

BGP Tutorial

Part 3 – Multihoming

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APRICOT 2003, Taipei

February 2003

Presentation Slides

Cisco.com

- Slides are available at
<ftp://ftp-eng.cisco.com/pfs/seminars/APRICOT02-BGP02.pdf>
- Feel free to ask questions any time

Introduction

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- **Presentation has many configuration examples**
- **Uses Cisco IOS CLI**
- **Aimed at Service Providers**
 - Techniques can be used by many enterprises too
- **Feel free to ask questions**

BGP Multihoming Techniques

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- **Definition & Options**
- **Connecting to the same ISP**
- **Connecting to different ISPs**
- **Service Provider Multihoming**
- **Using Communities**
- **Case Study**

Multihoming Definition & Options

Multihoming Definition

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- **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

AS Numbers

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- **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

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- **Three BASIC Principles**
 - prefix-lists** to filter **prefixes**
 - filter-lists** to filter **ASNs**
 - route-maps** to apply **policy**
- **Avoids confusion!**

Policy Tools

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- **Local preference**
outbound traffic flows
- **Metric (MED)**
inbound traffic flows (local scope)
- **AS-PATH prepend**
inbound traffic flows (Internet scope)
- **Communities**
specific inter-provider peering

Originating Prefixes

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- **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
called “Net Police” by some**

Part

```
!! APNIC
ip prefix-list FILTER permit 61.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 202.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 210.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 218.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 220.0.0.0/6 ge 9 le 20
!! ARIN
ip prefix-list FILTER permit 24.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 63.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 64.0.0.0/6 ge 9 le 20
ip prefix-list FILTER permit 68.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 199.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 204.0.0.0/6 ge 9 le 20
ip prefix-list FILTER permit 208.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 216.0.0.0/8 ge 9 le 20
!! RIPE NCC
ip prefix-list FILTER permit 62.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 80.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 82.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 193.0.0.0/8 ge 9 le 20
ip prefix-list FILTER permit 194.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 212.0.0.0/7 ge 9 le 20
ip prefix-list FILTER permit 217.0.0.0/8 ge 9 le 20
!! LACNIC
ip prefix-list FILTER permit 200.0.0.0/8 ge 9 le 20
```

“Net Police” prefix list issues

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- meant to “punish” ISPs who pollute the routing table with specifics rather than announcing aggregates
- impacts legitimate multihoming especially at the Internet’s edge
- 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 and you are prepared to keep the list current**

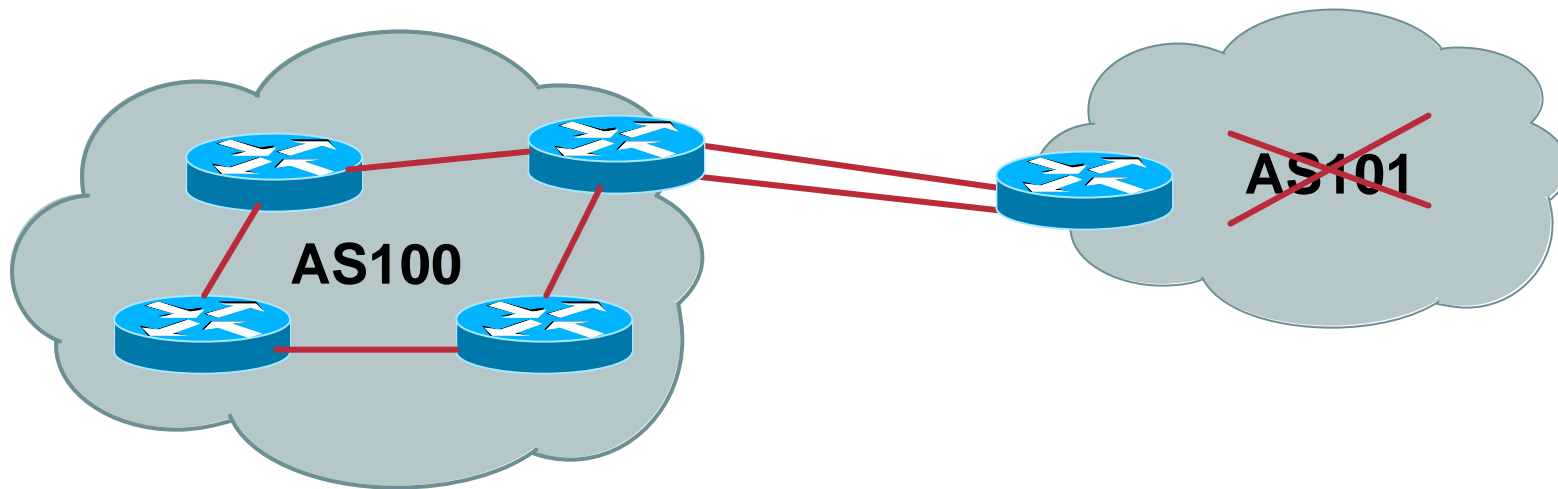
Multihoming Scenarios

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- **Stub network**
- **Multi-homed stub network**
- **Multi-homed network**
- **Configuration Options**

Stub Network

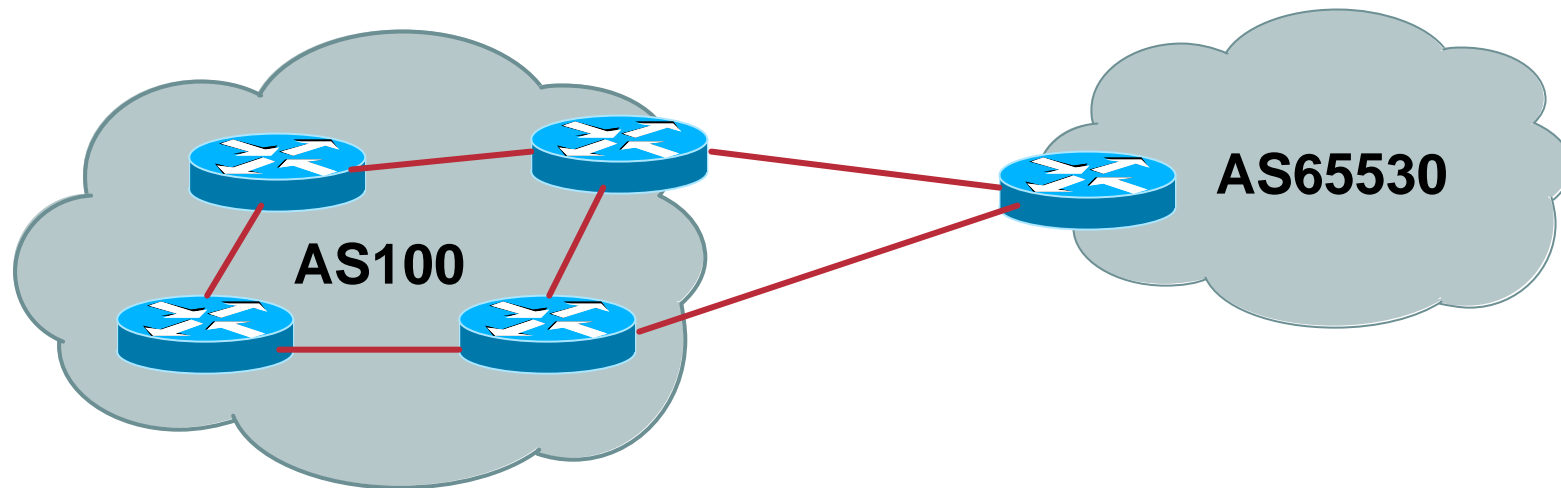
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- **No need for BGP**
- **Point static default to upstream ISP**
- **Upstream ISP advertises stub network**
- **Policy confined within upstream ISP's policy**

Multi-homed Stub Network

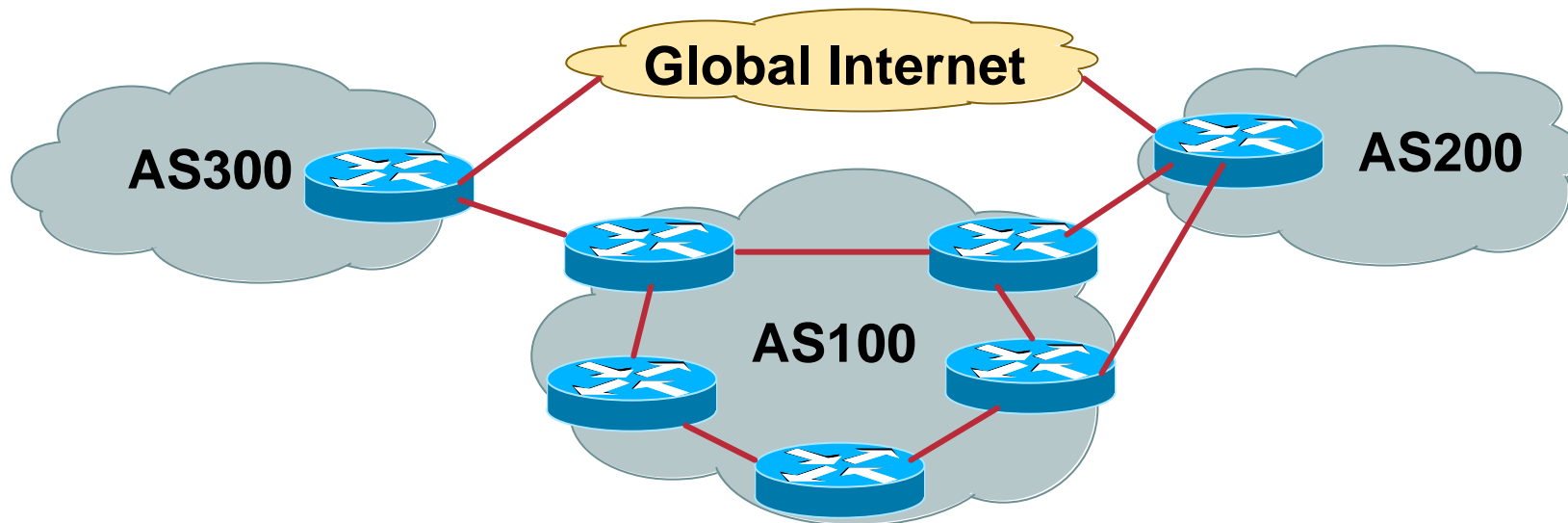
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- Use BGP (not IGP or static) to loadshare
- Use private AS (ASN > 64511)
- Upstream ISP advertises stub network
- Policy confined within upstream ISP's policy

Multi-Homed Network

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- **Many situations possible**
 - multiple sessions to same ISP
 - secondary for backup only
 - load-share between primary and secondary
 - selectively use different ISPs

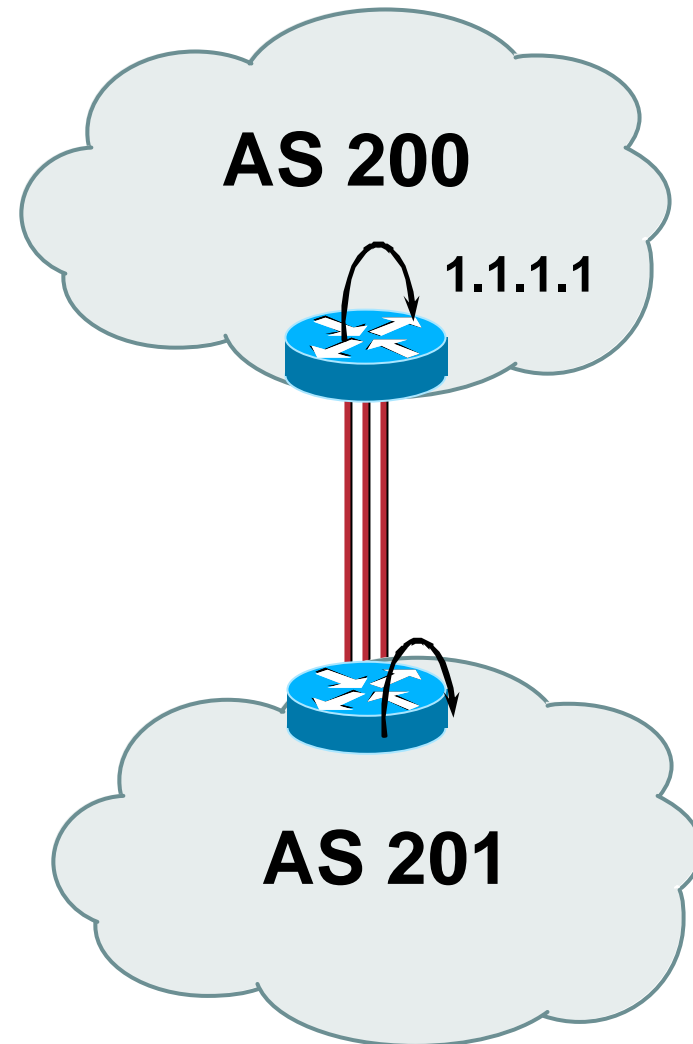
Multiple Sessions to an ISP

– Example One

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- eBGP multihop
- eBGP to loopback addresses
- eBGP prefixes learned with loopback address as next hop

```
router bgp 201
  neighbor 1.1.1.1 remote-as 200
  neighbor 1.1.1.1 ebgp-multihop 5
!
ip route 1.1.1.1 255.255.255.255 serial 1/0
ip route 1.1.1.1 255.255.255.255 serial 1/1
ip route 1.1.1.1 255.255.255.255 serial 1/2
```



Multiple Sessions to an ISP

– Example One

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- Try and avoid use of ebgp-multihop unless:

It's absolutely necessary –or–

Loadsharing across multiple links

- Many ISPs discourage it, for example:

We will run eBGP multihop, but do not support it as a standard offering because customers generally have a hard time managing it due to:

- routing loops
- failure to realise that BGP session stability problems are usually due connectivity problems between their CPE and their BGP speaker

Multiple Sessions to an ISP

– Example Two

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- **BGP multi-path**
- **Three BGP sessions required**
- **limit of 6 parallel paths**

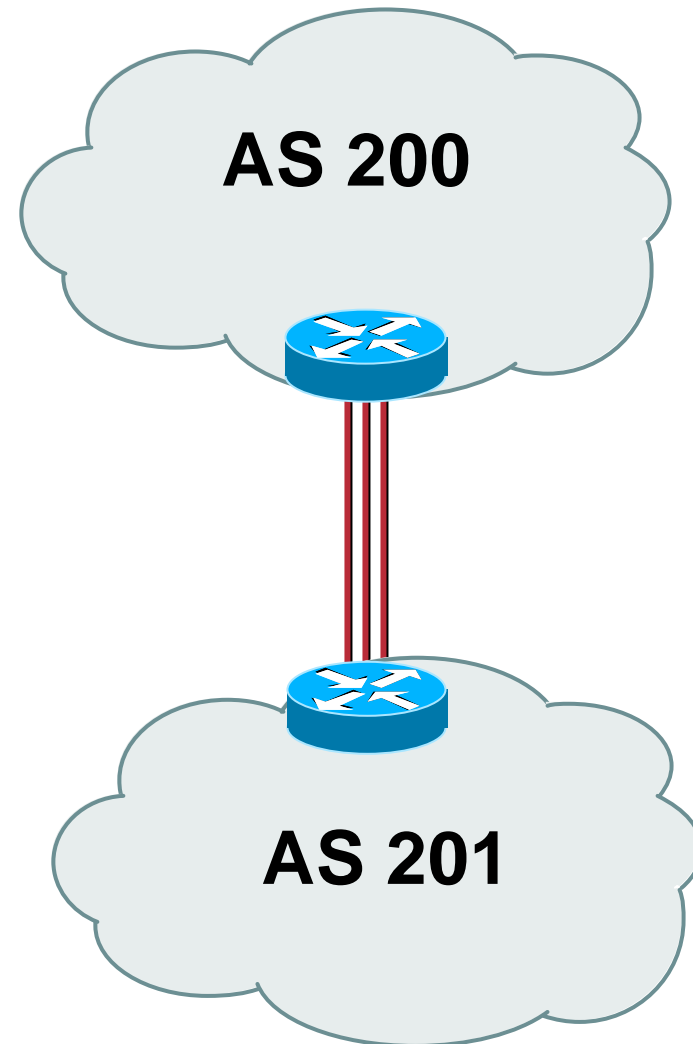
```
router bgp 201
```

```
neighbor 1.1.2.1 remote-as 200
```

```
neighbor 1.1.2.5 remote-as 200
```

```
neighbor 1.1.2.9 remote-as 200
```

