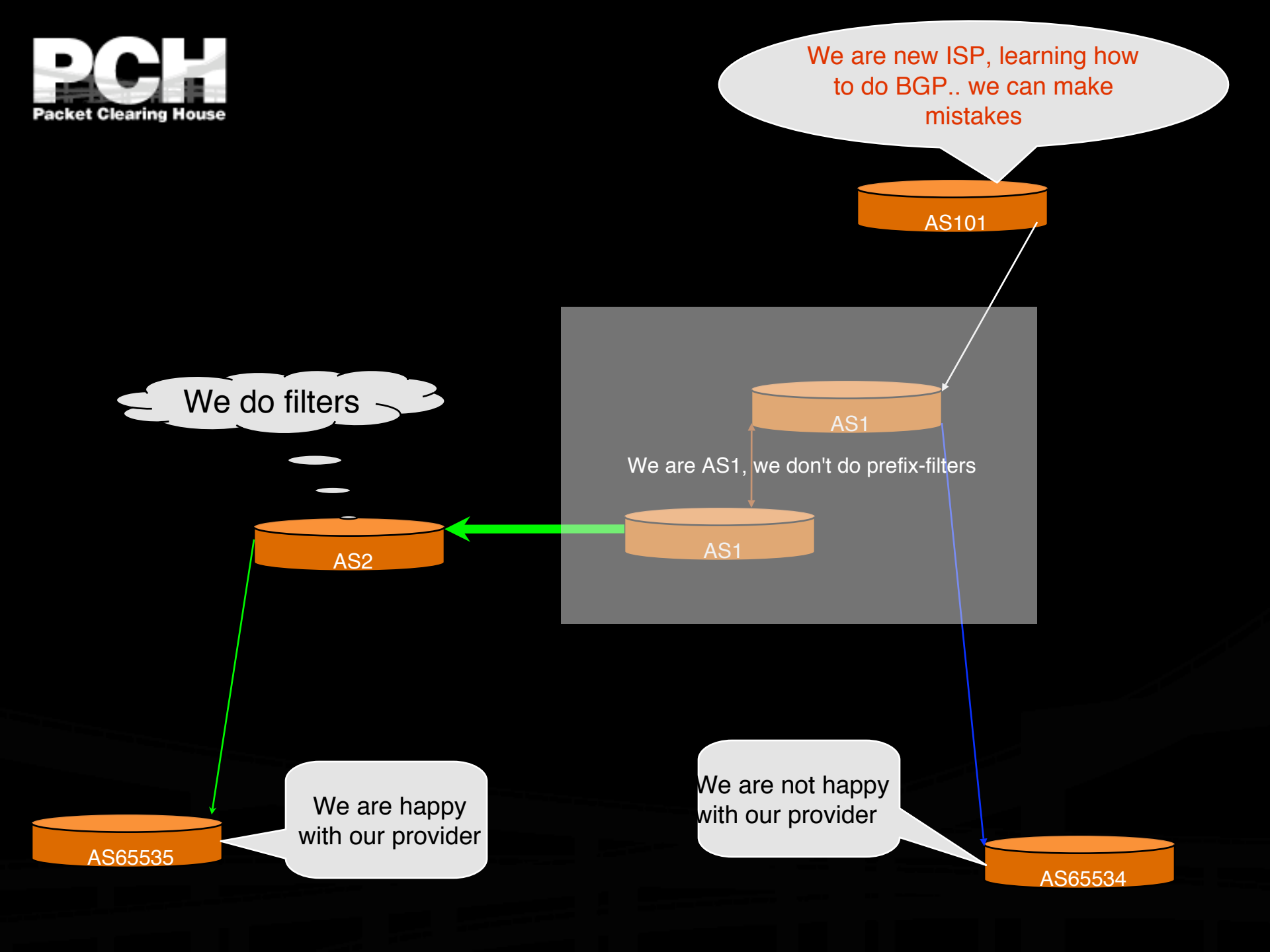
Why Prefix Filter?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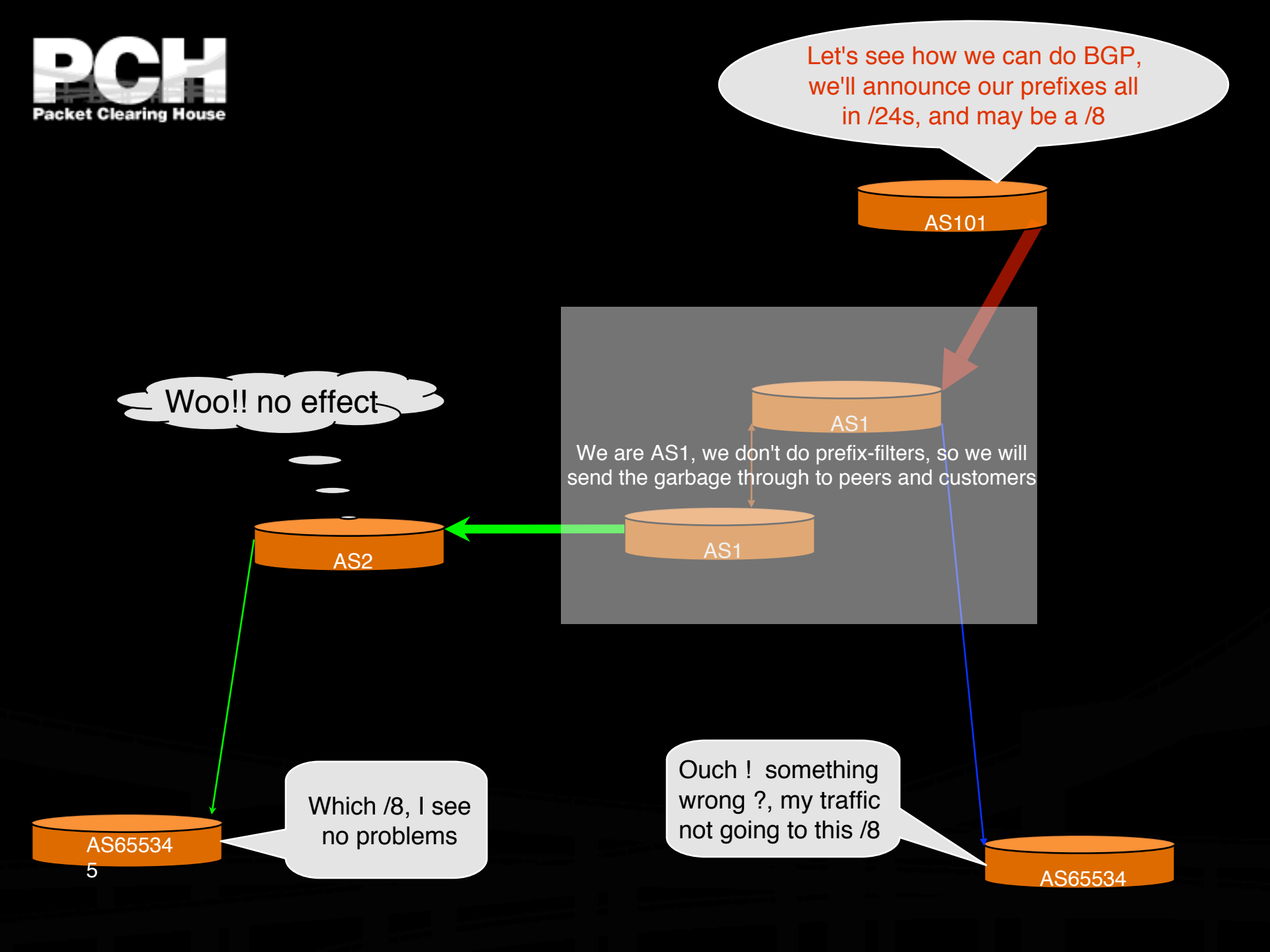
We are new ISP, learning how to do BGP.. we can make mistakes
AS101
We do filters
AS1
We are AS1, we don't do prefix-filters
AS1
AS2
AS65535
We are happy with our provider
We are not happy with our provider
AS65534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Let's see how we can do BGP, we'll announce our prefixes all in /24s, and may be a /8
AS101
AS1
We are AS1, we don't do prefix-filters, so we will send the garbage through to peers and customers
AS1
Woo!! no effect
AS2
AS65534
Which /8, I see no problems
Ouch ! something wrong ?, my traffic not going to this /8
AS65534

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It's REAL, does happen

- In 1997, this happened with AS 7007 - which was the most visible of all.
- Frequent Messages on IXes mailing list about hitting max prefix limits.
- Garbage in – Garbage out.

