BGP and the Internet

Multihoming

Cisco Systems

Multihoming Definition

- **More than one link external to the local network**

    two or more links to the same ISP

    two or more links to different ISPs

- **Usually two external facing routers**

    one router gives link and provider redundancy only

Multihoming

- **The scenarios described here apply equally well to end sites being customers of ISPs and ISPs being customers of other ISPs**

- **Implementation detail may be different**

  end site ® ISP   **ISP controls config**

  ISP1 ® ISP2   **ISPs share config**

AS Numbers

- **An Autonomous System Number is required by BGP**

- **Obtained from upstream ISP or Regional Registry**

- **Necessary when you have links to more than one ISP or exchange point**

Configuring Policy

- **Assumptions:**

  prefix-lists are used throughout

  easier/better/faster than access-lists

- **Three BASIC Principles**

  prefix-lists to filter prefixes

  filter-lists to filter ASNs

  route-maps to apply policy

Originating Prefixes

- **Basic Assumptions**

  MUST announce assigned address block to Internet

  MAY also announce subprefixes - reachability is not guaranteed

  RIR minimum allocation is /20 - several ISPs filter RIR blocks on this boundary - "Net Police"

Part of the "Net Police" prefix list

```
!! RIPE
ip prefix-list FILTER permit 62.0.0.0/8 ge 12 le 20
ip prefix-list FILTER permit 193.0.0.0/8 ge 12 le 20
ip prefix-list FILTER permit 194.0.0.0/7 ge 12 le 20
ip prefix-list FILTER permit 212.0.0.0/7 ge 12 le 20
!! APNIC
ip prefix-list FILTER permit 61.0.0.0/8 ge 12 le 20
ip prefix-list FILTER permit 202.0.0.0/7 ge 12 le 20
ip prefix-list FILTER permit 210.0.0.0/7 ge 12 le 20
!! ARIN
ip prefix-list FILTER permit 63.0.0.0/8 le 20
ip prefix-list FILTER permit 64.0.0.0/8 le 20
ip prefix-list FILTER permit 199.0.0.0/8 le 20
ip prefix-list FILTER permit 200.0.0.0/8 le 20
ip prefix-list FILTER permit 204.0.0.0/6 le 20
ip prefix-list FILTER permit 208.0.0.0/7 le 20
ip prefix-list FILTER permit 216.0.0.0/8 le 20
```

"Net Police" prefix list issues

- meant to "punish" ISPs who won't and don't aggregate

- impacts legitimate multihoming

- impacts regions where domestic backbone is unavailable or costs $$$ compared with international bandwidth

- hard to maintain - requires updating when RIRs start allocating from new address blocks

- **don't do it unless consequences understood**

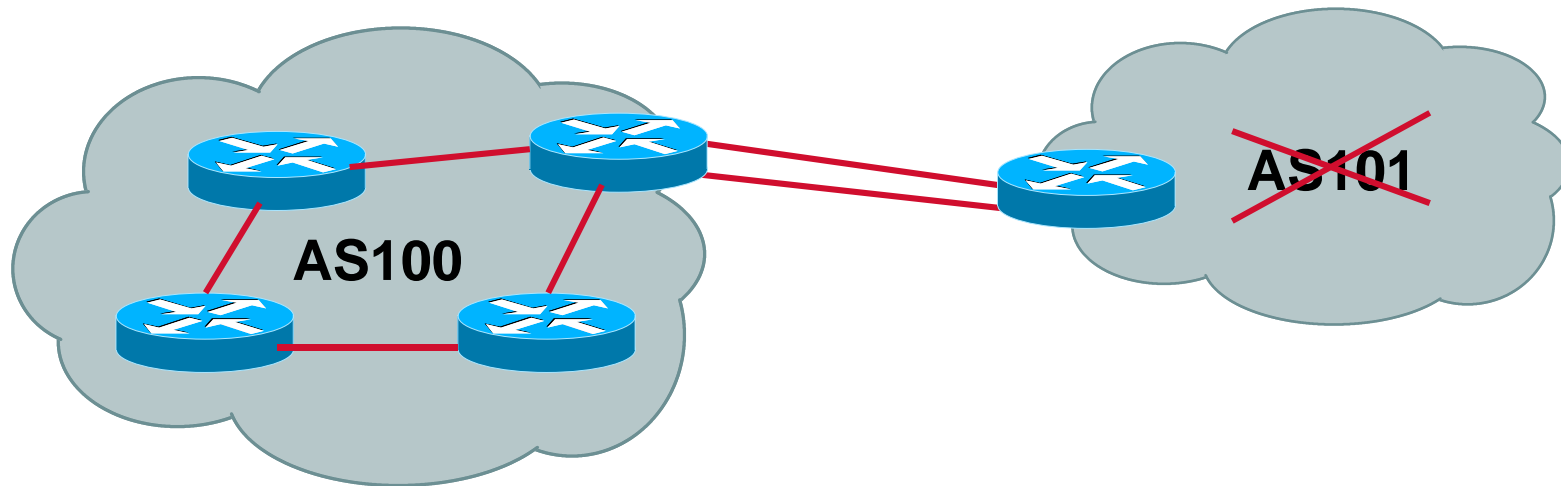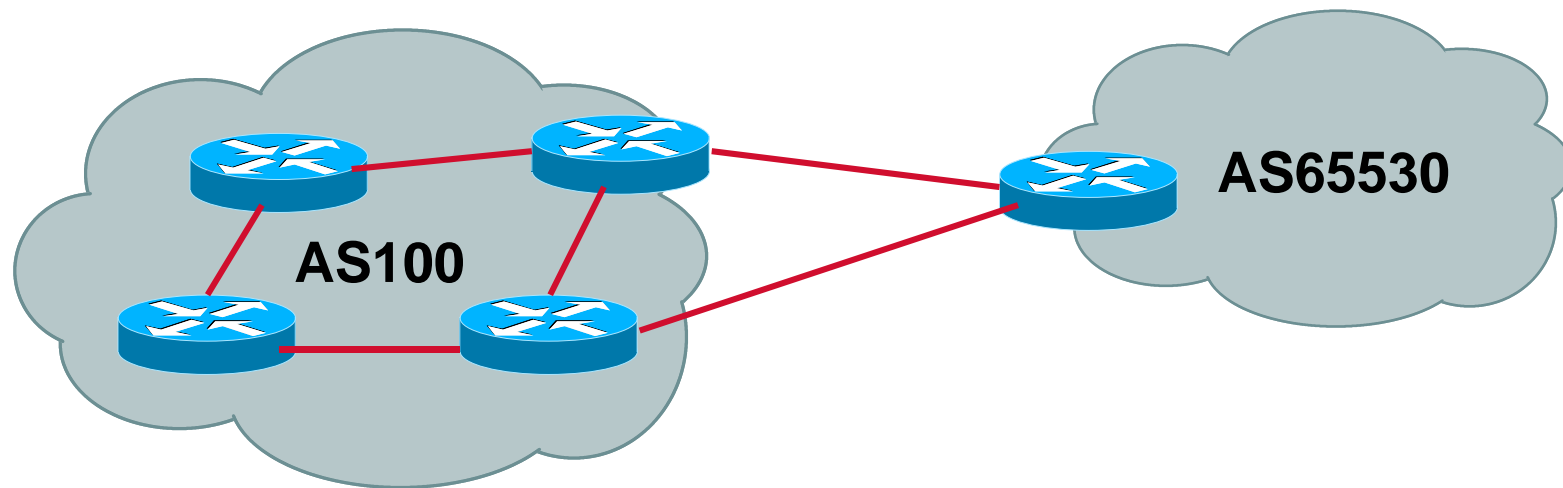# Multihoming Options