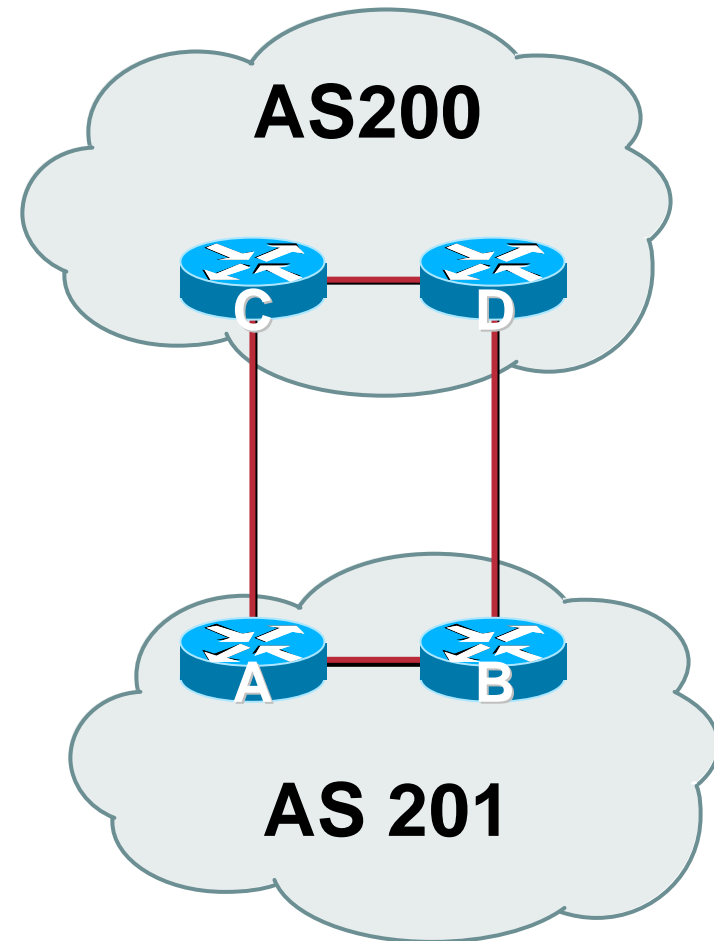
```
maximum-paths 3
```



Multiple Sessions to an ISP

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- Simplest scheme is to use defaults
- Learn/advertise prefixes for better control
- Planning and some work required to achieve loadsharing
- No magic solution



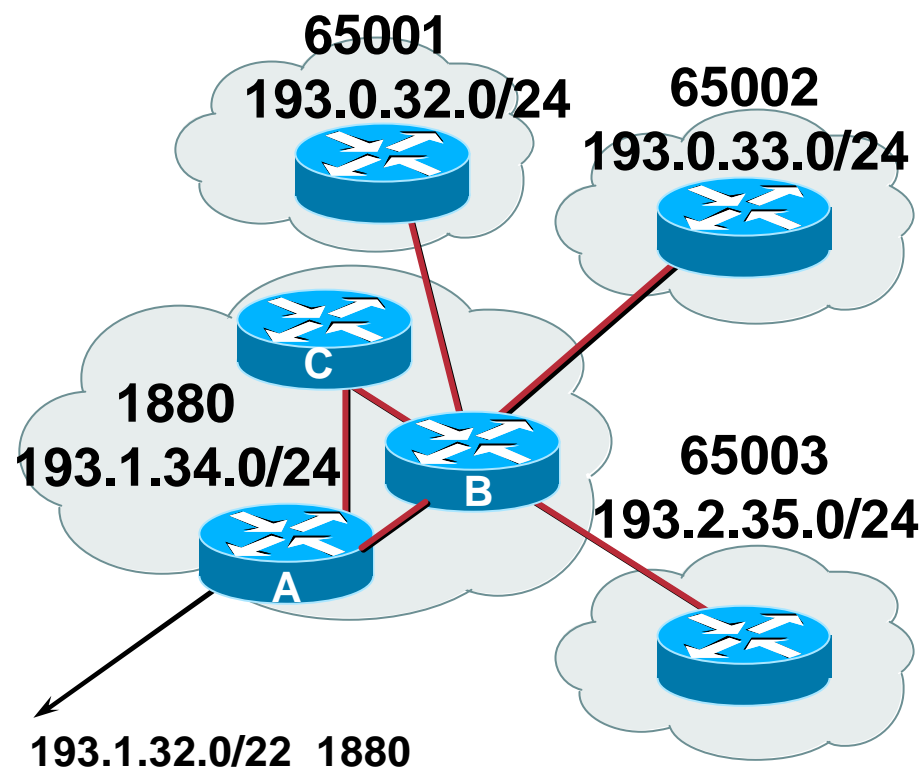
Private-AS – Application

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- **Applications**

ISP with single-homed customers (RFC2270)

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



Private-AS Removal

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- **neighbor x.x.x.x remove-private-AS**
- **Please include in all eBGP configurations**
- **Rules:**

Available for eBGP neighbours only

if the update has AS_PATH made up of private-AS numbers, the private-AS will be dropped

if the AS_PATH includes private and public AS numbers, private AS number will not be removed...it is a configuration error!

if AS_PATH contains the AS number of the eBGP neighbor, the private-AS numbers will not be removed

if used with confederations, it will work as long as the private AS numbers are after the confederation portion of the AS_PATH

BGP Multihoming Techniques

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- Definition & Options
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Multihoming to the same ISP

Multihoming to the same ISP

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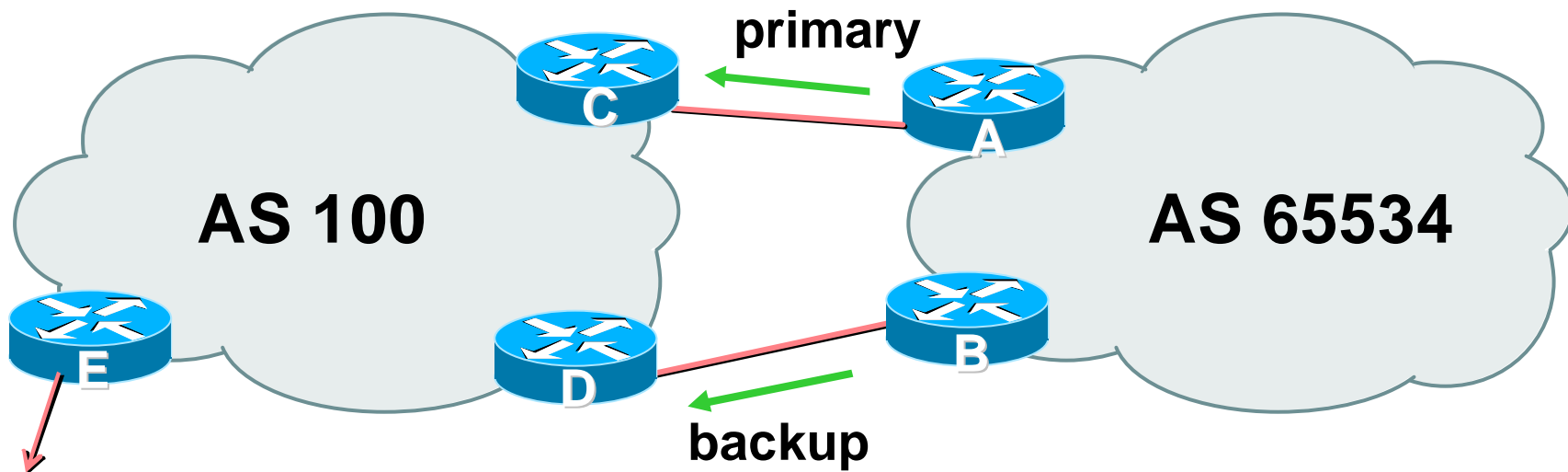
- **Use BGP for this type of multihoming**
use a private AS (ASN > 64511)
- **upstream ISP proxy aggregates**
in other words, announces only your address block to the Internet (as would be done if you had one statically routed connection)

Two links to the same ISP

One link primary, the other link backup only

Two links to the same ISP

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- **AS100 removes private AS and any customer subprefixes from Internet announcement**

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

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- **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)

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- Router A Configuration

```
router bgp 65534
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.2 remote-as 100
  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)

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- **Router B Configuration**

```
router bgp 65534
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.6 remote-as 100
  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)

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```
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)

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

```
router bgp 100
  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)

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- Router D Configuration (backup link)

```
router bgp 100
  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)

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- **Router E Configuration**

```
router bgp 100
  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
```

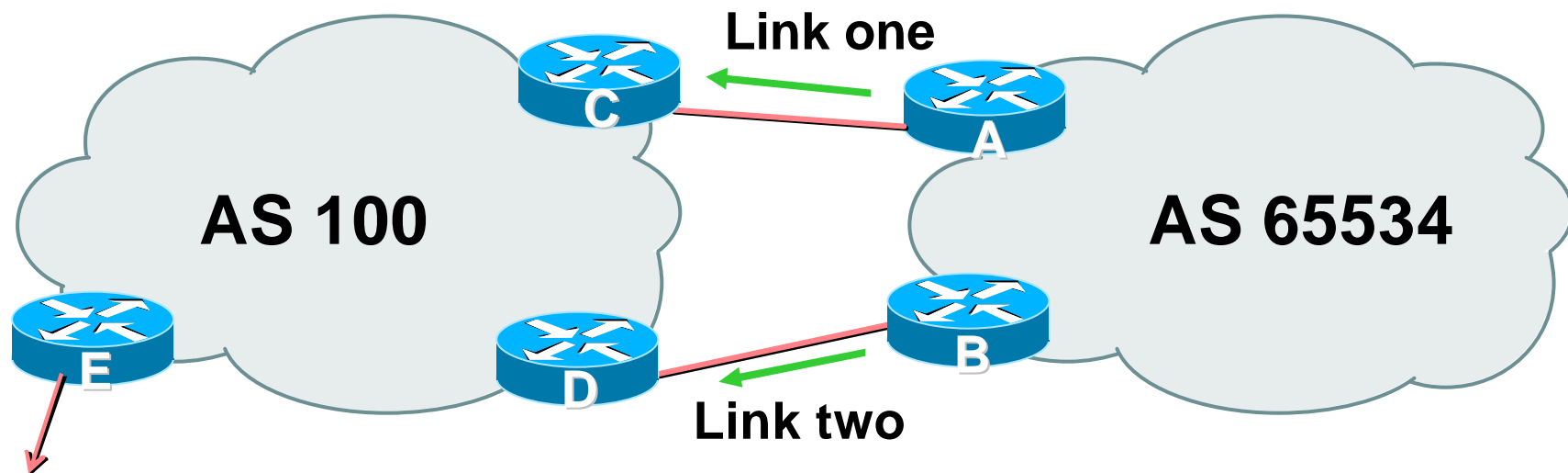
- **Router E removes the private AS and customer's subprefixes from external announcements**
- **Private AS still visible inside AS100**

Two links to the same ISP

With Loadsharing

Loadsharing to the same ISP

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- **AS100 removes private AS and any customer subprefixes from Internet announcement**

Loadsharing to the same ISP

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- **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**
- **Accept the default from upstream**
 - basic outbound loadsharing by nearest exit
 - okay in first approx as most ISP and end-site traffic is inbound

Loadsharing to the same ISP

Cisco.com

- **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 100
  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
```

Router B configuration is similar but with the other /20

Loadsharing to the same ISP

Cisco.com

- **Router C Configuration**

```
router bgp 100
  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**
- **Router D configuration is identical**

Loadsharing to the same ISP

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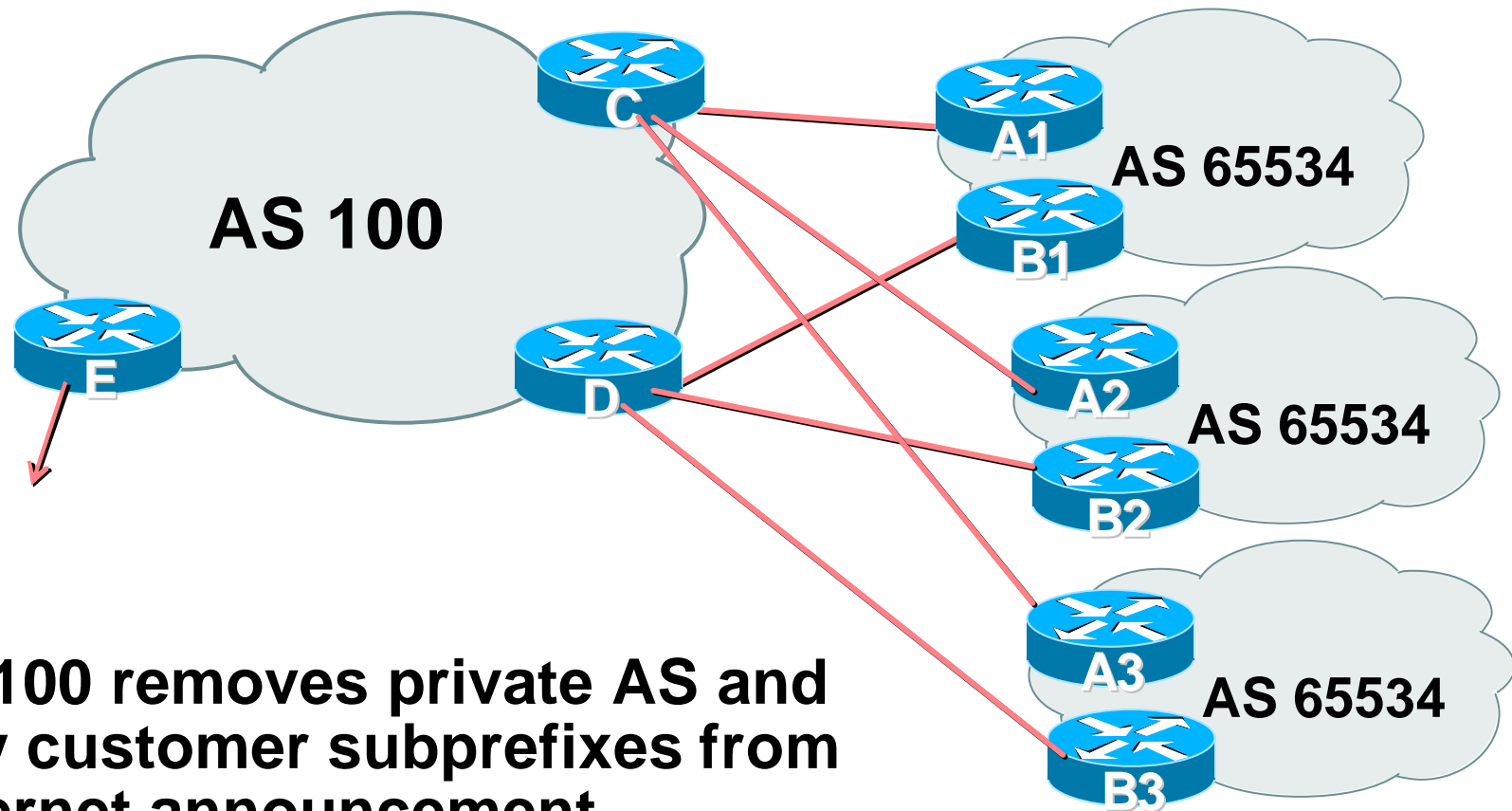
- **Loadsharing configuration is only on customer router**
- **Upstream ISP has to**
 - remove customer subprefixes from external announcements**
 - remove private AS from external announcements**
- **Could also use BGP communities**

Two links to the same ISP

**Multiple Dualhomed Customers
(RFC2270)**

Multiple Dualhomed Customers (RFC2270)

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- **AS100 removes private AS and any customer subprefixes from Internet announcement**

