BGP Multihoming Techniques

Philip Smith <pfs@cisco.com>

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Presentation Slides

- **Available on**

  ftp://ftp-eng.cisco.com/pfs/seminars/

Preliminaries

- **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

- Why Multihome?
- Definition & Options
- Preparing the Network
- 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?

- 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?

- **Reliability**

  Business critical applications demand continuous availability

  Lack of redundancy implies lack of reliability implies loss of revenue

Why Multihome?

- **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?

- Not really a reason, but oft quoted…
- Leverage:

  Playing one ISP off against the other for:

    Service Quality

    Service Offerings

    Availability

Why Multihome?

- **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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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

Private-AS – Application

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- **Applications**

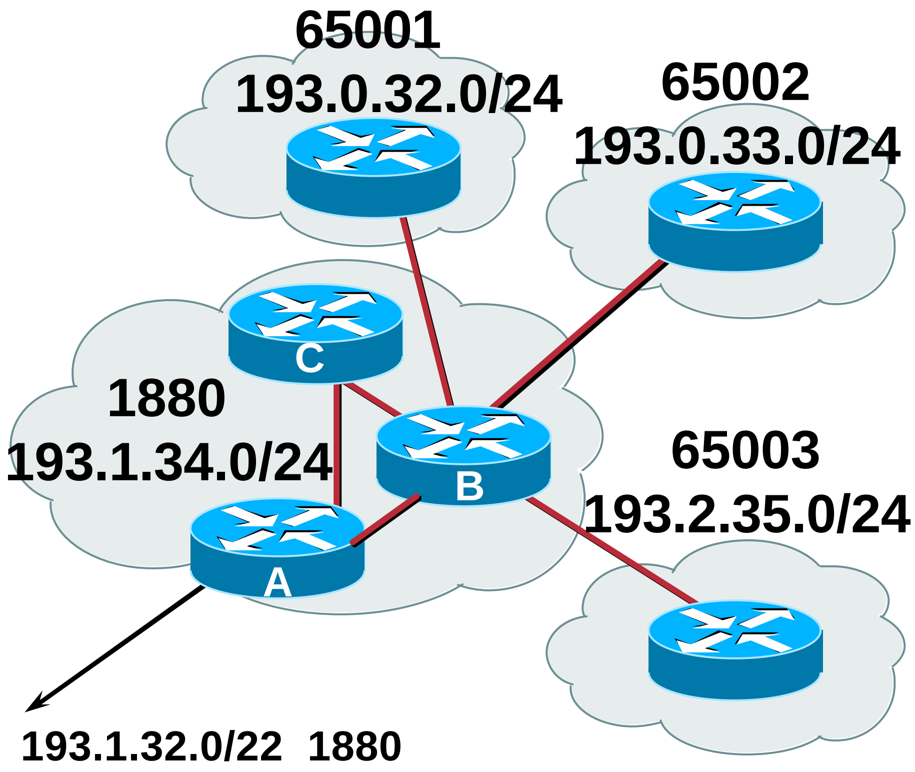
  An ISP with customers multihomed on their backbone (RFC2270)

  -or-

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

  -or-

  Within a BGP Confederation



Private-AS – removal

- **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

- **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

- **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

- **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

- **RIRs publish their minimum allocation sizes:**

  APNIC: www.apnic.net/db/min-alloc.html

  ARIN: ww1.arin.net/statistics/index.html#cidr

  LACNIC: *unknown*

  RIPE NCC: 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

- **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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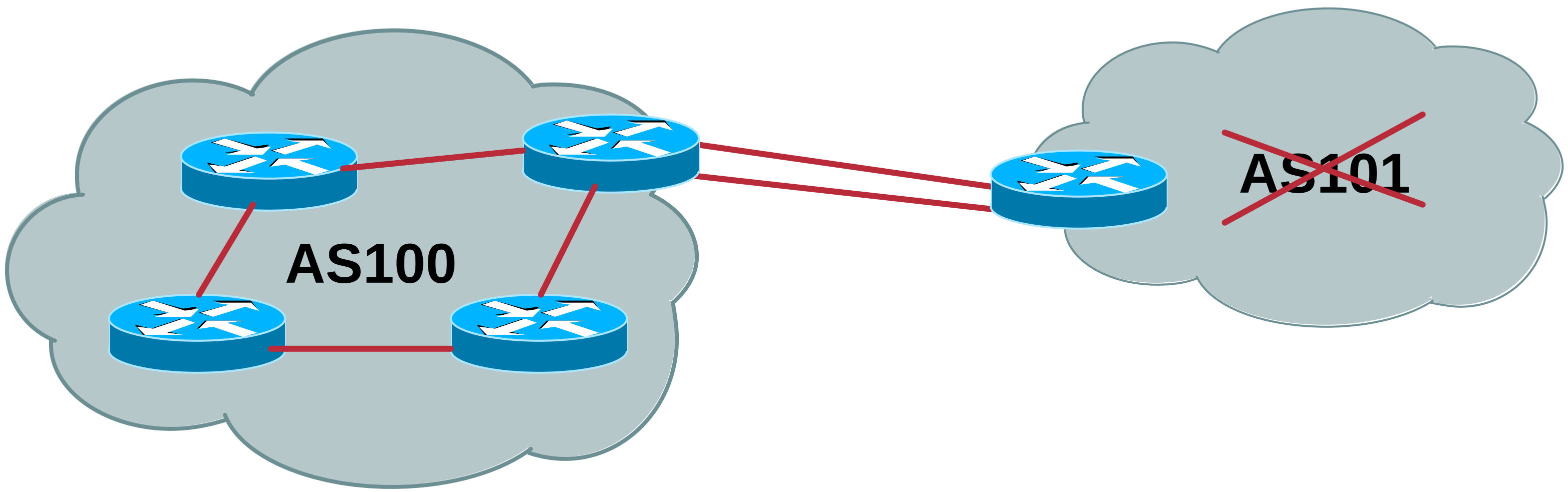
- meant to "punish" ISPs who pollute the routing table with specifics rather than announcing aggregates
- impacts legitimate multihoming especially at the Internet's edge
- impacts regions where domestic backbone is unavailable or costs $$$ compared with international bandwidth
- hard to maintain – requires 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

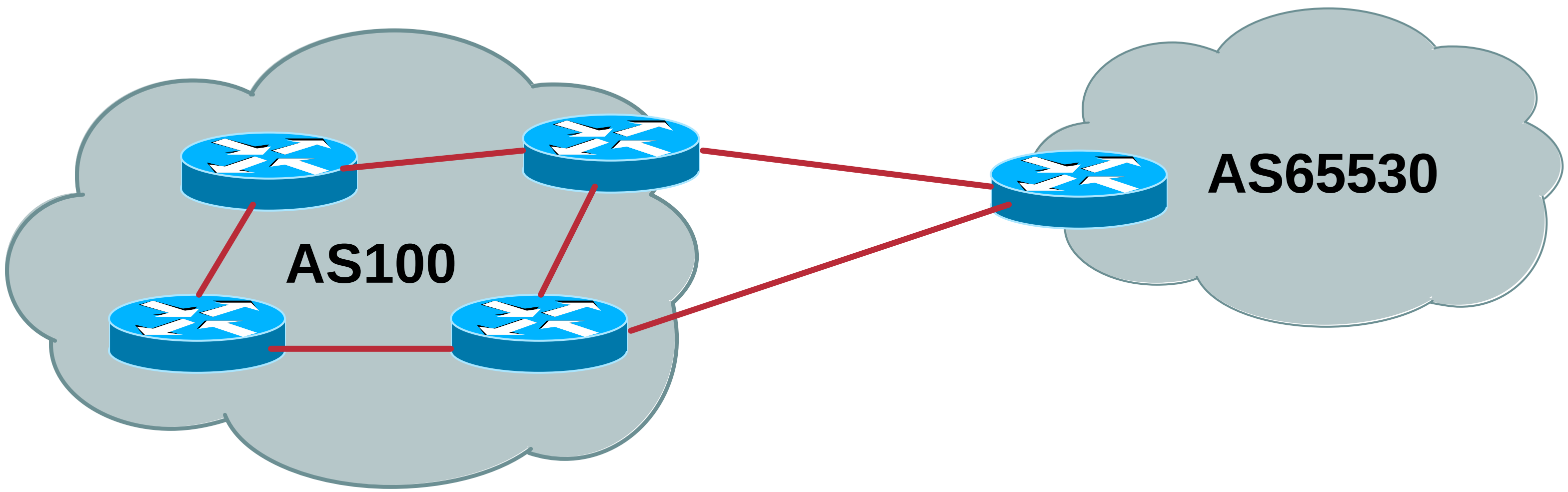
- Stub network
- Multi-homed stub network
- Multi-homed network
- Load-balancing

