

# BGP Multihoming Techniques

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# Preliminaries

Cisco.com

- **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 at any time**
- **Presentation slides are at:**  
**<ftp://ftp-eng.cisco.com/pfs/seminars/NANOG28-BGP-Multihoming.pdf>**  
**And also on the NANOG website**

# BGP Multihoming Techniques

Cisco.com

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

# Why Multihome?

**It's all about redundancy, diversity and reliability**

# Why Multihome?

Cisco.com

- **Redundancy**

**One connection to internet means the network is dependent on:**

**Local router (configuration, software, hardware)**

**WAN media (physical failure, carrier failure)**

**Upstream Service Provider (configuration, software, hardware)**

# Why Multihome?

Cisco.com

- **Reliability**

**Business critical applications demand continuous availability**

**Lack of redundancy implies lack of reliability  
implies loss of revenue**

# Why Multihome?

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- **Supplier Diversity**

**Many businesses demand supplier diversity as a matter of course**

**Internet connection from two or more suppliers**

**With two or more diverse WAN paths**

**With two or more exit points**

**With two or more international connections**

**Two of everything**

# Why Multihome?

Cisco.com

- **Not really a reason, but oft quoted...**

- **Leverage:**

**Playing one ISP off against the other for:**

**Service Quality**

**Service Offerings**

**Availability**

# Why Multihome?

Cisco.com

- **Summary:**

**Multihoming is easy to demand as requirement of any operation**

**But what does it really mean:**

**In real life?**

**For the network?**

**For the Internet?**

**And how do we do it?**

# BGP Multihoming Techniques

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

# Multihoming Definition & Options

**What does it mean and how do we do it?**

# 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

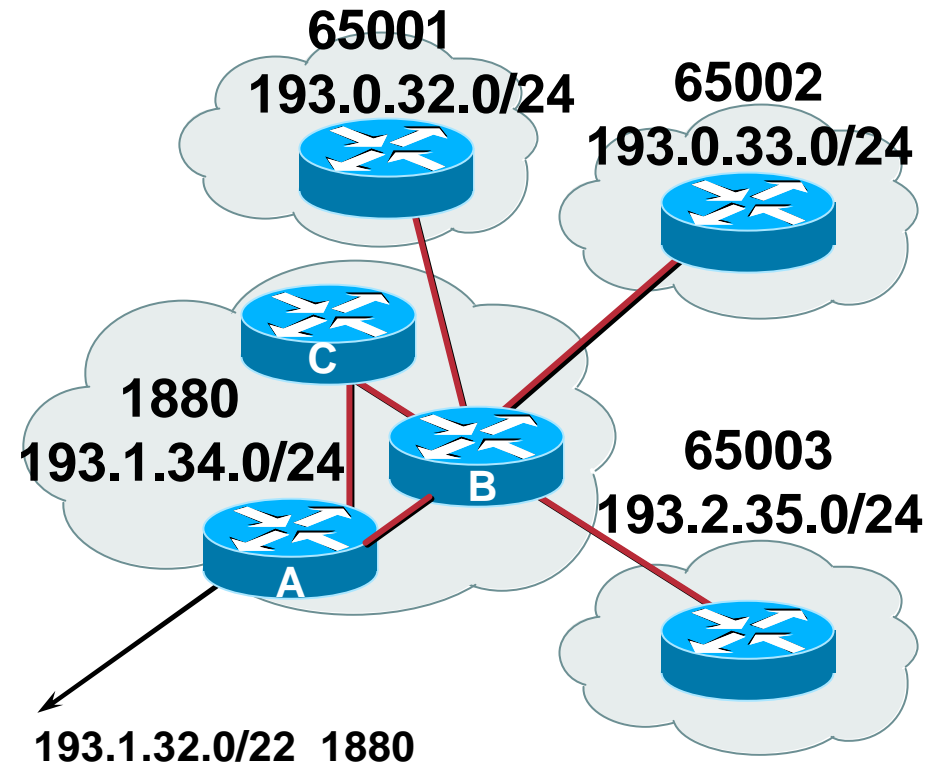
# AS Numbers

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- **An Autonomous System Number is required by BGP**
- **Obtained from upstream ISP or Regional Registry (RIR)**  
**APNIC, ARIN, LACNIC, RIPE NCC**
- **Necessary when you have links to more than one ISP or an exchange point**
- **16 bit integer, ranging from 1 to 65534**  
**Zero and 65535 are reserved**  
**64512 through 65534 are called Private ASNs**

Cisco.com

## Within a BGP Confederation



# Private-AS – removal

Cisco.com

- **Private ASNs MUST be removed from all prefixes announced to the public Internet**

Include configuration to remove private ASNs in the eBGP template

- **As with RFC1918 address space, private ASNs are intended for internal use**

They should not be leaked to the public Internet

- **Cisco IOS**

**neighbor x.x.x.x remove-private-AS**

# Configuring Policy

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- **Three BASIC Principles for IOS configuration examples throughout presentation:**
  - prefix-lists** to filter **prefixes**
  - filter-lists** to filter **ASNs**
  - route-maps** to apply **policy**
- **Route-maps can be used for filtering, but this is more “advanced” configuration**

# 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: Assumptions

Cisco.com

- **MUST** announce assigned address block to Internet
- **MAY** also announce subprefixes – reachability is not guaranteed
- **Current RIR minimum allocation is /20**

Several ISPs filter RIR blocks on this boundary

Several ISPs filter the rest of address space according to the IANA assignments

This activity is called “Net Police” by some

# Originating Prefixes

Cisco.com

- RIRs publish their minimum allocation sizes:
  - APNIC: [www.apnic.net/db/min-alloc.html](http://www.apnic.net/db/min-alloc.html)
  - ARIN: [ww1.arin.net/statistics/index.html#cidr](http://ww1.arin.net/statistics/index.html#cidr)
  - LACNIC: *unknown*
  - RIPE NCC: [www.ripe.net/ripe/docs/smallest-alloc-sizes.html](http://www.ripe.net/ripe/docs/smallest-alloc-sizes.html)
- IANA publishes the address space it has assigned to end-sites and allocated to the RIRs:  
[www.iana.org/assignments/ipv4-address-space](http://www.iana.org/assignments/ipv4-address-space)
- Several ISPs use this published information to filter prefixes on:
  - What should be routed (from IANA)
  - The minimum allocation size from the RIRs

# “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**

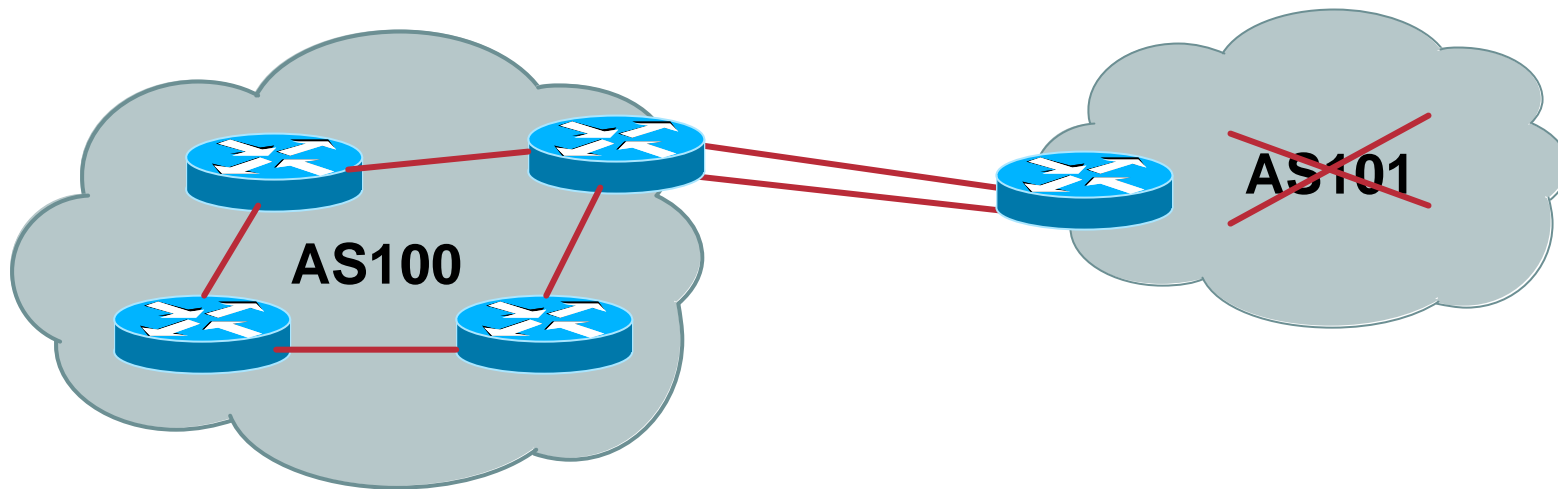
# Multihoming Scenarios

Cisco.com

- **Stub network**
- **Multi-homed stub network**
- **Multi-homed network**
- **Load-balancing**

# Stub Network

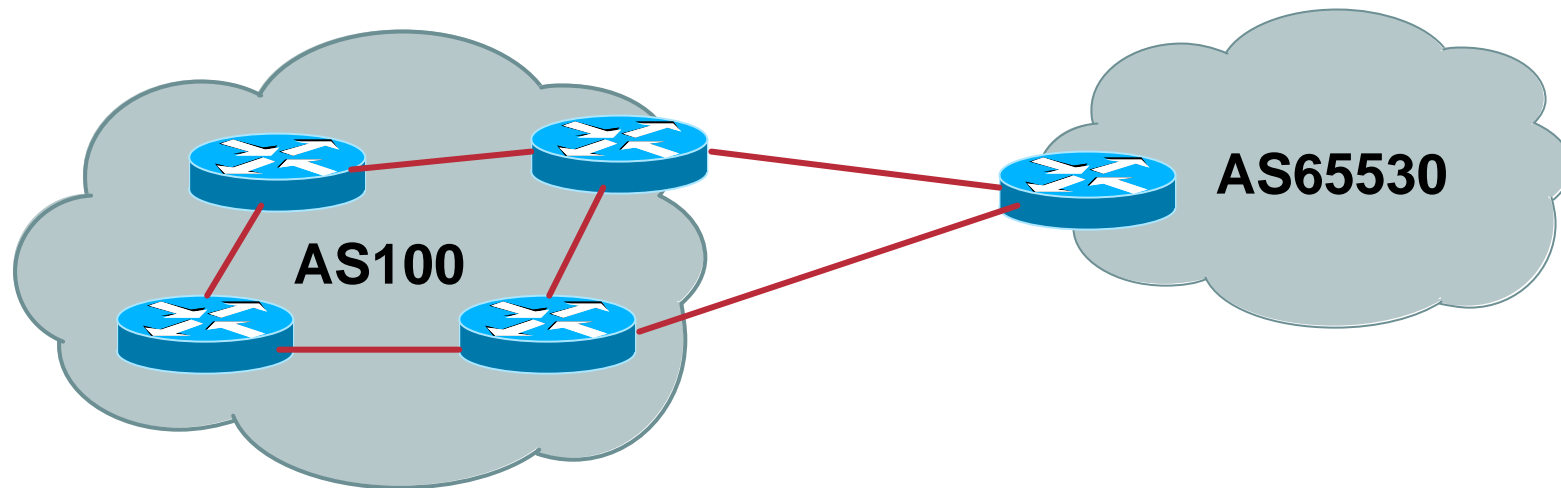
Cisco.com



- **No need for BGP**
- **Point static default to upstream ISP**
- **Router will load share on the two parallel circuits**
- **Upstream ISP advertises stub network**
- **Policy confined within upstream ISP's policy**