Multiple Dualhomed Customers

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- **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**

Two links to the same ISP

Cisco.com

- **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 100
  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
```

Router B1 configuration is similar but for the other /20

Multiple Dualhomed Customers

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- Router C Configuration

```
router bgp 100

  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

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```
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
- Router D configuration is almost identical

Multiple Dualhomed Customers

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- **Router E Configuration**

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

```
router bgp 100
  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 AS100**

Multiple Dualhomed Customers

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- 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 100
  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
```


BGP Multihoming Techniques

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- Definition & Options
- Connecting to the same ISP
- **Connecting to different ISPs**
- Service Provider Multihoming
- Using Communities
- Case Study

Multihoming to different ISPs

Two links to different ISPs

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- **Use a Public AS**
or use private AS if agreed with the other ISP
- **Address space comes from**
both upstreams **or**
Regional Internet Registry
- **Configuration concepts very similar**

Two links to different ISPs

One link primary, the other link backup only

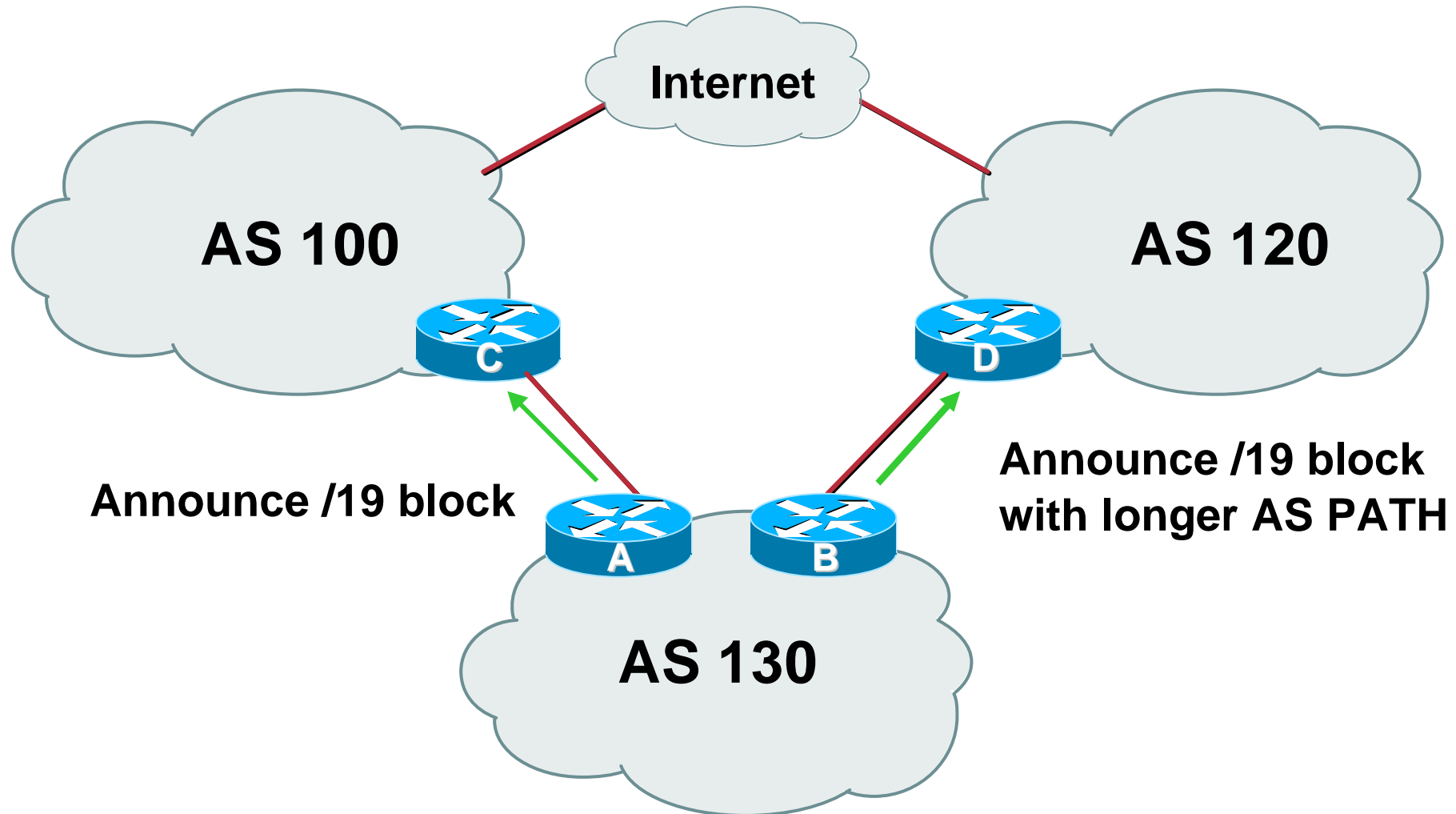
Two links to different ISPs (one as backup only)

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- **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)

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Two links to different ISPs (one as backup only)

Cisco.com

- **Router A Configuration**

```
router bgp 130
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 100
  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)

Cisco.com

- Router B Configuration

```
router bgp 130
  network 221.10.0.0 mask 255.255.224.0
  neighbor 220.1.5.1 remote-as 120
  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
!
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 130 130 130
!
route-map routerD-in permit 10
  set local-preference 80
```


Two links to different ISPs

With Loadsharing

Two links to different ISPs (with loadsharing)

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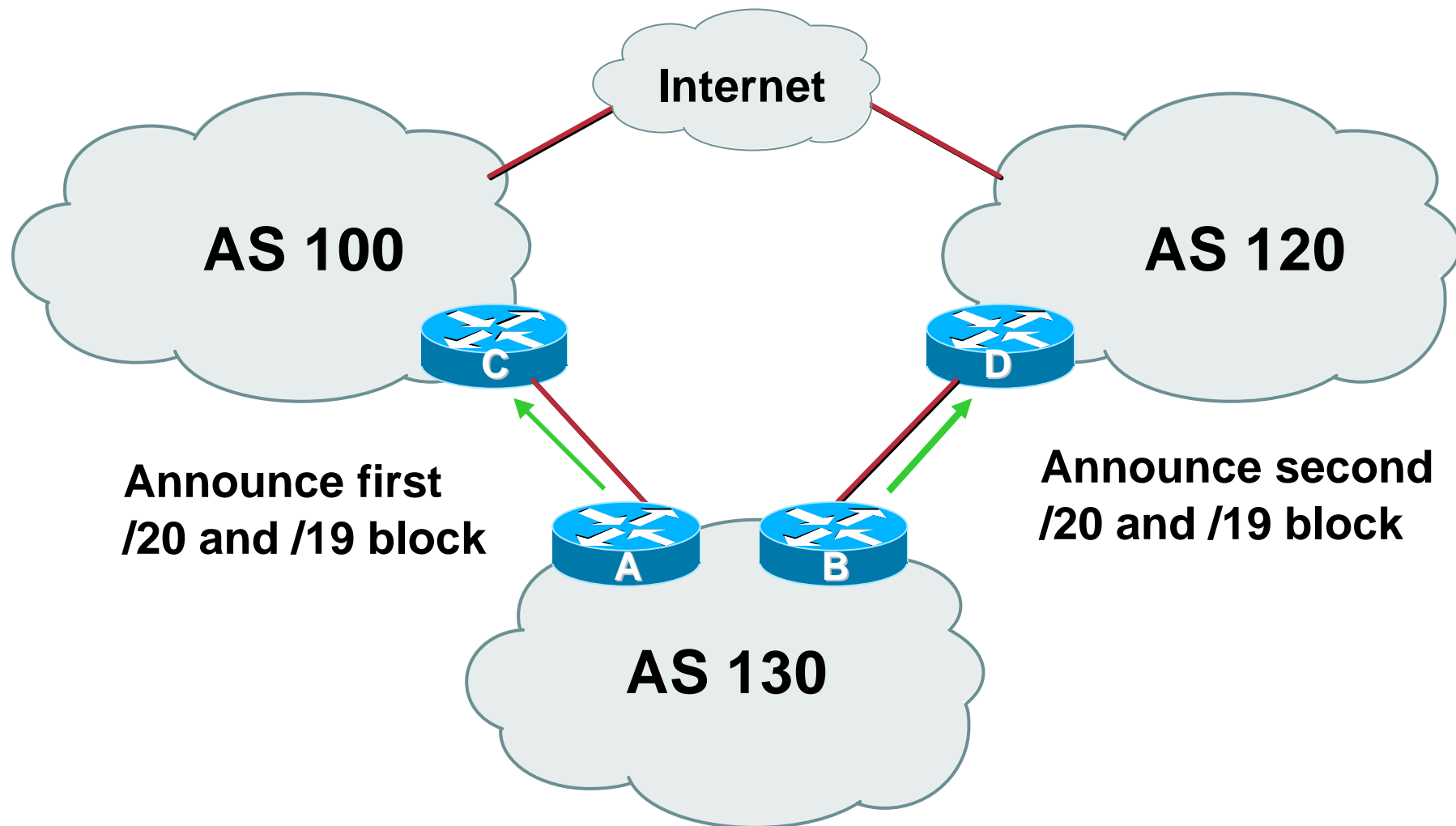
- **Announce /19 aggregate on each link**
- **Split /19 and announce as two /20s, one on each link**

basic 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 loadsharing)

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Two links to different ISPs (with loadsharing)

Cisco.com

- Router A Configuration

```
router bgp 130
  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 100
  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 loadsharing)

Cisco.com

- Router B Configuration

```
router bgp 130
  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 120
  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

More Controlled Loadsharing

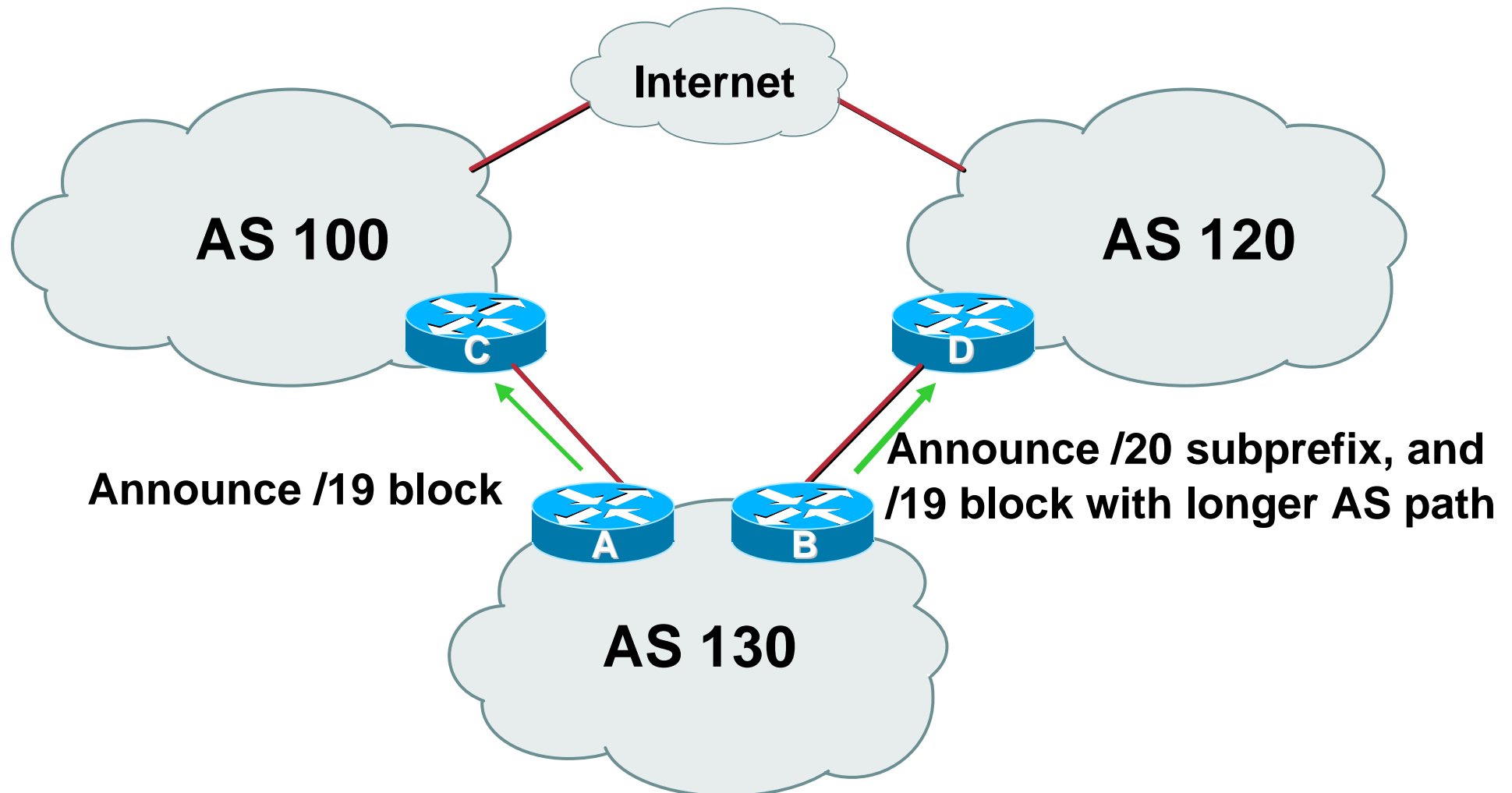
Loadsharing with different ISPs

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- **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

Cisco.com



Loadsharing with different ISPs

Cisco.com

- **Router A Configuration**

```
router bgp 130
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 100
  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

Cisco.com

- Router B Configuration

```
router bgp 130
  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 120
  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
!
route-map routerD permit 10
  match ip address prefix-list aggregate
  set as-path prepend 130 130
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
```

BGP Multihoming Techniques

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- **Definition & Options**
- **Connecting to the same ISP**
- **Connecting to different ISPs**
- **Service Provider Multihoming**
- **Using Communities**
- **Case Study**

Service Provider Multihoming

Service Provider Multihoming

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- **Previous examples dealt with loadsharing inbound traffic**
 - Of primary concern at Internet edge
 - What about outbound traffic?
- **Transit ISPs strive to balance traffic flows in both directions**
 - Balance link utilisation
 - Try and keep most traffic flows symmetric

Service Provider Multihoming

Cisco.com

- **Balancing outbound traffic requires inbound routing information**

Common solution is “full routing table”

Rarely necessary

Why use the “routing mallet” to try solve loadsharing problems?