Stub Network



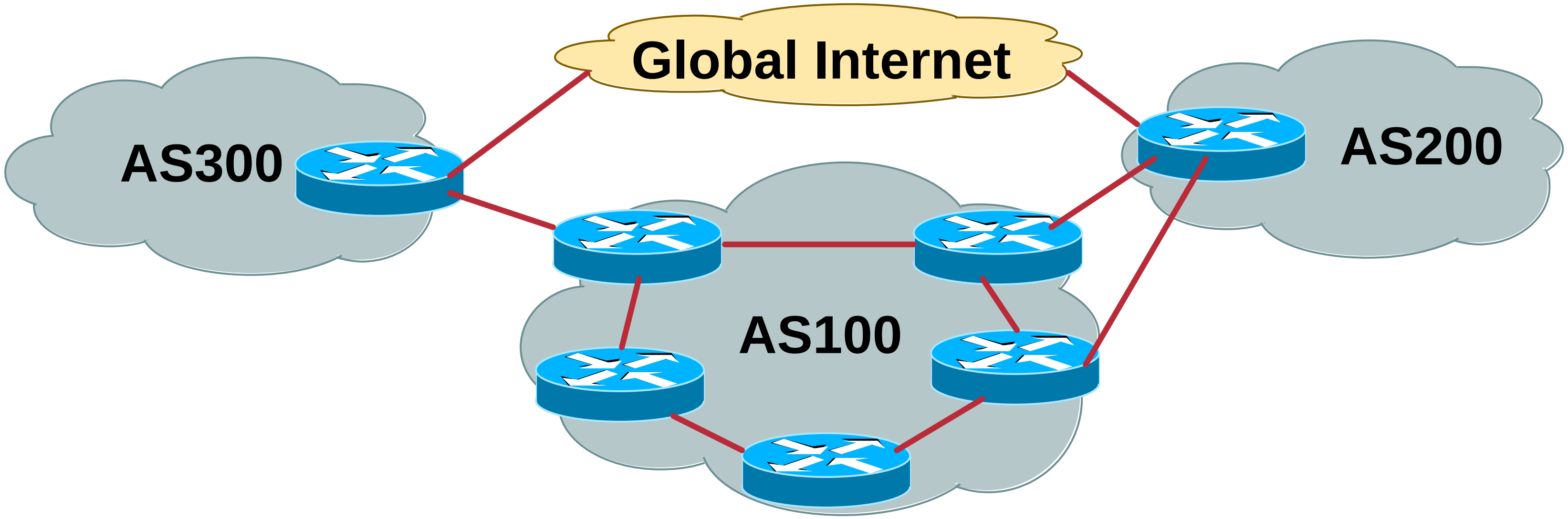
- No need for BGP
- Point static default to upstream ISP
- Router will load share on the two parallel circuits
- Upstream ISP advertises stub network
- Policy confined within upstream ISP's policy

Multi-homed Stub Network



- 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

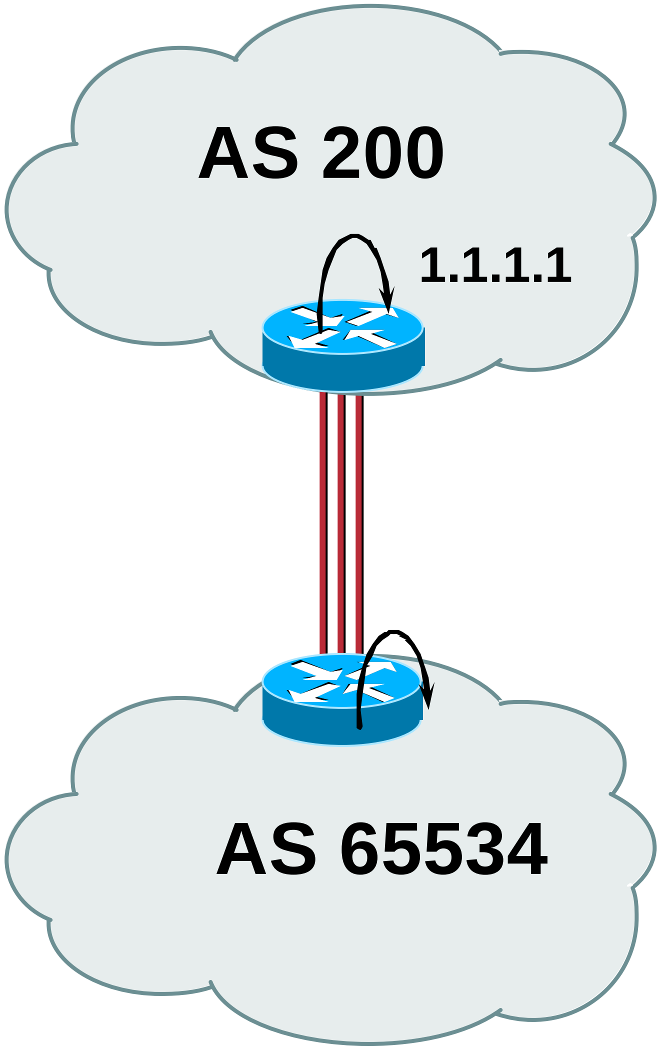


- **Many situations possible**
  - **multiple sessions to same ISP**
  - **secondary for backup only**
  - **load-share between primary and secondary**
  - **selectively use different ISPs**