# Multi-homed Stub Network

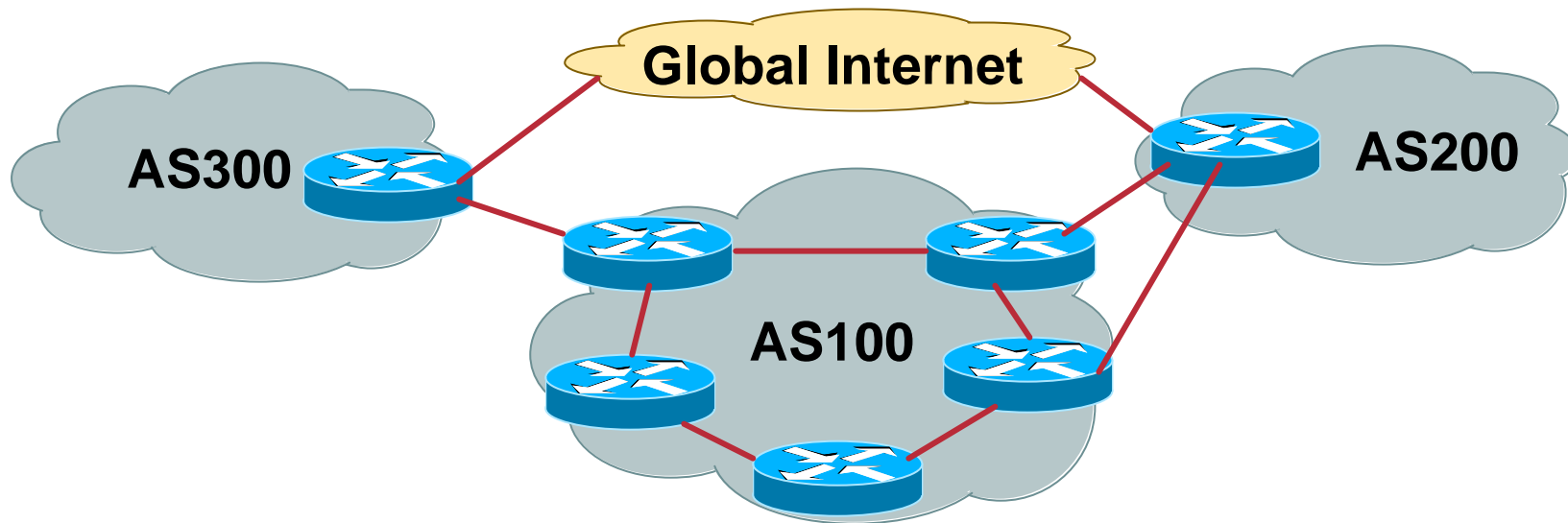
Cisco.com



- 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

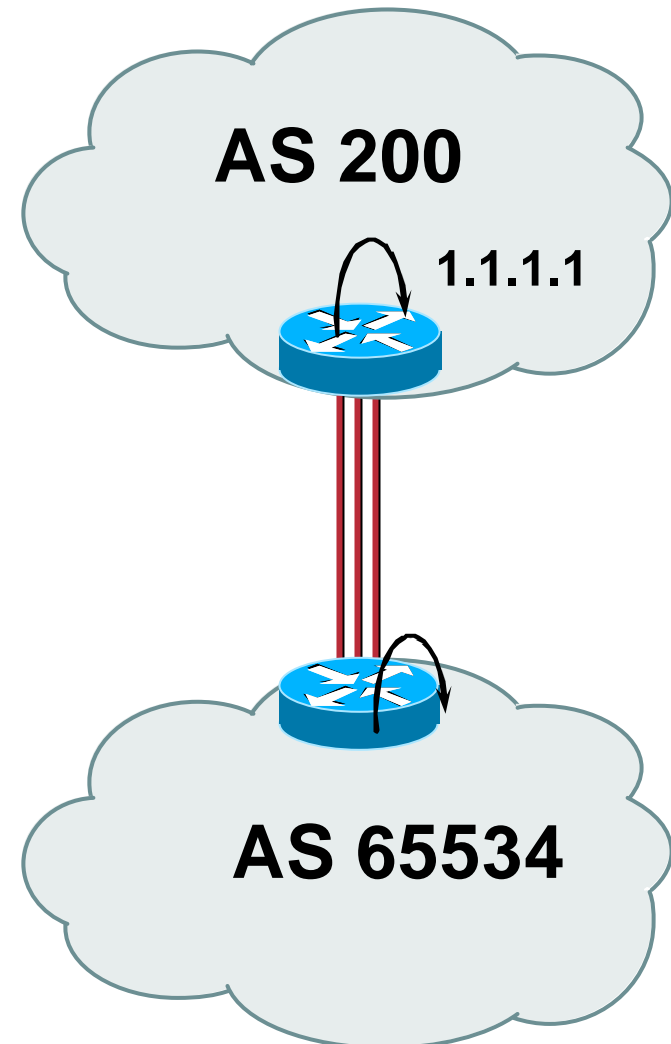
## – Example One

Cisco.com

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

- **Cisco IOS**

```
router bgp 65534
  neighbor 1.1.1.1 remote-as 200
  neighbor 1.1.1.1 ebgp-multihop 2
!
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

Cisco.com

- **Try and avoid use of ebgp-multihop unless:**  
It's absolutely necessary **–or–**  
Loadsharing across multiple links
- **Many ISPs discourage its use, 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

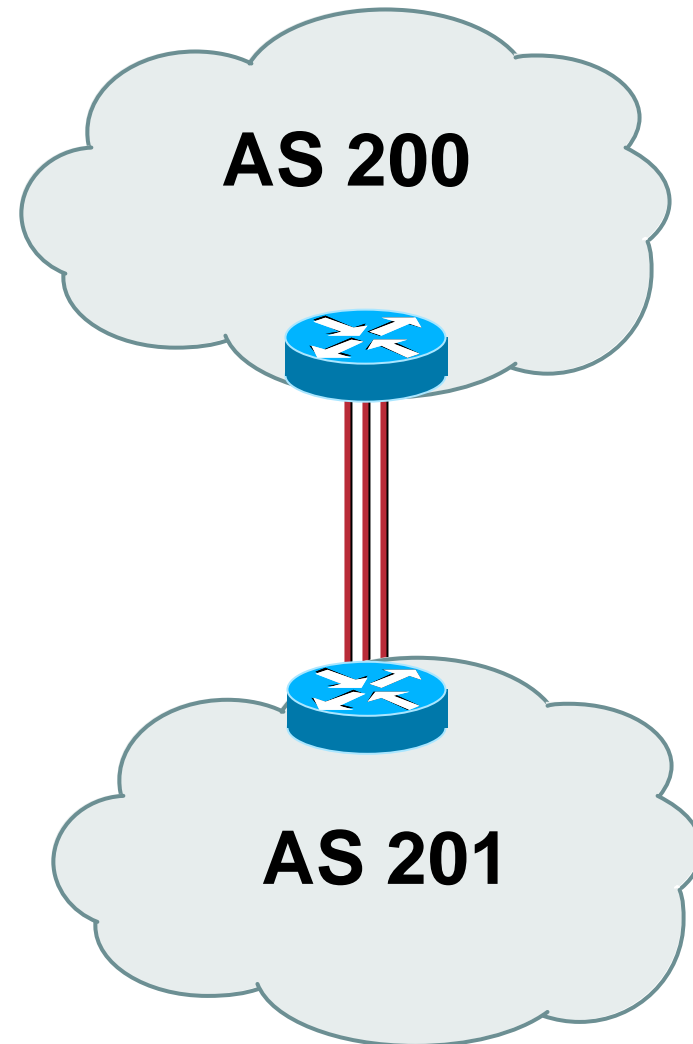
# Multiple Sessions to an ISP

## – Example Two

Cisco.com

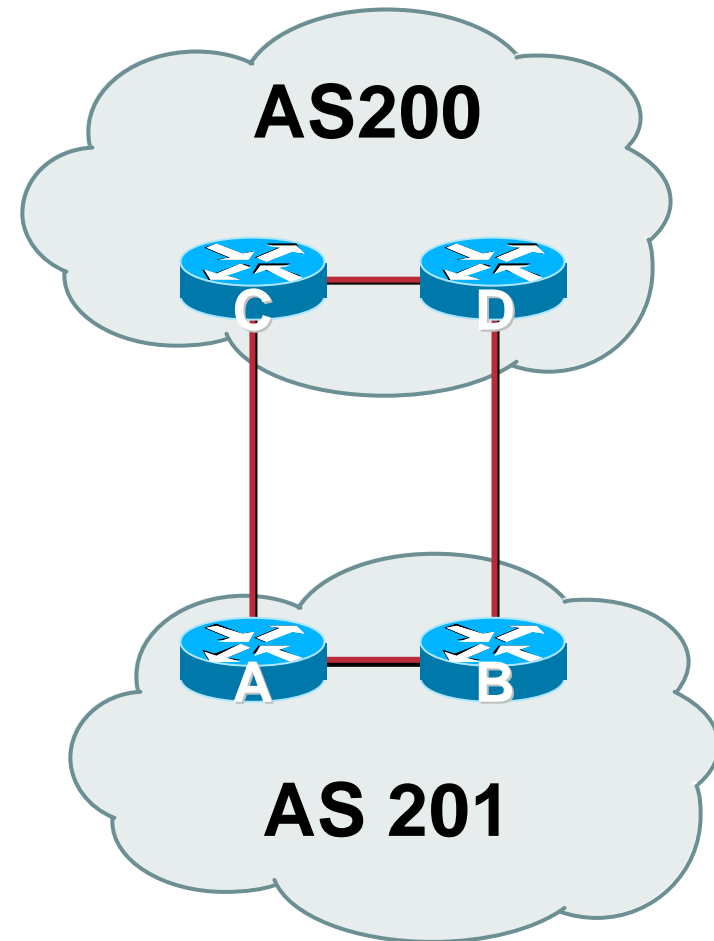
- **BGP multi-path**
- **Three BGP sessions required**
- **limit of 6 parallel paths in Cisco IOS**
- **Cisco IOS Configuration**

```
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

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



# BGP Multihoming Techniques

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- **Why Multihome?**
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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)**

**There is no need or justification for a public ASN**

**Making the nets of the end-site visible gives no useful information to the Internet**

- **upstream ISP proxy aggregates**

**in other words, announces only your address block to the Internet from their AS (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 (one as backup only)

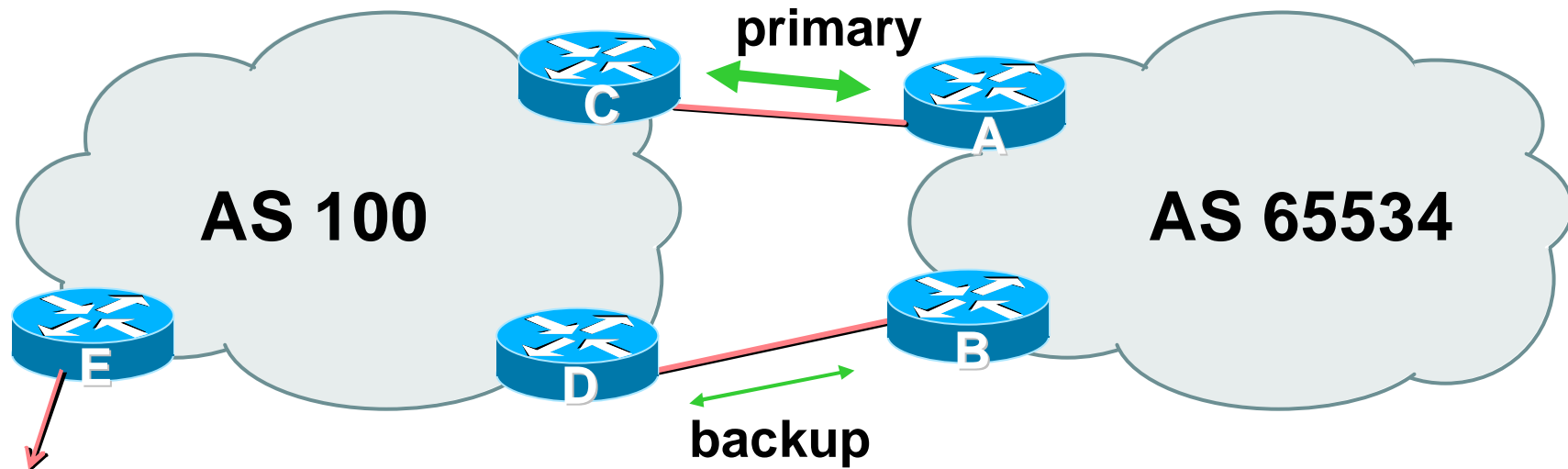
Cisco.com

- **Applies when end-site has bought a large primary WAN link to their upstream a small secondary WAN link as the backup**