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So, what should we do ?

- Don't send Junk
  - Filter your own advertisement
  - Filter your customers
- Don't Accept Junk
  - Filter your customers
  - Filter your peers
- Help Others mitigate impact - Net Police
  - Help others and they'll help you

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Prefix Filter - How

BGP Prefix Filtering

- Two ways to implement prefix filtering:
  - Prefix list - easy to use, not highly scalable
  - AS-PATH - widely used, highly scalable
    - Distribute list is now considered obsolete
- Two filtering techniques:
  - Explicit Permit (permit then deny any)
  - Explicit Deny (deny then permit any)

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BGP Route Filtering

Prefix-List example

```
ip prefix-list rfc1918 deny   0.0.0.0/8 le 32
ip prefix-list rfc1918 deny   10.0.0.0/8 le 32
ip prefix-list rfc1918 deny   127.0.0.0/8 le 32
ip prefix-list rfc1918 deny   169.254.0.0/16 le 32
ip prefix-list rfc1918 deny   172.16.0.0/12 le 32
ip prefix-list rfc1918 deny   192.0.2.0.0/24 le 32
ip prefix-list rfc1918 deny   192.168.0.0/16 le 32
ip prefix-list rfc1918 deny   224.0.0.0/3 le 32
ip prefix-list rfc1918 permit 0.0.0.0/0 le 32
```

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BGP Filtering

Applying the previous prefix-list to peers

```
router bgp 65564
 no synchronization
 neighbor 198.32.231.200 remote-as 65200
 neighbor 198.32.231.200 prefix-list rfc1918 in
 neighbor 198.32.231.200 prefix-list rfc1918 out
 neighbor 198.32.231.210 remote-as 65210
 neighbor 198.32.231.210 prefix-list rfc1918 in
 neighbor 198.32.231.210 prefix-list rfc1918 out
 no auto-summary
!
```

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Using AS-PATH filters

Using AS-PATH filters

- Filter routes based on AS path
  - Applied same way as prefix-list filters
  - AS-PATH syntax is different, can use regular expressions
- Example Configuration:

```
router bgp 65564
 network 10.12.0.0 mask 255.255.0.0
 neighbor 198.32.231.200 remote-as 65200
 neighbor 198.32.231.200 filter-list 1 out
 neighbor 198.32.231.200 filter-list 200 in
!
ip as-path access-list 1 permit ^65564$
ip as-path access-list 200 permit ^65200$
```

Regular Expressions

- Most router OS uses Unix regular expressions

.	Match one character
*	Match any number of preceding expression
+	Match at least one of preceding expression
^	Beginning of line
$	End of line
_	Beginning, end, white-space, brace
|	Or
( )	brackets to contain expression

Regular Expressions examples

- Examples

.*	match anything
.+	match at least one character
^$	match routes local to this AS
_3856$	originated by AS3856
^3856_	received from AS3856
_3856_	via AS3856
_3856_42_	via AS3856 and AS42
_(3856_)+	multiple AS3856 in sequence (used to match AS-PATH prepends)

Regular Expressions examples

- Complex Examples

^[0-9]+$	Match AS_PATH length of one
^[0-9]+_[0-9]+$	Match AS_PATH length of two
^[0-9]*_[0-9]+$	Match AS_PATH length of one or two
^[0-9]*_[0-9]*$	Match AS_PATH length of one or two (will also match zero)
^[0-9]+_[0-9]+_[0-9]+$	Match AS_PATH length of three
_(3856|42)_	Match anything which has gone through AS42 or AS3856
_2914(_.+_)42$	Match anything of origin AS42 and passed through AS2914

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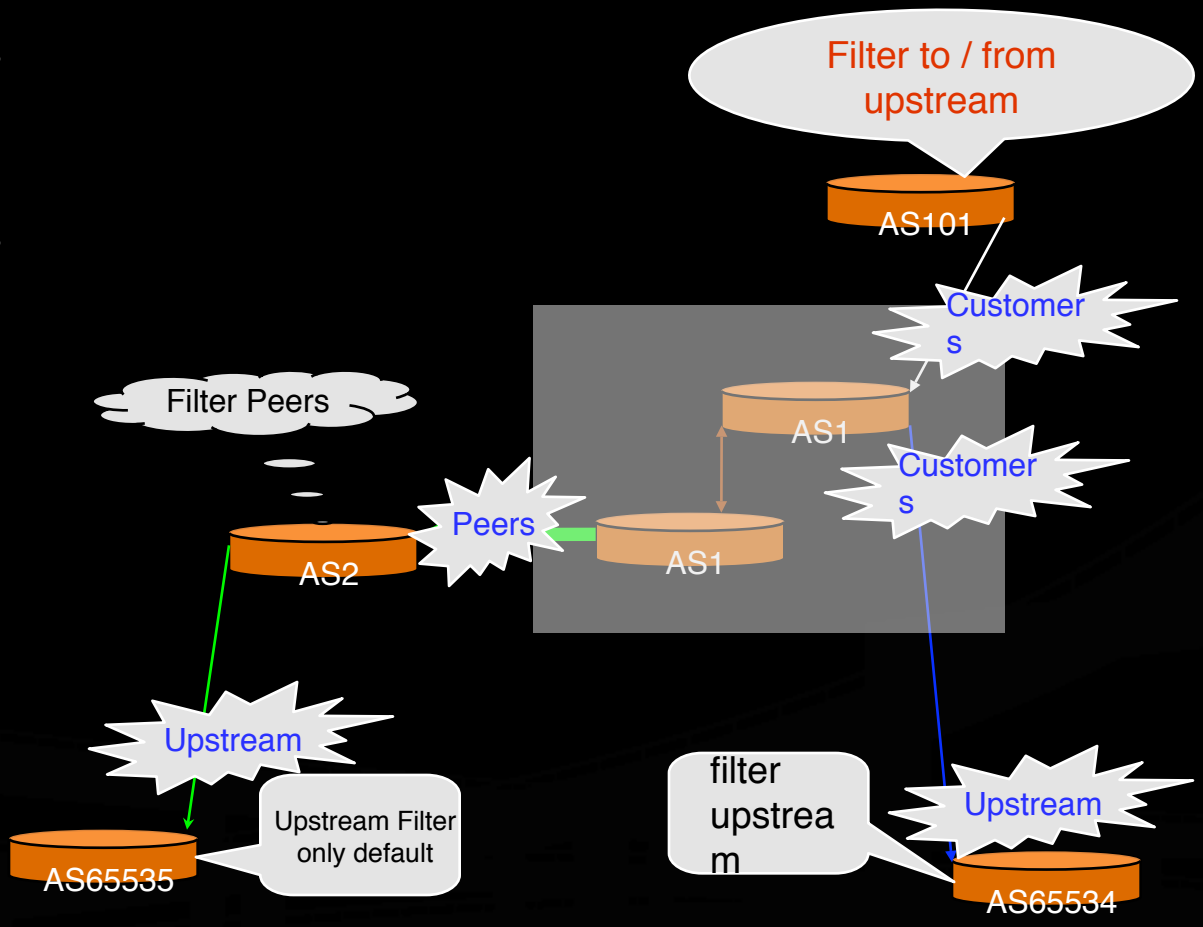
Where to Prefix Filter?

Where to Prefix Filter?