Multiple Sessions to an ISP – Example One

- 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

- 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

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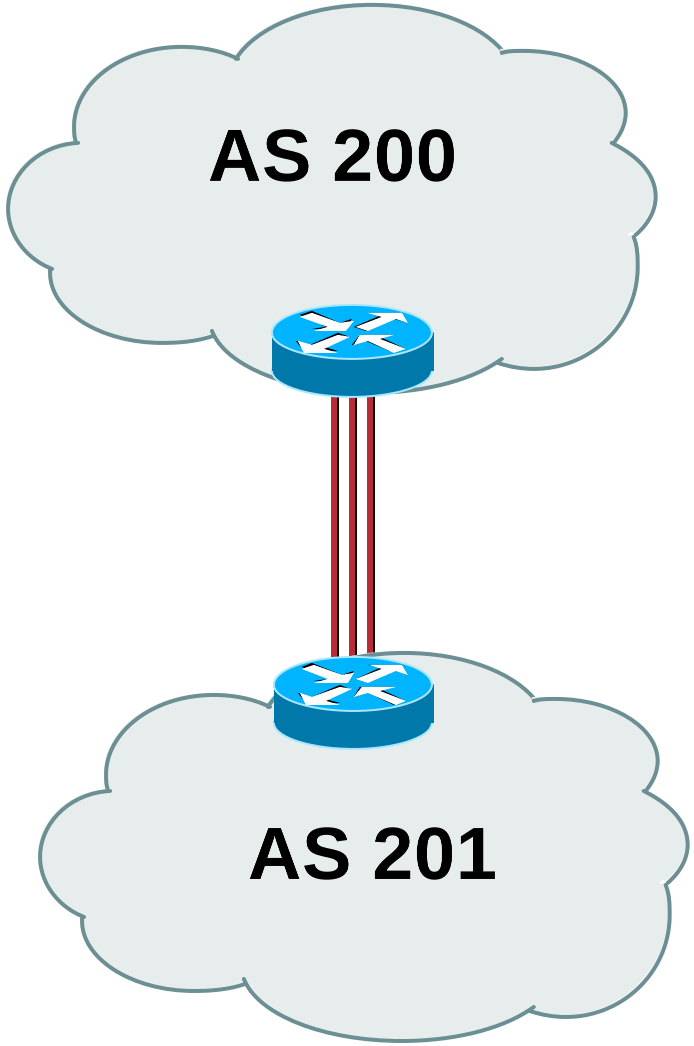
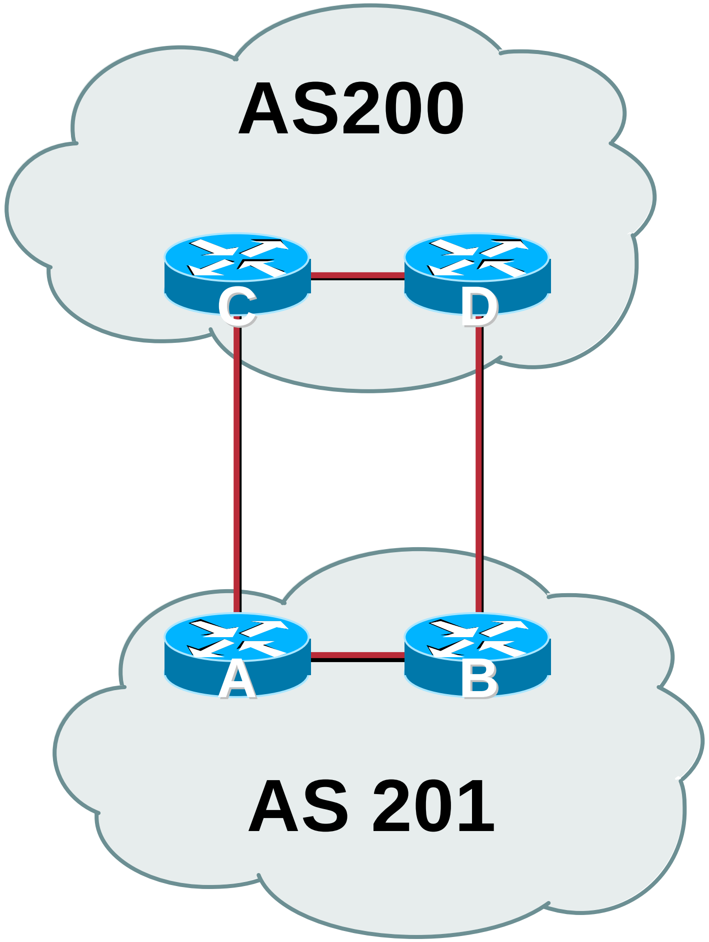
- BGP multi-path
- Three BGP sessions required
- limit of 6 parallel paths in Cisco IOS
- Cisco IOS Configuration

```
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

- Why Multihome?
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Preparing the Network
Initial Assumptions

- The network is not running any BGP at the moment

  single statically routed connection to upstream ISP

- The network is not running any IGP at all

  Static default and routes through the network to do "routing"

- If multihoming to two different ISPs, AS number has been applied for and received

Preparing the Network
First Step: IGP

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- **Decide on IGP: OSPF or ISIS ☺**
- **Assign loopback interfaces and /32 addresses to each router which will run the IGP**
  - **Loopback is OSPF and BGP router id**
  - **Used for iBGP and route origination**
- **Deploy IGP (e.g. OSPF)**
  - **IGP can be deployed with NO IMPACT on the existing static routing**
    - **OSPF distance is 110, static distance is 1**
    - **Smallest distance wins**

Preparing the Network
Second Step: iBGP

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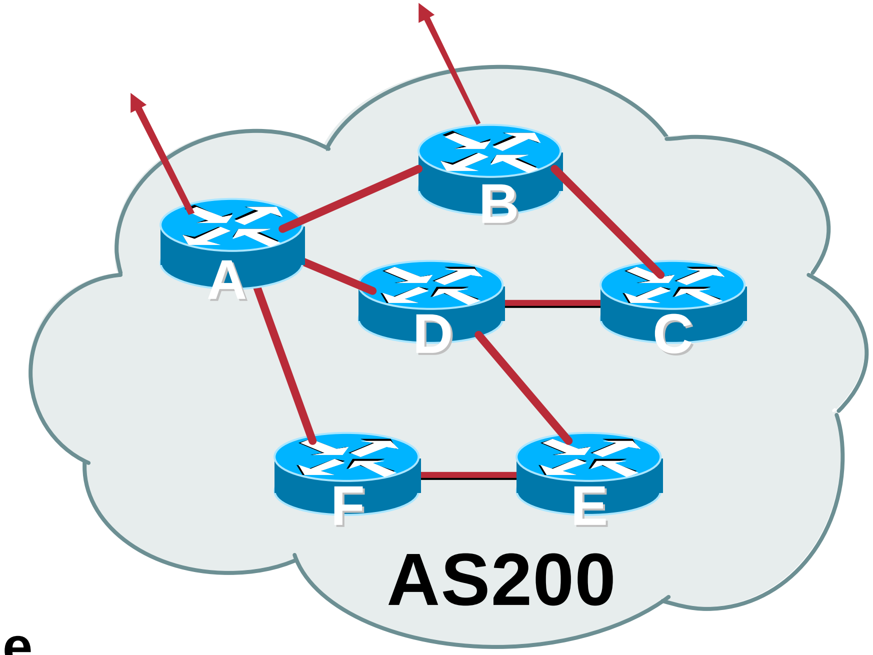
- **Second step is to configure the local network to use iBGP**
- **iBGP can run on**

  all routers, or

  a subset of routers, or

  just on the upstream edge

- ***iBGP must run on all routers which are in the transit path between external connections***



Preparing the Network
Second Step: iBGP (Transit Path)

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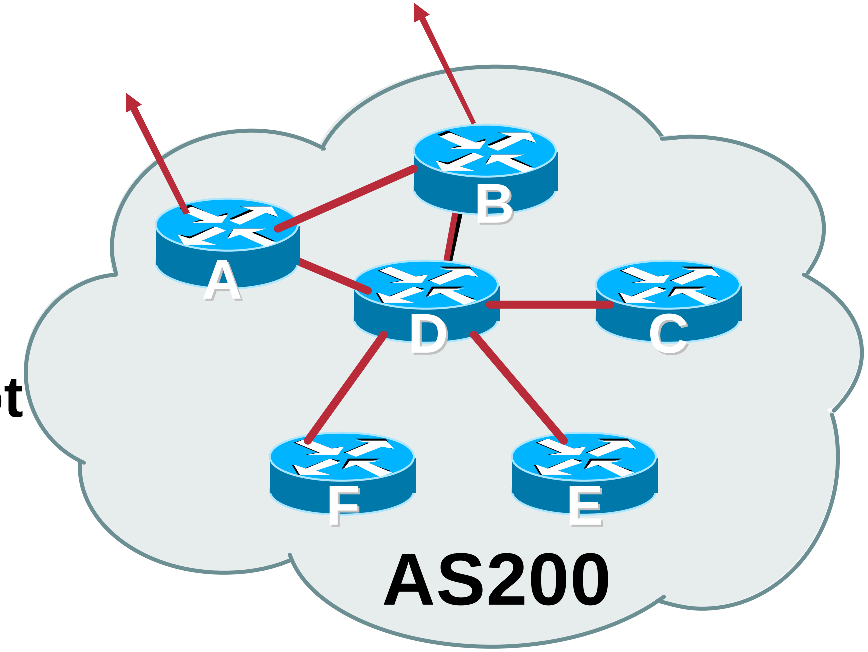
- ***iBGP must run on all routers which are in the transit path between external connections***
- **Routers C, E and F are not in the transit path**

    Static routes or IGP will suffice

- **Router D is in the transit path**

    Will need to be in iBGP mesh, otherwise routing loops will result



Preparing the Network Layers

- Typical SP networks have three layers:

  Core – the backbone, usually the transit path

  Distribution – the middle, PoP aggregation layer

  Aggregation – the edge, the devices connecting customers

Preparing the Network Aggregation Layer

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- **iBGP is optional**
  - **Many ISPs run iBGP here, either partial routing (more common) or full routing (less common)**
  - **Full routing is not needed unless customers want full table**
  - **Partial routing is cheaper/easier, might usually consist of internal prefixes and, optionally, external prefixes to aid external load balancing**
    - **Communities and peer-groups make this administratively easy**
- **Many aggregation devices can't run iBGP**
  - **Static routes from distribution devices for address pools**
  - **IGP for best exit**

Preparing the Network
Distribution Layer

- **Usually runs iBGP**
  - **Partial or full routing (as with aggregation layer)**
- **But does not have to run iBGP**
  - **IGP is then used to carry customer prefixes (does not scale)**
  - **IGP is used to determine nearest exit**
- **Networks which plan to grow large should deploy iBGP from day one**
  - **Migration at a later date is extra work**
  - **No extra overhead in deploying iBGP, indeed IGP benefits**

Preparing the Network
Core Layer

- Core of network is usually the transit path
- iBGP necessary between core devices

    Full routes or partial routes:

        Transit ISPs carry full routes in core

        Edge ISPs carry partial routes only

- Core layer includes AS border routers

Preparing the Network
iBGP Implementation

- **Decide on:**
  - **Best iBGP policy (full vs partial route mix)**
  - **iBGP scaling technique (communities, route-reflectors, peer-groups)**
- **Then deploy iBGP:**
  - **Step 1: Introduce iBGP (making sure that iBGP distance is greater than IGP distance)**
  - **Step 2: Install customer prefixes into iBGP**
  - **Step 3: Make iBGP distance less than IGP**
    - **Check! Does the network still work?**
  - **Step 4: Withdraw customer prefixes from the IGP**
  - **Step 5: Deployment of eBGP follows**

Preparing the Network Configuration – Before BGP

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```
interface serial 0/0
 ip address 221.10.0.1 255.255.255.252
!
interface serial 0/1
 ip address 221.10.0.5 255.255.255.252
!
router ospf 100
 redistribute connected subnets       ! Point-to-point link
 redistribute static subnets          ! Customer networks
!
ip route 221.10.24.0 255.255.252.0 serial 0/0
ip route 221.10.28.0 255.255.254.0 serial 0/1
```

Preparing the Network Configuration – Steps 1 & 2


```
interface serial 0/0
 ip address 221.10.0.1 255.255.255.252
!
interface serial 0/1
 ip address 221.10.0.5 255.255.255.252
!
router ospf 100
 redistribute connected subnets          ! point-to-point links
 redistribute static subnets             ! customer nets into OSPF
!
router bgp 100
 neighbor 221.10.1.2 remote-as 100
 neighbor 221.10.1.2 description iBGP with Router2
 ...
 network 221.10.24.0 mask 255.255.252.0
 network 221.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200
!
ip route 221.10.24.0 255.255.252.0 serial 0/0
ip route 221.10.28.0 255.255.254.0 serial 0/1
```