**For example, primary path might be a T1,  
backup might be 56kbps**

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

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- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

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

Cisco.com

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

**primary link:**

**Outbound – announce /19 unaltered**

**Inbound – receive default route**

**backup link:**

**Outbound – announce /19 with increased metric**

**Inbound – received default, and reduce local preference**

- **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 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 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)

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 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 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

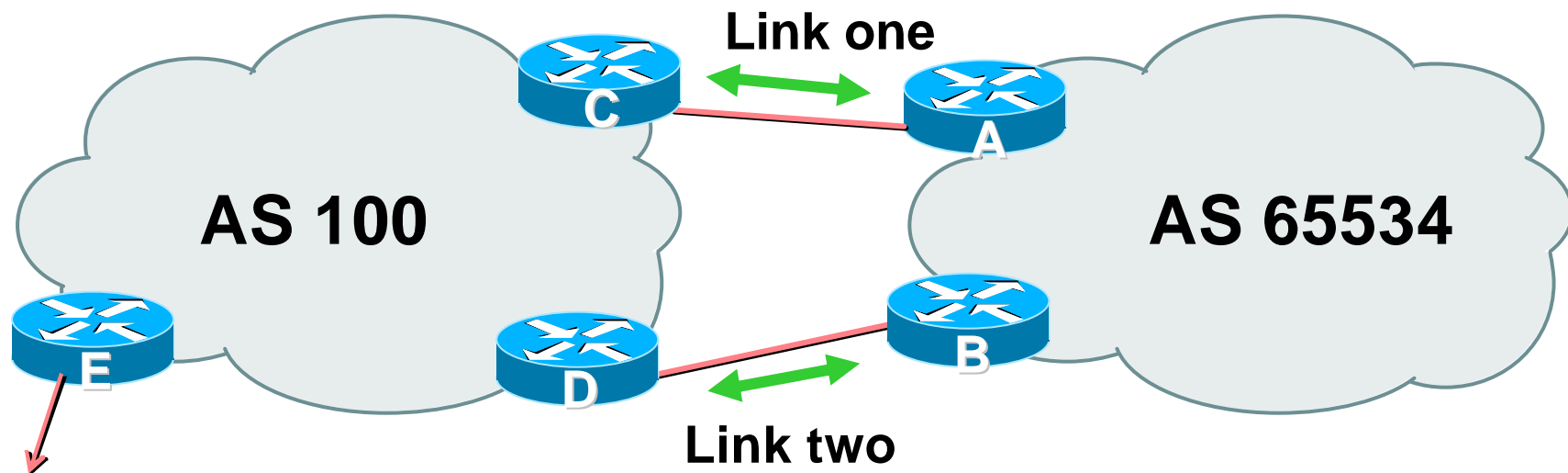
# Loadsharing to the same ISP

Cisco.com

- **More common case**
- **End sites tend not to buy circuits and leave them idle, only used for backup as in previous example**
- **This example assumes equal capacity circuits**  
**Unequal capacity circuits requires more refinement – see later**

# Loadsharing to the same ISP

Cisco.com



- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

# Loadsharing to the same ISP

Cisco.com

- **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

Cisco.com

- **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)**

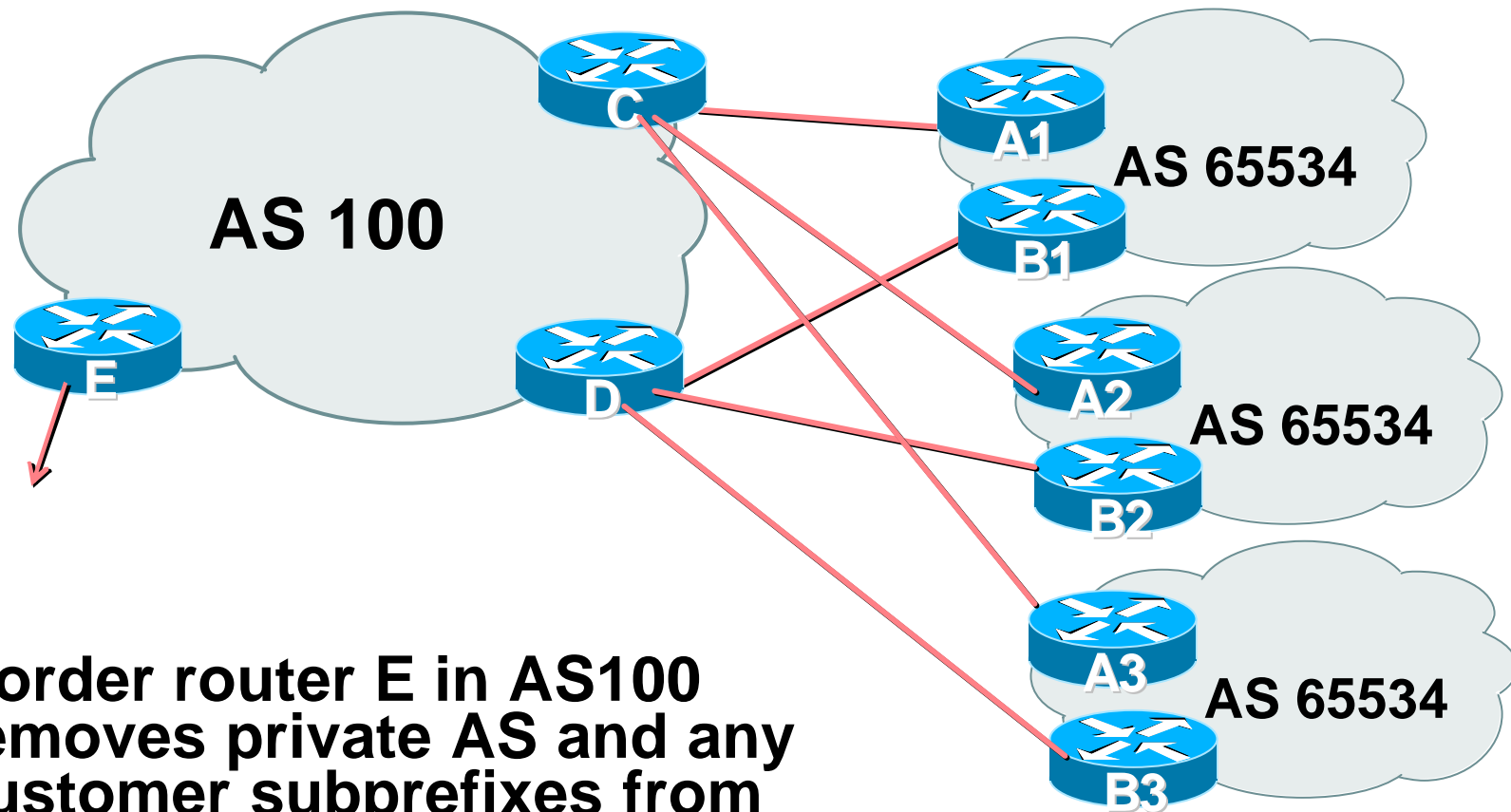
# Multiple Dualhomed Customers (RFC2270)

Cisco.com

- **Unusual for an ISP just to have one dualhomed customer**  
**Valid/valuable service offering for an ISP with multiple PoPs**  
**Better for ISP than having customer multihome with another provider!**
- **Look at scaling the configuration**
  - ▮ **Simplifying the configuration**  
**Using templates, peer-groups, etc**  
**Every customer has the same configuration (basically)**

# Multiple Dualhomed Customers (RFC2270)

Cisco.com



- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

# Multiple Dualhomed Customers

Cisco.com

- **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<sub>n</sub>* and *B<sub>n</sub>* configuration same as Router A and B previously**