Multihoming Scenarios

- ## Stub network

- ## Multi-homed stub network

- ## Multi-homed network
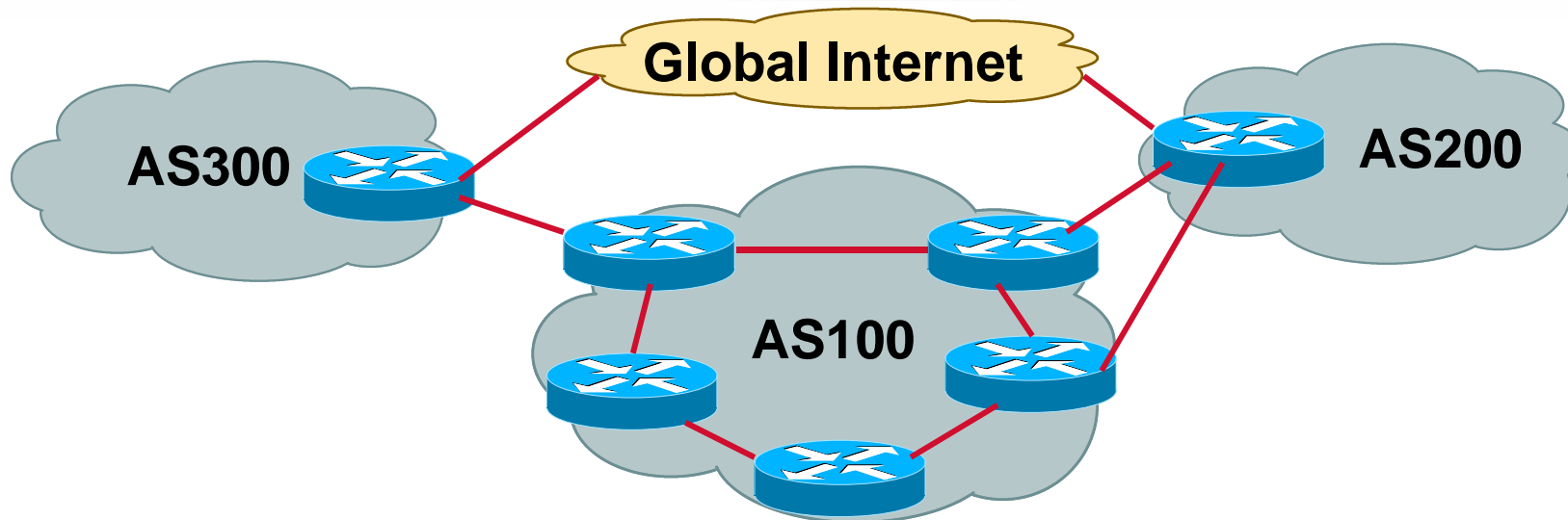
- ## Configuration Options

Stub Network

- **No need for BGP**

- **Point static default to upstream ISP**

- **Upstream ISP advertises stub network**

- **Policy confined within upstream ISP's policy**

Multi-homed Stub Network

AS65530

AS100

- **Use BGP (not IGP or static) to loadshare**

- **Use private AS (ASN > 64511)**

- **Upstream ISP advertises stub network**

- **Policy confined within upstream ISP's policy**

Multi-Homed Network

Global Internet

AS300

AS200

AS100

- **Many situations possible**

    multiple sessions to same ISP

    secondary for backup only

    load-share between primary and secondary

    selectively use different ISPs

Multiple Sessions to ISPs

- **Planning and some work required to achieve load sharing**

  Point default towards one ISP

  Learn selected prefixes from second ISP

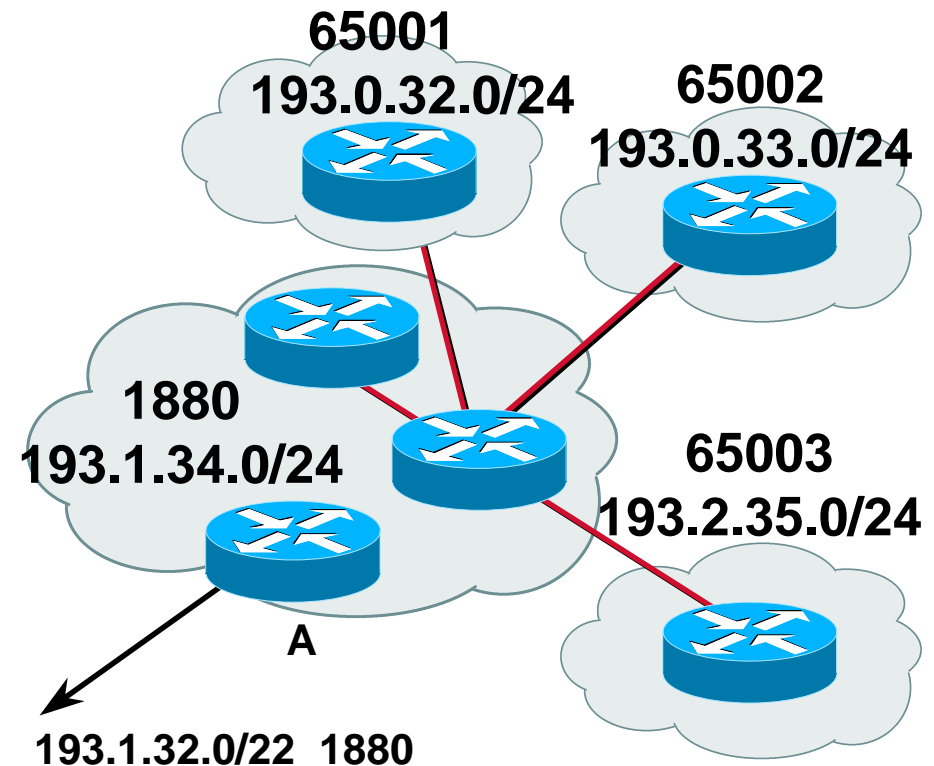 **Modify the number of prefixes learnt to achieve acceptable load sharing**

- **No magic solution**

Private-AS - Application

- ## Applications

  ### ISP with single-homed customers

  corporate network with several regions and connections to the Internet only in the core

65001
193.0.32.0/24

65002
193.0.33.0/24

1880
193.1.34.0/24

65003
193.2.35.0/24

A

193.1.32.0/22   1880

Two links to the same ISP

One link primary, the other link backup only

Two links to the same ISP

primary

AS 109

AS 65534

backup

- **AS109 removes private AS and any customer subprefixes from Internet announcement**

Two links to the same ISP (one as backup only)

- **Announce /19 aggregate on each link**

  - **primary link makes standard announcement**

  - **backup link increases metric on outbound, and reduces local-pref on inbound**

- **When one link fails, the announcement of the /19 aggregate via the other link ensures continued connectivity**

Two links to the same ISP (one as backup only)

- **Router A Configuration**

```
router bgp 65534

 network 221.10.0.0 mask 255.255.224.0

 neighbor 222.222.10.2 remote-as 109

 neighbor 222.222.10.2 description RouterC

 neighbor 222.222.10.2 prefix-list aggregate out

 neighbor 222.222.10.2 prefix-list default in

!

ip prefix-list aggregate permit 221.10.0.0/19

ip prefix-list default permit 0.0.0.0/0

!
```

Two links to the same ISP (one as backup only)

- **Router B Configuration**

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 neighbor 222.222.10.6 remote-as 109
 neighbor 222.222.10.6 description RouterD
 neighbor 222.222.10.6 prefix-list aggregate out
 neighbor 222.222.10.6 route-map routerD-out out
 neighbor 222.222.10.6 prefix-list default in
 neighbor 222.222.10.6 route-map routerD-in in
!
..next slide
```

Two links to the same ISP (one as backup only)

```
ip prefix-list aggregate permit 221.10.0.0/19

ip prefix-list default permit 0.0.0.0/0

!

route-map routerD-out permit 10
 match ip address prefix-list aggregate
 set metric 10
route-map routerD-out permit 20

!

route-map routerD-in permit 10
 set local-preference 90

!
```

Two links to the same ISP (one as backup only)

- **Router C Configuration (main link)**

```
router bgp 109
  neighbor 222.222.10.1 remote-as 65534
  neighbor 222.222.10.1 default-originate
  neighbor 222.222.10.1 prefix-list Customer in
  neighbor 222.222.10.1 prefix-list default out
!
ip prefix-list Customer permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP (one as backup only)

- **Router D Configuration (backup link)**

```
router bgp 109
  neighbor 222.222.10.5 remote-as 65534
  neighbor 222.222.10.5 default-originate
  neighbor 222.222.10.5 prefix-list Customer in
  neighbor 222.222.10.5 prefix-list default out
!
ip prefix-list Customer permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP (one as backup only)

- **Router E Configuration**