Preparing the Network Configuration – Steps 3 & 4

```
interface serial 0/0
 ip address 221.10.0.1 255.255.255.252
!
interface serial 0/1
 ip address 221.10.0.5 255.255.255.252
!
router ospf 100
 redistribute connected subnets           ! point-to-point links
!
router bgp 100
 neighbor 221.10.1.2 remote-as 100
 neighbor 221.10.1.2 description iBGP with Router2
 ...
 network 221.10.24.0 mask 255.255.252.0
 network 221.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200
!
ip route 221.10.24.0 255.255.252.0 serial 0/0
ip route 221.10.28.0 255.255.254.0 serial 0/1
```

Preparing the Network
Configuration Summary

- Customer networks are now in iBGP
  - iBGP deployed over the backbone
  - Full or Partial or Upstream Edge only
- BGP distance is greater than any IGP
- Now ready to deploy eBGP

BGP Multihoming Techniques

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Multihoming to the same ISP

Multihoming to the same ISP

- **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)

- **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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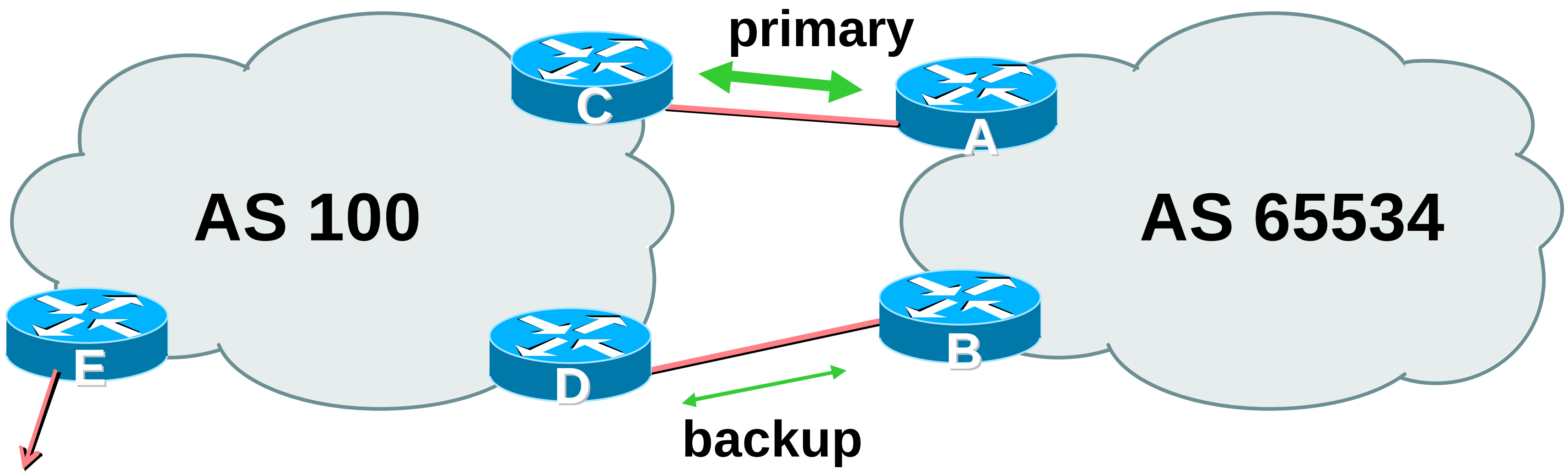

- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

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

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- **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)

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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)

- 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)

- **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**

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Two links to the same ISP

With Loadsharing

Loadsharing to the same ISP

- **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

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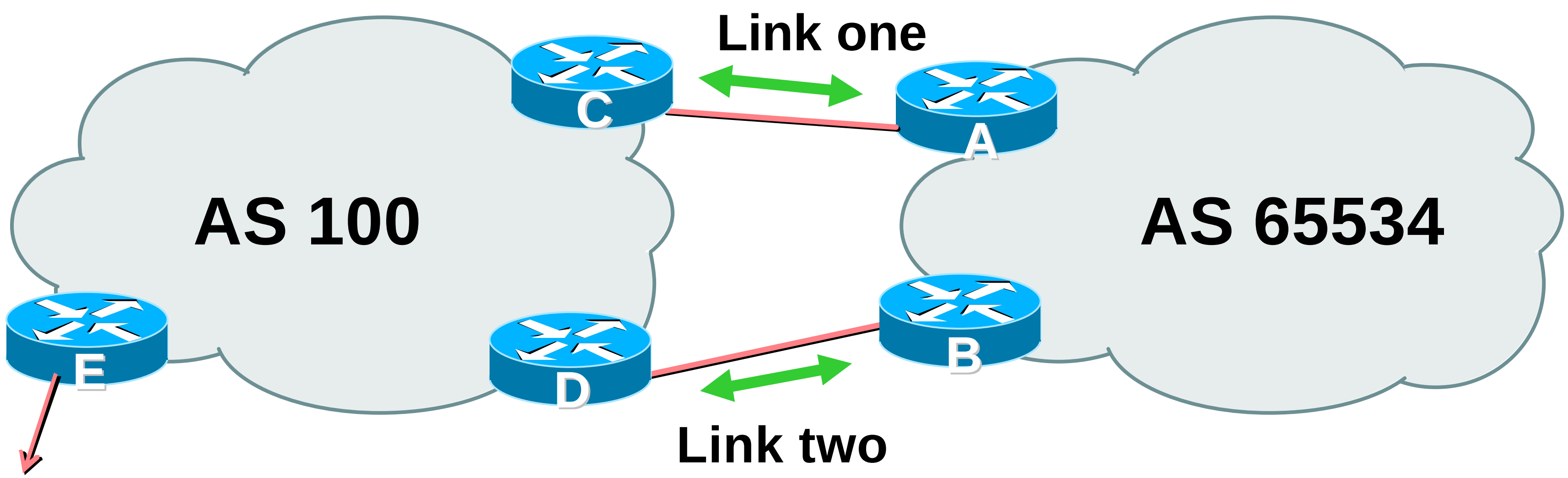

- **Border router E in AS100 removes private AS and any customer subprefixes from Internet announcement**

Loadsharing to the same ISP

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

  basic inbound loadsharing

  assumes equal circuit capacity and even spread of traffic across address block
- **Vary the split until "perfect" loadsharing achieved**
- **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

- **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

- **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

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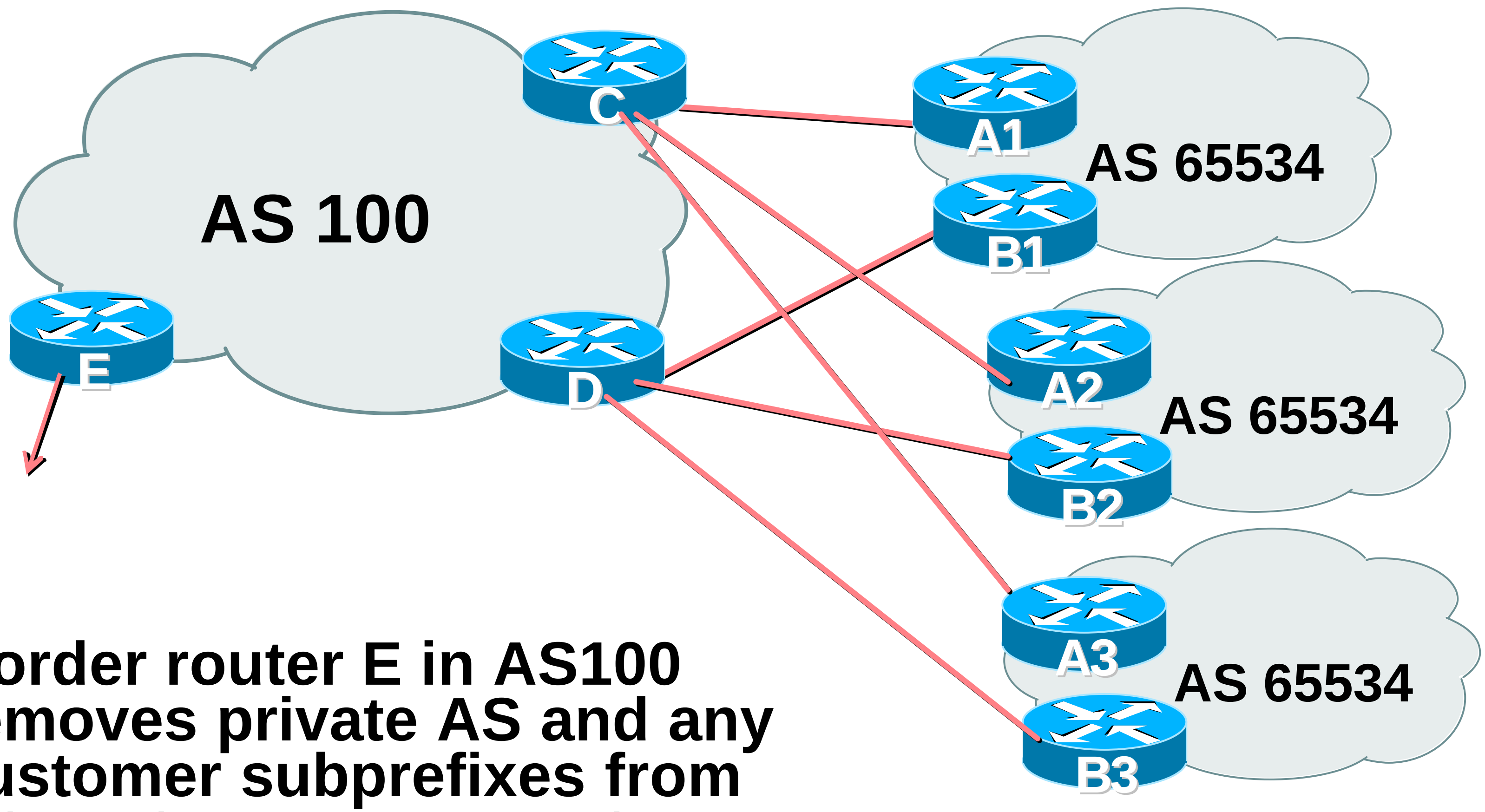
- Unusual for an ISP just to have one dualhomed customer
  - Valid/valuable service offering for an ISP with multiple PoPs
  - Better for ISP than having customer multihome with another provider!
- Look at scaling the configuration
  - Þ Simplifying the configuration
  - Using templates, peer-groups,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