# Multiple Dualhomed Customers

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

Cisco.com

- 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

Cisco.com

```
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

Cisco.com

- **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

Cisco.com

- 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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- **Why Multihome?**
- **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

But some people don't like the "inconsistent-AS" which results from use of a private-AS

- **Address space comes from**

both upstreams **or**

Regional Internet Registry

- **Configuration concepts very similar**

# Inconsistent-AS?

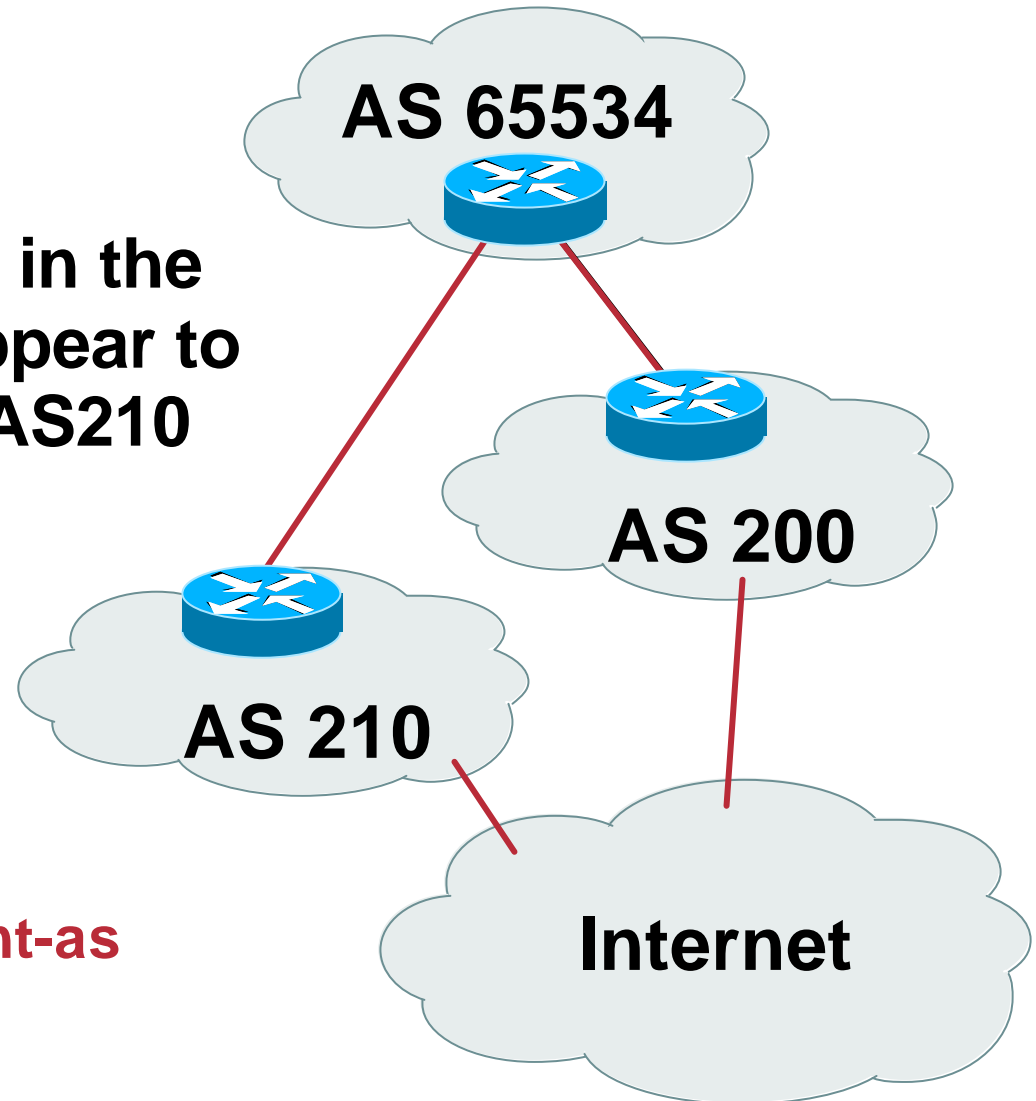
Cisco.com

- Viewing the prefixes originated by AS65534 in the Internet shows they appear to be originated by both AS210 and AS200

This is NOT bad

Nor is it illegal

- IOS command is  
**show ip bgp inconsistent-as**



# Two links to different ISPs

**One link primary, the other link backup only**

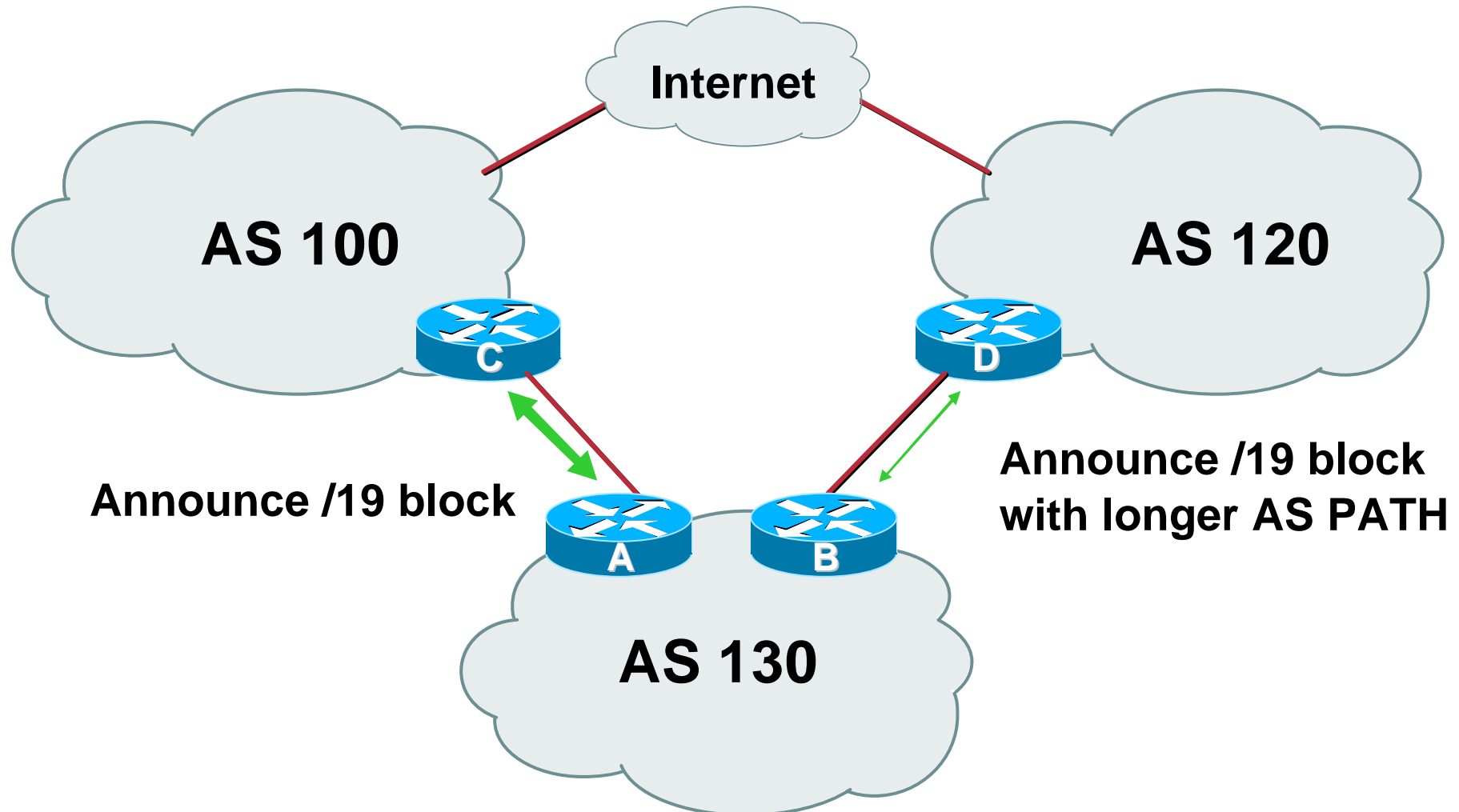
## Two links to different ISPs (one as backup only)

Cisco.com

- **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)

Cisco.com



# 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 (one as backup only)

Cisco.com

- **Not a common situation as most sites tend to prefer using whatever capacity they have**
- **But it shows the basic concepts of using local-prefs and AS-path prepends for engineering traffic in the chosen direction**

# Two links to different ISPs

With Loadsharing

# Two links to different ISPs (with loadsharing)

Cisco.com

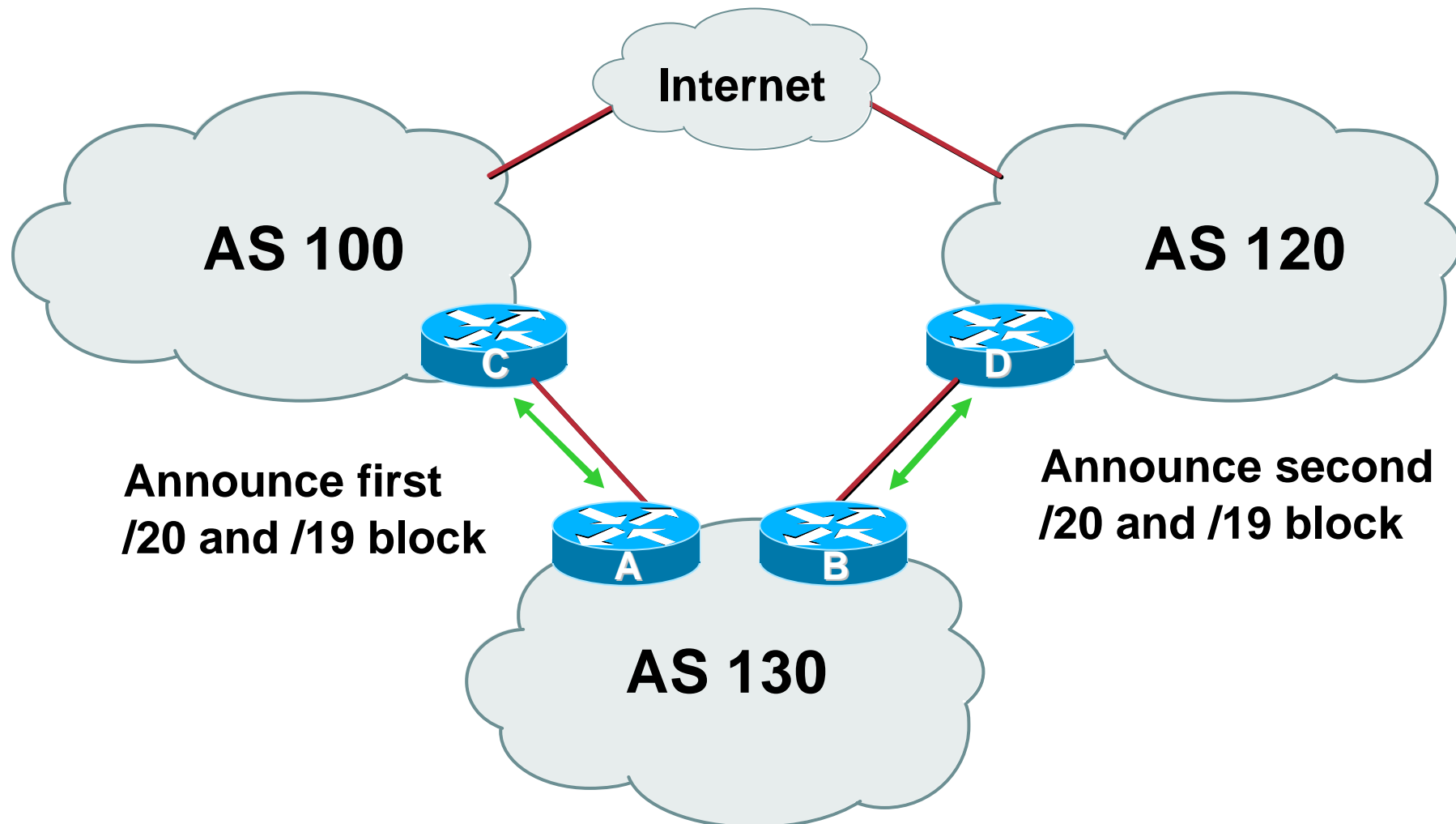
- **Announce /19 aggregate on each link**
- **Split /19 and announce as two /20s, one on each link**

## 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)

Cisco.com



# 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 (with loadsharing)

Cisco.com

- **Loadsharing in this case is very basic**
- **But shows the first steps in designing a load sharing solution**

**Start with a simple concept**

**And build on it...!**

# Two links to different ISPs

## More Controlled Loadsharing

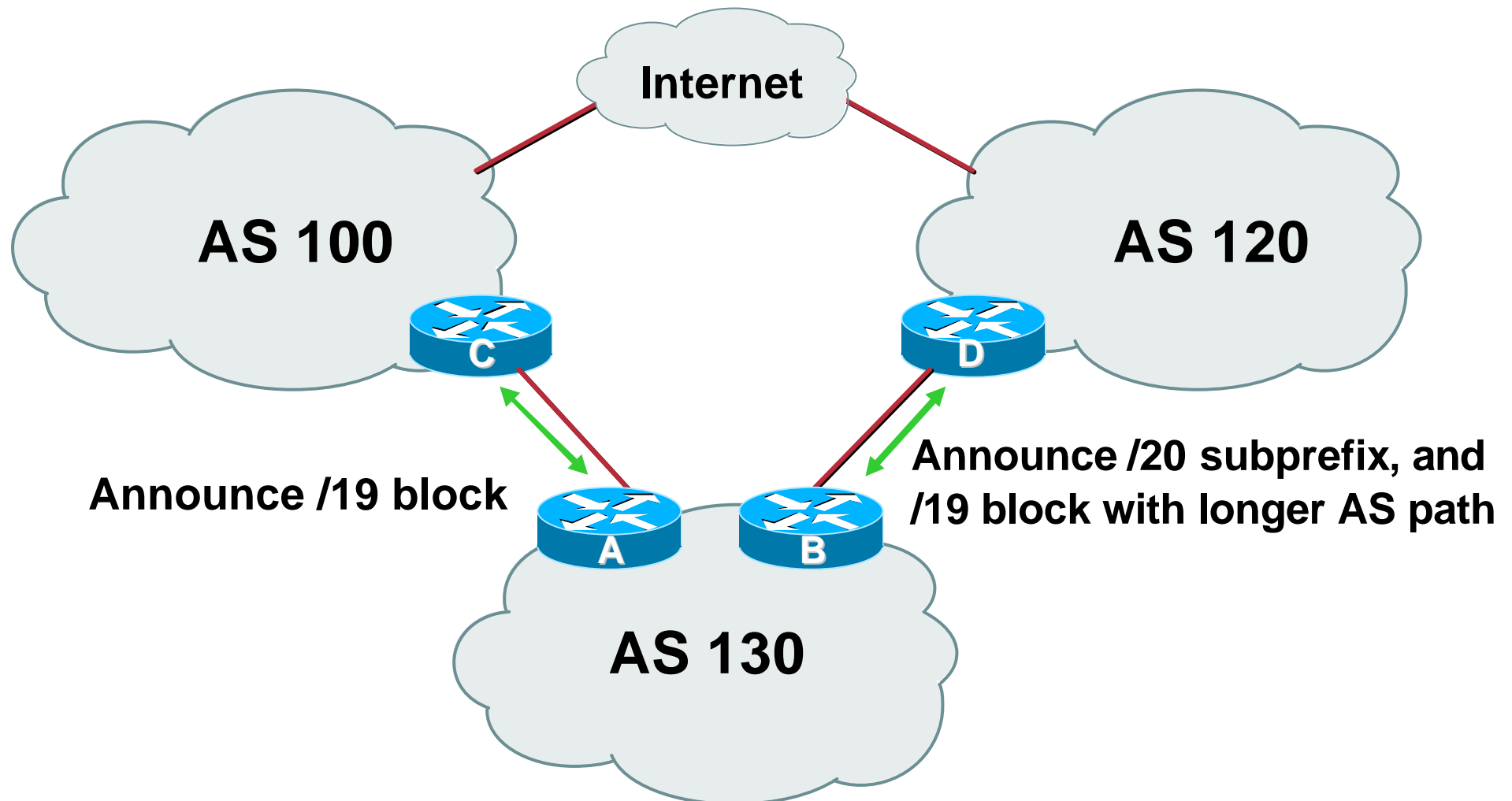
# Loadsharing with different ISPs

Cisco.com

- **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
```