```
router bgp 109
 neighbor 222.222.10.17 remote-as 110
 neighbor 222.222.10.17 remove-private-AS
 neighbor 222.222.10.17 prefix-list Customer out
!
ip prefix-list Customer permit 221.10.0.0/19
```
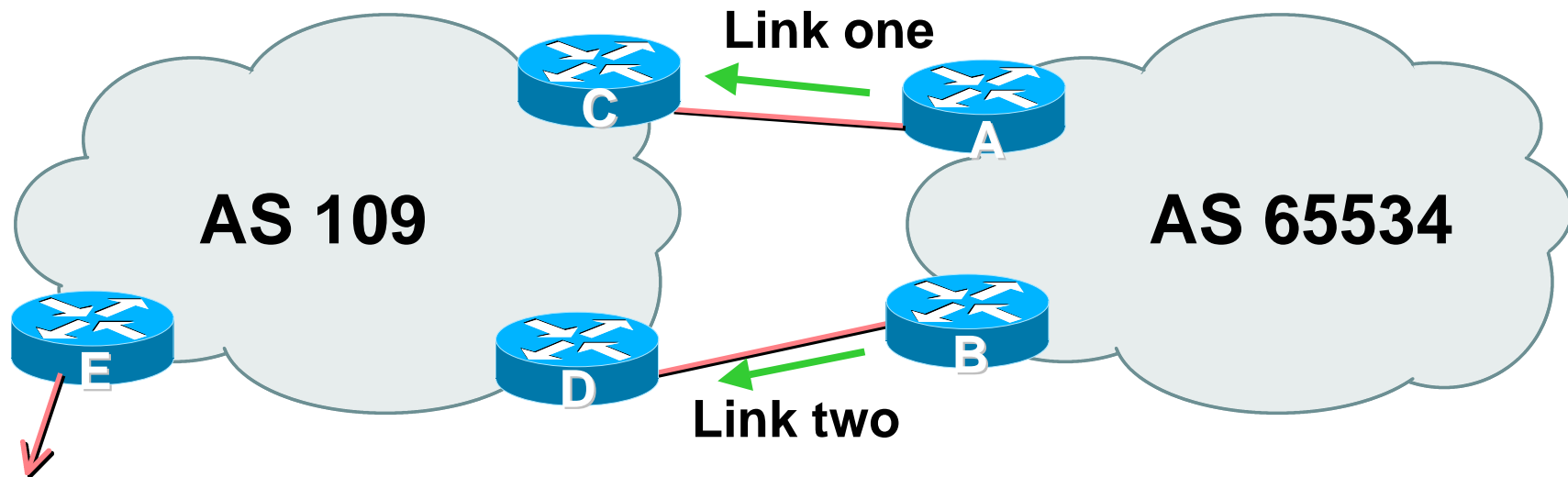
- **Router E removes the private AS and customer's subprefixes from external announcements**

- **Private AS still visible inside AS109**

Two links to the same ISP

With Redundancy and Loadsharing

Two links to the same ISP (with redundancy)

Link one

C

A

AS 109

AS 65534

E

D

B

Link two

- **AS109 removes private AS and any customer subprefixes from Internet announcement**

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Loadsharing to the same ISP

- **Announce /19 aggregate on each link**

- **Split /19 and announce as two /20s, one on each link**

  basic inbound loadsharing

  assumes equal circuit capacity and even spread of traffic across address block

- **Vary the split until "perfect" loadsharing achieved**

Two links to the same ISP

- **Router A Configuration**

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.0.0 mask 255.255.240.0
 neighbor 222.222.10.2 remote-as 109
 neighbor 222.222.10.2 prefix-list routerC out
 neighbor 222.222.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 221.10.0.0/20
ip prefix-list routerC permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.240.0 null0
ip route 221.10.0.0 255.255.224.0 null0
```

Two links to the same ISP

- **Router B Configuration**

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.16.0 mask 255.255.240.0
 neighbor 222.222.10.6 remote-as 109
 neighbor 222.222.10.6 prefix-list routerD out
 neighbor 222.222.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 221.10.16.0/20
ip prefix-list routerD permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.224.0 null0
ip route 221.10.16.0 255.255.240.0 null0
```

Loadsharing to the same ISP

- ## Default route for outbound traffic?

  ### Use default-information originate for the IGP and rely on IGP metrics for nearest exit

  ### e.g. on router A:

  ```
  router ospf 65534
    default-information originate metric 2 metric-type 1
  ```

Two links to the same ISP

- ## Router C Configuration

```
router bgp 109

  neighbor 222.222.10.1 remote-as 65534

  neighbor 222.222.10.1 default-originate

  neighbor 222.222.10.1 prefix-list Customer in

  neighbor 222.222.10.1 prefix-list default out

!

ip prefix-list Customer permit 221.10.0.0/19 le 20

ip prefix-list default permit 0.0.0.0/0
```

- ## Router C only allows in /19 and /20 prefixes from customer block

Two links to the same ISP

- ## Router D Configuration

```
router bgp 109
  neighbor 222.222.10.5 remote-as 65534
  neighbor 222.222.10.5 default-originate
  neighbor 222.222.10.5 prefix-list Customer in
  neighbor 222.222.10.5 prefix-list default out
!
ip prefix-list Customer permit 221.10.0.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- ## Router D only allows in /19 and /20 prefixes from customer block

Two links to the same ISP

- **Router E is AS109 border router**

  removes subprefixes in the private AS from external announcements

  removes the private AS from external announcement of the customer /19

Two links to the same ISP (with redundancy)

- **Router E Configuration**

```
router bgp 109

 neighbor 222.222.10.17 remote-as 110

 neighbor 222.222.10.17 remove-private-AS

 neighbor 222.222.10.17 prefix-list Customer out

!

ip prefix-list Customer permit 221.10.0.0/19
```

- **Private AS still visible inside AS109**
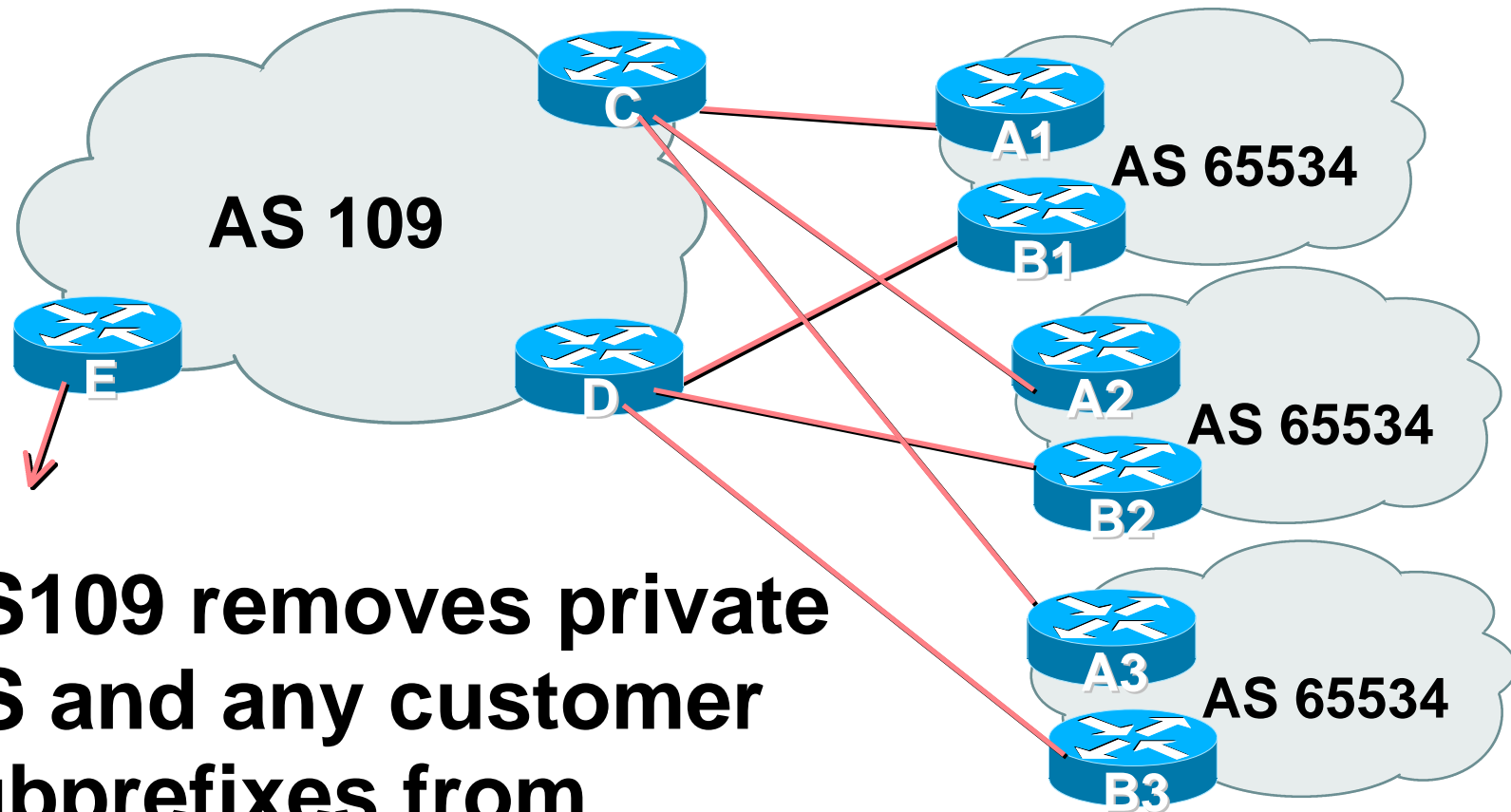
Loadsharing to the same ISP

- **Loadsharing configuration is only on customer router**

- **Upstream ISP has to**

  remove customer subprefixes from external announcements

  remove private AS from external announcements

- **Could also use BGP communities**

Two links to the same ISP

Multiple Dualhomed Customers

(RFC2270)