Multiple Dualhomed Customers (RFC2270)



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

Multiple Dualhomed Customers

- **Customer announcements as per previous example**
- **Use the *same* private AS for each customer**

  documented in RFC2270

  address space is not overlapping

  each customer hears default only

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

Multiple Dualhomed Customers

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- **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


```
 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

- **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

- Why Multihome?
- Definition & Options
- Preparing the Network
- 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

- **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

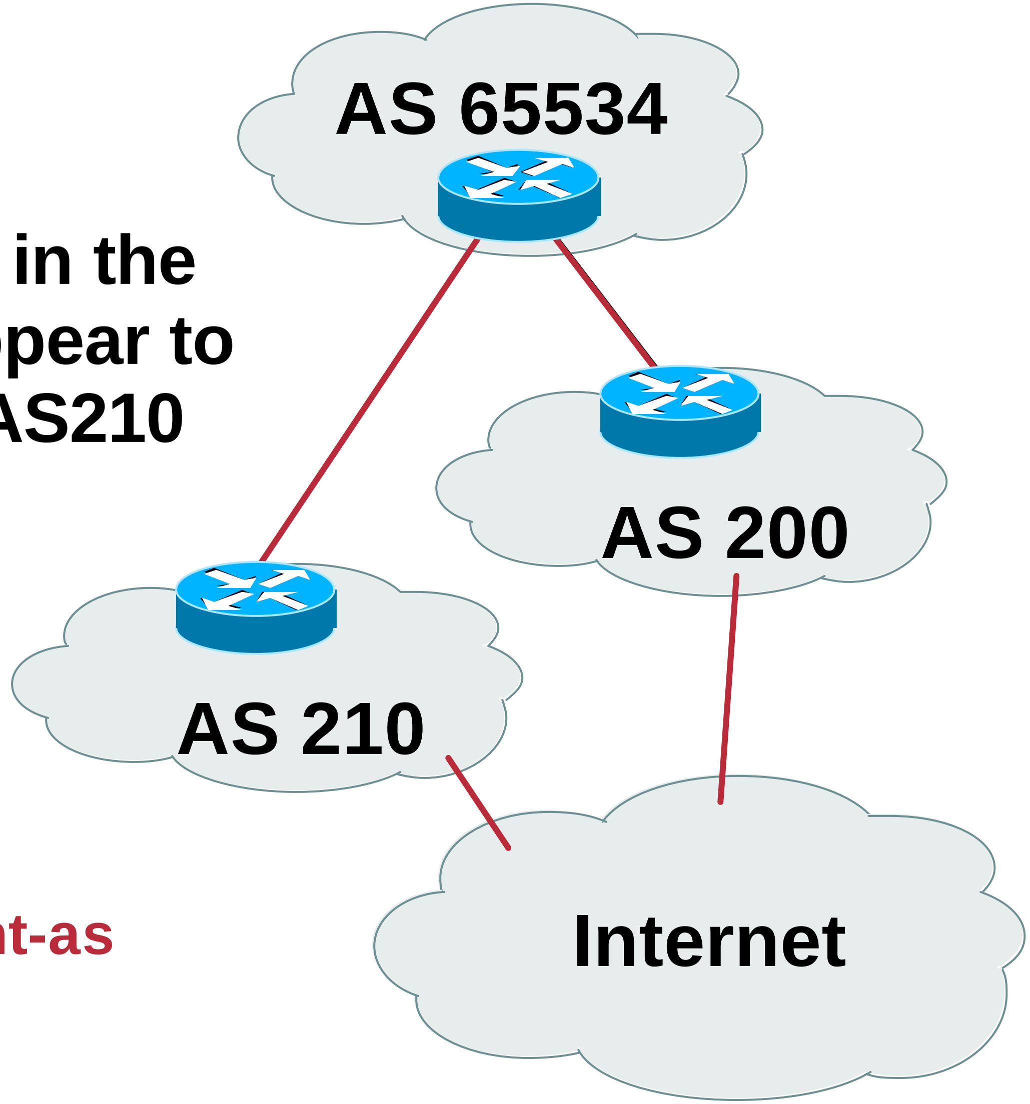
- Viewing the prefixes originated by AS65534 in the Internet shows they appear to be originated by both AS210 and AS200

    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)

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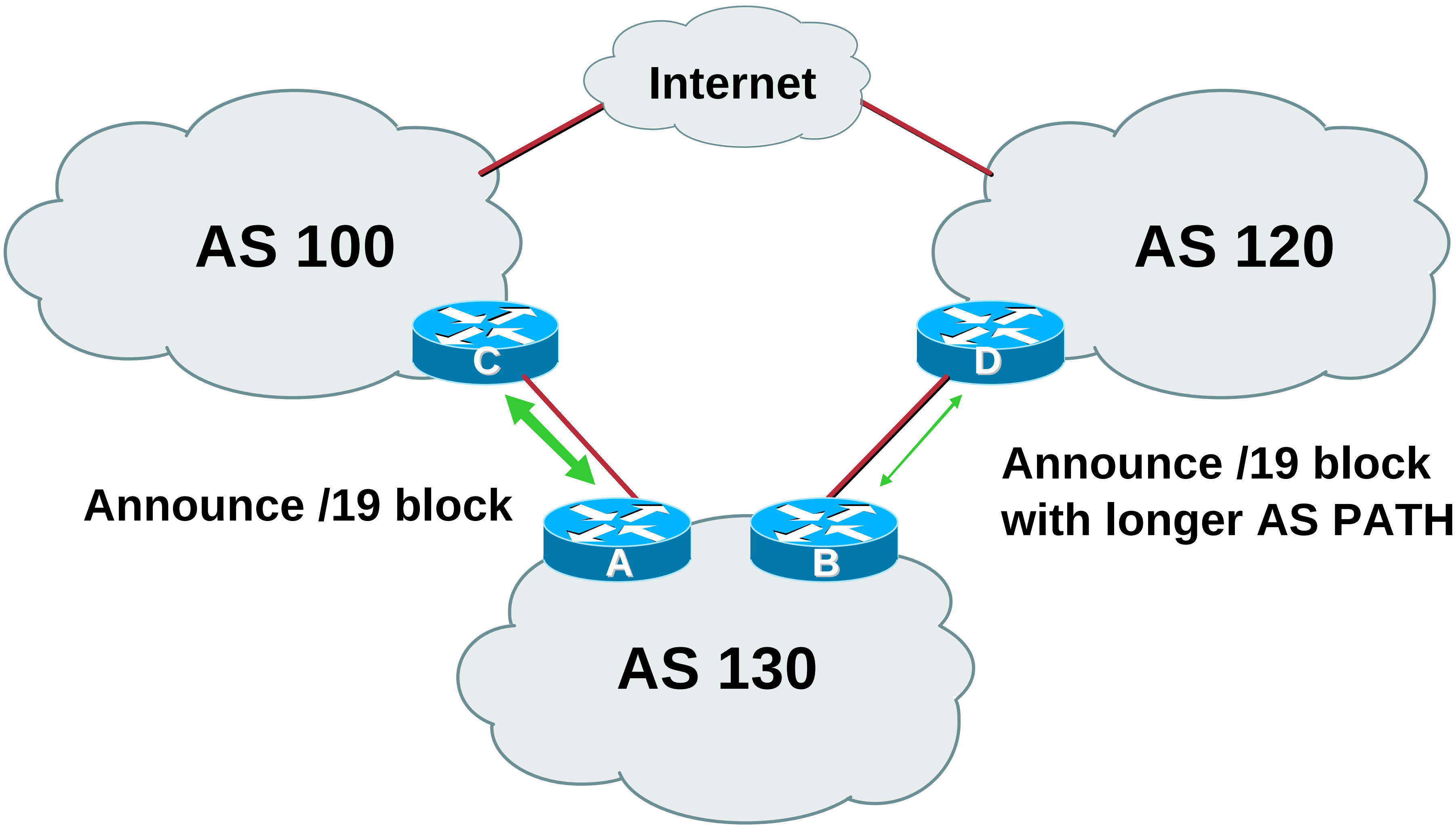

Two links to different ISPs (one as backup only)

- **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)

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- **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)