# Loadsharing with different ISPs

Cisco.com

- **This example is more commonplace**
- **Shows how ISPs and end-sites subdivide address space frugally, as well as use the AS-PATH prepend concept to optimise the load sharing between different ISPs**
- **Notice that the /19 aggregate block is ALWAYS announced**

# BGP Multihoming Techniques

Cisco.com

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

# Service Provider Multihoming

# Service Provider Multihoming

Cisco.com

- **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 MYTHS!!

Cisco.com

- **Common MYTHS**
- **1: You need the full routing table to multihome**
  - People who sell router memory would like you to believe this
  - Only true if you are a transit provider
  - Full routing table can be a significant hindrance to multihoming
- **2: You need a BIG router to multihome**
  - Router size is related to data rates, not running BGP
  - In reality, to multihome, your router needs to:
    - Have two interfaces,
    - Be able to talk BGP to at least two peers,
    - Be able to handle BGP attributes,
    - Handle at least one prefix
- **3: BGP is complex**
  - In the wrong hands, yes it can be! Keep it Simple!

# 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

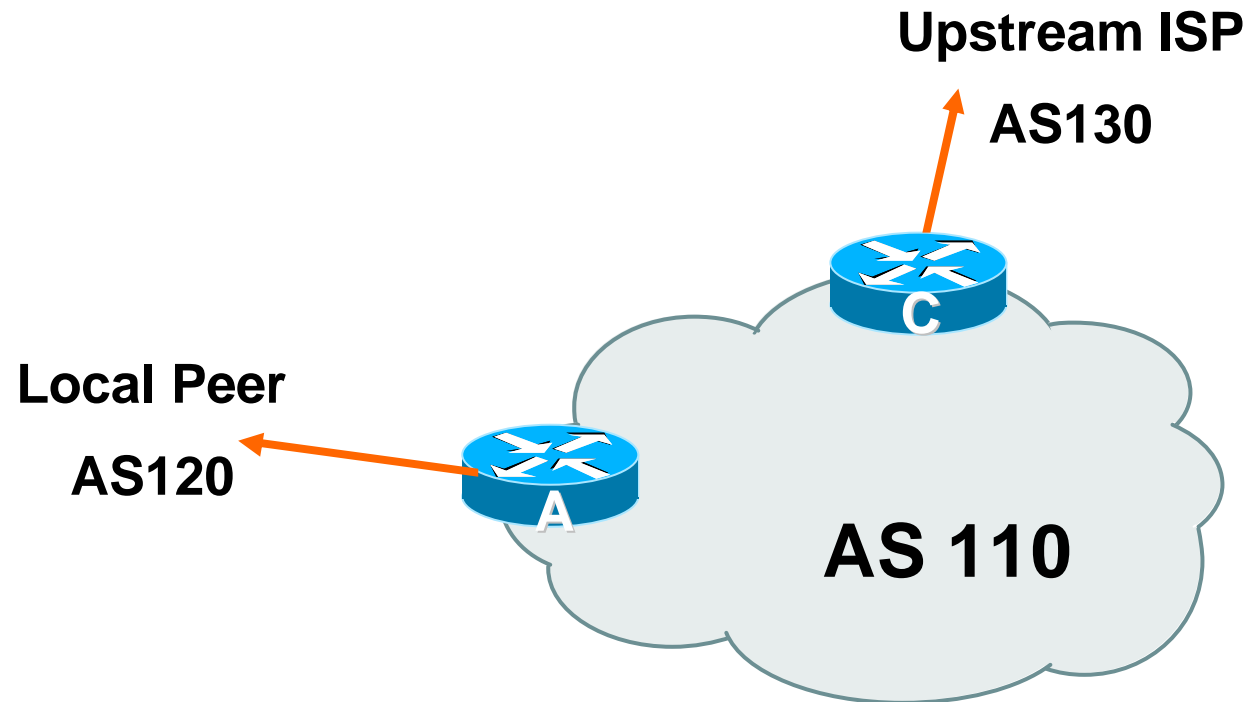
Cisco.com

- **Very common situation in many regions of the Internet**
- **Connect to upstream transit provider to see the “Internet”**
- **Connect to the local competition so that local traffic stays local**

**Saves spending valuable \$ on upstream transit costs for local traffic**

# One Upstream, One Local Peer

Cisco.com



# 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

- 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

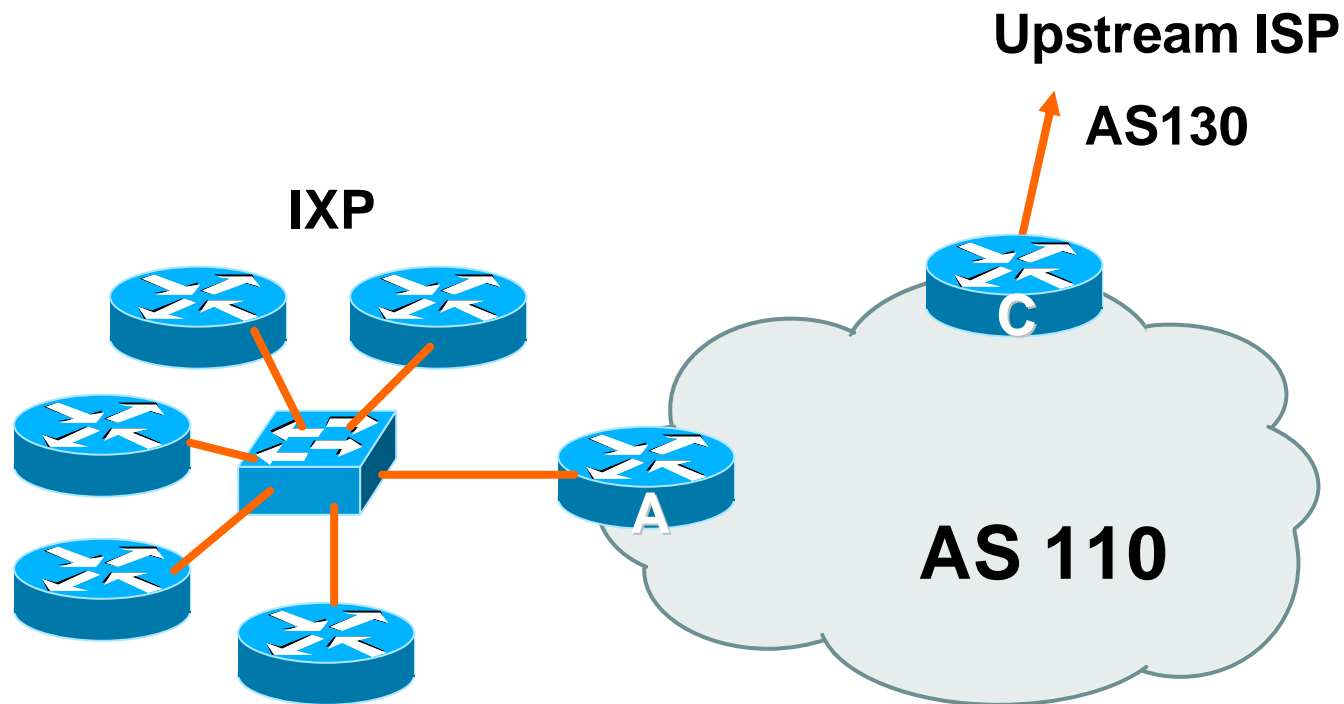
Cisco.com

- **Very common situation in many regions of the Internet**
- **Connect to upstream transit provider to see the “Internet”**
- **Connect to the local Internet Exchange Point so that local traffic stays local**

**Saves spending valuable \$ on upstream transit costs for local traffic**

# One Upstream, Local Exchange Point

Cisco.com



# 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

- **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

- **Connect to both upstream transit providers to see the “Internet”**

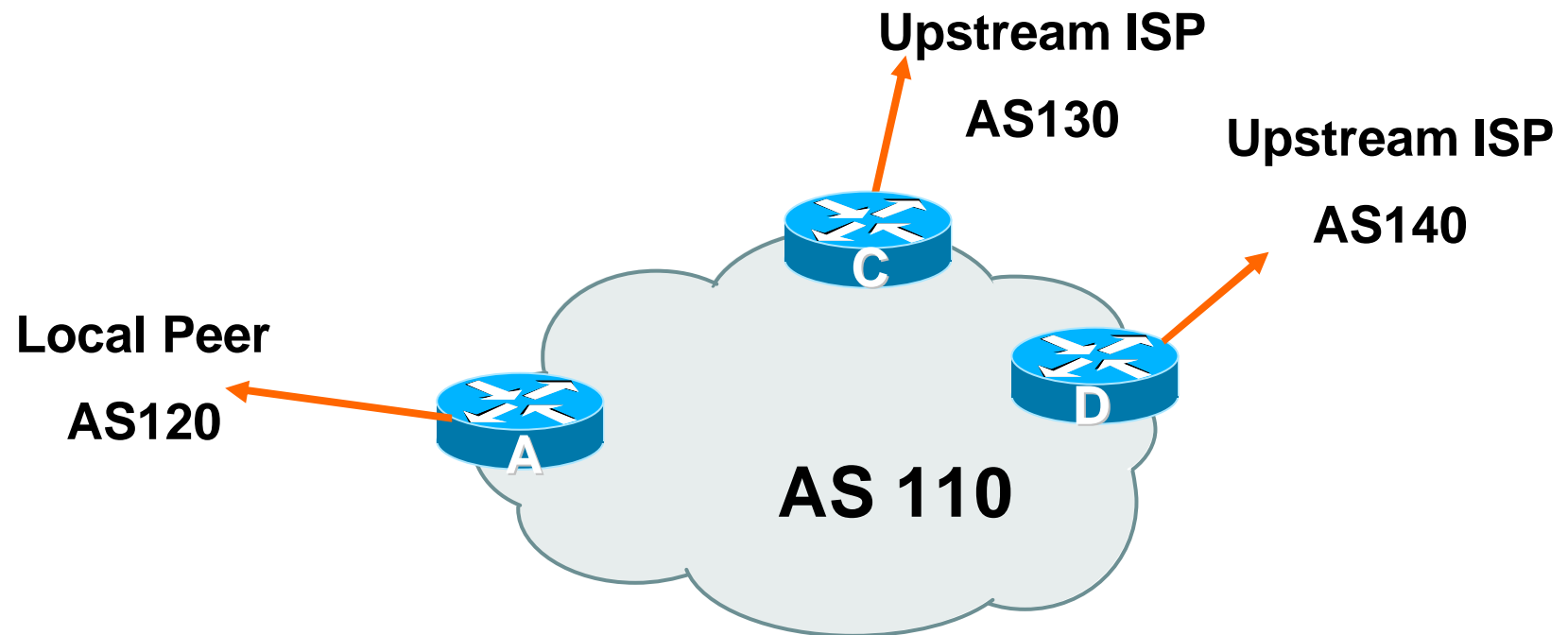
**Provides external redundancy and diversity – the reason to multihome**