- Customers
  - Ingress / Egress
- Upstream
  - Ingress / Egress
  - Use default if single homed
- Peers
  - Ingress and Egress at all points of peering



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Special Use Addresses

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Special Use Addresses

- There are routes that should NOT be routed on the Internet
  - RFC 1918 and “Martian” networks
  - 127.0.0.0/8 and multicast blocks
  - Certain RFC3330 addresses:
  - http://www.rfc-editor.org/rfc/rfc3330.txt
- BGP should have filters applied so that these routes are not advertised to or propagated through the Internet

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Special Use Addresses

- Quick review
  - 0.0.0.0/8 and 0.0.0.0/32—Default and broadcast
  - 127.0.0.0/8—Host loopback
  - 192.0.2.0/24—TEST-NET for documentation
  - 10.0.0.0/8, 172.16.0.0/12, and 192.168.0.0/16—RFC 1918 private addresses
  - 169.254.0.0/16—End node auto-configuration

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Special Use Addresses

```
ip prefix-list deny-sua deny 0.0.0.0/8 le 32
ip prefix-list deny-sua deny 10.0.0.0/8 le 32
ip prefix-list deny-sua deny 127.0.0.0/8 le 32
ip prefix-list deny-sua deny 169.254.0.0/16 le 32
ip prefix-list deny-sua deny 172.16.0.0/12 le 32
ip prefix-list deny-sua deny 192.0.2.0/24 le 32
ip prefix-list deny-sua deny 192.168.0.0/16 le 32
ip prefix-list deny-sua deny 224.0.0.0/3 le 32
ip prefix-list deny-sua deny 0.0.0.0/0 ge 25
ip prefix-list deny-sua permit 0.0.0.0/0 le 32
```

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Bogons

- IANA publishes the list of IP Address that have been assigned to RIRs and end-users
  - http://www.iana.org/assignments/ipv4-address-space
- Only these blocks of IPv4 addresses should be visible and used on the Internet.
- Filters should be applied on Ingress / Egress of your AS for all other address range

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Bogons

- The IP Address is 32 Bits. The range is
  - 0.0.0.0 to 255.255.255.255
- Not all IP Address are allocated by IANA
- Few are not to be used on the public internet (RFC 1918)
- Few blocks are reserved (> 223/8)
- The IP Address that are not supposed to be seen on the Internet are known as ‘Bogons’, sometime also referred to as “Martian”

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Bogons

- To be a good Internet citizen, ISPs should not route them
  - Many DoS attacks originate from these unallocated address blocks, so it's also good security
- ISPs can get the bogons list from IANA and set up their prefix filters to route traffic
- When new address is assigned, generally the announcements are sent far and wide on many different mailing lists (eg. sanog, nanog, apops, afnog etc.)
- Same procedure is also applied for IPv6 address space

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Router Configuration

- This is how you configure your Cisco routers in your networks
  - Static Route to Null0, good idea for RFC1918 space
    - ip route 192.0.2.0 mask 255.255.255.0 null0
  - BGP prefix-list for Unallocated blocks
    - neighbor x.x.x.x prefix-list bogons
    - ip prefix-list bogons seq 5 deny 10.0.0.0/0 le 32
    - ip prefix-list bogons seq 10 deny 127.0.0.0/0 le 32

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Router Configuration

- The problem with the static configuration is many fold
  - The Bogons list keeps on changing
  - People move into new jobs, new people start managing the network
  - New engineers may have no clue on why those configurations are in there
  - The network is working, so let's leave it there triumphs over further digging

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Bogon Route Server Project

- Thus, the Bogon Route Server Project
  - Provides bogons over a eBGP Multihop session. There are four Bogons Route Server. Connecting to at least two is recommended.
  - You can run a BGP session with the Bogon route server
  - You receive the bogons list through BGP, then you can either
    - Either set the next-hop for the bogons to a static IP address and help in research work
    - Or set the next-hop for the bogons to a static IP address that is statically routed to Null0

Configuring Routers for Bogon RS

- Full Details are available at http://www.cymru.com/BGP/bogon-rs.html

```
router bgp <your asn>
   neighbor x.x.x.x remote-as 65333
   neighbor x.x.x.x ebgp-multihop 255
   neighbor x.x.x.x description <your description>
   neighbor x.x.x.x prefix-list cymru-out out
   neighbor x.x.x.x route-map CYMRUBOGONS in
   neighbor x.x.x.x password <your password>
   neighbor x.x.x.x maximum-prefix 100 threshold 90
!
ip bgp-community new-format
!
ip route 192.0.2.1 255.255.255.255 null0
!
ip community-list 10 permit 65333:888
!
route-map CYMRUBOGONS permit 10
   description Filter bogons learned from cymru.com bogon route-servers
   match community 10
```

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How do I set up the peering ?

- To peer with the Bogon Route Server,
  - contact team-cymru@cymru.com.
- When requesting a peering session, you should include the following information in your email:
  - Your AS number
  - The IP address(es) you want to use for peering
  - If your equipment support MD5 passwords for BGP sessions?
  - Your PGP/GPG public key, if you have one (not mandatory)
- The session is set up through eBGP multihop with a private ASN. It currently has 95 prefixes. Your router must at least support these requirements.

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Team Cymru

- The bogon list is maintained by the Team Cymru (www.cymru.com)
- While you are at the Team Cymru website, you can also take a look at the secure Router Configuration Template
- You'll find loads of useful information for ISPs and Network people there

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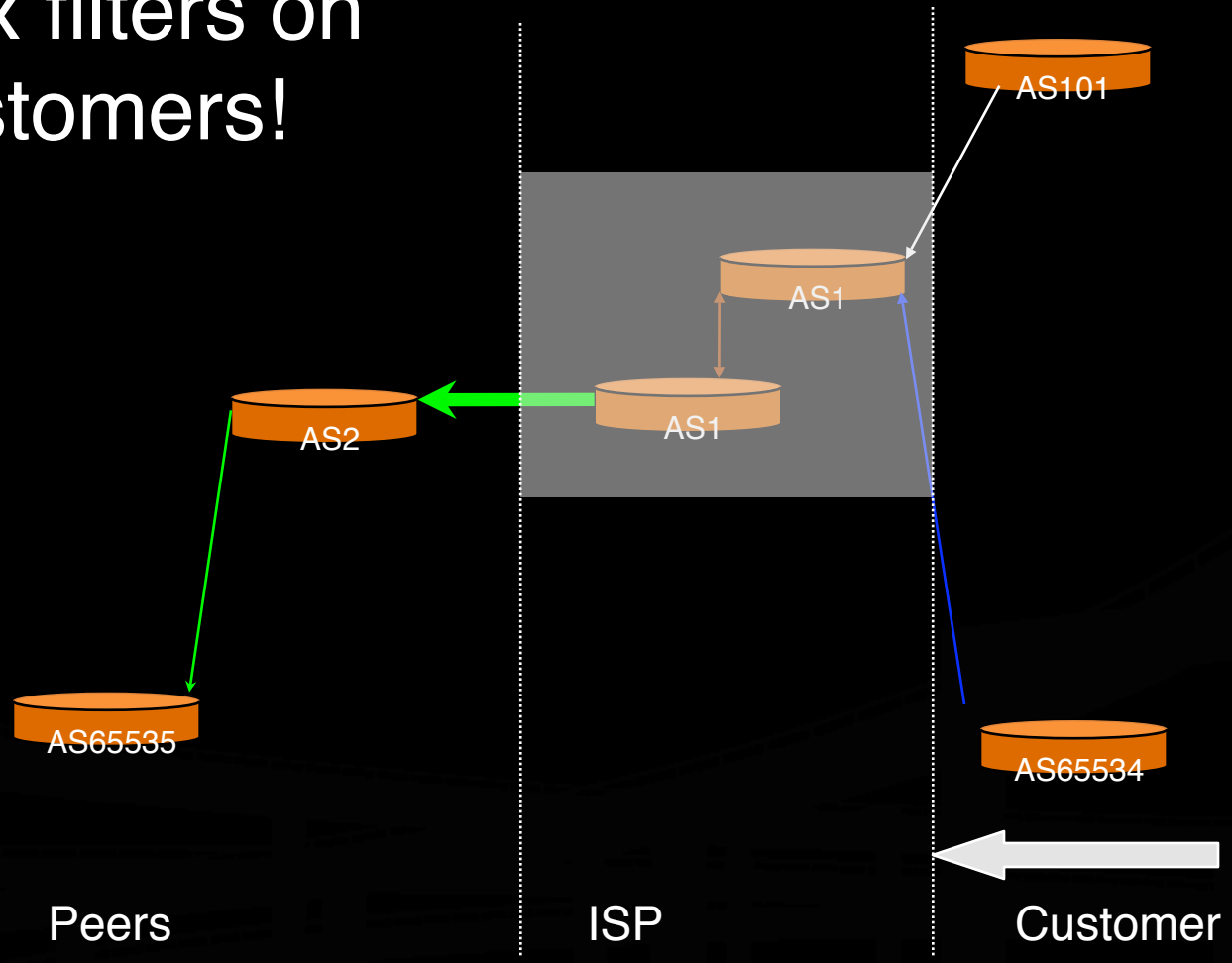
Prefix Filters on Customers

Prefix Filters on Customers

- Apply prefix filters on all your customers!