- 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

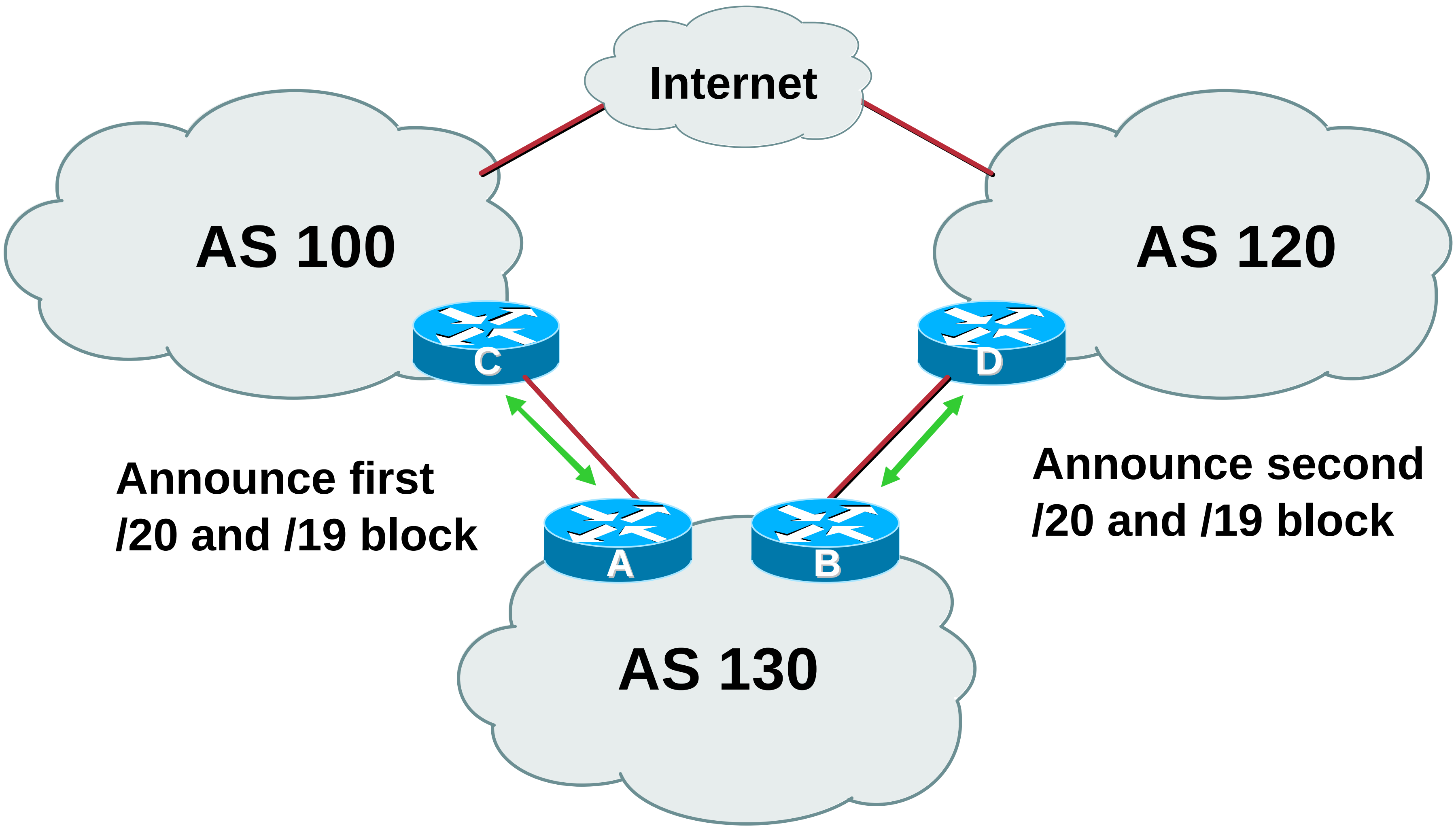
Two links to different ISPs (with loadsharing)

- **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)



Two links to different ISPs (with loadsharing)

- **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…!

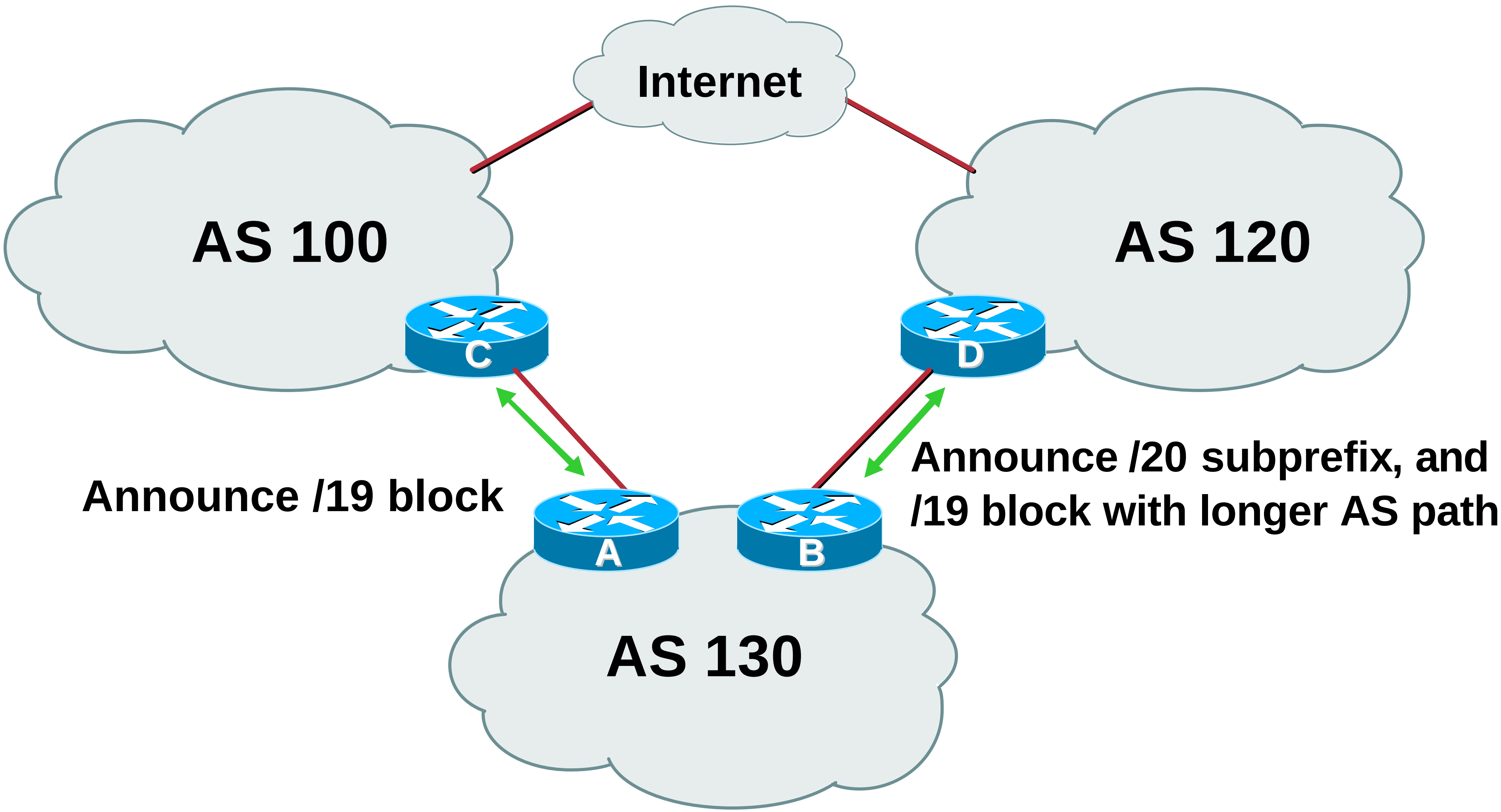
Two links to different ISPs

More Controlled Loadsharing

Loadsharing with different ISPs

- **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



Loadsharing with different ISPs

- **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

- 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

- Why Multihome?
- Definition & Options
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- 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

- **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!!

- 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

- **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

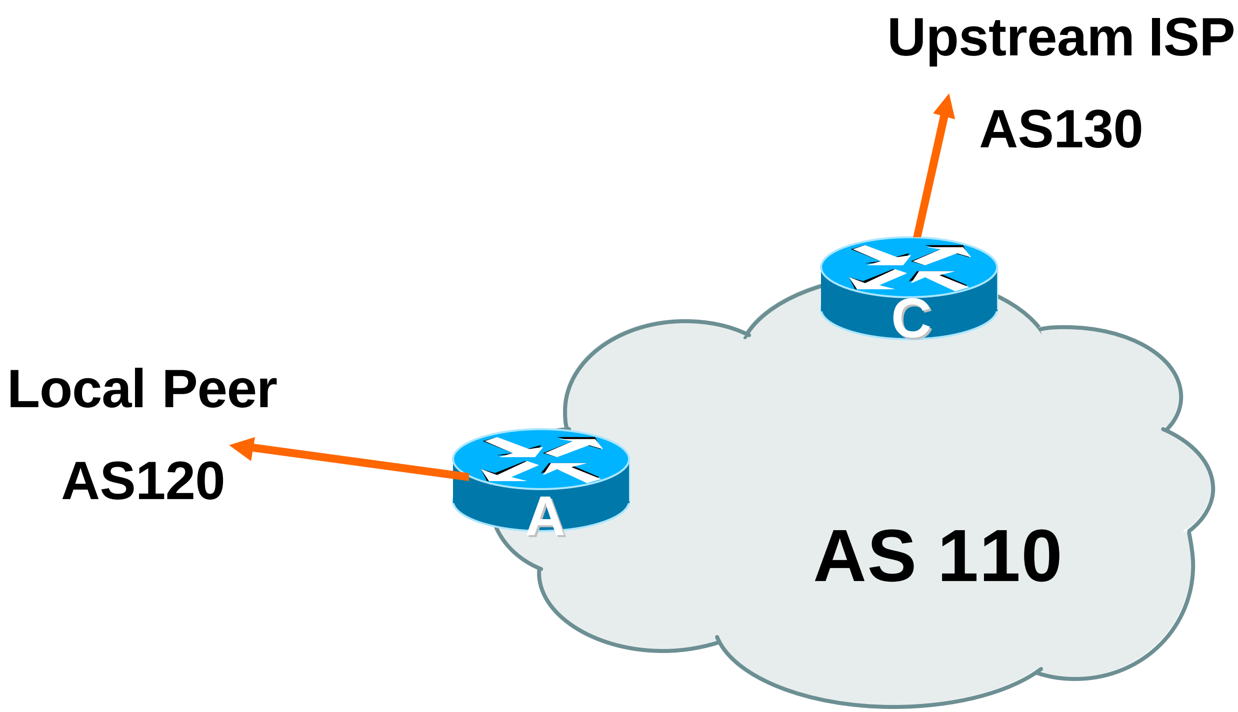
One Upstream, One local peer

One Upstream, One Local Peer

- **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



One Upstream, One Local Peer

- 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

- **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

- **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