“Keep It Simple” is often easier (and \$\$\$ cheaper) than carrying N-copies of the full routing table

Service Provider Multihoming

Cisco.com

- **Examples**
 - One upstream, one local peer**
 - One upstream, local exchange point**
 - Two upstreams, one local peer**
 - Tier-1 and regional upstreams, with local peers**
 - Disconnected Backbone**
 - IDC Multihoming**
- **All examples require BGP and a public ASN**

Service Provider Multihoming

One Upstream, One local peer

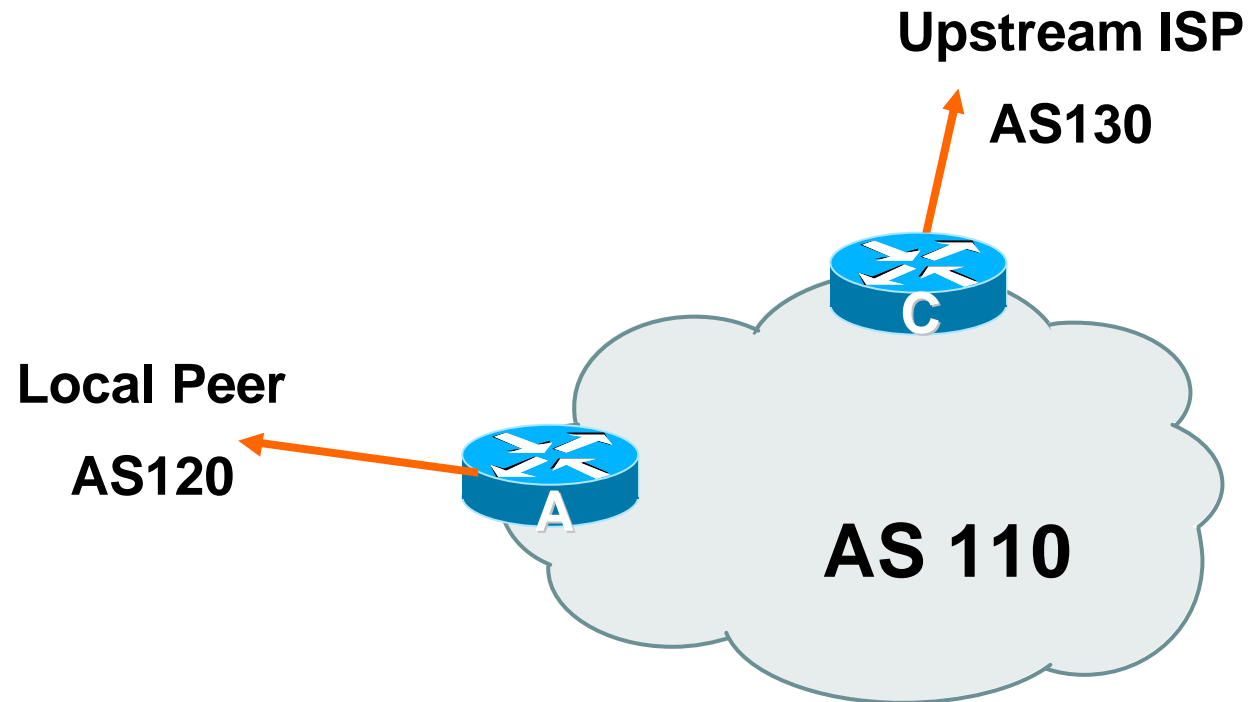
One Upstream, One Local Peer

Cisco.com

- **Announce /19 aggregate on each link**
- **Accept default route only from upstream**
Either 0.0.0.0/0 or a network which can be used as default
- **Accept all routes from local peer**

One Upstream, One Local Peer

Cisco.com



One Upstream, One Local Peer

Cisco.com

- Router A Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.2 remote-as 120
  neighbor 222.222.10.2 prefix-list my-block out
  neighbor 222.222.10.2 prefix-list AS120-peer in
!
ip prefix-list AS120-peer permit 222.5.16.0/19
ip prefix-list AS120-peer permit 221.240.0.0/20
ip prefix-list my-block permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.224.0 null0
```

One Upstream, One Local Peer

Cisco.com

- **Router A – Alternative Configuration**

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.2 remote-as 120
  neighbor 222.222.10.2 prefix-list my-block out
  neighbor 222.222.10.2 filter-list 10 in
!
ip as-path access-list 10 permit ^(120_)+$
!
ip prefix-list my-block permit 221.10.0.0/19
!
ip route 221.10.0.0 255.255.224.0 null0
```

One Upstream, One Local Peer

Cisco.com

- Router C Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 130
  neighbor 222.222.10.1 prefix-list default in
  neighbor 222.222.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
```

One Upstream, One Local Peer

Cisco.com

- **Two configurations possible for Router A**
 - Filter-lists assume peer knows what they are doing**
 - Prefix-list higher maintenance, but safer**
 - Some ISPs use both**
- **Local traffic goes to and from local peer, everything else goes to upstream**

Service Provider Multihoming

One Upstream, Local Exchange Point

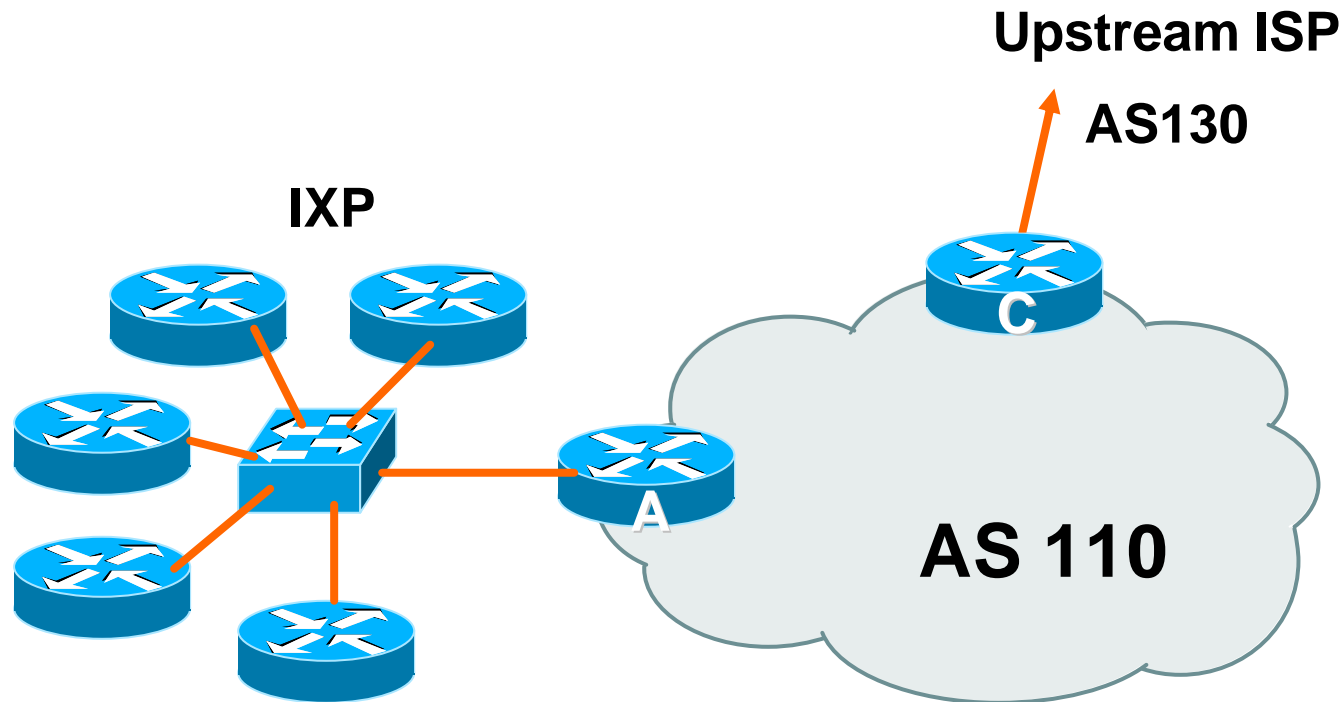
One Upstream, Local Exchange Point

Cisco.com

- **Announce /19 aggregate to every neighbouring AS**
- **Accept default route only from upstream**
Either 0.0.0.0/0 or a network which can be used as default
- **Accept all routes from IXP peers**

One Upstream, Local Exchange Point

Cisco.com



One Upstream, Local Exchange Point

Cisco.com

- **Router A Configuration**

```
interface fastethernet 0/0
  description Exchange Point LAN
  ip address 220.5.10.1 mask 255.255.255.224
  ip verify unicast reverse-path
  no ip directed-broadcast
  no ip proxy-arp
  no ip redirects
!
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor ixp-peers peer-group
  neighbor ixp-peers soft-reconfiguration in
  neighbor ixp-peers prefix-list my-block out
..next slide
```

One Upstream, Local Exchange Point

Cisco.com

```
neighbor 220.5.10.2 remote-as 100
neighbor 222.5.10.2 peer-group ixp-peers
neighbor 222.5.10.2 prefix-list peer100 in
neighbor 220.5.10.3 remote-as 101
neighbor 222.5.10.3 peer-group ixp-peers
neighbor 222.5.10.3 prefix-list peer101 in
neighbor 220.5.10.4 remote-as 102
neighbor 222.5.10.4 peer-group ixp-peers
neighbor 222.5.10.4 prefix-list peer102 in
neighbor 220.5.10.5 remote-as 103
neighbor 222.5.10.5 peer-group ixp-peers
neighbor 222.5.10.5 prefix-list peer103 in
..next slide
```

One Upstream, Local Exchange Point

Cisco.com

```
ip route 221.10.0.0 255.255.224.0 null0
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list peer100 permit 222.0.0.0/19
ip prefix-list peer101 permit 222.30.0.0/19
ip prefix-list peer102 permit 222.12.0.0/19
ip prefix-list peer103 permit 222.18.128.0/19
!
```

One Upstream, Local Exchange Point

Cisco.com

- Router C Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 130
  neighbor 222.222.10.1 prefix-list default in
  neighbor 222.222.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
```

One Upstream, Local Exchange Point

Cisco.com

- **Note Router A configuration**
Prefix-list higher maintenance, but safer
uRPF on the FastEthernet interface
- **IXP traffic goes to and from local IXP,**
everything else goes to upstream

Service Provider Multihoming

Two Upstreams, One local peer

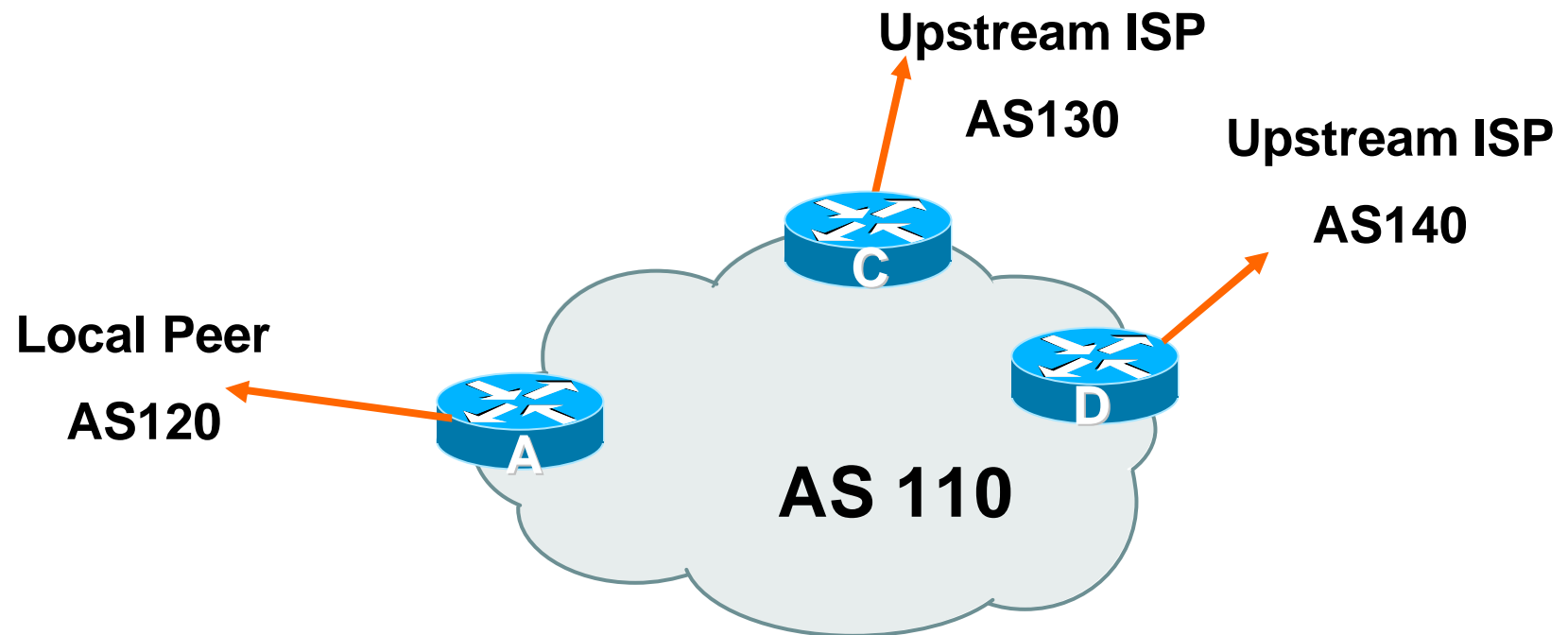
Two Upstreams, One Local Peer

Cisco.com

- **Announce /19 aggregate on each link**
- **Accept default route only from upstreams**
Either 0.0.0.0/0 or a network which can be used as default
- **Accept all routes from local peer**

Two Upstreams, One Local Peer

Cisco.com



Two Upstreams, One Local Peer

Cisco.com

- **Router A**

Same routing configuration as in example with one upstream and one local peer

Same hardware configuration

Two Upstreams, One Local Peer

Cisco.com

- Router C Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 130
  neighbor 222.222.10.1 prefix-list default in
  neighbor 222.222.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
```

Two Upstreams, One Local Peer

Cisco.com

- Router D Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.5 remote-as 140
  neighbor 222.222.10.5 prefix-list default in
  neighbor 222.222.10.5 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
```

Two Upstreams, One Local Peer

Cisco.com

- **This is the simple configuration for Router C and D**
- **Traffic out to the two upstreams will take nearest exit**

Inexpensive routers required

This is not useful in practice especially for international links

Loadsharing needs to be better

Two Upstreams, One Local Peer

Cisco.com

- **Better configuration options:**

Accept full routing from both upstreams

Expensive & unnecessary!

Accept default from one upstream and some routes from the other upstream

The way to go!

Two Upstreams, One Local Peer – Full Routes

Cisco.com

- Router C Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 130
  neighbor 222.222.10.1 prefix-list rfc1918-deny in
  neighbor 222.222.10.1 prefix-list my-block out
  neighbor 222.222.10.1 route-map AS130-loadshare in
!
ip prefix-list my-block permit 221.10.0.0/19
! See earlier presentation for RFC1918 list
..next slide
```

Two Upstreams, One Local Peer – Full Routes

Cisco.com

```
ip route 221.10.0.0 255.255.224.0 null0
!
ip as-path access-list 10 permit ^(130_)+$
ip as-path access-list 10 permit ^(130_)+_[0-9]+$
!
route-map AS130-loadshare permit 10
    match ip as-path 10
    set local-preference 120
route-map AS130-loadshare permit 20
    set local-preference 80
!
```


Two Upstreams, One Local Peer – Full Routes

Cisco.com

- **Router D Configuration**

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.5 remote-as 140
  neighbor 222.222.10.5 prefix-list rfc1918-deny in
  neighbor 222.222.10.5 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
! See earlier in presentation for RFC1918 list
```

Two Upstreams, One Local Peer – Full Routes

- **Router C configuration:**
 - Accept full routes from AS130**
 - Tag prefixes originated by AS130 and AS130's neighbouring ASes with local preference 120**
 - Traffic to those ASes will go over AS130 link**
 - Remaining prefixes tagged with local preference of 80**
 - Traffic to other all other ASes will go over the link to AS140**
- **Router D configuration same as Router C without the route-map**

Two Upstreams, One Local Peer – Full Routes

Cisco.com

- **Full routes from upstreams**

Expensive – needs 128Mbytes RAM today

Need to play preference games

Previous example is only an example – real life will need improved fine-tuning!

Previous example doesn't consider inbound traffic – see earlier in presentation for examples

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- Router C Configuration

```
router bgp 110
```

```
network 221.10.0.0 mask 255.255.224.0
```

```
neighbor 222.222.10.1 remote-as 130
```

```
neighbor 222.222.10.1 prefix-list rfc1918-nodef-deny in
```

```
neighbor 222.222.10.1 prefix-list my-block out
```

```
neighbor 222.222.10.1 filter-list 10 in
```

```
neighbor 222.222.10.1 route-map tag-default-low in
```

```
!
```

```
..next slide
```

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

```
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
!
ip as-path access-list 10 permit ^(130_)+$
ip as-path access-list 10 permit ^(130_)+_[0-9]+$
!
route-map tag-default-low permit 10
  match ip address prefix-list default
  set local-preference 80
route-map tag-default-low permit 20
!
```

Two Upstreams, One Local Peer – Partial Routes

- Router D Configuration

```
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.5 remote-as 140
  neighbor 222.222.10.5 prefix-list default in
  neighbor 222.222.10.5 prefix-list my-block out
!
ip prefix-list my-block permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 221.10.0.0 255.255.224.0 null0
```

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- **Router C configuration:**

Accept full routes from AS130

(or get them to send less)

Filter ASNs so only AS130 and AS130's neighbouring ASes are accepted

Allow default, and set it to local preference 80

Traffic to those ASes will go over AS130 link

Traffic to other all other ASes will go over the link to AS140

If AS106 link fails, backup via AS130 – and vice-versa

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- **Partial routes from upstreams**

Not expensive – only carry the routes necessary for loadsharing

Need to filter on AS paths

Previous example is only an example – real life will need improved fine-tuning!