- **Connect to the local peer so that local traffic stays local**

**Saves spending valuable \$ on upstream transit costs for local traffic**

# Two Upstreams, One Local Peer

Cisco.com



# 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

- **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

Cisco.com

- **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 lots of memory and CPU**

**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

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

## 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 AS140 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

Cisco.com

```
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**

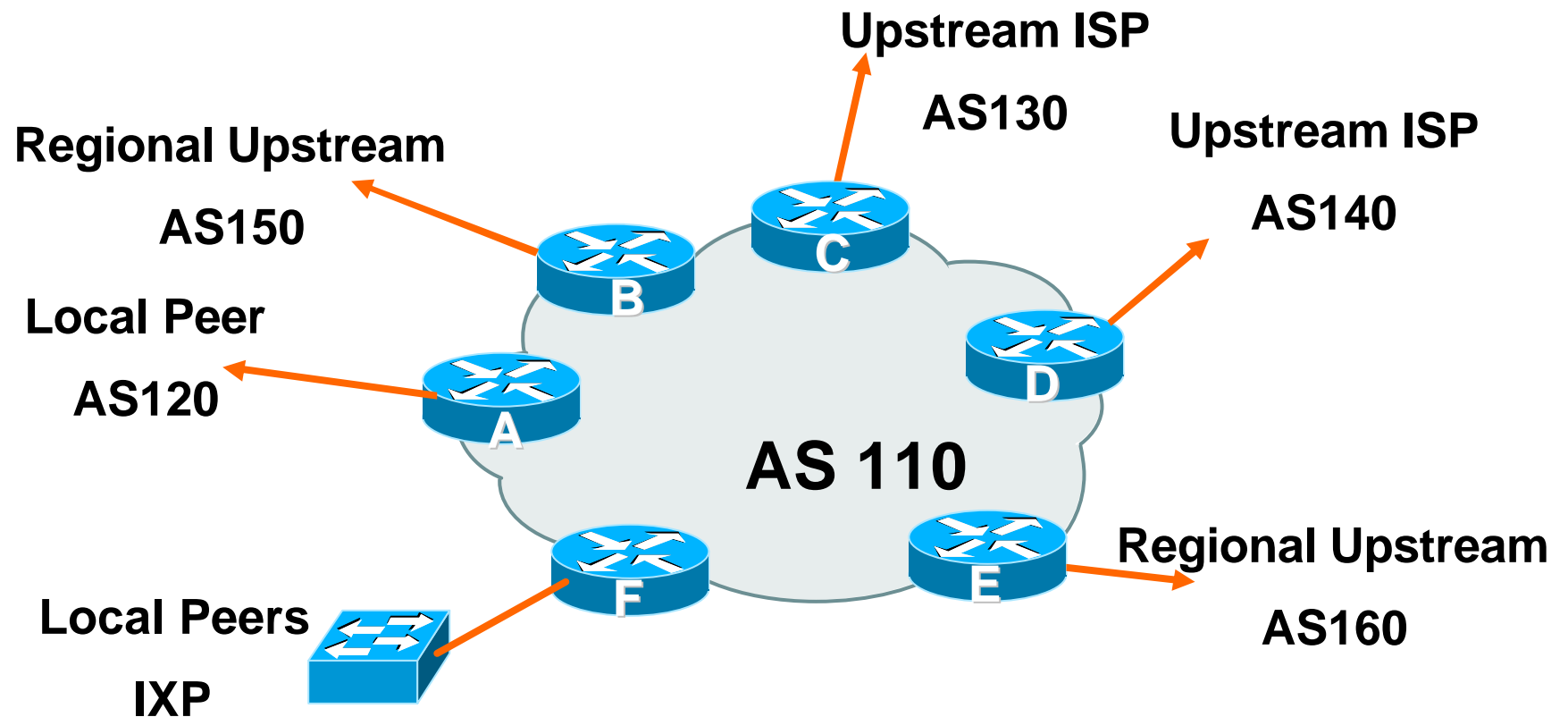
# Tier-1 & Regional Upstreams, Local Peers

Cisco.com

- **This is a complex example, bringing together all the concepts learned so far**
- **Connect to both upstream transit providers to see the “Internet”**
  - Provides external redundancy and diversity – the reason to multihome**
- **Connect to regional upstreams**
  - Hopefully a less expensive and lower latency view of the regional internet than is available through upstream transit provider**
- **Connect to private peers for local peering purposes**
- **Connect to the local Internet Exchange Point so that local traffic stays local**
  - Saves spending valuable \$ on upstream transit costs for local traffic**

# Tier-1 & Regional Upstreams, Local Peers

Cisco.com



# 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 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

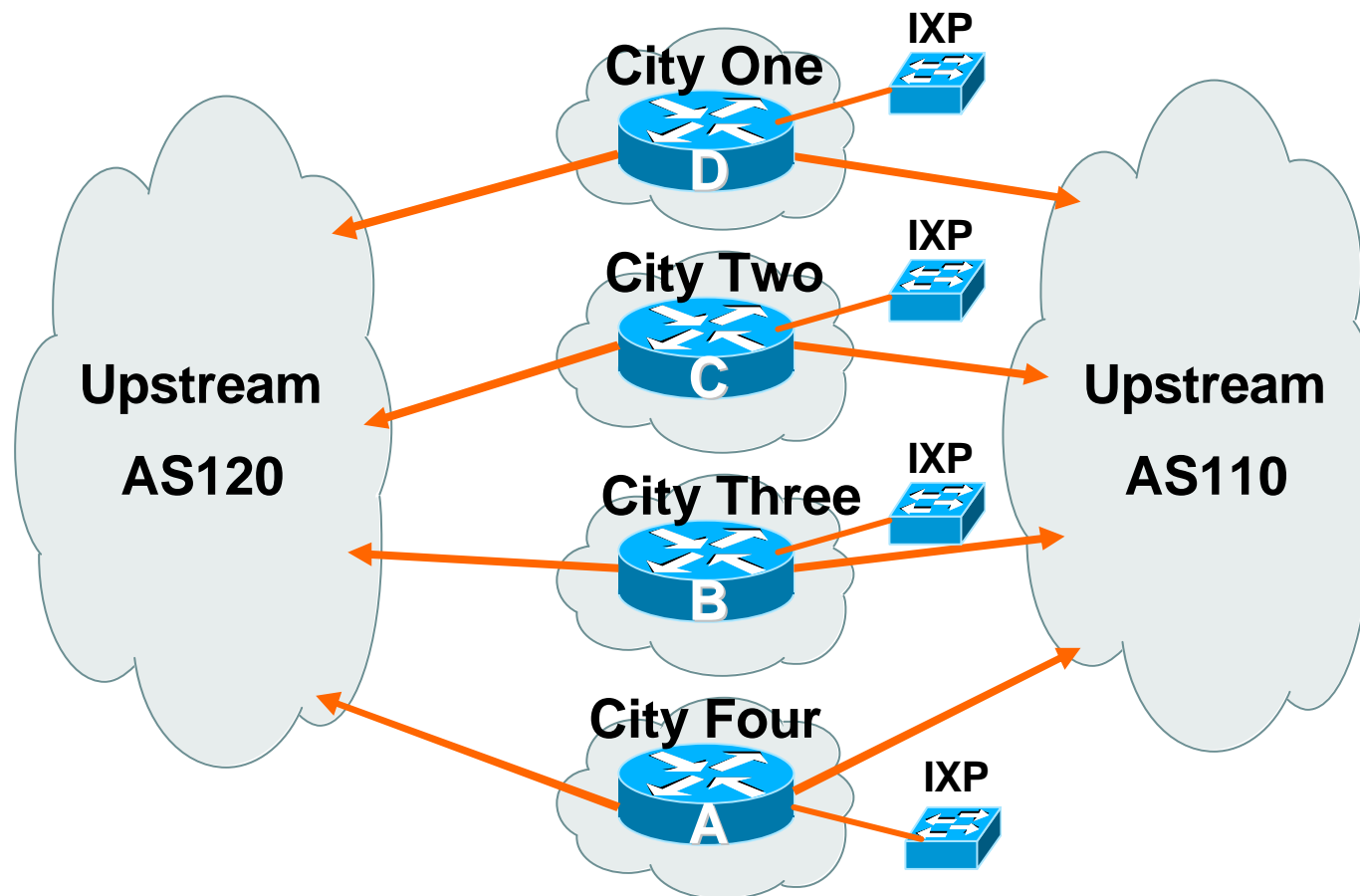
# Disconnected Backbone

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**
- **This is to show how it could be done**
  - Not impossible, nothing “illegal”**

# 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

Cisco.com

- 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

Cisco.com

```
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**

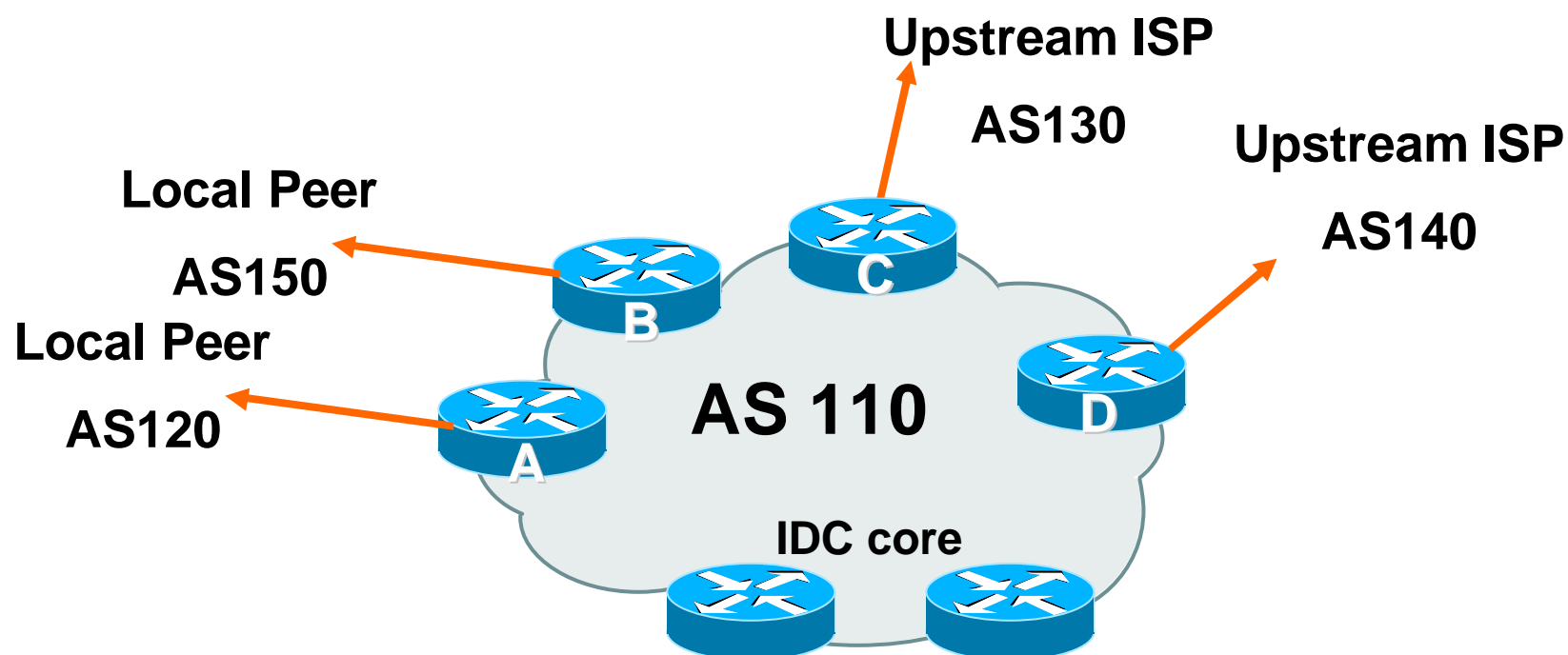
**Should be apportioned according to size of circuit to upstream**