- **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

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- **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

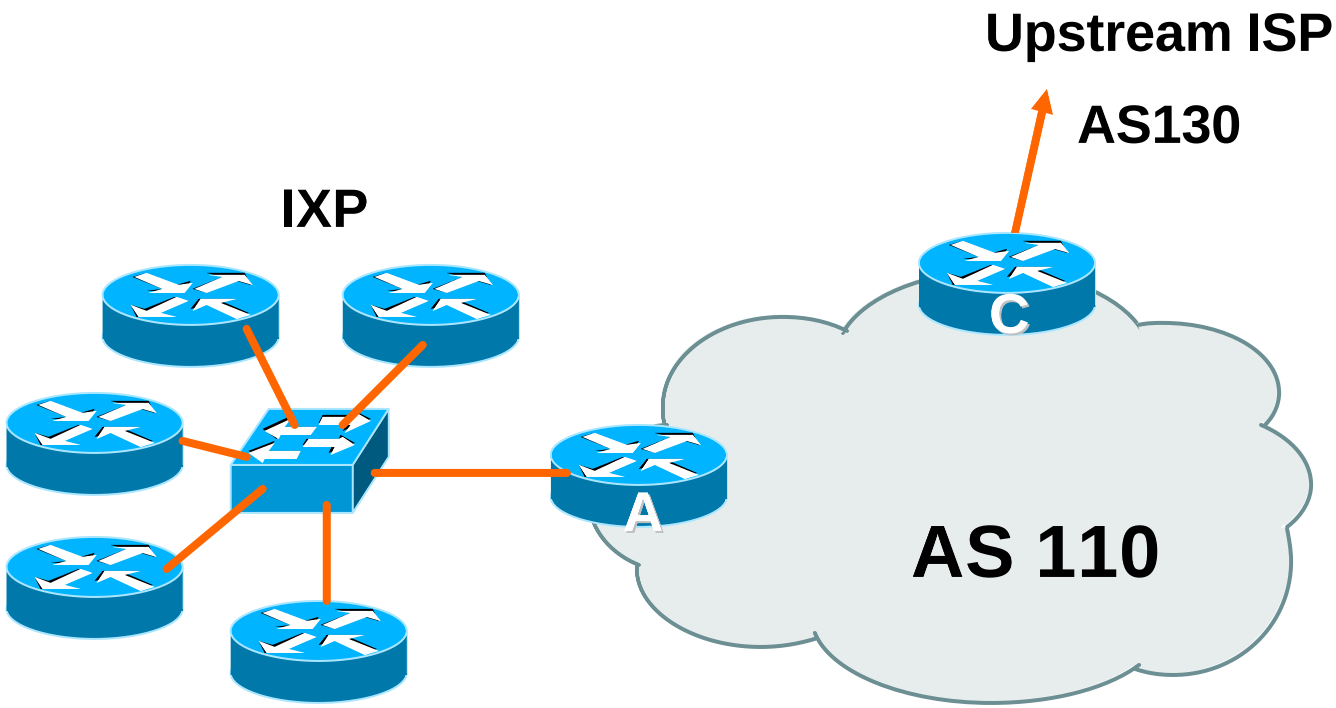
One Upstream, Local Exchange Point

One Upstream, Local Exchange Point

- 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



One Upstream, Local Exchange Point

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- **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

- **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

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```
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

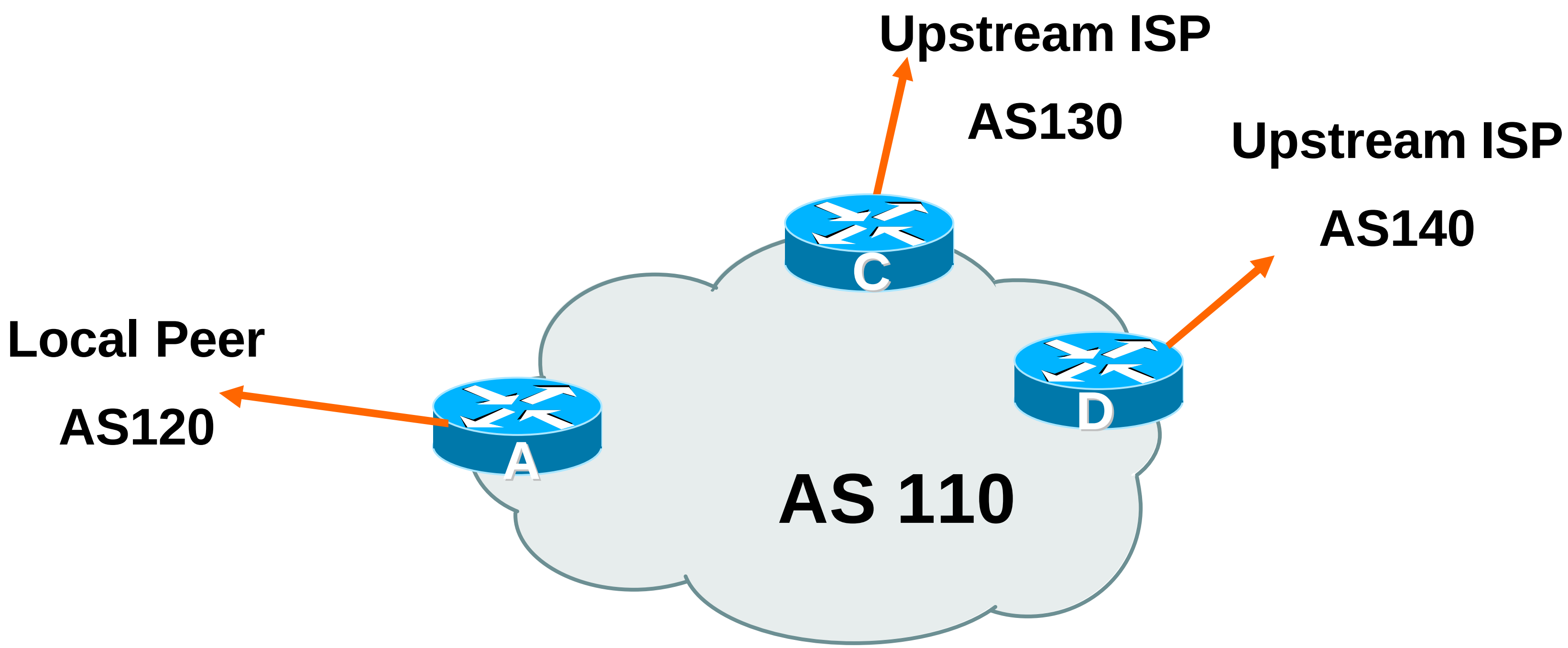
- **Connect to both upstream transit providers to see the "Internet"**

  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



Two Upstreams, One Local Peer

- 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

- **Router A**

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

  Same hardware configuration

Two Upstreams, One Local Peer

- **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

- **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

- **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

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- **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