Previous example doesn't consider inbound traffic – see earlier in presentation for examples

Two Upstreams, One Local Peer

Cisco.com

- **When upstreams cannot or will not announce default route**

Because of operational policy against using “default-originate” on BGP peering

Solution is to use IGP to propagate default from the edge/peering routers

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- Router C Configuration

```
router ospf 110
  default-information originate metric 30
  passive-interface Serial 0/0
!
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.1 remote-as 130
  neighbor 222.222.10.1 prefix-list rfc1918-deny in
  neighbor 222.222.10.1 prefix-list my-block out
  neighbor 222.222.10.1 filter-list 10 in
!
..next slide
```

Two Upstreams, One Local Peer – Partial Routes

```
ip prefix-list my-block permit 221.10.0.0/19
! See earlier for RFC1918 list
!
ip route 221.10.0.0 255.255.224.0 null0
ip route 0.0.0.0 0.0.0.0 serial 0/0 254
!
ip as-path access-list 10 permit ^(130_)+$
ip as-path access-list 10 permit ^(130_)+_[0-9]+$
!
```

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- **Router D Configuration**

```
router ospf 110
  default-information originate metric 10
  passive-interface Serial 0/0
!
router bgp 110
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.5 remote-as 140
  neighbor 222.222.10.5 prefix-list deny-all in
  neighbor 222.222.10.5 prefix-list my-block out
!
..next slide
```

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

```
ip prefix-list deny-all deny 0.0.0.0/0 le 32
ip prefix-list my-block permit 221.10.0.0/19
! See earlier in presentation for RFC1918 list
!
ip route 221.10.0.0 255.255.224.0 null0
ip route 0.0.0.0 0.0.0.0 serial 0/0 254
!
```

Two Upstreams, One Local Peer – Partial Routes

Cisco.com

- **Partial routes from upstreams**

Use OSPF to determine outbound path

Router D default has metric 10 – primary outbound path

Router C default has metric 30 – backup outbound path

Serial interface goes down, static default is removed from routing table, OSPF default withdrawn

Service Provider Multihoming

Two Tier-1 upstreams, two regional upstreams, and local peers

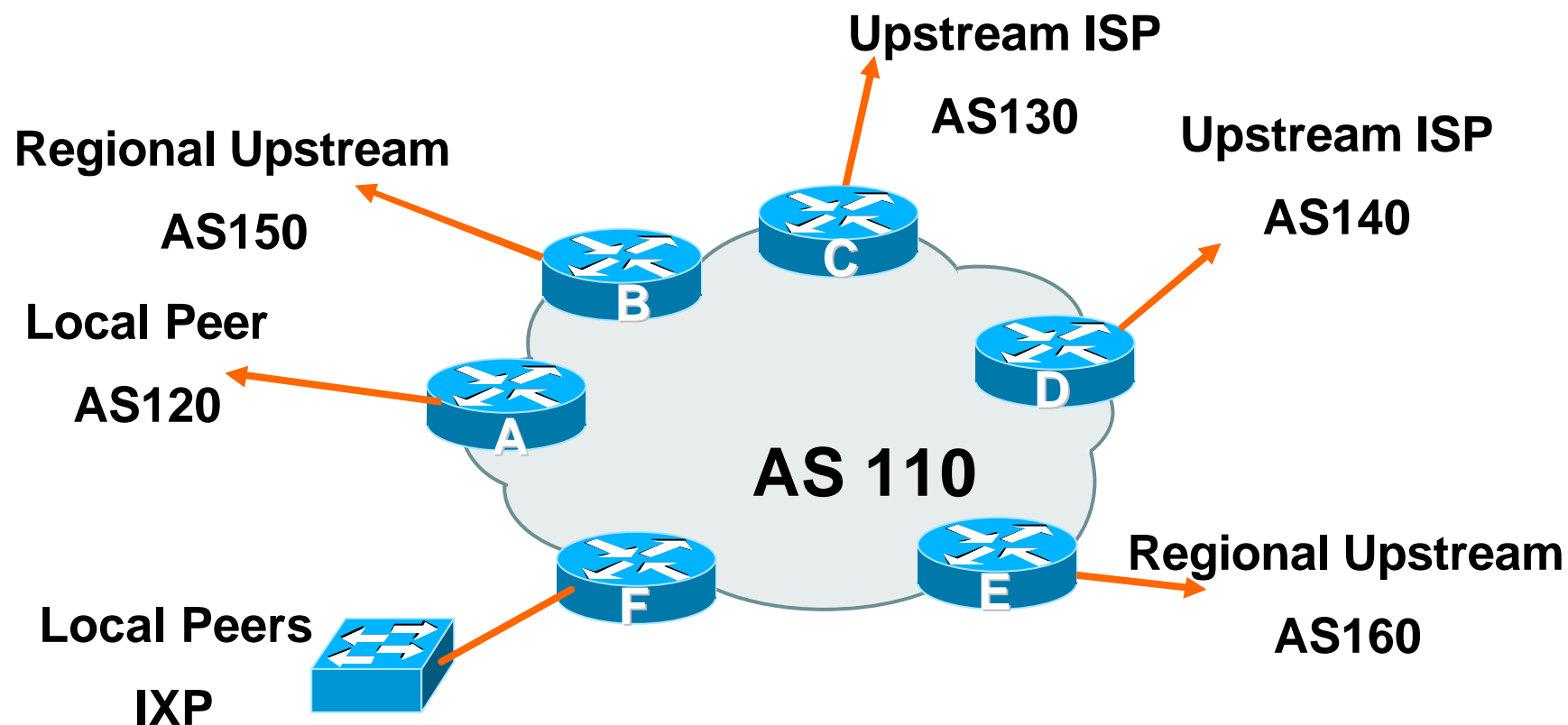
Tier-1 & Regional Upstreams, Local Peers

Cisco.com

- **Announce /19 aggregate on each link**
- **Accept partial/default routes from upstreams**
 - For default, use 0.0.0.0/0 or a network which can be used as default
- **Accept all routes from local peer**
- **Accept all partial routes from regional upstreams**
- **This is more complex, but a very typical scenario**

Tier-1 & Regional Upstreams, Local Peers

Cisco.com



Tier-1 & Regional Upstreams, Local Peers – Detail

Cisco.com

- **Router A – local private peer**
 - Accept all (local) routes**
 - Local traffic stays local**
 - Use prefix and/or AS-path filters**
 - Use local preference (if needed)**
- **Router F – local IXP peering**
 - Accept all (local) routes**
 - Local traffic stays local**
 - Use prefix and/or AS-path filters**

Tier-1 & Regional Upstreams, Local Peers – Detail

Cisco.com

- **Router B – regional upstream**

They provide transit to Internet, but longer AS path than Tier-1s

Accept all regional routes from them

e.g. ^150_[0-9]+\$

Ask them to send default, or send a network you can use as default

Set local pref on “default” to 60

Will provide backup to Internet only when direct Tier-1 links go down

Tier-1 & Regional Upstreams, Local Peers – Detail

Cisco.com

- **Router E – regional upstream**

They provide transit to Internet, but longer AS path than Tier-1s

Accept all regional routes from them

e.g. `^160_[0-9]+$`

Ask them to send default, or send a network you can use as default

Set local pref on “default” to 70

Will provide backup to Internet only when direct Tier-1 links go down

Tier-1 & Regional Upstreams, Local Peers – Detail

Cisco.com

- **Router C – first Tier-1**

Accept all their customer and AS neighbour routes from them

e.g. `^130_[0-9]+$`

Ask them to send default, or send a network you can use as default

Set local pref on “default” to 80

Will provide backup to Internet only when link to second Tier-1 goes down

Tier-1 & Regional Upstreams, Local Peers – Detail

Cisco.com

- **Router D – second Tier-1**

Ask them to send default, or send a network you can use as default

This has local preference 100 by default

All traffic without any more specific path will go out this way

Tier-1 & Regional Upstreams, Local Peers – Summary

Cisco.com

- **Local traffic goes to local peer and IXP**
- **Regional traffic goes to two regional upstreams**
- **Everything else is shared between the two Tier-1s**
- **To modify loadsharing tweak what is heard from the two regionals and the first Tier-1**

Best way is through modifying the AS-path filter

Tier-1 & Regional Upstreams, Local Peers

Cisco.com

- **What about outbound announcement strategy?**

This is to determine incoming traffic flows

/19 aggregate must be announced to everyone!

/20 or /21 more specifics can be used to improve or modify loadsharing

See earlier for hints and ideas

Tier-1 & Regional Upstreams, Local Peers

Cisco.com

- **What about unequal circuit capacity?**
AS-path filters are very useful
- **What if upstream will only give me full routing table or nothing**
AS-path and prefix filters are very useful

Service Provider Multihoming

Disconnected Backbone

Disconnected Backbone

Cisco.com

- **ISP runs large network**

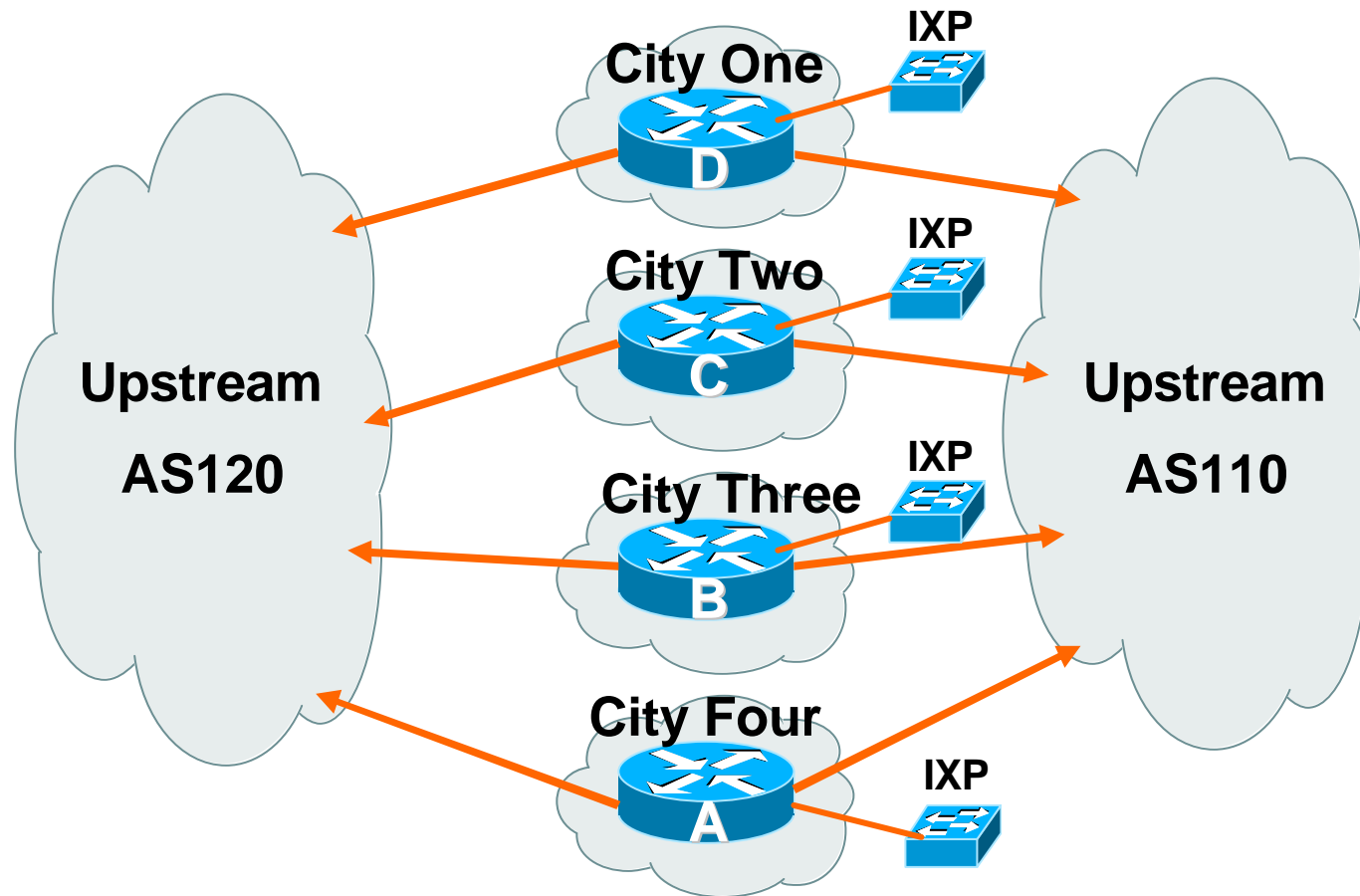
Network has no backbone, only large PoPs in each location

Each PoP multihomes to upstreams

Common in some countries where backbone circuits are hard to obtain

Disconnected Backbone

Cisco.com



Disconnected Backbone

Cisco.com

- **Works with one AS number**
Not four – no BGP loop detection problem
- **Each city operates as separate network**
Uses defaults and selected leaked prefixes for loadsharing
Peers at local exchange point

Disconnected Backbone

- Router A Configuration

```
router bgp 100
  network 221.10.0.0 mask 255.255.248.0
  neighbor 222.200.0.1 remote-as 120
  neighbor 222.200.0.1 description AS120 - Serial 0/0
  neighbor 222.200.0.1 prefix-list default in
  neighbor 222.222.0.1 prefix-list my-block out
  neighbor 222.222.10.1 remote-as 110
  neighbor 222.222.10.1 description AS110 - Serial 1/0
  neighbor 222.222.10.1 prefix-list rfc1918-sua in
  neighbor 222.222.10.1 prefix-list my-block out
  neighbor 222.222.10.1 filter-list 10 in
!
```

...continued on next page...