Customer Prefixes

- Service Providers should only accept assigned or allocated prefixes from their downstream peer/customer.
- E.g
  - If the RIR has assigned 202.52.224.0/19 to your customer, accept only that from it
  - If your customer is mulihomed, then accept specific prefix assigned to them by the other ISP, if required

Receiving Customer Prefixes

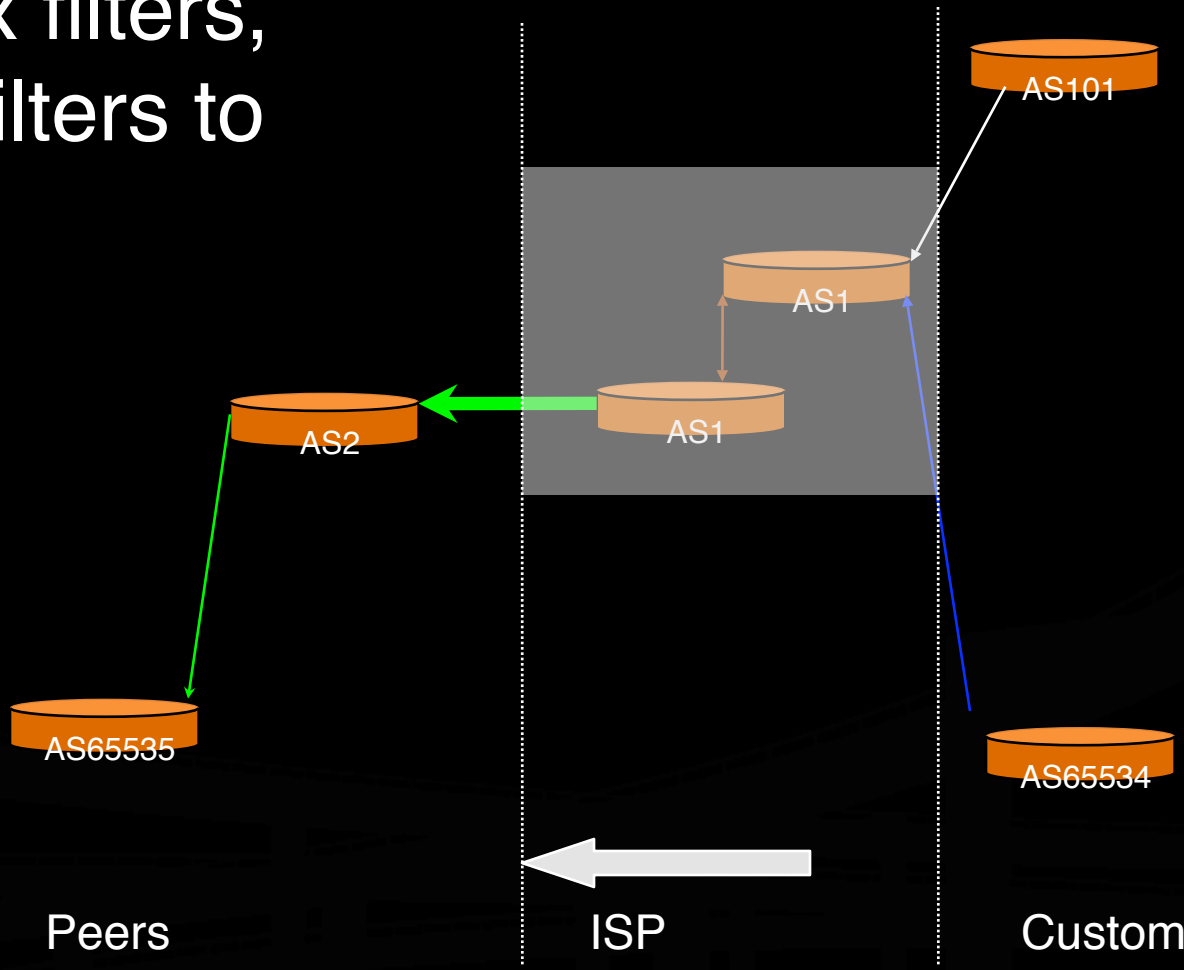
- Configuration example on upstream:

```
router bgp 65534
  neighbor 198.32.231.201 remote-as 201
  neighbor 198.32.231.201 prefix-list CUSTOMER-AS201 in
  !
ip prefix-list CUSTOMER-AS201 permit 201.1.0.0/20
ip prefix-list CUSTOMER-AS201 deny 0.0.0.0/0 le 32
```

Prefixes to Peers

Prefixes to Peers

- Apply prefix filters, AS-PATH filters to your peers!



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Prefixes to Peers

- What do you announce to other networks?
  - Your prefixes.
  - Customer's Provider Independent (PI) prefixes
  - More specific customers prefixes (customers who are multihoming)

- What do you *not* send to other network?
  - RFC3330 Prefixes – assume junk will leak into your iBGP.
  - Bogons – assume garbage will leak into your iBGP.
  - Prefixes longer than /24, i.e, /25 to /32

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Egress Filter to Peers

- The egress prefix list can grow to be very large:
  - More specifics for customers.
  - Specific blocks from other ISPs
- AS-PATH filters are more scalable
  - Peer Mailing lists generally send updates about new downstream prefixes

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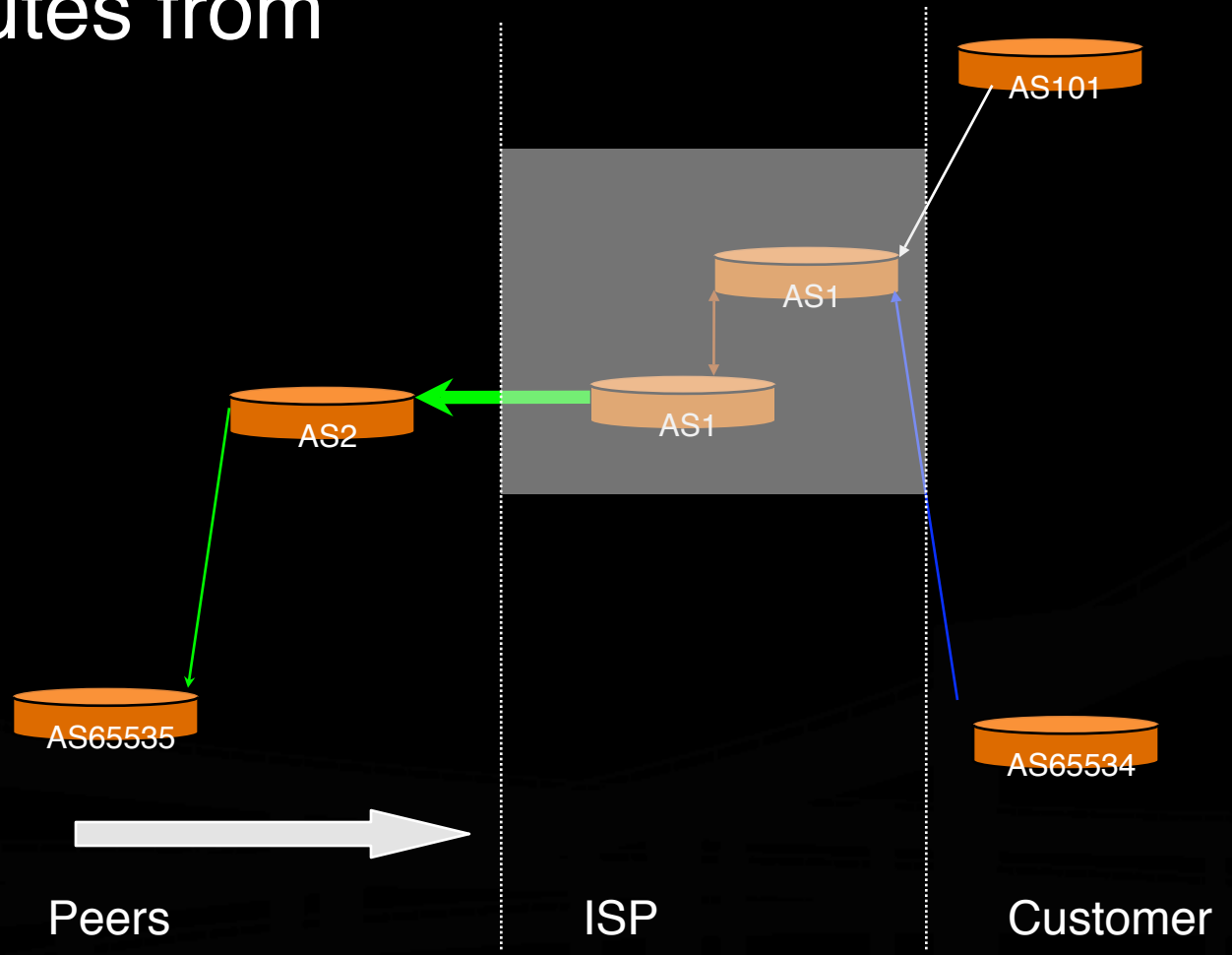
Ingress Prefix Filtering from Peers

Prefixes from Peers

- Filter all routes from your peers!