- **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

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

# Communities

**How they are used in practice**

# Using Communities: 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**

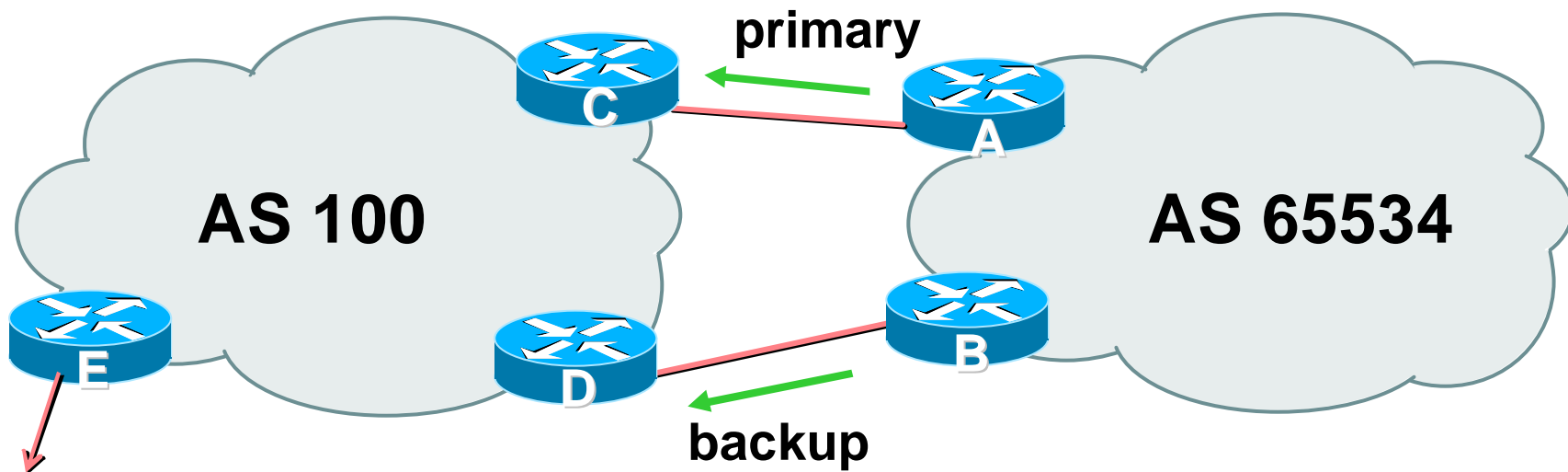
**if you do, insert comment in AS object in the IRR**

# 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
```

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

Cisco.com

- **This is a simple example**
- **It looks more complicated than the same example presented earlier which used local preference and MEDs**
- **But the advantage is that this scales better**  
**With larger configurations, more customers, more options, it becomes easier to handle each and every requirement**

# **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

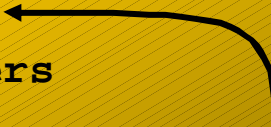
## UUNET

```
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 ISP

## 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

- **Why Multihome?**
- **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**

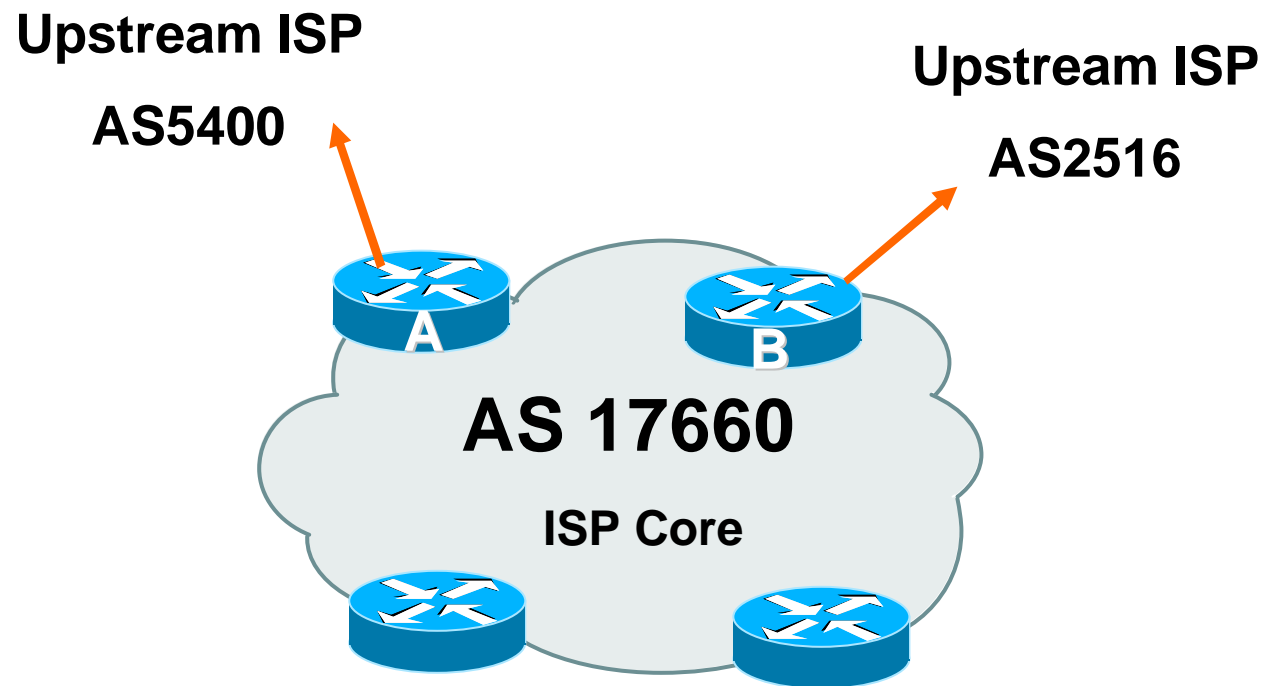
# Case Study – Requirements (2)