Disconnected Backbone

```
ip prefix-list my-block permit 221.10.0.0/21
ip prefix-list default permit 0.0.0.0/0
!
ip as-path access-list 10 permit ^(110_)+$
ip as-path access-list 10 permit ^(110_)+_[0-9]+$
!...etc to achieve outbound loadsharing
!
ip route 0.0.0.0 0.0.0.0 Serial 1/0 250
ip route 221.10.0.0 255.255.248.0 null0
!
```

Disconnected Backbone

Cisco.com

- **Peer with AS120**
 - Receive just default route**
 - Announce /22 address**
- **Peer with AS110**
 - Receive full routing table – filter with AS-path filter**
 - Announce /22 address**
 - Point backup static default – distance 252 – in case AS120 goes down**

Disconnected Backbone

Cisco.com

- **Default ensures that disconnected parts of AS100 are reachable**
 - Static route backs up AS120 default**
 - No BGP loop detection – relying on default route**
- **Do not announce /19 aggregate**
 - No advantage in announcing /19 and could lead to problems**

IDC Multihoming

IDC Multihoming

Cisco.com

- **IDCs typically are not registry members so don't get their own address block**

**Situation also true for small ISPs and
“Enterprise Networks”**

- **Smaller address blocks being announced**

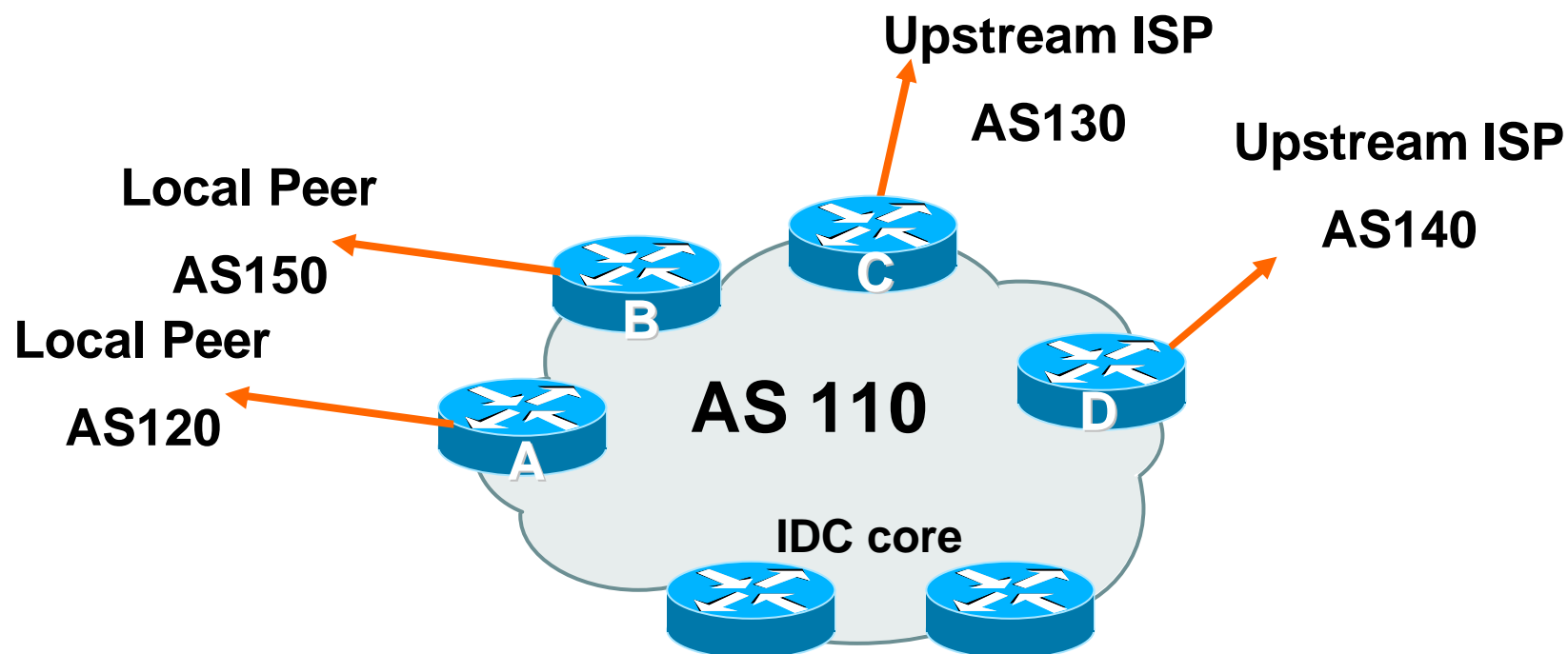
Address space comes from both upstreams

**Should be apportioned according to size of
circuit to upstream**

- **Outbound traffic paths matter**

Two Upstreams, Two Local Peers – IDC

Cisco.com



Assigned /24 from AS130 and /23 from AS140.

Circuit to AS130 is 2Mbps, circuit to AS140 is 4Mbps

IDC Multihoming

Cisco.com

- **Router A and B configuration**

In: Should accept all routes from AS120 and AS150

Out: Should announce all address space to AS120 and AS150

Straightforward

IDC Multihoming

Cisco.com

- **Router C configuration**

In: Accept partial routes from AS130

e.g. `^130_[0-9]+$`

In: Ask for a route to use as default

set local preference on default to 80

Out: Send /24, and send /23 with AS-PATH
prepend of one AS

IDC Multihoming

Cisco.com

- **Router D configuration**

In: Ask for a route to use as default

Leave local preference of default at 100

Out: Send /23, and send /24 with AS-PATH
prepend of one AS

IDC Multihoming – Fine Tuning

Cisco.com

- **For local fine tuning, increase circuit capacity**
Local circuits usually are cheap
Otherwise...
- **For longer distance fine tuning**
In: Modify as-path filter on Router C
Out: Modify as-path prepend on Routers C and D
Outbound traffic flow is usual critical for an IDC so **inbound** policies need to be carefully thought out

IDC Multihoming – Other Details

Cisco.com

- **Redundancy**

Circuits are terminated on separate routers

- **Apply thought to address space use**

Request from both upstreams

Utilise address space evenly across IDC

Don't start with /23 then move to /24 – use both blocks at the same time in the same proportion

Helps with loadsharing – yes, really!

IDC Multihoming – Other Details

Cisco.com

- **What about failover?**

/24 and /23 from upstreams' blocks announced to the Internet routing table all the time

No obvious alternative at the moment

Conditional advertisement can help in steady state, but subprefixes still need to be announced in failover condition

BGP Multihoming Techniques

Cisco.com

- **Definition & Options**
- **Connecting to the same ISP**
- **Connecting to different ISPs**
- **Service Provider Multihoming**
- **Using Communities**
- **Case Study**

Communities

Community usage

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- **RFC1998**
- **Examples of SP applications**

RFC1998

Cisco.com

- **Informational RFC**
- **Describes how to implement loadsharing and backup on multiple inter-AS links**
 - BGP communities used to determine local preference in upstream's network**
- **Gives control to the customer**
- **Simplifies upstream's configuration**
 - simplifies network operation!**

- **Community values defined to have particular meanings:**

ASx:100 set local pref 100 preferred route

ASx:90 set local pref 90 backup route if dualhomed on ASx

ASx:80 set local pref 80 main link is to another ISP with same AS path length

ASx:70 set local pref 70 main link is to another ISP

- **Sample Customer Router Configuration**

```
router bgp 130
  neighbor x.x.x.x remote-as 100
  neighbor x.x.x.x description Backup ISP
  neighbor x.x.x.x route-map config-community out
  neighbor x.x.x.x send-community
!
ip as-path access-list 20 permit ^$
ip as-path access-list 20 deny .*
!
route-map config-community permit 10
  match as-path 20
  set community 100:90
```


- **Sample ISP Router Configuration**

```
! Homed to another ISP
ip community-list 70 permit 100:70
! Homed to another ISP with equal ASPATH length
ip community-list 80 permit 100:80
! Customer backup routes
ip community-list 90 permit 100:90
!
route-map set-customer-local-pref permit 10
  match community 70
  set local-preference 70
```

- **Sample ISP Router Configuration**

```
route-map set-customer-local-pref permit 20
  match community 80
  set local-preference 80
!
route-map set-customer-local-pref permit 30
  match community 90
  set local-preference 90
!
route-map set-customer-local-pref permit 40
  set local-preference 100
```

- **Supporting RFC1998**

many ISPs do, more should

check AS object in the Internet Routing Registry

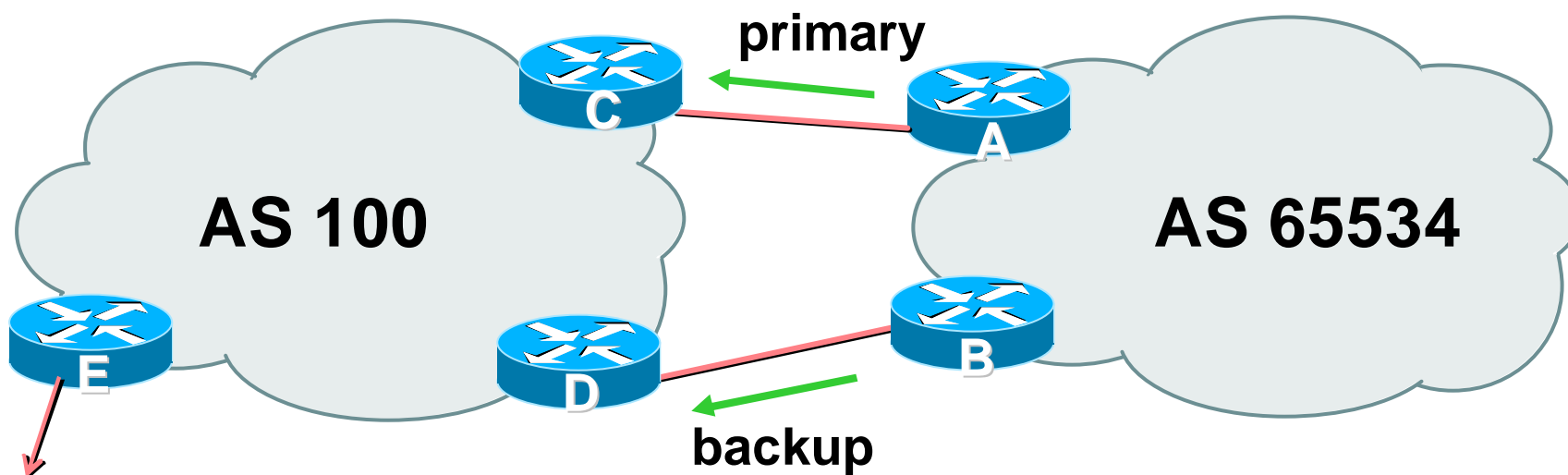
if you do, insert comment in AS object in the IRR

Two links to the same ISP

One link primary, the other link backup only

Two links to the same ISP

Cisco.com



- **AS100 proxy aggregates for AS 65534**

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

Cisco.com

- **Announce /19 aggregate on each link**
primary link makes standard announcement
backup link sends community
- **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)

Cisco.com

- Router A Configuration

```
router bgp 65534
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.2 remote-as 100
  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)

Cisco.com

- **Router B Configuration**

```
router bgp 65534
  network 221.10.0.0 mask 255.255.224.0
  neighbor 222.222.10.6 remote-as 100
  neighbor 222.222.10.6 description RouterD
  neighbor 222.222.10.6 send-community
  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)

Cisco.com

```
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 community 100:90
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)

Cisco.com

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

```
router bgp 100
  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)

Cisco.com

- Router D Configuration (backup link)

```
router bgp 100
  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 route-map bgp-cust-in 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
!
..next slide
```

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

Cisco.com

```
ip prefix-list Customer permit 221.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip community-list 90 permit 100:90
!
<snip>
route-map bgp-cust-in permit 30
  match community 90
  set local-preference 90
route-map bgp-cust-in permit 40
  set local-preference 100
```

Service Provider use of Communities

Some working examples

Background

Cisco.com

- **RFC1998 is okay for “simple” multihomed customers**
assumes that upstreams are interconnected
- **ISPs create many other communities to handle more complex situations**
Simplify ISP BGP configuration
Give customer more policy control

Some ISP Examples

Cisco.com

- **Public policy is usually listed in the IRR**

Following examples are all in the IRR or referenced from the AS Object in the IRR

- **Consider creating communities to give policy control to customers**

Reduces technical support burden

Reduces the amount of router reconfiguration, and the chance of mistakes

Some ISP

Connect

```
aut-num:          AS2764
as-name:          ASN-CONNECT-NET
descr:            connect.com.au pty ltd
admin-c:          CC89
tech-c:           MP151
remarks:          Community Definition
remarks:          -----
remarks:          2764:1 Announce to "domestic" rate ASes only
remarks:          2764:2 Don't announce outside local POP
remarks:          2764:3 Lower local preference by 25
remarks:          2764:4 Lower local preference by 15
remarks:          2764:5 Lower local preference by 5
remarks:          2764:6 Announce to non customers with "no-export"
remarks:          2764:7 Only announce route to customers
remarks:          2764:8 Announce route over satellite link
notify:           routing@connect.com.au
mnt-by:           CONNECT-AU
changed:          mrp@connect.com.au 19990506
source:           CCAIR
```


Some IS

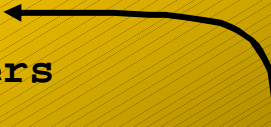
UUNET

```
aut-num: AS702
as-name: AS702
descr: UUNET - Commercial IP service provider in Europe
remarks: -----
remarks: UUNET uses the following communities with its customers:
remarks: 702:80 Set Local Pref 80 within AS702
remarks: 702:120 Set Local Pref 120 within AS702
remarks: 702:20 Announce only to UUNET AS'es and UUNET customers
remarks: 702:30 Keep within Europe, don't announce to other UUNET AS's
remarks: 702:1 Prepend AS702 once at edges of UUNET to Peers
remarks: 702:2 Prepend AS702 twice at edges of UUNET to Peers
remarks: 702:3 Prepend AS702 thrice at edges of UUNET to Peers
remarks: Details of UUNET's peering policy and how to get in touch with
remarks: UUNET regarding peering policy matters can be found at:
remarks: http://www.uu.net/peering/
remarks: -----
mnt-by: UUNET-MNT
changed: eric-apps@eu.uu.net 20010928
source: RIPE
```

Some ISPs

BT Ignite

```
aut-num: AS5400
as-name: CIPCORE
descr: BT Ignite European Backbone
remarks: The following BGP communities can be set by BT Ignite
remarks: BGP customers to affect announcements to major peers.
remarks:
remarks: Community to Community to
remarks: Not announce To peer: AS prepend 5400
remarks:
remarks: 5400:1000 European peers 5400:2000
remarks: 5400:1001 Sprint (AS1239) 5400:2001
remarks: 5400:1003 Unisource (AS3300) 5400:2003
remarks: 5400:1005 UUnet (AS702) 5400:2005
remarks: 5400:1006 Carrier1 (AS8918) 5400:2006
remarks: 5400:1007 SupportNet (8582) 5400:2007
remarks: 5400:1008 AT&T (AS2686) 5400:2008
remarks: 5400:1009 Level 3 (AS9057) 5400:2009
remarks: 5400:1010 RIPE (AS3333) 5400:2010
<snip>
remarks: 5400:1100 US peers 5400:2100
notify: notify@eu.ignite.net
mnt-by: CIP-MNT
source: RIPE
```



**And many
many more!**

Some ISP Carrier

```
aut-num:      AS8918
descr:        Carrier1 Autonomous System
<snip>
remarks:      Community Support Definitions:
remarks:      Communities that determine the geographic
remarks:      entry point of routes into the Carrier1 network:
remarks:      *
remarks:      Community      Entry Point
remarks:      -----
remarks:      8918:10         London
remarks:      8918:15         Hamburg
remarks:      8918:18         Chicago
remarks:      8918:20         Amsterdam
remarks:      8918:25         Milan
remarks:      8918:28         Berlin
remarks:      8918:30         Frankfurt
remarks:      8918:35         Zurich
remarks:      8918:40         Geneva
remarks:      8918:45         Stockholm
<snip>
notify:        inoc@carrier1.net
mnt-by:        CARRIER1-MNT
source:        RIPE
```

And many
many more!

Some ISP Level

```
aut-num:          AS3356
descr:            Level 3 Communications
<snip>
remarks:          -----
remarks:          customer traffic engineering communities - Suppression
remarks:          -----
remarks:          64960:XXX - announce to AS XXX if 65000:0
remarks:          65000:0   - announce to customers but not to peers
remarks:          65000:XXX - do not announce at peerings to AS XXX
remarks:          -----
remarks:          customer traffic engineering communities - Prepending
remarks:          -----
remarks:          65001:0    - prepend once   to all peers
remarks:          65001:XXX - prepend once   at peerings to AS XXX
remarks:          65002:0    - prepend twice  to all peers
remarks:          65002:XXX - prepend twice  at peerings to AS XXX
remarks:          65003:0    - prepend 3x     to all peers
remarks:          65003:XXX - prepend 3x      at peerings to AS XXX
remarks:          65004:0    - prepend 4x     to all peers
remarks:          65004:XXX - prepend 4x      at peerings to AS XXX
<snip>
mnt-by:           LEVEL3-MNT
source:           RIPE
```

And many
many more!