Multiple Dualhomed Customers (RFC2270)

AS 109

AS 65534

AS 65534

AS 65534

C   A1   B1   D   A2   B2   A3   B3   E

- **AS109 removes private AS and any customer subprefixes from Internet announcement**

Multiple Dualhomed Customers

- **Customer announcements as per previous example**

- **Use the *same* private AS for each customer**

   documented in RFC2270

   address space is not overlapping

   each customer hears default only

- **Router A*n* and B*n* configuration same as Router A and B previously**

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Two links to the same ISP

- **Router A1 Configuration**

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.0.0 mask 255.255.240.0
 neighbor 222.222.10.2 remote-as 109
 neighbor 222.222.10.2 prefix-list routerC out
 neighbor 222.222.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 221.10.0.0/20
ip prefix-list routerC permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.240.0 null0
ip route 221.10.0.0 255.255.224.0 null0
```

Two links to the same ISP

- ## Router B1 Configuration

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.16.0 mask 255.255.240.0
 neighbor 222.222.10.6 remote-as 109
 neighbor 222.222.10.6 prefix-list routerD out
 neighbor 222.222.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 221.10.16.0/20
ip prefix-list routerD permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.224.0 null0
ip route 221.10.16.0 255.255.240.0 null0
```

Multiple Dualhomed Customers

- ## Router C Configuration

```
router bgp 109

  neighbor bgp-customers peer-group

  neighbor bgp-customers remote-as 65534

  neighbor bgp-customers default-originate

  neighbor bgp-customers prefix-list default out

  neighbor 222.222.10.1 peer-group bgp-customers

  neighbor 222.222.10.1 description Customer One

  neighbor 222.222.10.1 prefix-list Customer1 in

  neighbor 222.222.10.9 peer-group bgp-customers

  neighbor 222.222.10.9 description Customer Two

  neighbor 222.222.10.9 prefix-list Customer2 in
```

Multiple Dualhomed Customers

```
 neighbor 222.222.10.17 peer-group bgp-customers

 neighbor 222.222.10.17 description Customer Three

 neighbor 222.222.10.17 prefix-list Customer3 in

!

ip prefix-list Customer1 permit 221.10.0.0/19 le 20

ip prefix-list Customer2 permit 221.16.64.0/19 le 20

ip prefix-list Customer3 permit 221.14.192.0/19 le 20

ip prefix-list default permit 0.0.0.0/0
```

- **Router C only allows in /19 and /20 prefixes from customer block**

Multiple Dualhomed Customers

- **Router D Configuration**

```
router bgp 109

  neighbor bgp-customers peer-group

  neighbor bgp-customers remote-as 65534

  neighbor bgp-customers default-originate

  neighbor bgp-customers prefix-list default out

  neighbor 222.222.10.5 peer-group bgp-customers

  neighbor 222.222.10.5 description Customer One

  neighbor 222.222.10.5 prefix-list Customer1 in

  neighbor 222.222.10.13 peer-group bgp-customers

  neighbor 222.222.10.13 description Customer Two

  neighbor 222.222.10.13 prefix-list Customer2 in
```

Multiple Dualhomed Customers

```
neighbor 222.222.10.21 peer-group bgp-customers

neighbor 222.222.10.21 description Customer Three

neighbor 222.222.10.21 prefix-list Customer3 in
!
ip prefix-list Customer1 permit 221.10.0.0/19 le 20

ip prefix-list Customer2 permit 221.16.64.0/19 le 20

ip prefix-list Customer3 permit 221.14.192.0/19 le 20

ip prefix-list default permit 0.0.0.0/0
```

- **Router D only allows in /19 and /20 prefixes from customer block**

Multiple Dualhomed Customers

- ## **Router E Configuration is as previously**

  assumes customer address space is not part of upstream's address block

```
router bgp 109
 neighbor 222.222.10.17 remote-as 110
 neighbor 222.222.10.17 remove-private-AS
 neighbor 222.222.10.17 prefix-list Customers out
!
ip prefix-list Customers permit 221.10.0.0/19
ip prefix-list Customers permit 221.16.64.0/19
ip prefix-list Customers permit 221.14.192.0/19
```

- ## **Private AS still visible inside AS109**

Multiple Dualhomed Customers

- **If customers' prefixes come from ISP's address block**

  do NOT announce them to the Internet

  announce ISP aggregate only

- **Router E configuration:**

```
router bgp 109
  neighbor 222.222.10.17 remote-as 110
  neighbor 222.222.10.17 prefix-list my-aggregate out
!
ip prefix-list my-aggregate permit 221.8.0.0/13
```

Multihoming Summary

- **Use private AS for multihoming to upstream**

- **Leak subprefixes to upstream only to aid loadsharing**

- **Upstream router E configuration is uniform across all scenarios**

Two links to different ISPs

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Two links to different ISPs

- **Use Public ASes**

    or use private AS if agreed with the other ISP

- **Address space comes from**

    both upstreams (PA space) or

    Regional Internet Registry (PI space)

- **Configuration concepts very similar**

Two links to different ISPs
With Redundancy

Two links to different ISPs (with redundancy)
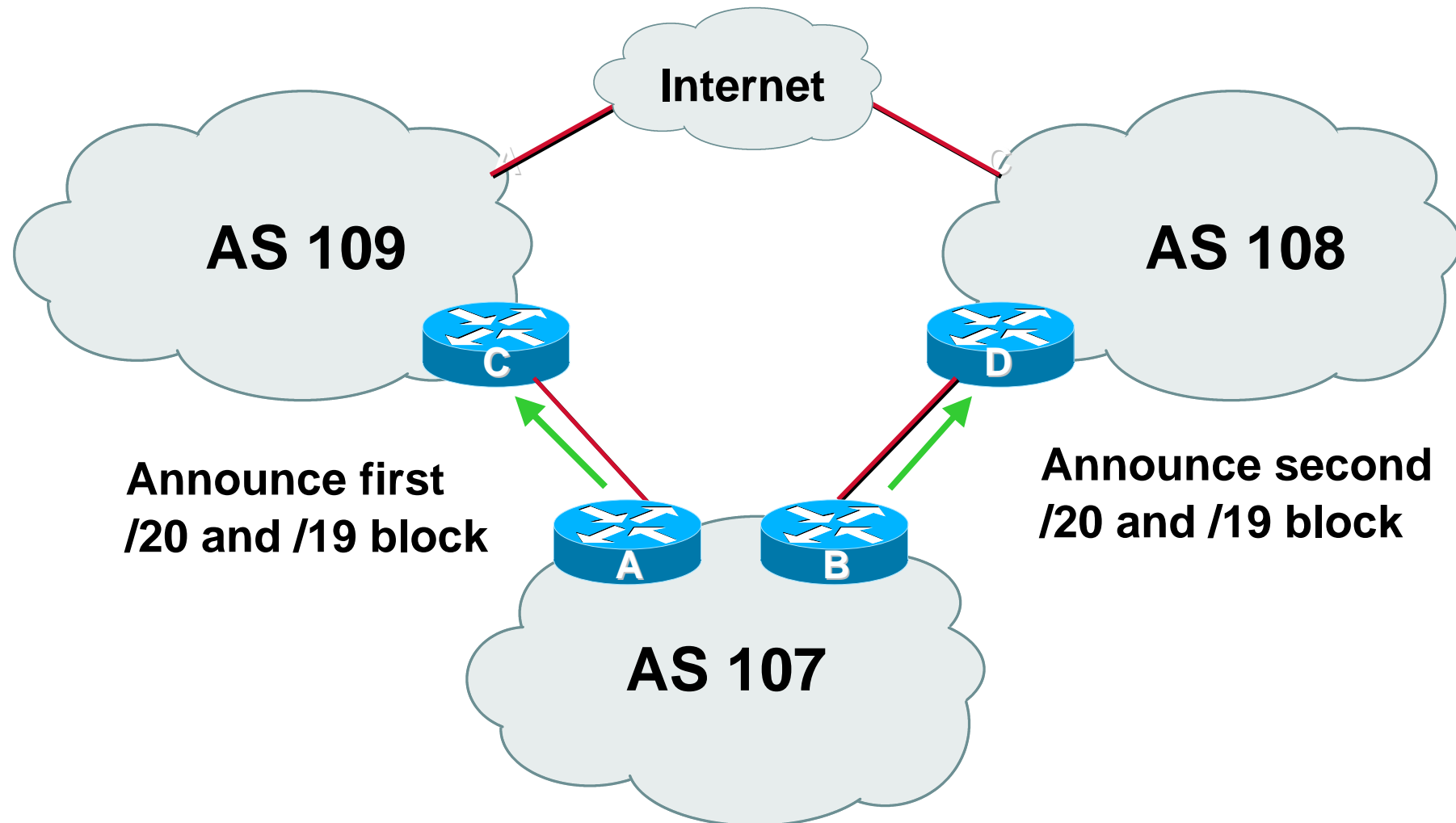
- **Example for PI space**