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Filtering Ingress Routes

- Peers and Upstream provide access to the Internet routes
- Ingress filters with Peers
  - The peering policy should have requirements so that filters can be built
  - Max Prefix limit are important
- Ingress filters with Upstream
  - Unless you multihome, full routes are not required, accept only default

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Best Practices for ingress filters

- Don’t accept RFC1918 etc prefixes
- Don’t accept your own prefix
- Don’t accept default (unless you need it)
- Don’t accept prefixes longer than /24
- Consider *Net Police* Filtering

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Ingress example - Cisco IOS

```
router bgp 65534
 network 202.52.0.0 mask 255.255.224.0
 neighbor 198.32.231.201 remote-as 201
 neighbor 198.32.231.201 prefix-list in-filter in
!
ip prefix-list in-filter deny 0.0.0.0/0          ! Block default
ip prefix-list in-filter deny 0.0.0.0/8 le 32
ip prefix-list in-filter deny 10.0.0.0/8 le 32
ip prefix-list in-filter deny 127.0.0.0/8 le 32
ip prefix-list in-filter deny 169.254.0.0/16 le 32
ip prefix-list in-filter deny 172.16.0.0/12 le 32
ip prefix-list in-filter deny 192.0.2.0/24 le 32
ip prefix-list in-filter deny 192.168.0.0/16 le 32
ip prefix-list in-filter deny 202.52.0.0/19 le 32 ! Block local prefix
ip prefix-list in-filter deny 224.0.0.0/3 le 32
ip prefix-list in-filter deny 0.0.0.0/0 ge 25            ! Block prefixes >/24
ip prefix-list in-filter permit 0.0.0.0/0 le 32
```

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Packet Filtering Principles

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

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Routing Protocol Updates MD5 Authentication

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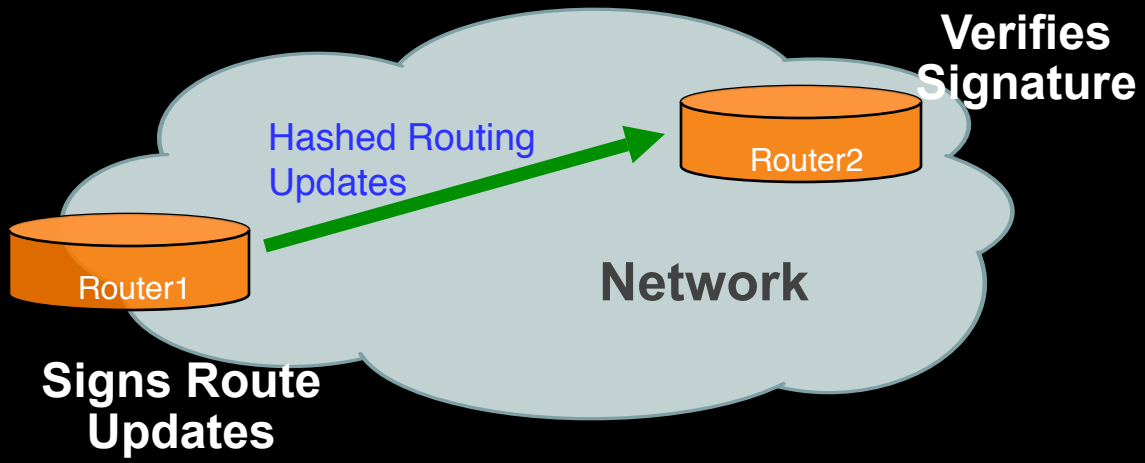
Route Authentication



Certifies Authenticity of Neighbor and Integrity of Route Updates

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BGP Route Authentication

- Router1 Example

```
router bgp 200
      neighbor 2.2.2.1 remote-as 201
      neighbor 2.2.2.1 description Link to AS-201-Peer
      neighbor 2.2.2.1 password 7 cisco
```

- Router2 Example

```
router bgp 201
      neighbor 2.2.2.2 remote-as 200
      neighbor 2.2.2.2 description Link to AS-200-Peer
      neighbor 2.2.2.2 password 7 cisco
```

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Additional BGP Knobs

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BGP Maximum Prefix Tracking

- Allow configuration of the maximum number of prefixes a BGP router will receive from a peer
- Two level control
  - Warning threshold: Log warning message
  - Maximum: Tear down the BGP peering, can be setup renew the session after a time period
- Vendor Implementation varies a little bit

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BGP Maximum-prefix - Cisco

```
neighbor <x.x.x.x> maximum-prefix <max>
  [<threshold>] [warning-only]
```

- Threshold is an optional parameter between 1 to 100 percent
  - Specify the percentage of <max> that a warning message will be generated; Default is 75%
- Warning-only is an optional keyword which allows log messages to be generated but peering session will not be torn down

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Avoid Default Routes

- ISPs with full BGP feeds should avoid default routes.
- DOS/DDOS attack use spoofed addresses from the un-allocated IPV4 space.
  - See http://www.iana.org/assignments/ipv4-address-space for the latest macro allocations.
- Backscatter traffic from DOS/DDOS targets need to go somewhere. If there is a default, then this traffic will go to this one router and get dropped.
- Dropping backscatter traffic might overload the router.

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RFC 2827/BCP 38

Network Ingress Filtering:
Defeating Denial of Service Attacks which employ IP Source Address Spoofing

"Thou shalt only sendth and receiveth IP packets you have rights for"

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RFC 2827/BCP 38 Ingress Packet Filtering

- Packets should be sourced from valid, allocated address space, consistent with the topology and space allocation

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Guidelines for BCP38

- Networks connecting to the Internet
  - Must use inbound and outbound packet filters to protect network
- Configuration example
  - Outbound—only allow my network source addresses out
  - Inbound—only allow specific ports to specific destinations in

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NO BCP38 may mean :

- Devices can (wittingly or unwittingly) send traffic with spoofed and/or randomly changing source addresses out to the network
- Complicates traceback immensely
- Sending bogus traffic is not free

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Techniques for BCP 38 Filtering

- Static ACLs on the edge of the network
- Dynamic ACLs with AAA profiles
- Unicast RPF strict mode
- IP source guard
- Cable source verify (DHCP)