BGP Multihoming Techniques

Cisco.com

- **Definition & Options**
- **Connecting to the same ISP**
- **Connecting to different ISPs**
- **Service Provider Multihoming**
- **Using Communities**
- **Case Study**

Case Study

First Visit

Case Study – Requirements (1)

Cisco.com

- **ISP needs to multihome:**
 - To AS5400 in Europe**
 - To AS2516 in Japan**
 - /19 allocated by APNIC**
 - AS 17660 assigned by APNIC**
 - 1Mbps circuits to both upstreams**

Case Study – Requirements (2)

Cisco.com

- **ISP wants:**

- Symmetric routing and equal link utilisation in and out (as close as possible)**

- international circuits are expensive**

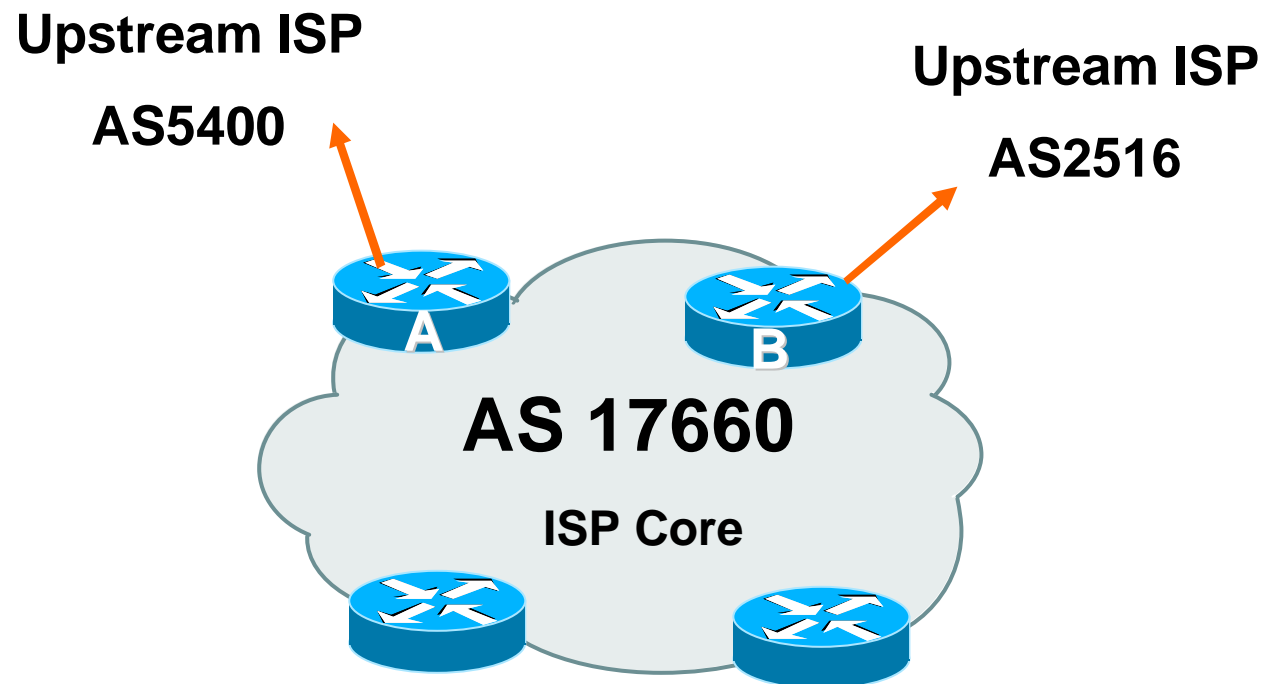
- Has two Cisco 2600 border routers with 64Mbytes memory**

- Cannot afford to upgrade memory or hardware on border routers or internal routers**

- **“Philip, make it work, please”**

Case Study

Cisco.com



Allocated /19 from APNIC

Circuit to AS5400 is 1Mbps, circuit to AS2516 is 1Mbps

Case Study

Cisco.com

- Both providers stated that routers with 128Mbytes memory required for AS17660 to multihome

Wrong!

Full routing table is rarely required or desired

- **Solution:**

Accept default from one upstream

Accept partial prefixes from the other

Case Study – Inbound Loadsharing

Cisco.com

- **First cut: Went to a few US Looking Glasses**

Checked the AS path to AS5400

Checked the AS path to AS2516

AS2516 was one hop “closer”

Sent AS-PATH prepend of one AS on AS2516 peering

Case Study – Inbound Loadsharing

Cisco.com

- **Refinement**

Did not need any

First cut worked, seeing on average 600kbps inbound on each circuit

Does vary according to time of day, but this is as balanced as it can get, given customer profile



Case Study – Outbound Loadsharing

Cisco.com

- **First cut:**
 - Requested default from AS2516**
 - Requested full routes from AS5400**
- **Then looked at my Routing Report**
 - Picked the top 5 ASNs and created a filter-list**
 - If 701, 1, 7018, 1239 or 7046 are in AS-PATH, prefixes are discarded**
 - Allowed prefixes originated by AS5400 and up to two AS hops away**
 - Resulted in 32000 prefixes being accepted in AS17660**

Case Study – Outbound Loadsharing

Cisco.com

- **Refinement**

32000 prefixes quite a lot, seeing more outbound traffic on the AS5400 path

Traffic was very asymmetric

out through AS5400, in through AS2516

Added the next 3 ASNs from the Top 20 list

209, 2914 and 3549

Now seeing 14000 prefixes

Traffic is now evenly loadshared outbound

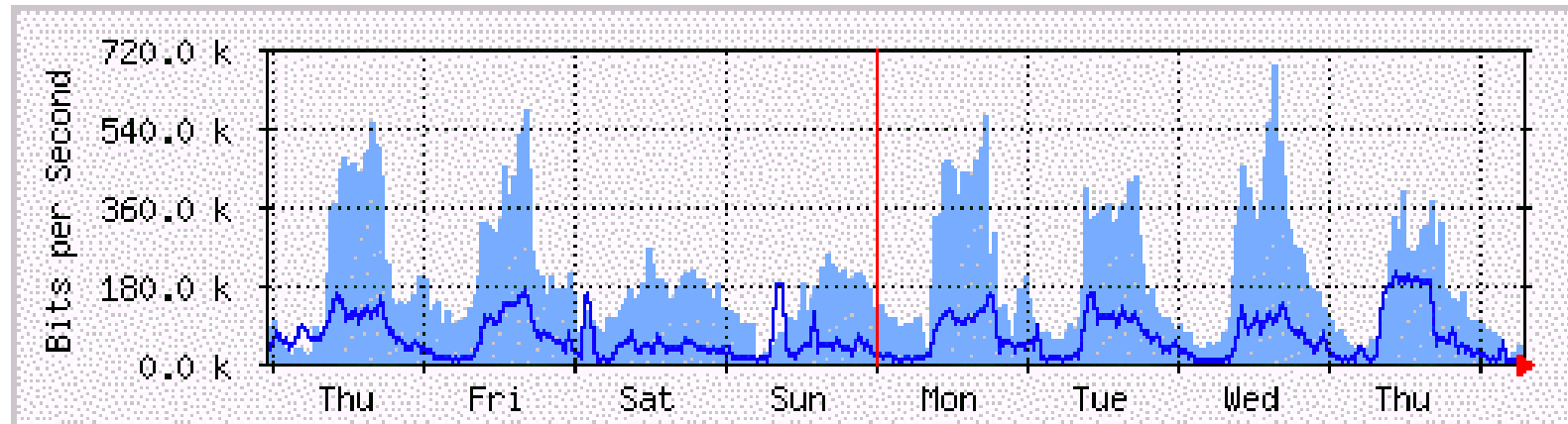
Around 200kbps on average

Mostly symmetric

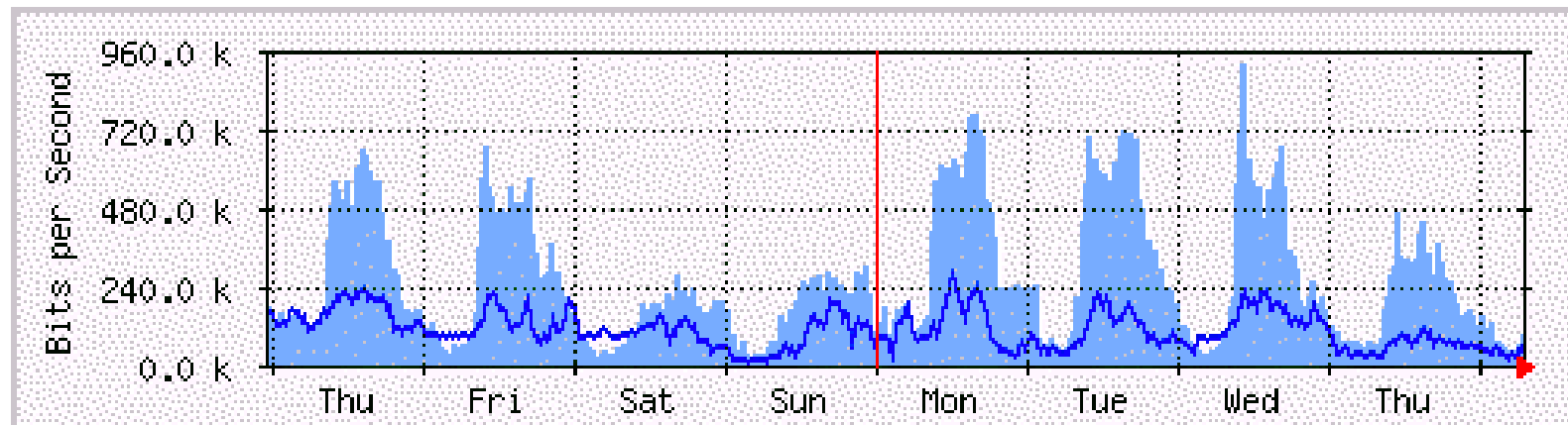
Case Study

MRTG Graphs

Cisco.com



Router A to AS5400



Router B to AS2516

Case Study

Configuration Router A

Cisco.com

```
router ospf 100
  log-adjacency-changes
  passive-interface default
  no passive-interface Ethernet0/0
  default-information originate metric 20
!
router bgp 17660
  no synchronization
  no bgp fast-external-fallover
  bgp log-neighbor-changes
  bgp deterministic-med
...next slide
```


Case Study

Configuration Router A

Cisco.com

```
neighbor 166.49.165.13 remote-as 5400
neighbor 166.49.165.13 description eBGP multihop to AS5400
neighbor 166.49.165.13 ebgp-multihop 5
neighbor 166.49.165.13 update-source Loopback0
neighbor 166.49.165.13 prefix-list in-filter in
neighbor 166.49.165.13 prefix-list out-filter out
neighbor 166.49.165.13 filter-list 1 in
neighbor 166.49.165.13 filter-list 3 out
!
prefix-list in-filter deny rfc1918etc in
prefix-list out-filter permit 202.144.128.0/19
!
ip route 0.0.0.0 0.0.0.0 serial 0/0 254
...next slide
```

Case Study

Configuration Router A

Cisco.com

```
ip as-path access-list 1 deny _701_  
ip as-path access-list 1 deny _1_  
ip as-path access-list 1 deny _7018_  
ip as-path access-list 1 deny _1239_  
ip as-path access-list 1 deny _7046_  
ip as-path access-list 1 deny _209_  
ip as-path access-list 1 deny _2914_  
ip as-path access-list 1 deny _3549_  
ip as-path access-list 1 permit _5400$  
ip as-path access-list 1 permit _5400_[0-9]+$  
ip as-path access-list 1 permit _5400_[0-9]+_[0-9]+$  
ip as-path access-list 1 deny .*  
ip as-path access-list 3 permit ^$  
!
```

Case Study

Configuration Router B

Cisco.com

```
router ospf 100
  log-adjacency-changes
  passive-interface default
  no passive-interface Ethernet0/0
  default-information originate
!
router bgp 17660
  no synchronization
  no auto-summary
  no bgp fast-external-fallover
...next slide
```

Case Study

Configuration Router B

Cisco.com

```
bgp log-neighbor-changes
bgp deterministic-med
  neighbor 210.132.92.165 remote-as 2516
  neighbor 210.132.92.165 description eBGP peering
  neighbor 210.132.92.165 soft-reconfiguration inbound
  neighbor 210.132.92.165 prefix-list default-route in
  neighbor 210.132.92.165 prefix-list out-filter out
  neighbor 210.132.92.165 route-map as2516-out out
  neighbor 210.132.92.165 maximum-prefix 100
  neighbor 210.132.92.165 filter-list 2 in
  neighbor 210.132.92.165 filter-list 3 out
!
```

...next slide

Case Study

Configuration Router B

Cisco.com

```
!  
prefix-list default-route permit 0.0.0.0/0  
prefix-list out-filter permit 202.144.128.0/19  
!  
ip as-path access-list 2 permit _2516$  
ip as-path access-list 2 deny .*  
ip as-path access-list 3 permit ^$  
!  
route-map as2516-out permit 10  
    set as-path prepend 17660  
!
```

Configuration Summary

Cisco.com

- **Router A**

Hears full routing table – throws away most of it

AS5400 BGP options are all or nothing

Static default pointing to serial interface – if link goes down, OSPF default removed

- **Router B**

Hears default from AS2516

If default disappears (BGP goes down or link goes down), OSPF default is removed

Case Study Summary

Cisco.com

- **Multihoming is not hard, really!**
 - Needs a bit of thought, a bit of planning**
 - Use this case study as an example strategy**
 - Does not require sophisticated equipment, big memory, fast CPUs...**

Case Study

Second Visit

Case Study – Current Status

Cisco.com

- **ISP currently multihomes:**
 - To AS5400 in the UK**
 - To AS2516 in Japan**
 - /19 allocated by APNIC**
 - AS 17660 assigned by APNIC**
 - 1Mbps circuits to both upstreams**

Case Study – Requirements

Cisco.com

- **ISP wants:**

- To add a new satellite connection, a 640K link to AS22351 in Germany to support the AS5400 link to UK**

- Still want symmetric routing and equal link utilisation in and out (as close as possible)**

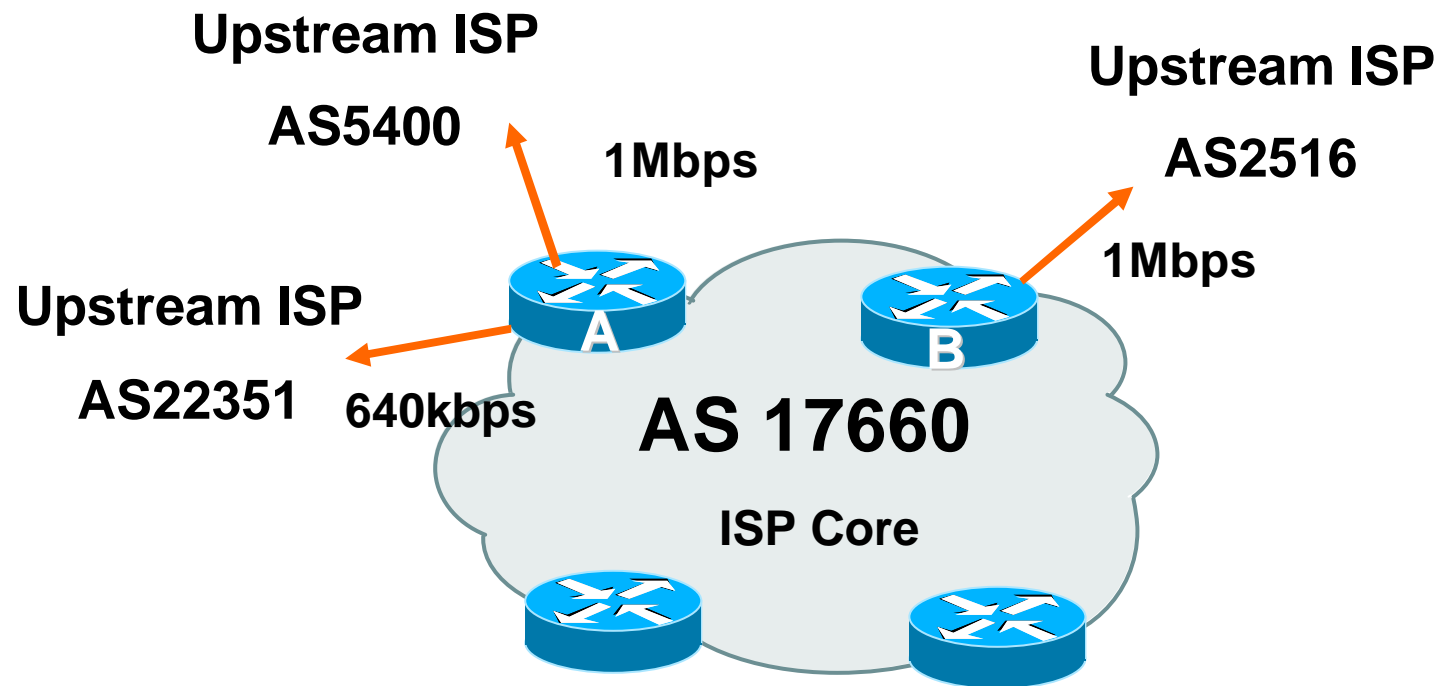
- international circuits are expensive**