  ISP network, or large enterprise site

- **Announce /19 aggregate on each link**

- **Split /19 and announce as two /20s, one on each link**

  <u>basic</u> inbound loadsharing

- **When one link fails, the announcement of the /19 aggregate via the other ISP ensures continued connectivity**

Two links to different ISPs (with redundancy)

Internet

AS 109

AS 108

C

D

Announce first /20 and /19 block

Announce second /20 and /19 block

A   B

AS 107

Two links to different ISPs (with redundancy)

- **Router A Configuration**

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.0.0 mask 255.255.240.0
 neighbor 222.222.10.1 remote-as 109
 neighbor 222.222.10.1 prefix-list firstblock out
 neighbor 222.222.10.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list firstblock permit 221.10.0.0/20
ip prefix-list firstblock permit 221.10.0.0/19
```

Two links to different ISPs (with redundancy)

- **Router B Configuration**

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.16.0 mask 255.255.240.0
 neighbor 220.1.5.1 remote-as 108
 neighbor 220.1.5.1 prefix-list secondblock out
 neighbor 220.1.5.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list secondblock permit 221.10.16.0/20
ip prefix-list secondblock permit 221.10.0.0/19
```

Two links to different ISPs (with redundancy)

- ## Router C Configuration

```
router bgp 109
  neighbor 221.10.1.1 remote-as 107
  neighbor 221.10.1.1 default-originate
  neighbor 221.10.1.1 prefix-list AS107cust in
  neighbor 221.10.1.1 prefix-list default-out out
!
```

- ## Router C only announces default to AS 107

- ## Router C only accepts AS107's prefix block

Two links to different ISPs (with redundancy)

- **Router D Configuration**

```
router bgp 108
  neighbor 220.1.5.1 remote-as 107
  neighbor 220.1.5.1 default-originate
  neighbor 220.1.5.1 prefix-list AS107cust in
  neighbor 220.1.5.1 prefix-list default-out out
!
```

- **Router D only announces default to AS 107**

- **Router D only accepts AS107's prefix block**

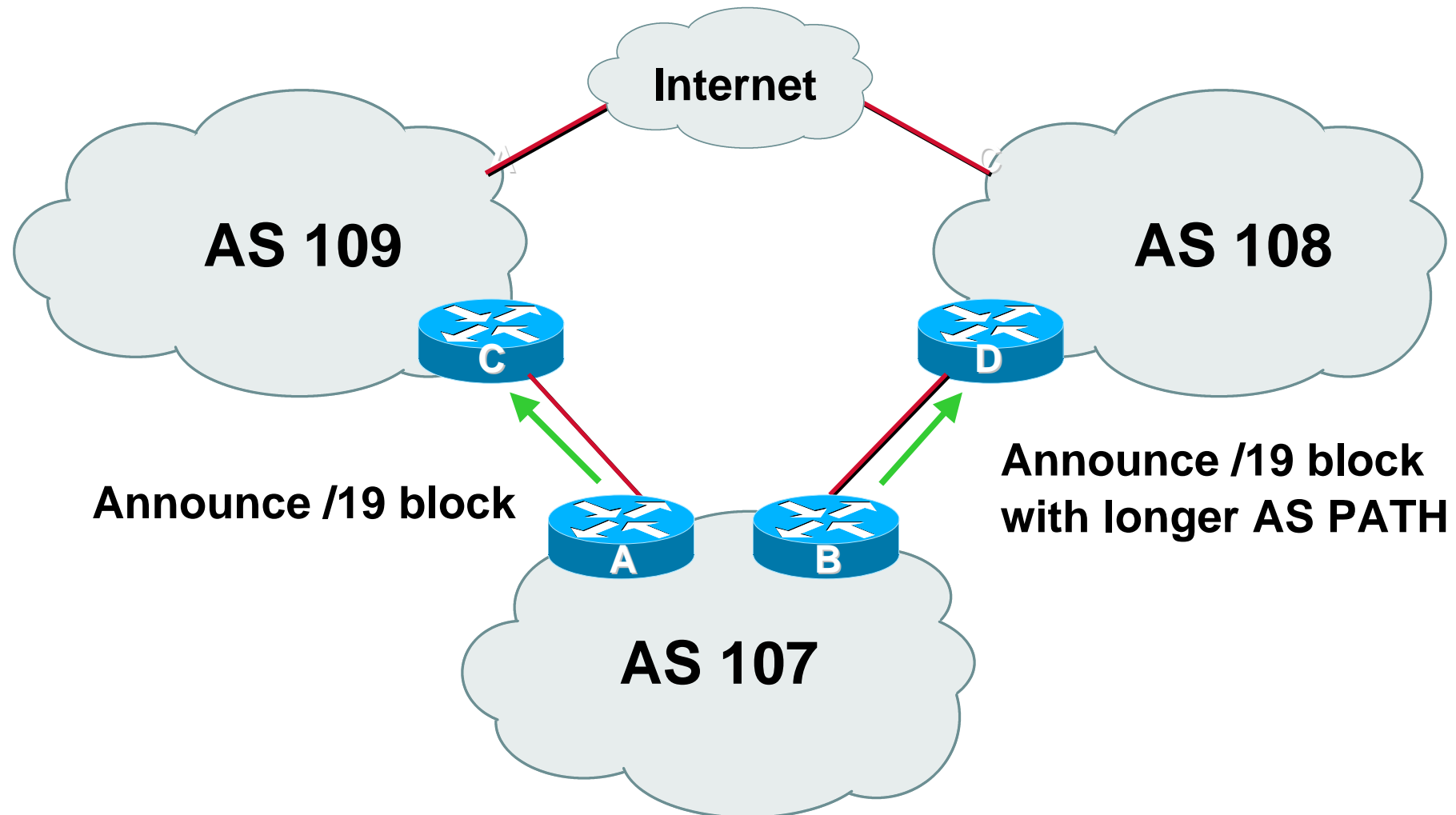# Two links to different ISPs

One link primary, the other link backup only

Two links to different ISPs (one as backup only)

- **Announce /19 aggregate on each link**

  primary link makes standard announcement

  backup link lengthens the AS PATH by using AS PATH prepend

- **When one link fails, the announcement of the /19 aggregate via the other link ensures continued connectivity**

Two links to different ISPs (one as backup only)

Internet

AS 109

AS 108

C

D

Announce /19 block

Announce /19 block with longer AS PATH

A

B

AS 107

Two links to different ISPs (one as backup only)

- ## Router A Configuration

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 neighbor 222.222.10.1 remote-as 109
 neighbor 222.222.10.1 prefix-list aggregate out
 neighbor 222.222.10.1 prefix-list default in
!
ip prefix-list aggregate permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```

Two links to different ISPs (one as backup only)

- **Router B Configuration**

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 neighbor 220.1.5.1 remote-as 108
 neighbor 220.1.5.1 prefix-list aggregate out
 neighbor 220.1.5.1 route-map routerD-out out
 neighbor 220.1.5.1 prefix-list default in
 neighbor 220.1.5.1 route-map routerD-in in
!
..next slide
```

Two links to different ISPs (one as backup only)

- **Router B Configuration**