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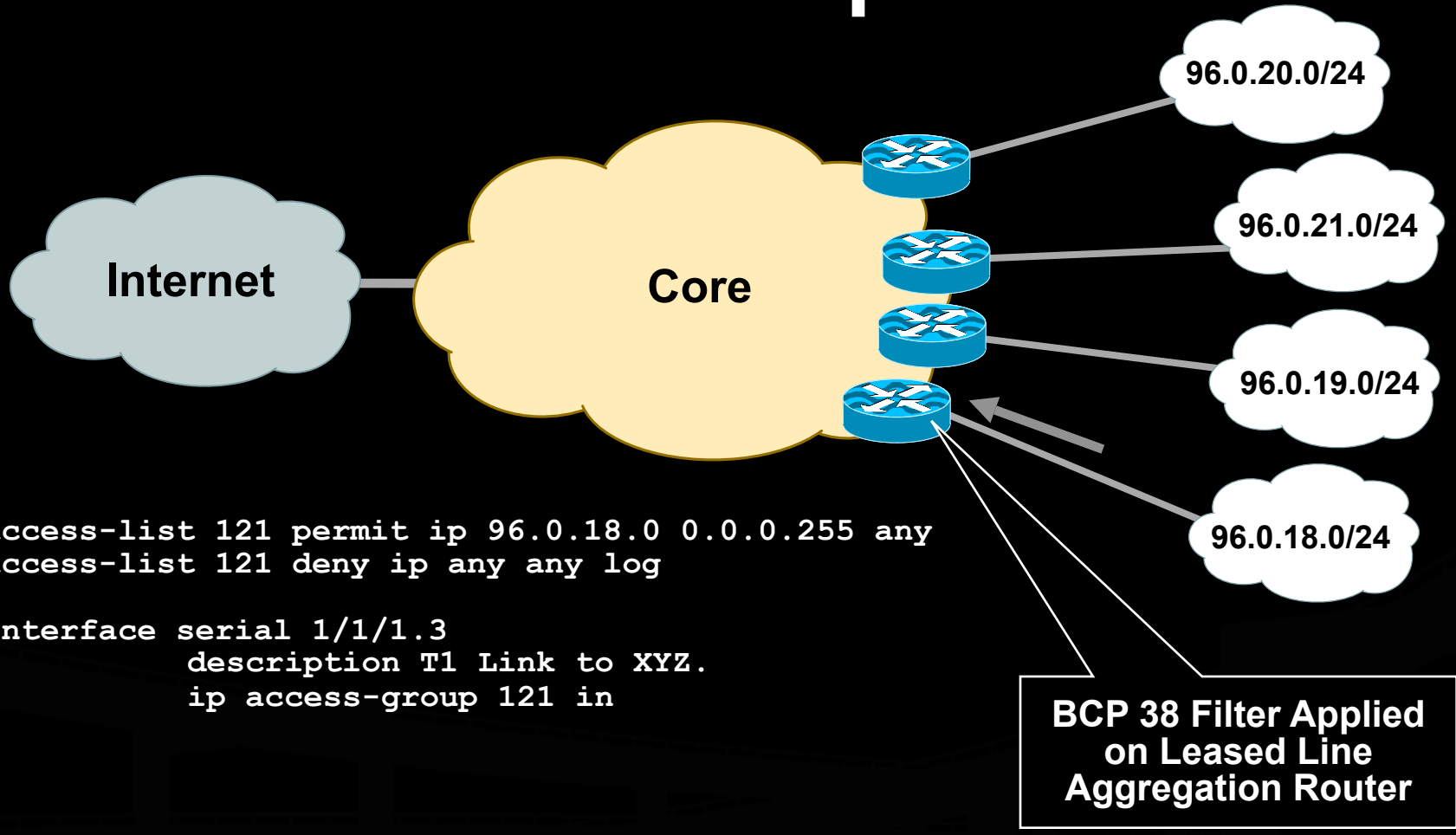
Using ACLs to Enforce BCP38

- Static ACLs are the traditional method of ensuring that source addresses are not spoofed:
  - Permit all traffic whose source address equals the allocation block
  - Deny any other packet
- Principles:
  - Filter as close to the edge as possible
  - Filter as precisely as possible
  - Filter both source and destination where possible

Static ACL example - Cisco




```
access-list 121 permit ip 96.0.18.0 0.0.0.255 any
access-list 121 deny ip any any log
!
interface serial 1/1/1.3
          description T1 Link to XYZ.
          ip access-group 121 in
!
```

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BCP ACL Guidelines

- ISPs
  - Make sure your customers install filters on their routers—give them a template they can use
- Customer end-sites
  - Make sure you install strong filters on routers you use
    to connect to the Internet
  - First line of defense—never assume your ISP will do it

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IPv4 Anycast Routing

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What *isn't* Anycast?

- Not a protocol, not a different version of IP, nobody's proprietary technology.
- Doesn't require any special capabilities in the servers, clients, or network.
- Doesn't break or confuse existing infrastructure.

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What *is* Anycast?

- Just a configuration methodology.
- Mentioned, although not described in detail, in numerous RFCs since time immemorial.
- It's been the basis for large-scale content-distribution networks since at least 1995.
- It's gradually taking over the core of the DNS infrastructure, as well as much of the periphery of the world wide web.

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How Does Anycast Work?

- The basic idea is extremely simple:
- Multiple instances of a service share the same IP address.
- The routing infrastructure directs any packet to the topologically nearest instance of the service.
- What little complexity exists is in the optional details.

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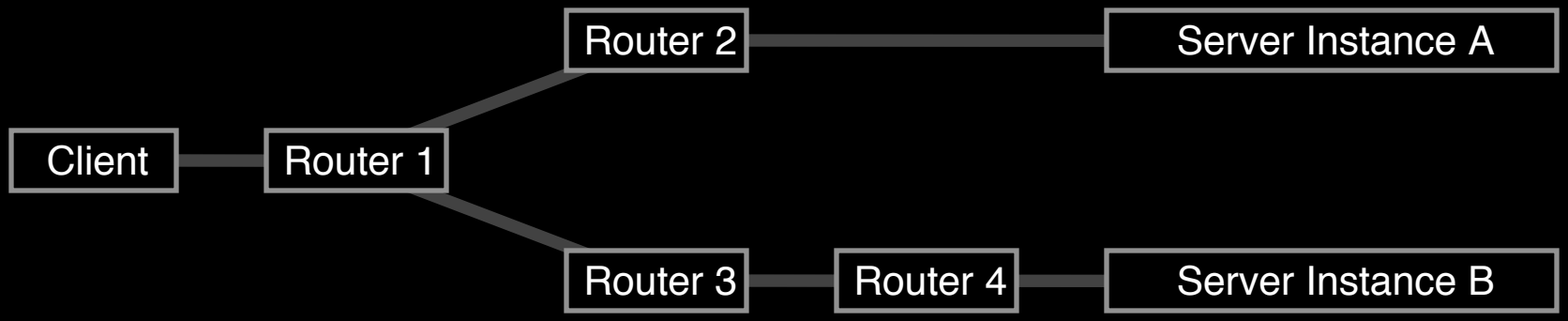
Example



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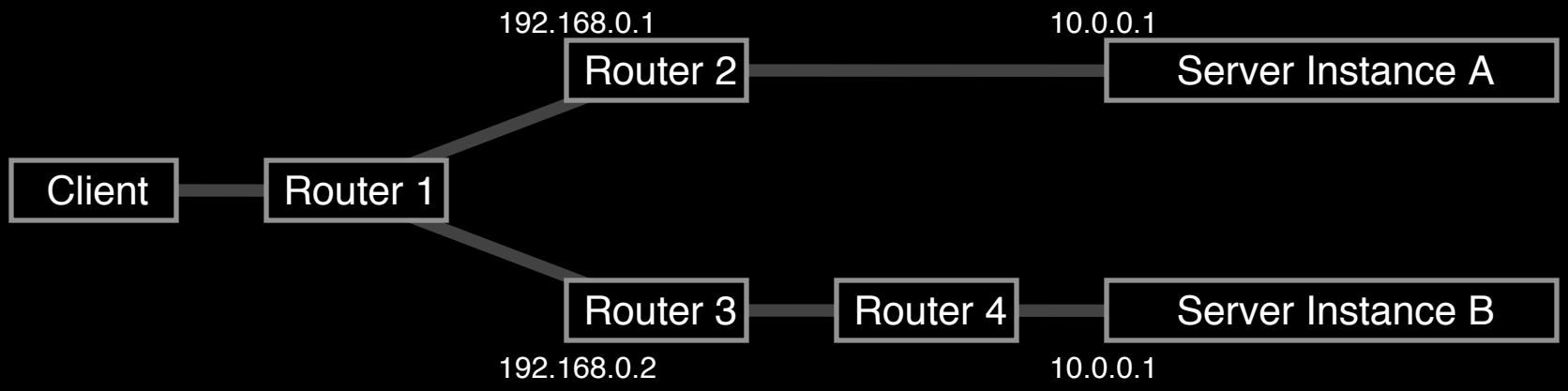
Example