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**

*Those myths again* ☹️

**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**

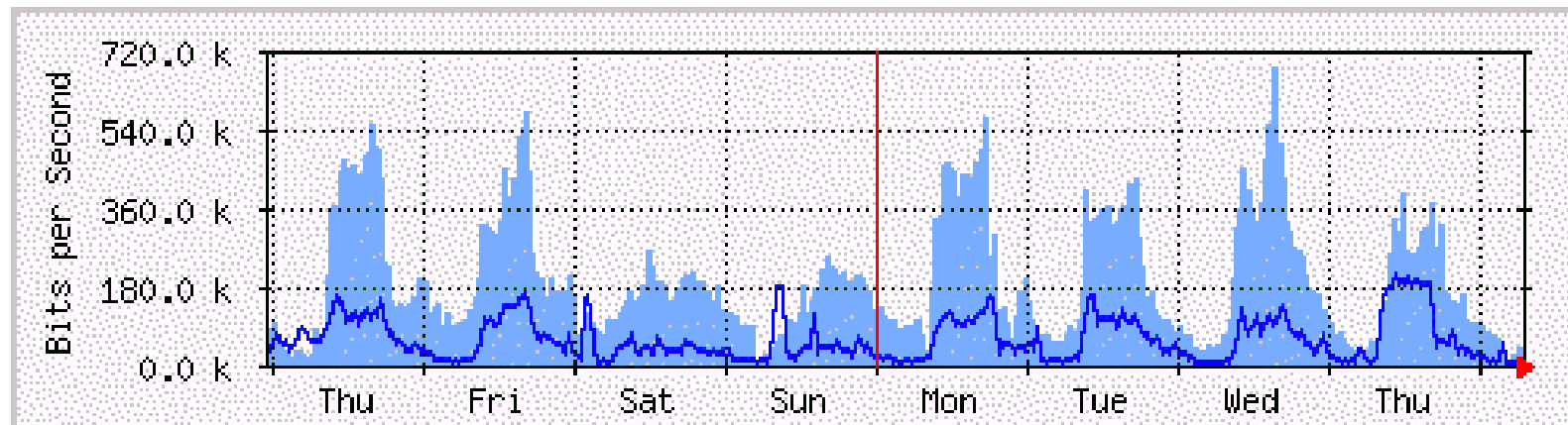
**Around 200kbps on average**

**Mostly symmetric**

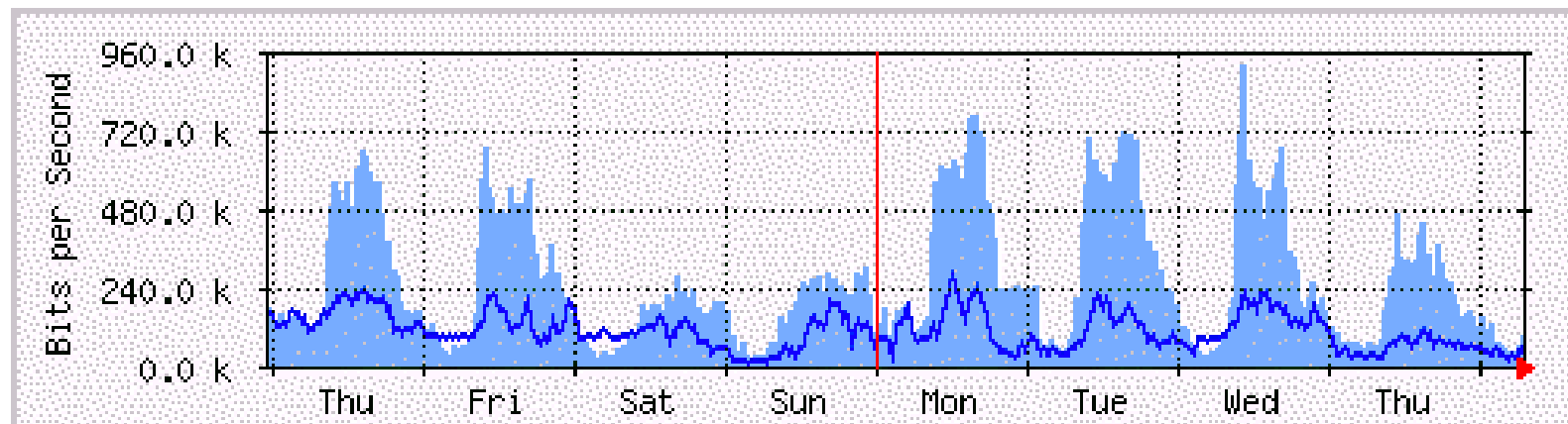
# Case Study

## 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)**

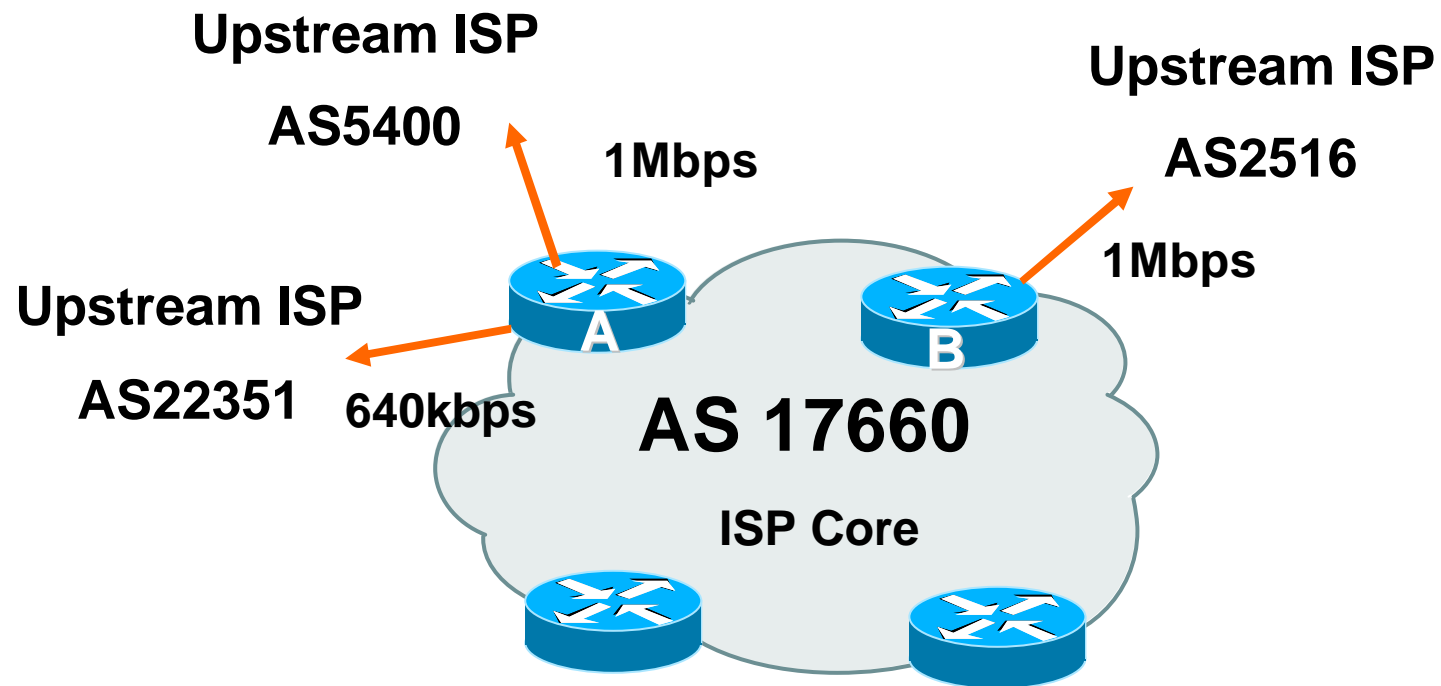
- international circuits are expensive**

- 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**

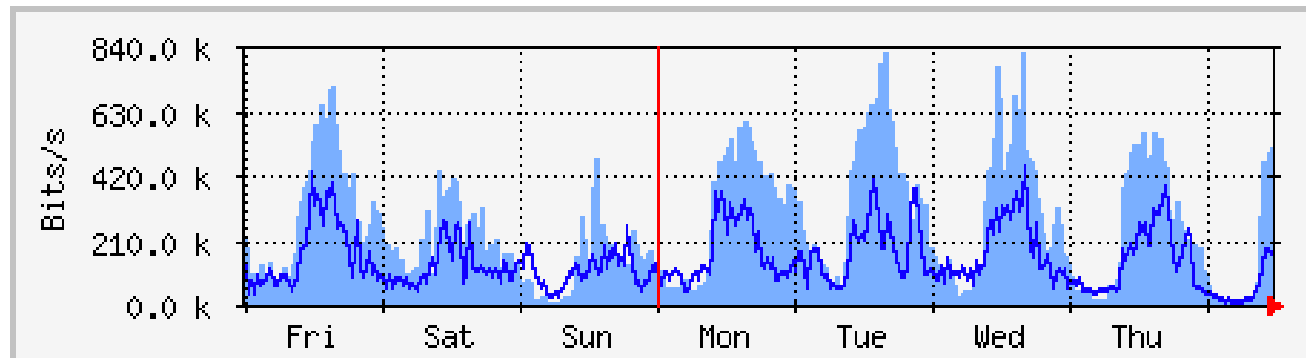
- **Status:**

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

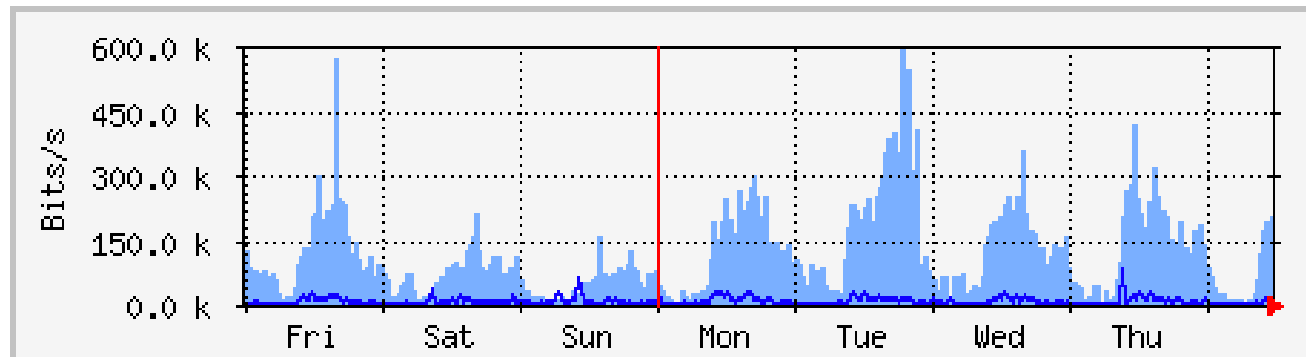
# Case Study

## MRTG Graphs

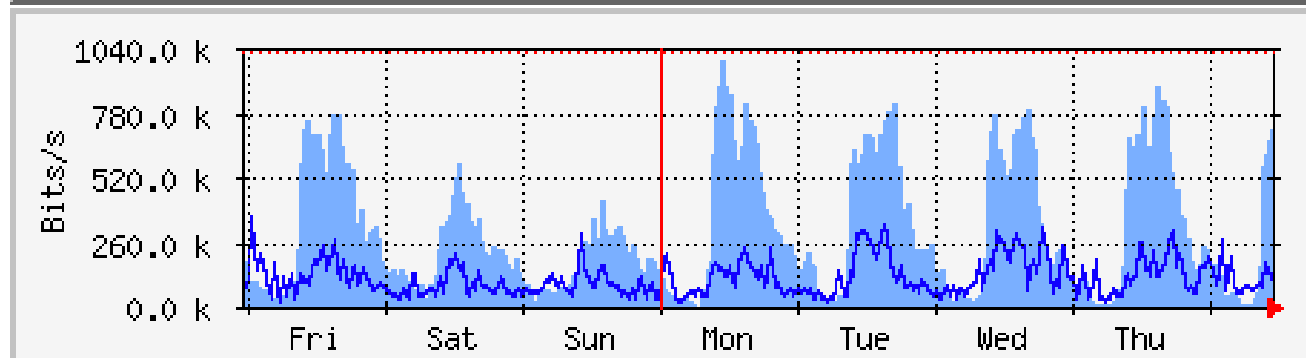
Cisco.com



**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**

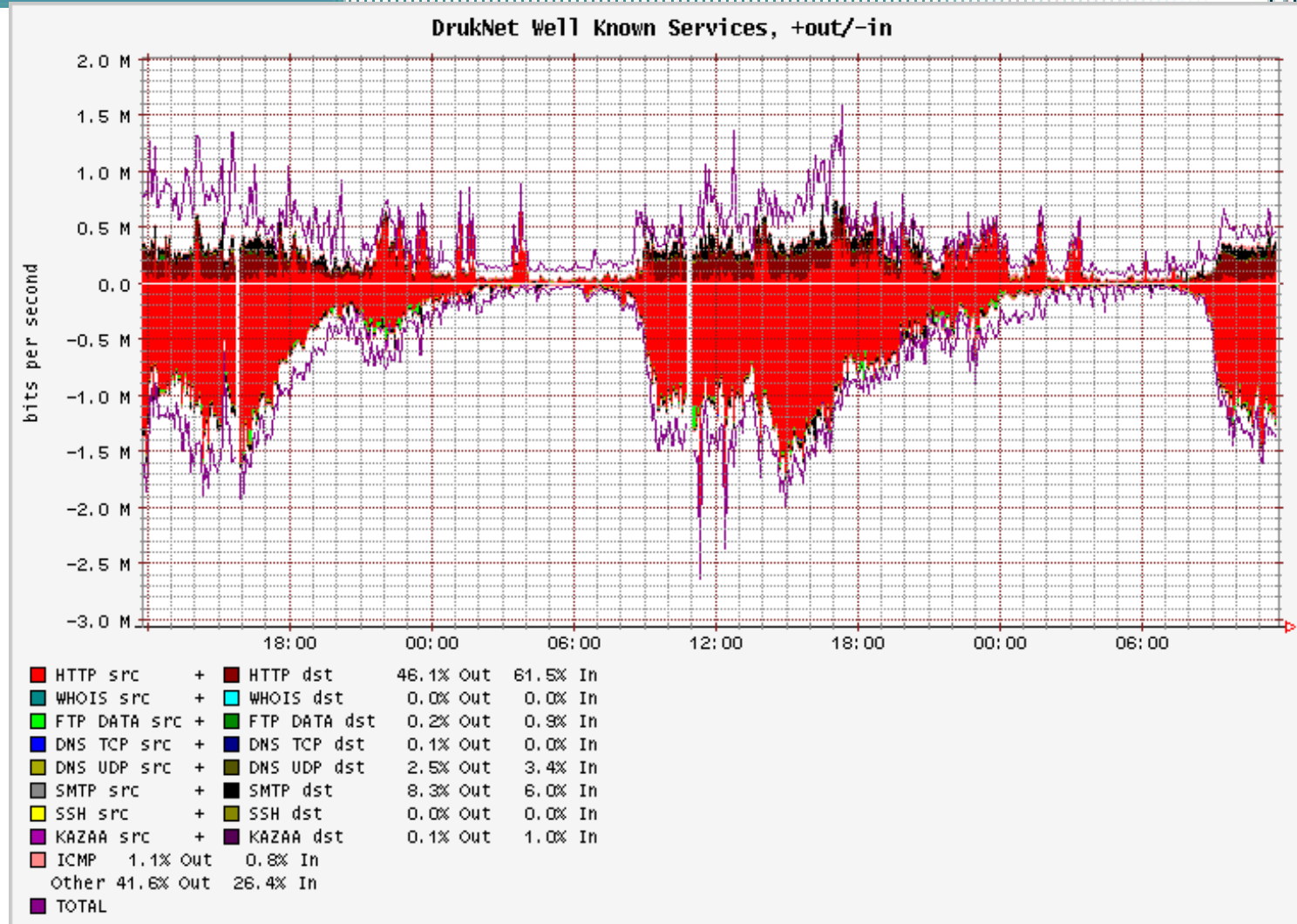
**Inbound and outbound ACLs on border routers had tcp/1214 filters added**

```
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

# Case Study 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 & Stupid!***

- **Full routing table is rarely required**

**A default is just as good**

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

# BGP Multihoming Techniques

**End of Tutorial**