```
!
ip prefix-list aggregate permit 221.10.0.0/19

ip prefix-list default permit 0.0.0.0/0
!
route-map routerD-out permit 10
 set as-path prepend 107 107
!
route-map routerD-in permit 10
 set local-preference 80
```
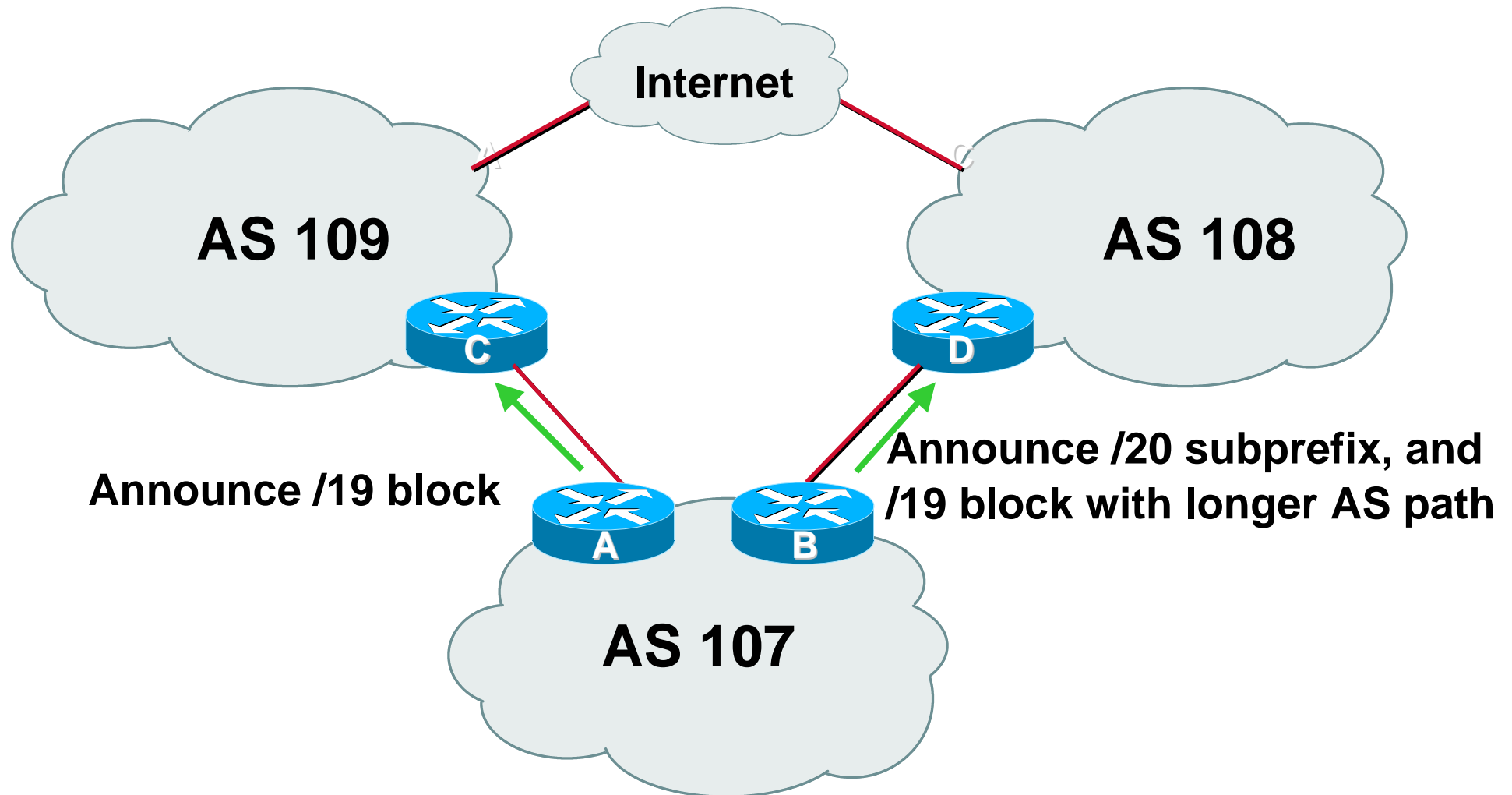
Two links to different ISPs

More Controlled Loadsharing

Loadsharing with different ISPs

- **Announce /19 aggregate on each link**

  On first link, announce /19 as normal

  On second link, announce /19 with longer AS PATH, and announce one /20 subprefix

  controls loadsharing between upstreams and the Internet

- **Vary the subprefix size and AS PATH length until "perfect" loadsharing achieved**

- **Still require redundancy!**

Loadsharing with different ISPs

Internet

AS 109

AS 108

C

D

Announce /19 block

Announce /20 subprefix, and /19 block with longer AS path

A

B

AS 107

Loadsharing with different ISPs

- ## Router A Configuration

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 neighbor 222.222.10.1 remote-as 109
 neighbor 222.222.10.1 prefix-list default in
 neighbor 222.222.10.1 prefix-list aggregate out
!
ip prefix-list aggregate permit 221.10.0.0/19
```

Loadsharing with different ISPs

- ## Router B Configuration

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.16.0 mask 255.255.240.0
 neighbor 220.1.5.1 remote-as 108
 neighbor 220.1.5.1 prefix-list default in
 neighbor 220.1.5.1 prefix-list subblocks out
 neighbor 220.1.5.1 route-map routerD out
!
..next slide..
```
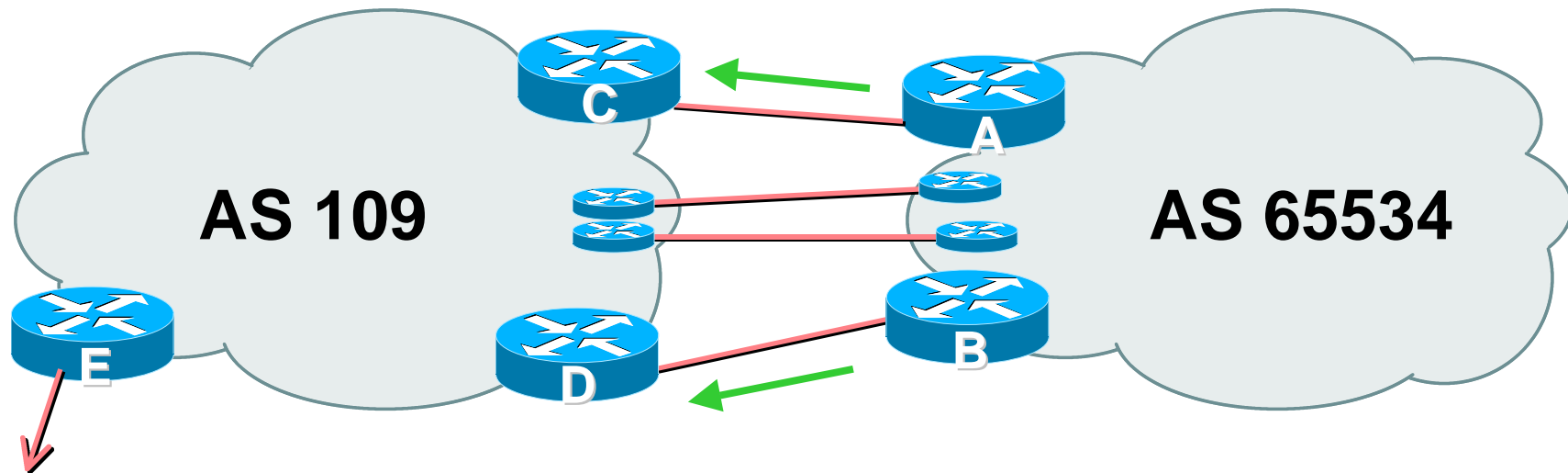
Loadsharing with different ISPs

```
route-map routerD permit 10
 match ip address prefix-list aggregate
 set as-path prepend 107 107
route-map routerD permit 20
!
ip prefix-list subblocks permit 221.10.0.0/19 le 20
ip prefix-list aggregate permit 221.10.0.0/19
```

Loadsharing Using Communities

4 links - Private AS

Private AS

- **AS109 removes private AS and any customer subprefixes from Internet announcement**

Private AS

- **Announce /19 aggregate on each link**

- **Split /19 and announce as four /21s, one on each link**

  basic inbound loadsharing

  assumes equal circuit capacity and even spread of traffic across address block

- **Vary the split until "perfect" loadsharing achieved**

  use the no-export community for subprefixes

Private AS

- **Router A Configuration**

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.0.0 mask 255.255.248.0
 neighbor 222.222.10.2 remote-as 109
 neighbor 222.222.10.2 send-community
 neighbor 222.222.10.2 prefix-list subblocks1 out
 neighbor 222.222.10.2 route-map routerC-out out
 neighbor 222.222.10.2 prefix-list default in
!
..next slide
```

Private AS

```
ip prefix-list subblocks1 permit 221.10.0.0/19

ip prefix-list subblocks1 permit 221.10.0.0/21

!

ip prefix-list firstblock permit 221.10.0.0/21

ip prefix-list default permit 0.0.0.0/0

!

route-map routerC-out permit 10
 match ip address prefix-list firstblock
  set community no-export
route-map routerC-out permit 20
```

Private AS

- ## Router B Configuration

```
router bgp 65534
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.24.0 mask 255.255.248.0
 neighbor 222.222.20.2 remote-as 109
 neighbor 222.222.20.2 send-community
 neighbor 222.222.20.2 prefix-list subblocks2 out
 neighbor 222.222.20.2 route-map routerD-out out
 neighbor 222.222.20.2 prefix-list default in
!
..next slide
```

Private AS

```
ip prefix-list subblocks2 permit 221.10.0.0/19

ip prefix-list subblocks2 permit 221.10.24.0/21

!

ip prefix-list secondblock permit 221.10.24.0/21

ip prefix-list default permit 0.0.0.0/0

!

route-map routerD-out permit 10
 match ip address prefix-list secondblock
  set community no-export
route-map routerD-out permit 20
```

Private AS

- ## Router E Configuration

```
router bgp 109
  neighbor 222.222.10.17 remote-as 110
  neigbhor 222.222.10.17 remove-private-AS
!
```