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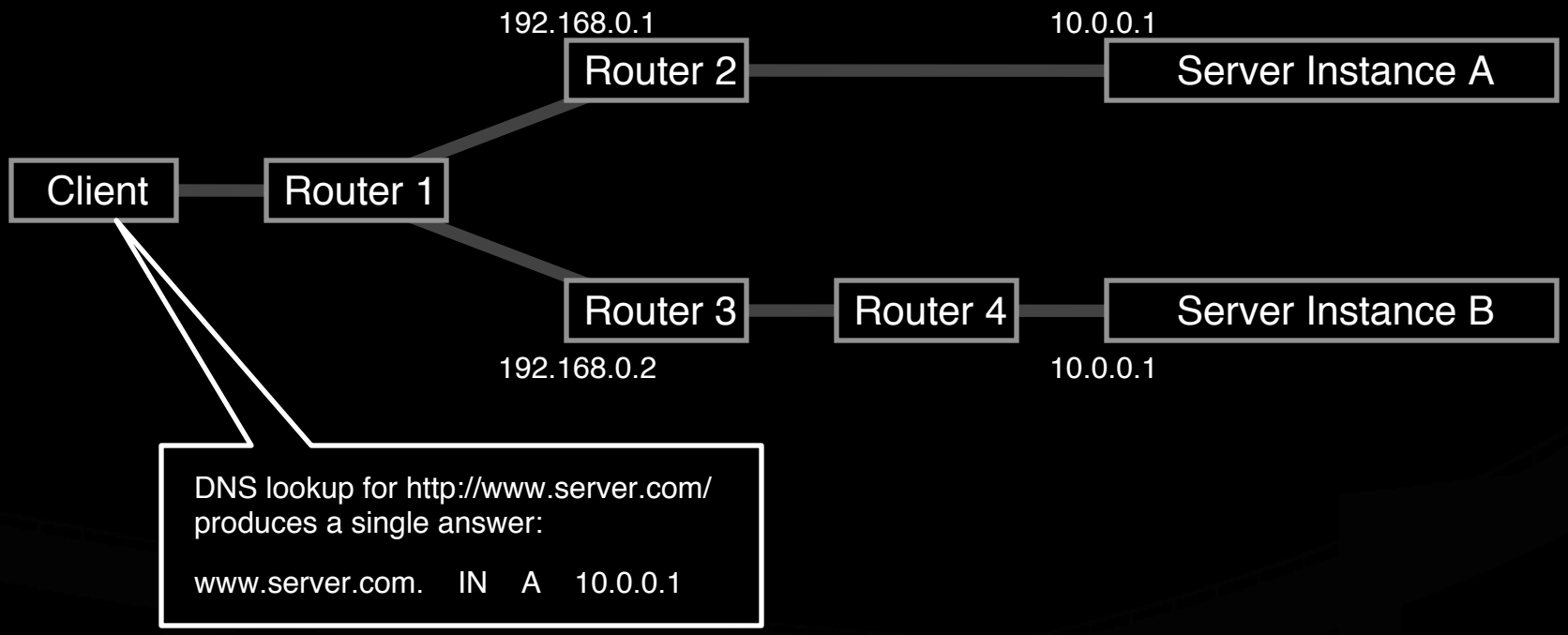
Example



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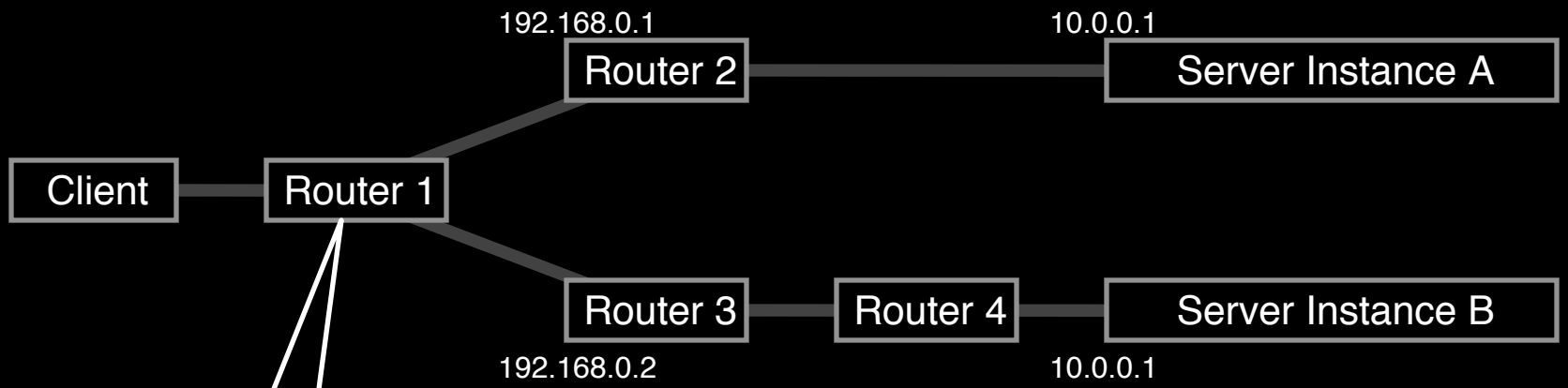
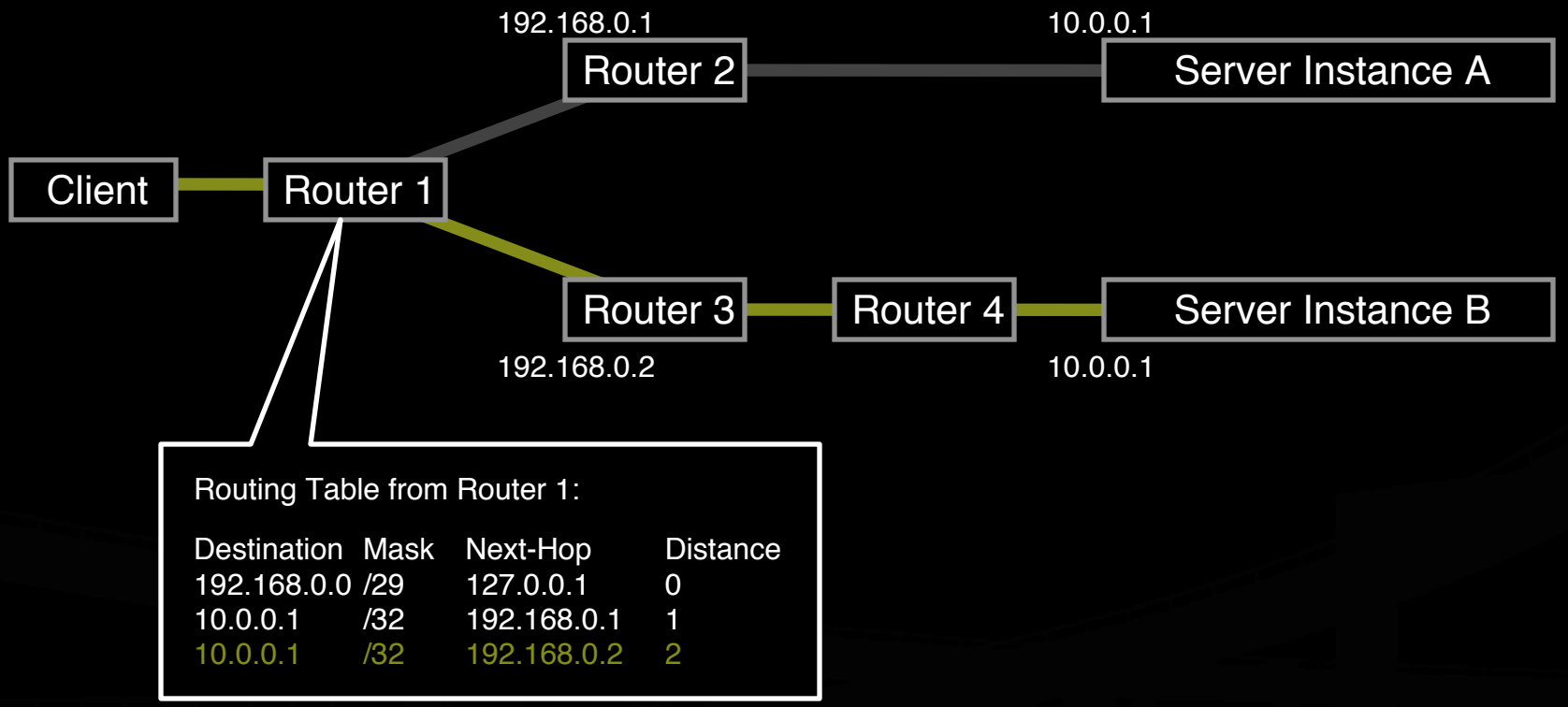
Example



Routing Table from Router 1:

Destination	Mask	Next-Hop	Distance
192.168.0.0	/29	127.0.0.1	0
10.0.0.1	/32	192.168.0.1	1
10.0.0.1	/32	192.168.0.2	2