- Has upgraded to two Cisco 3725 border routers with plenty of memory**

- **Despite the working previous configuration with “sparse routing table”, wanted full prefixes**
- **Talked them out of that, and here is how...**

Case Study

Cisco.com



Allocated /19 from APNIC

Case Study – Inbound Loadsharing

Cisco.com

- **First cut: Went to a few US Looking Glasses**
 - Checked the AS path to AS5400**
 - Checked the AS path to AS2516**
 - Checked the AS path to AS22351**
 - AS2516 was one hop “closer” than the other two**
 - Sent AS-PATH prepend of one AS on AS2516 peering**
 - this is unchanged from two years ago**

Case Study – Inbound Loadsharing

Cisco.com

- **Refinement**

Needed some – AS5400 seemed to be always preferred over AS22351

AS5400 now supports RFC1998 style communities for customer use

see `whois -h whois.ripe.net AS5400`

Sent AS5400 some communities to insert prepends towards specific peers

Now saw some traffic on AS22351 link but not much

Sent a /23 announcement out AS22351 link

Now saw more traffic on AS22351 link

Case Study – Inbound Loadsharing

Cisco.com

- **Results:**

- Around 600kbps on the AS5400 link**

- Around 750kbps on the AS2516 link**

- Around 300kbps on the AS22351 link**

- Inbound traffic fluctuates quite substantially based on time of day**

- **Status:**

- Situation left pending monitoring by the ISP's NOC**

Case Study – Outbound Loadsharing

Cisco.com

- **First cut:**
 - Already receiving default from AS2516**
 - Receiving full routes from AS5400**
 - Requested full routes from AS22351 – the only option**
- **Retained the AS5400 configuration**
 - Discard prefixes which had top 5 ASNs in the path**
- **AS22351 configuration uses similar ideas to AS5400 configuration**
 - But only accepted prefixes originated from AS22351 or their immediate peers**

Case Study – Outbound Loadsharing

Cisco.com

- **Results:**

- Around 35000 prefixes from AS5400**

- Around 2000 prefixes from AS22351**

- Around 200kbps on both the AS5400 and AS2516 links**

- Around 50kbps on the AS22351 link**

- Outbound traffic fluctuates quite substantially based on time of day**

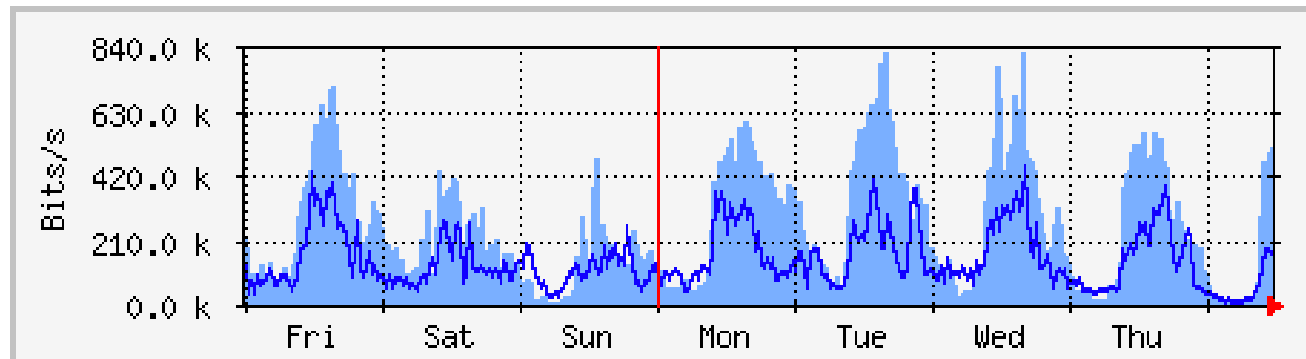
- **Status:**

- Situation left pending monitoring by the ISP's NOC**

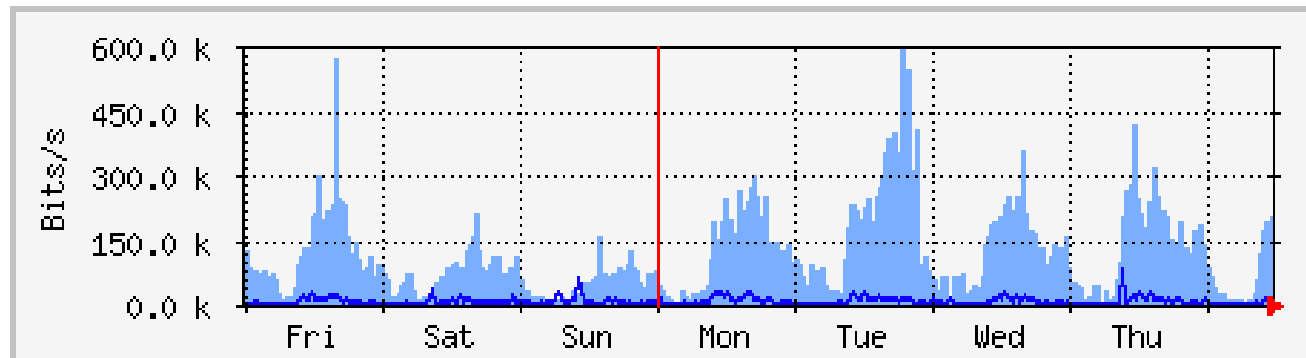
Case Study

MRTG Graphs

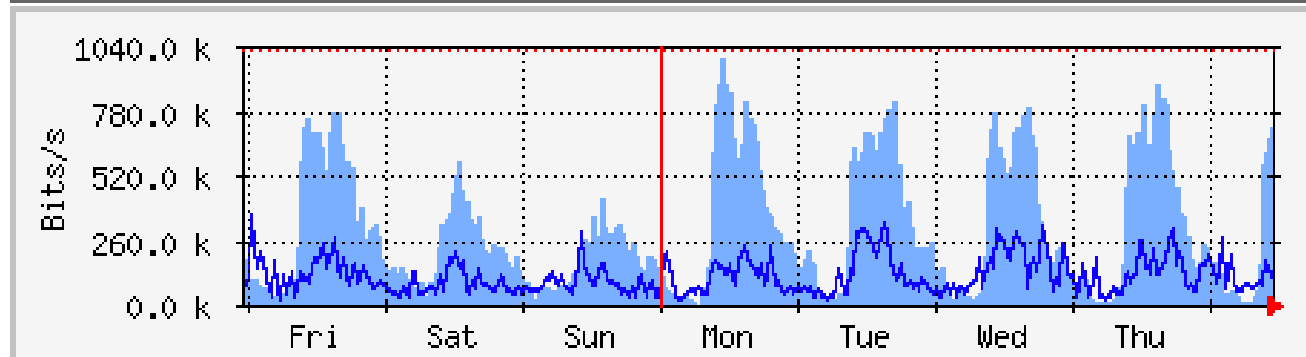
Cisco.com



**Router A to
AS5400**



**Router A to
AS22351**



**Router B to
AS2516**

Case Study

Configuration Router A

Cisco.com

```
router bgp 17660
  no synchronization
  no bgp fast-external-fallover
  bgp log-neighbor-changes
  bgp deterministic-med
  neighbor 80.255.39.241 remote-as 22351
  neighbor 80.255.39.241 description ebgp peer to AS22351
  neighbor 80.255.39.241 send-community
  neighbor 80.255.39.241 prefix-list in-filter in
  neighbor 80.255.39.241 prefix-list out-filter-as22351 out
  neighbor 80.255.39.241 route-map as22351-out out
  neighbor 80.255.39.241 maximum-prefix 120000 95 warning-only
  neighbor 80.255.39.241 filter-list 3 in
  neighbor 80.255.39.241 filter-list 5 out
...next slide
```

Case Study

Configuration Router A

Cisco.com

```
neighbor 166.49.165.13 remote-as 5400
neighbor 166.49.165.13 description eBGP multihop to AS5400
neighbor 166.49.165.13 ebgp-multihop 5
neighbor 166.49.165.13 update-source Loopback0
neighbor 166.49.165.13 send-community
neighbor 166.49.165.13 prefix-list in-filter in
neighbor 166.49.165.13 prefix-list out-filter out
neighbor 166.49.165.13 route-map as5400-out out
neighbor 166.49.165.13 filter-list 1 in
neighbor 166.49.165.13 filter-list 5 out
!
ip prefix-list in-filter deny rfc1918 prefixes etc
ip prefix-list out-filter permit 202.144.128.0/19
ip prefix-list out-filter-as22351 permit 202.144.128.0/19
ip prefix-list out-filter-as22351 permit 202.144.158.0/23
...next slide
```

Case Study

Configuration Router A

Cisco.com

```
ip as-path access-list 1 deny _701_  
ip as-path access-list 1 deny _1_  
ip as-path access-list 1 deny _7018_  
ip as-path access-list 1 deny _1239_  
ip as-path access-list 1 deny _7046_  
ip as-path access-list 1 permit _5400$  
ip as-path access-list 1 permit _5400_[0-9]+$  
ip as-path access-list 1 permit _5400_[0-9]+_[0-9]+$  
ip as-path access-list 1 deny .*  
ip as-path access-list 3 permit _22351$  
ip as-path access-list 3 permit _22351_[0-9]+$  
ip as-path access-list 3 deny .*  
ip as-path access-list 5 permit ^$  
!  
route-map as5400-out permit 10  
    set community 5400:2001 5400:2101 5400:2119 5400:2124 5400:2128  
route-map as22351-out permit 10
```

Case Study

Configuration Router B

Cisco.com

```
router bgp 17660
  no synchronization
  no auto-summary
  no bgp fast-external-fallover
  bgp log-neighbor-changes
  bgp deterministic-med
  neighbor 210.132.92.165 remote-as 2516
  neighbor 210.132.92.165 description eBGP Peering with AS2516
  neighbor 210.132.92.165 send-community
  neighbor 210.132.92.165 prefix-list default-route in
  neighbor 210.132.92.165 prefix-list out-filter out
  neighbor 210.132.92.165 route-map as2516-out out
  neighbor 210.132.92.165 maximum-prefix 100
  neighbor 210.132.92.165 filter-list 2 in
  neighbor 210.132.92.165 filter-list 5 out
...next slide
```

Case Study

Configuration Router B

Cisco.com

```
!  
prefix-list default-route permit 0.0.0.0/0  
prefix-list out-filter permit 202.144.128.0/19  
!  
ip as-path access-list 2 permit _2516$  
ip as-path access-list 2 deny .*  
ip as-path access-list 5 permit ^$  
!  
route-map as2516-out permit 10  
    set as-path prepend 17660  
!
```

Interesting Aside

Cisco.com

- **Prior to installation of the new 640kbps link, ISP was complaining that both 1Mbps links were saturated inbound**

Hence the requirement for the new 640kbps circuit

- **Research using NetFlow, cflowd and FlowScan showed that Kazaa was to blame!**

Kazaa is a peer to peer file sharing utility

Consumes all available bandwidth

Found that many customers were using Kazaa for file sharing, saturating the links inbound

Interesting Aside

Cisco.com

- **Solution**

A time of day filter which blocked Kazaa during working hours, 8am to 8pm

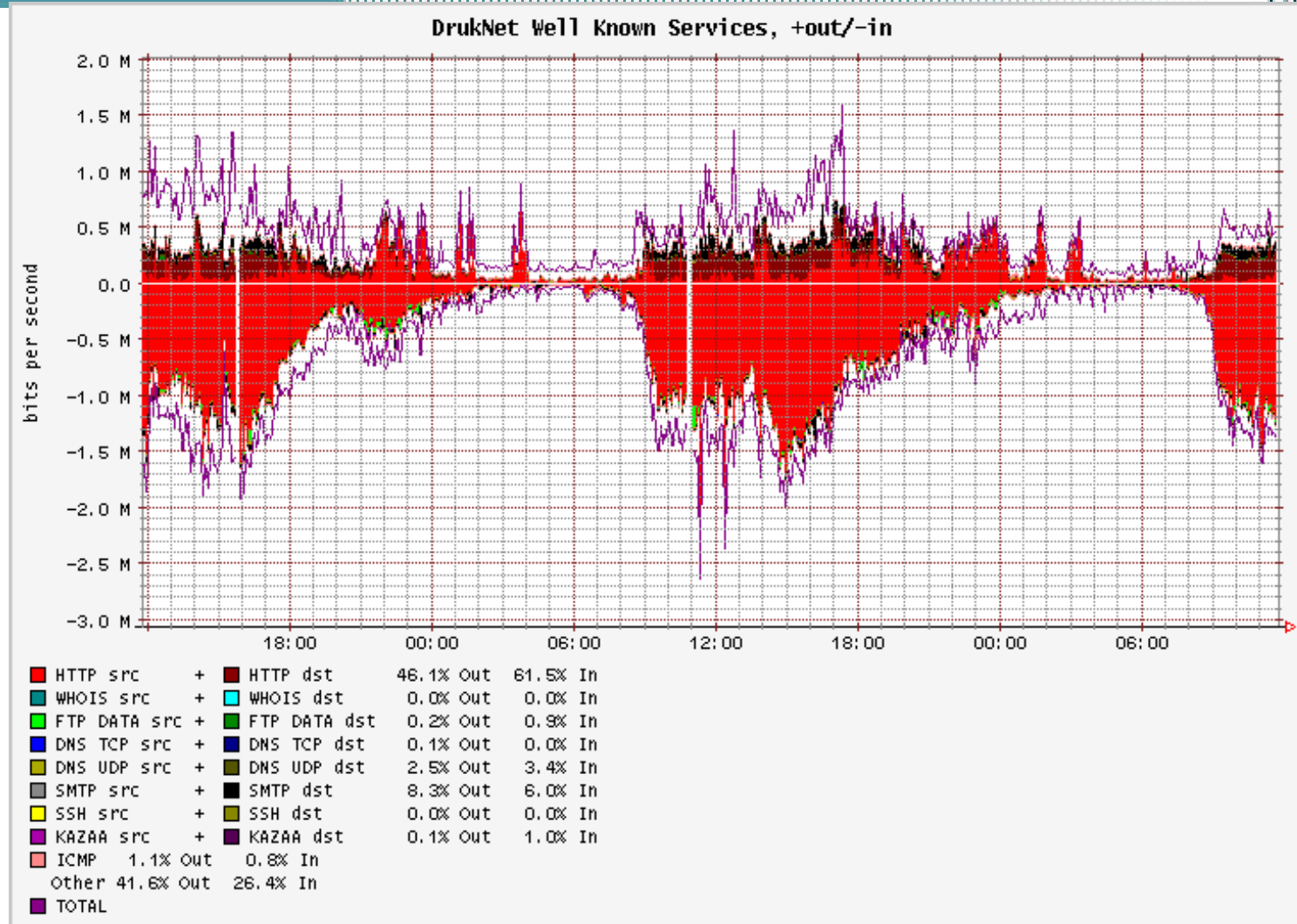
Inbound and outbound ACLs on border routers had tcp/1214 filters added

```
access-list 100 deny tcp any any eq 1214 time-range OfficeHours
access-list 101 deny tcp any any eq 1214 time-range OfficeHours
!
time-range OfficeHours
    periodic weekdays 8:00 to 20:00
```

The result: inbound traffic on external links dropped by 50%
And complaints about “the ‘net” being slow have reduced

Interesting Aside

Cisco.com



Typical FlowScan graph – no longer showing the effects of Kazaa

Summary

Cisco.com

- **Multihoming solution with three links of different bandwidths works well**

**Fluctuates significantly during the day time,
maybe reflecting users browsing habits?**

NOC is monitoring the situation

NOTE: Full routing table is not required 😊

Summary

Summary

Cisco.com

- **Multihoming is not hard, really...**

Keep It Simple! is a very good principle to follow

- **Full routing table is *rarely* required**

A default is just as good

If customers want 120k prefixes, charge them money for it

BGP Tutorial

End of Part 3 – Multihoming
Part 4 – Troubleshooting is next