- ## Router E removes the private AS from external announcements

- ## Router E automatically removes subprefixes with no-export community set

- ## Private AS still visible inside AS109

Private AS

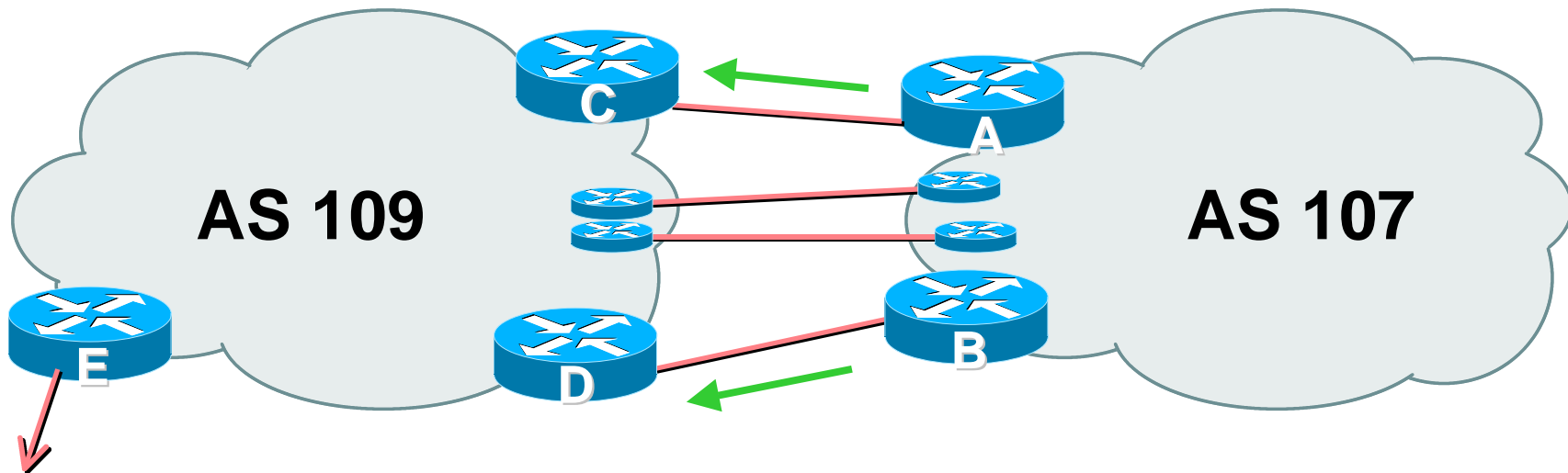- **Router C and D configuration is as previously**

- **AS109 routers will not advertise prefixes marked with community no-export to other ASes**

- **AS109 routers still need to filter the private AS**

- **Only a single /19 prefix is announced to the Internet - no routing table bloat! :-)**

Loadsharing Using Communities

4 links - Public AS

Public AS

AS 109

AS 107

- **4 links between AS107 and AS109**

Public AS

- **Announce /19 aggregate on each link**

- **Split /19 and announce as four /21s, one on each link**

    basic inbound loadsharing

    assumes equal circuit capacity and even spread of traffic across address block

- **Vary the split until "perfect" loadsharing achieved**

    use the no-export community for subprefixes

Public AS

- ## Router A Configuration

```
router bgp 107
 network 221.10.0.0 mask 255.255.224.0
 network 221.10.0.0 mask 255.255.248.0
 neighbor 222.222.10.2 remote-as 109
 neighbor 222.222.10.2 send-community
 neighbor 222.222.10.2 prefix-list subblocks1 out
 neighbor 222.222.10.2 route-map routerC-out out
 neighbor 222.222.10.2 prefix-list default in
!
..next slide
```

Public AS

```
ip prefix-list subblocks1 permit 221.10.0.0/19

ip prefix-list subblocks1 permit 221.10.0.0/21

!

ip prefix-list firstblock permit 221.10.0.0/21

ip prefix-list default permit 0.0.0.0/0

!

route-map routerC-out permit 10
 match ip address prefix-list firstblock
 set community no-export
route-map routerC-out permit 20
```

Public AS

- ## Router B Configuration

```
router bgp 107

 network 221.10.0.0 mask 255.255.224.0

 network 221.10.24.0 mask 255.255.248.0

 neighbor 222.222.20.2 remote-as 109

 neighbor 222.222.20.2 send-community

 neighbor 222.222.20.2 prefix-list subblocks2 out

 neighbor 222.222.20.2 route-map routerD-out out

 neighbor 222.222.20.2 prefix-list default in

!

..next slide
```

Public AS

```
ip prefix-list subblocks2 permit 221.10.0.0/19

ip prefix-list subblocks2 permit 221.10.24.0/21

!

ip prefix-list secondblock permit 221.10.24.0/21

ip prefix-list default permit 0.0.0.0/0

!

route-map routerD-out permit 10

 match ip address prefix-list secondblock

  set community no-export

route-map routerD-out permit 20
```

Public AS

- ## Router C Configuration

```
router bgp 109

  neighbor 222.222.10.1 remote-as 107

  neighbor 222.222.10.1 default-originate

  neighbor 222.222.10.1 prefix-list Customer in

  neighbor 222.222.10.1 prefix-list default out

!

ip prefix-list Customer permit 221.10.0.0/19 le 21

ip prefix-list default permit 0.0.0.0/0
```

Loadsharing to the same ISP

- ## Router D Configuration

```
router bgp 109
  neighbor 222.222.10.5 remote-as 107
  neighbor 222.222.10.5 default-originate
  neighbor 222.222.10.5 prefix-list Customer in
  neighbor 222.222.10.5 prefix-list default out
!
ip prefix-list Customer permit 221.10.0.0/19 le 21
ip prefix-list default permit 0.0.0.0/0
```

Loadsharing to the same ISP

- ## Router E Configuration

```
router bgp 109

 neighbor 222.222.10.17 remote-as 110

 neighbor 222.222.10.17 filter-list 1 out

!

ip as-path access-list 1 permit ^107$

ip as-path access-list 1 permit ^$
```

- ## Router E only has to announce AS107 in the same way it announces other ASes

Public AS

- **AS109 routers will not advertise prefixes marked with community no-export to other ASes**

- **AS109 ISP has no configuration work to do**

    AS107 ISP can control his own loadsharing

- **Only a single /19 prefix is announced to the Internet - no routing table bloat! :-)**

Enterprise Multihoming

Address Space from different ISPs

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Enterprise Multihoming

- **Common situation is enterprise multihoming**

    address space used by enterprise comes from both upstream ISPs

    multihoming and loadsharing more difficult

    want to avoid leaking subprefixes of upstream provider address space

Enterprise Multihoming
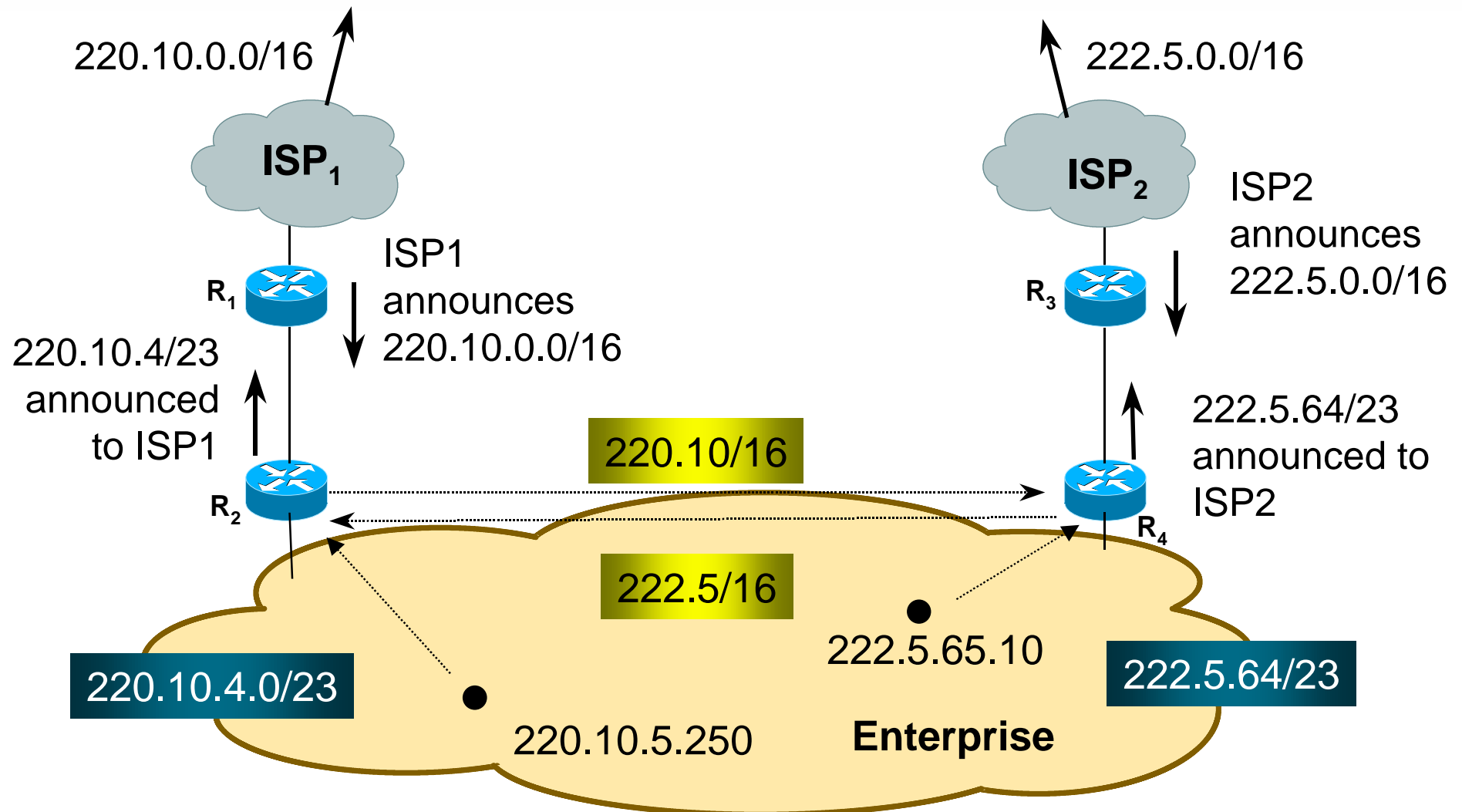
- ## New conditional advertisement feature in BGP