Example


192.168.0.1
10.0.0.1
Router 2
Server Instance A
Client
Router 1
Router 3
Router 4
Server Instance B
192.168.0.2
10.0.0.1
Routing Table from Router 1:
Destination Mask Next-Hop Distance
192.168.0.0 /29 127.0.0.1 0
10.0.0.1 /32 192.168.0.1 1
10.0.0.1 /32 192.168.0.2 2

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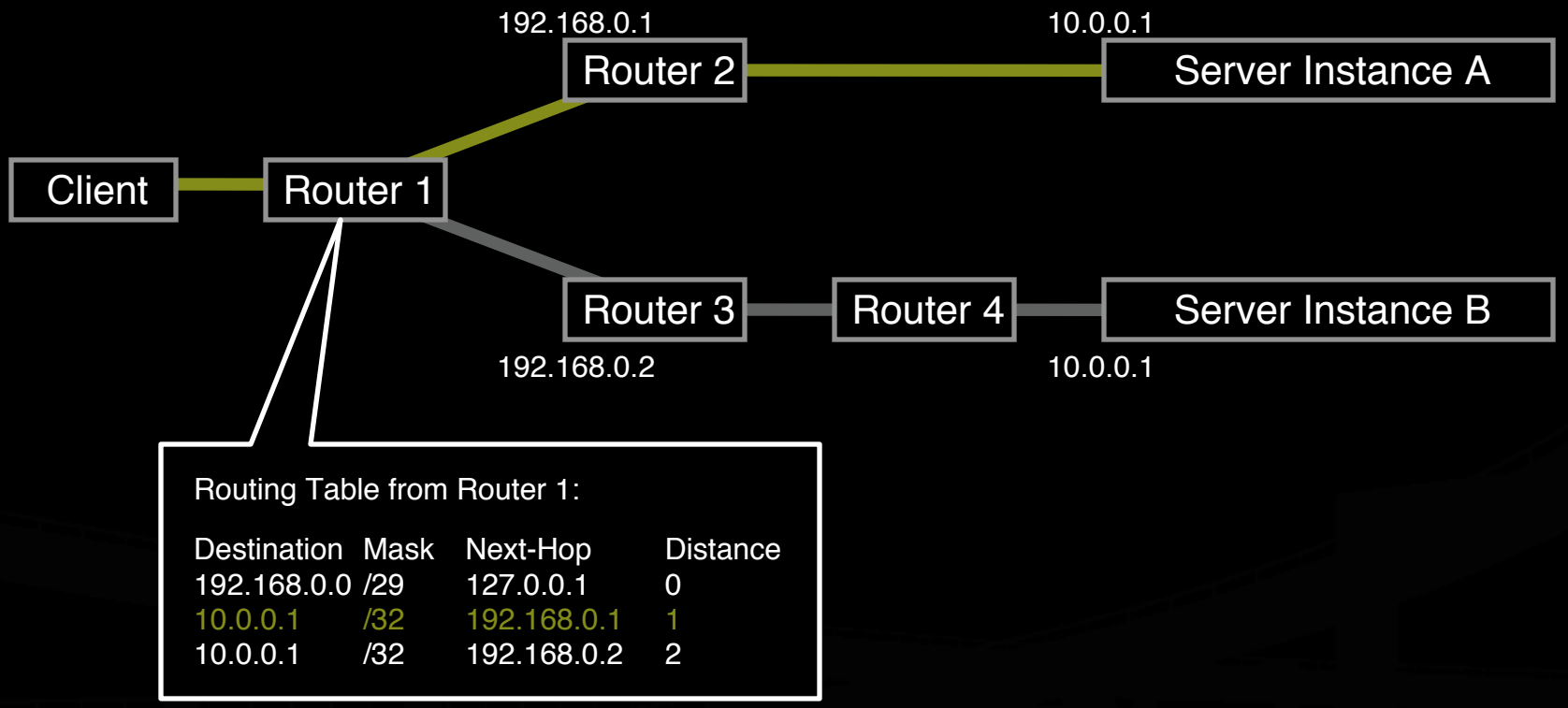
Example

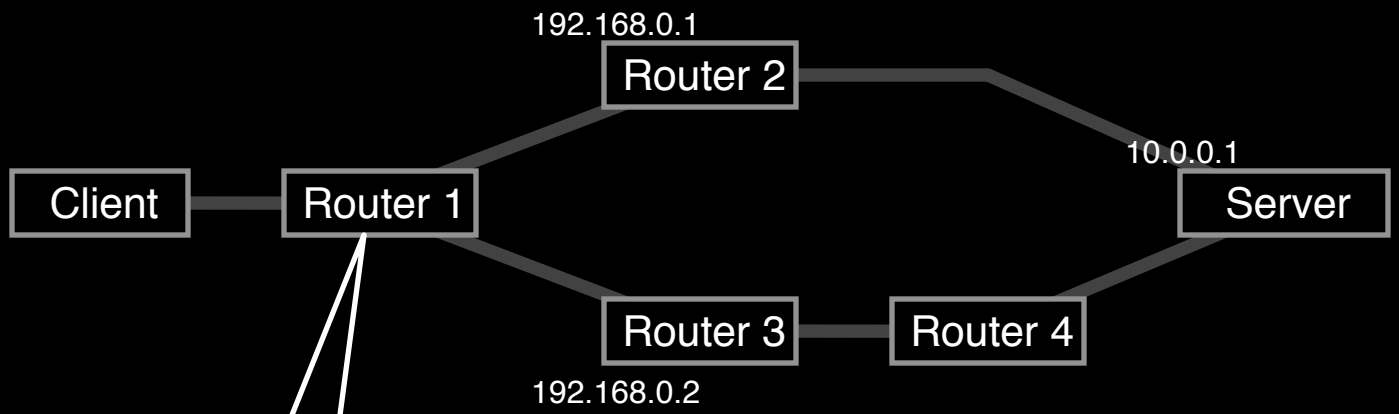


Routing Table from Router 1:

Destination	Mask	Next-Hop	Distance
192.168.0.0	/29	127.0.0.1	0
10.0.0.1	/32	192.168.0.1	1
10.0.0.1	/32	192.168.0.2	2

Example

What the routers think the topology looks like:



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A Security Ramification

- Anycast server clouds have the useful property of sinking DOS attacks at the instance nearest to the source of the attack, leaving all other instances unaffected.
- This is still of some utility even when DOS sources are widely distributed.

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More things to know

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Update your whois Information

"Please expect that advanced parts of the community are building filters straight - and strictly - from routing registry data (at least for the RIPE community this is fairly solid data - a benefit which is painfully missing in most other RIR's service areas)."

Ruediger Volk, Deutsche Telecom

(VIX Mailing List, August 17, 05)

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What else should I know ?

- Good ISPs know about their networks, and never block ICMP as a result of some virus activity
- ISPs should not be involved in blocking ports over their network
  - But they can always create a best practice document for their customers not to send internal information on the public internet
- Keep their abuse desk functional and have valid e-mails address for abuse
- Anycast can provide critical service redundancy

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Mailing Lists

- Most countries have regional if not local mailing lists for operational / bogons updates
  - SANOG is South Asia, NANOG is North America, AfNOG is Africa, APOPS is Asia Pacific, EOF is for Europe, Swinog is Swiss, NZNog is Kiwis….. list is long
- Security updates from vendors are sent to most of the list above plus
  - NSP-Sec Mailing List
  - Cisco-NSP, Juniper-NSP and other vendor specific lists
  - CERT mailing list

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Participate

- Networks are only useful when people can use it
- The only way you can make your network work for everyone is by talking to others, so you should participate in these forums.
- If you have an IX, the IX mailing list can be the ideal list for such technical discussion
- Remember, a rouge user anywhere on the Internet can effect you, and chances of attacks originating near your own network is always higher.

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INOC DBA

- INOC-DBA: Inter-NOC Dial-by-ASN
- Global Voice-over-IP hotline phone system, directly interconnecting NOCs and SIRTs within carriers, ISPs, exchange points, and vendors.

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How does it work?

- If you just dial an Autonomous System Number, it'll ring a predefined group of phones within that AS. (example: `42`)
- If you dial an ASN and an extension number, it'll ring the phones belonging to that person. (example: `42*WEW`)
- Also, well-known extensions for NOC, abuse, routing, SIRT, et cetera.

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Questions ?

Thank You

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With acknowledgements to Philip Fredrick Smith, Rob Thomas, Merike Kaeo and Bill Woodcock

The Best Practices for ISPs tutorial can be found at

http:// www.pch.net / resources / tutorials / ispbcp