  ### loadsharing under normal conditions

  ### subprefixes only announced in failure scenarios

  ### requires upstreams to announce only one prefix to enterprise border network

Steady State

220.10.0.0/16

ISP₁

222.5.0.0/16

ISP₂

ISP2
announces
222.5.0.0/16

R₁

ISP1
announces
220.10.0.0/16

R₃

220.10.4/23
announced
to ISP1

R₂

220.10/16

222.5.64/23
announced to
ISP2

R₄

222.5/16

222.5.65.10

220.10.4.0/23

222.5.64/23

220.10.5.250

Enterprise

Steady State

- **ISP1 has 220.10.0.0/16 address block**

- **ISP2 has 222.5.0.0/16 address block**

- **Enterprise customer multihomes**

    upstreams don't announce subprefixes

    can use private AS (ASN>64511)

    R2 and R4 originate default in their IGP

    outbound traffic uses nearest exit (IGP metrics)

Steady State

- ## Router2 configuration:

```
router bgp 65534
  network 220.10.4.0 mask 255.255.254.0
  network 222.5.64.0 mask 255.255.254.0
  neighbor <R1> remote-as 150
  neighbor <R1> prefix-list isp1-in in
  neighbor <R1> prefix-list isp1-out out
  neighbor <R1> advertise-map isp2-sb non-exist-map isp2-bb
  neighbor <R4> remote-as 65534
  neighbor <R4> update-source loopback 0
!
ip route 220.10.4.0 255.255.254.0 null0 250
..next slide
```
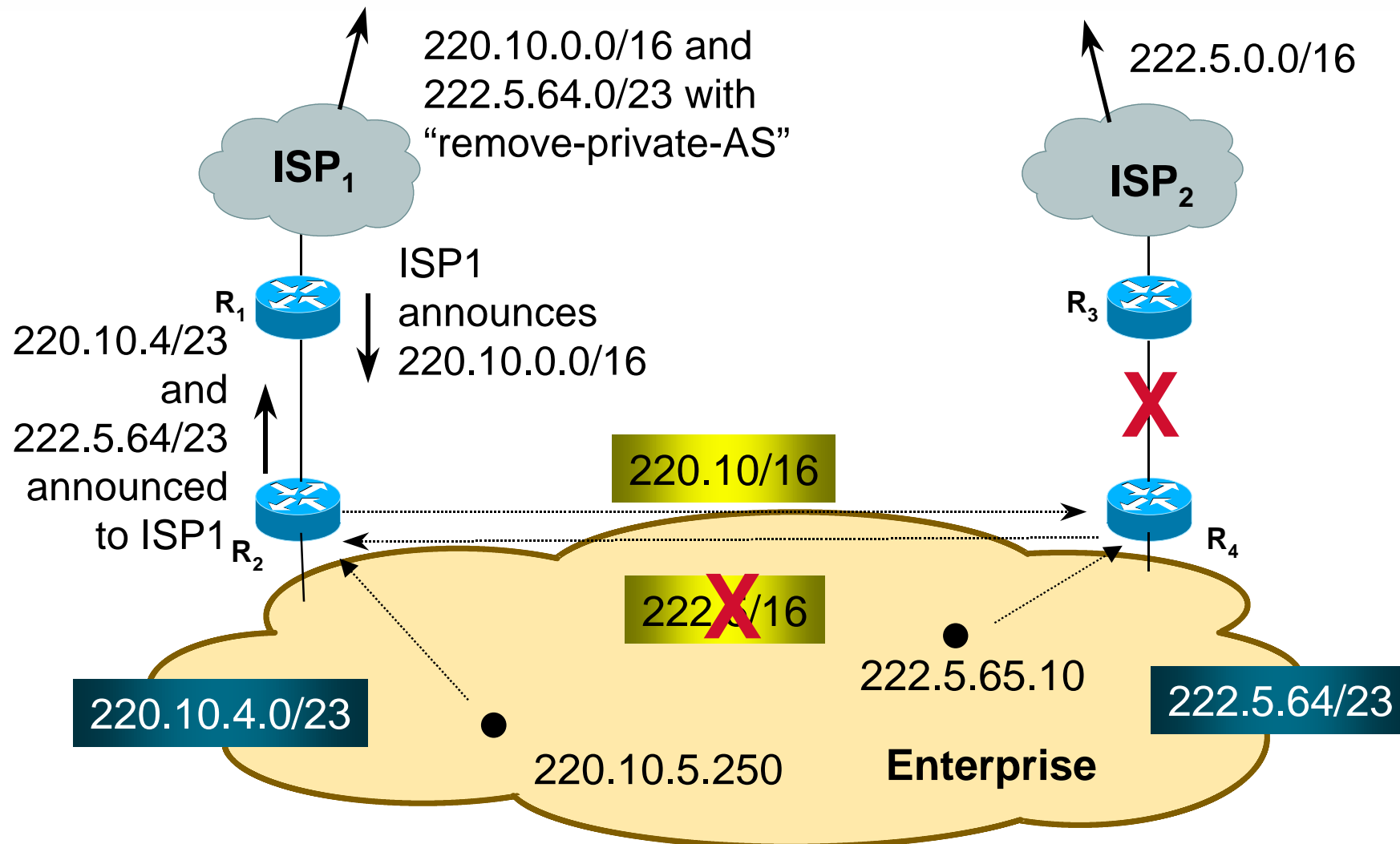
Steady State

```
ip route 222.5.64.0 255.255.254.0 null0 250
!
ip prefix-list isp1-out permit 220.10.4.0/23
ip prefix-list isp2-out permit 222.5.64.0/23
!
ip prefix-list isp1-in permit 220.10.0.0/16
ip prefix-list isp2-in permit 222.5.0.0/16
!
route-map isp2-sb permit 10
 match ip address prefix-list isp2-out
!
route-map isp2-bb permit 10
 match ip address prefix-list isp2-in
!
```

Steady State

- **Router2 peers iBGP with Router4**

  hears ISP2's /16 prefix

- **Router2 peers eBGP with Router1**

  hears ISP1's /16 prefix only

  announces 220.10.4.0/23 only

Link Failure

220.10.0.0/16 and
222.5.64.0/23 with
"remove-private-AS"

222.5.0.0/16

ISP$_1$

ISP$_2$

R$_1$

ISP1
announces
220.10.0.0/16

R$_3$

220.10.4/23
and
222.5.64/23
announced
to ISP1

X

R$_2$

220.10/16

R$_4$

222.X/16

220.10.4.0/23

222.5.65.10

222.5.64/23

220.10.5.250

Enterprise

Link Failure

- **Peering between Router 4 and Router3 (ISP2) goes down**

  222.5.0.0/16 prefix withdrawn

- **Conditional advertisement process activated**

  Router2 starts to announce 222.5.64.0/23 to Router1

- **Connectivity for Enterprise maintained**

Enterprise Multihoming

- ## Conditional advertisement useful when address space comes from both upstreams

  no subprefixes leaked to Internet unless in failure situation

- ## Alternative backup mechanism would be to leak /23 prefixes with longer AS path

  routing table bloat, reachability issues

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Summary

- **Private vs Public ASes**

- **Multihoming to Same ISP**

- **Multihoming to Different ISPs**

- **Community based multihoming**

- **Enterprise multihoming**