```
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

- **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

- **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

- **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

- **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

- **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

- **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


```
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

- **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

- 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

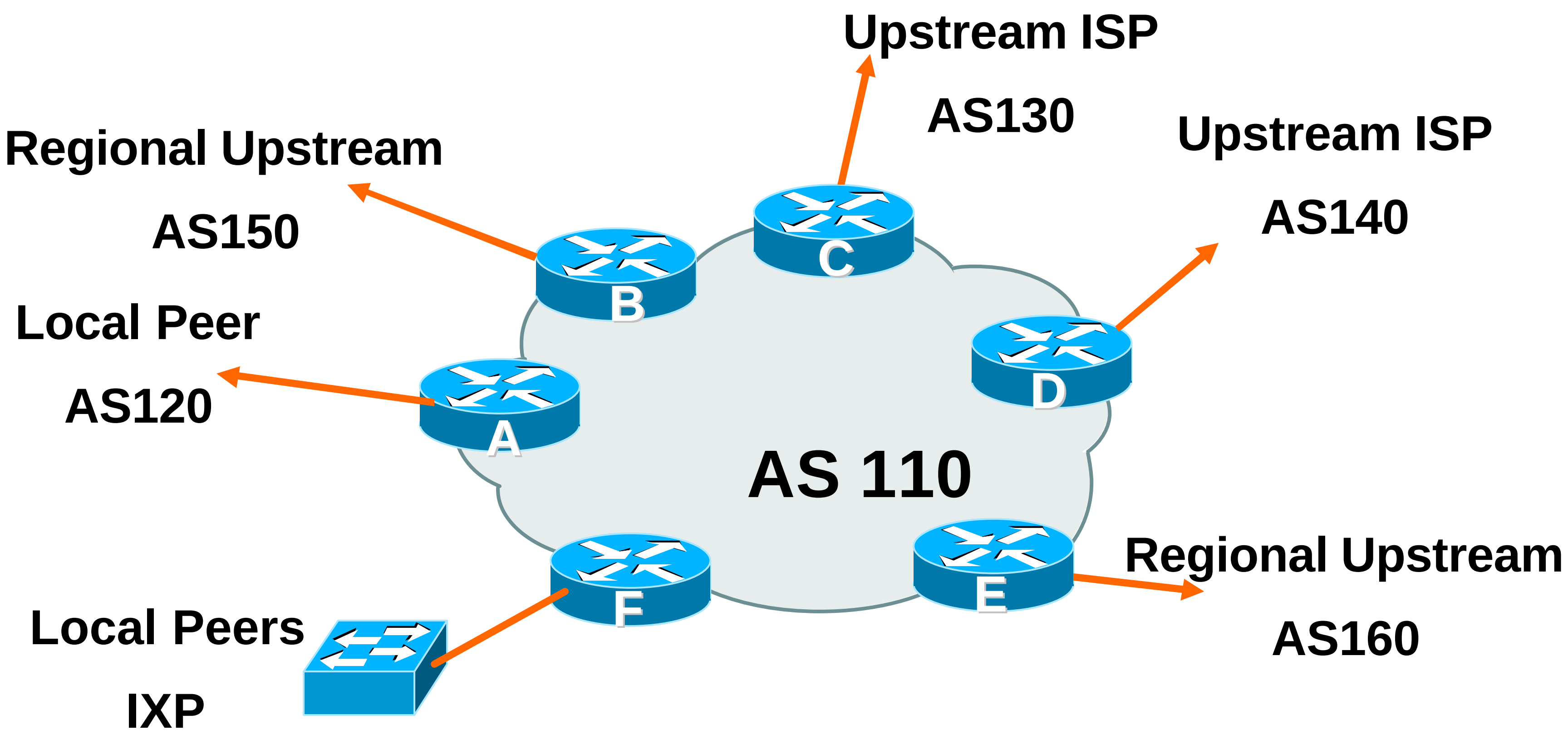
- Connect to regional upstreams

  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



Tier-1 & Regional Upstreams, Local Peers

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- **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

- **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

- **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

- **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

- **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

- **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

- **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

- **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

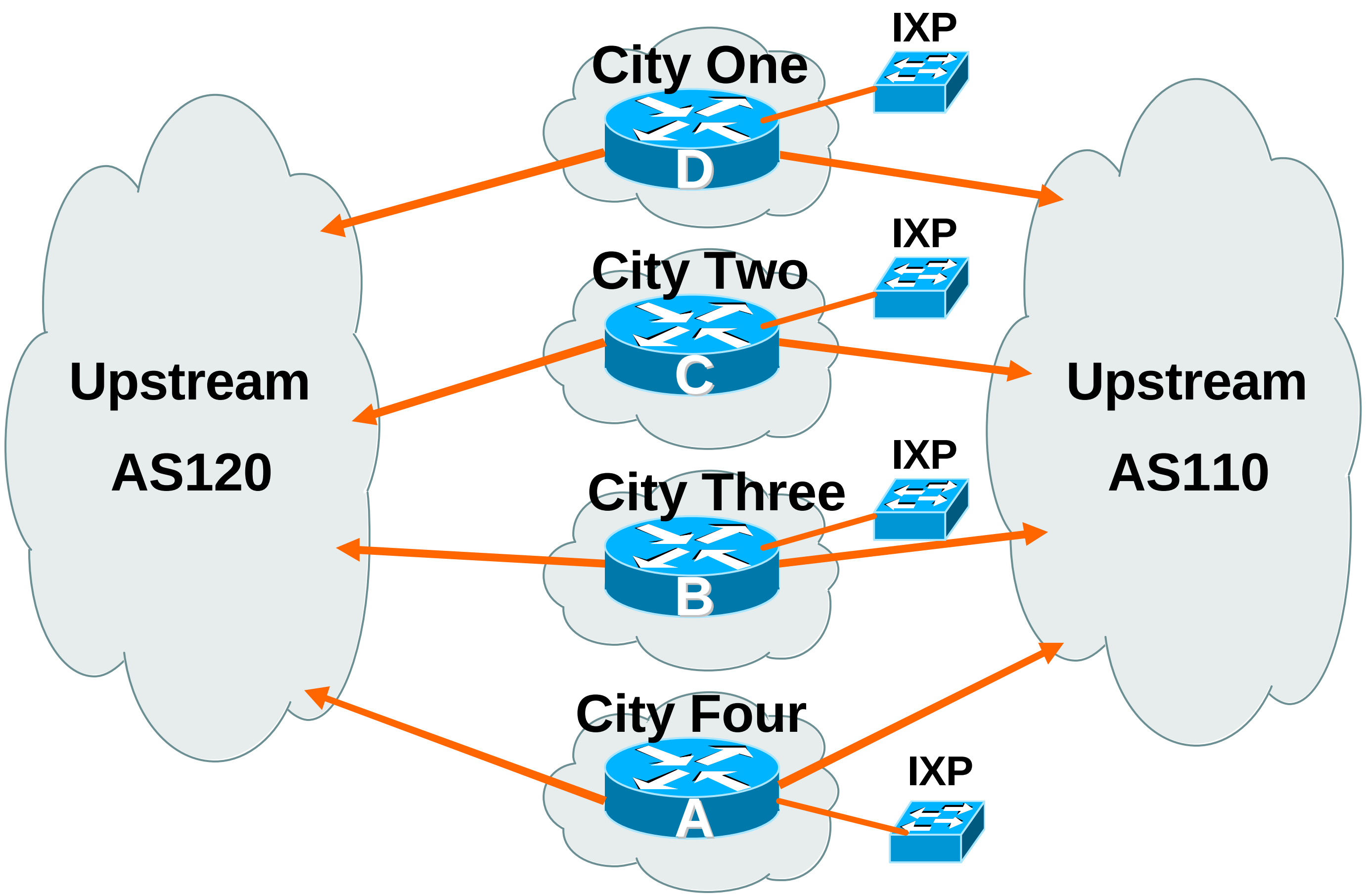
Disconnected Backbone

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



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

- **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

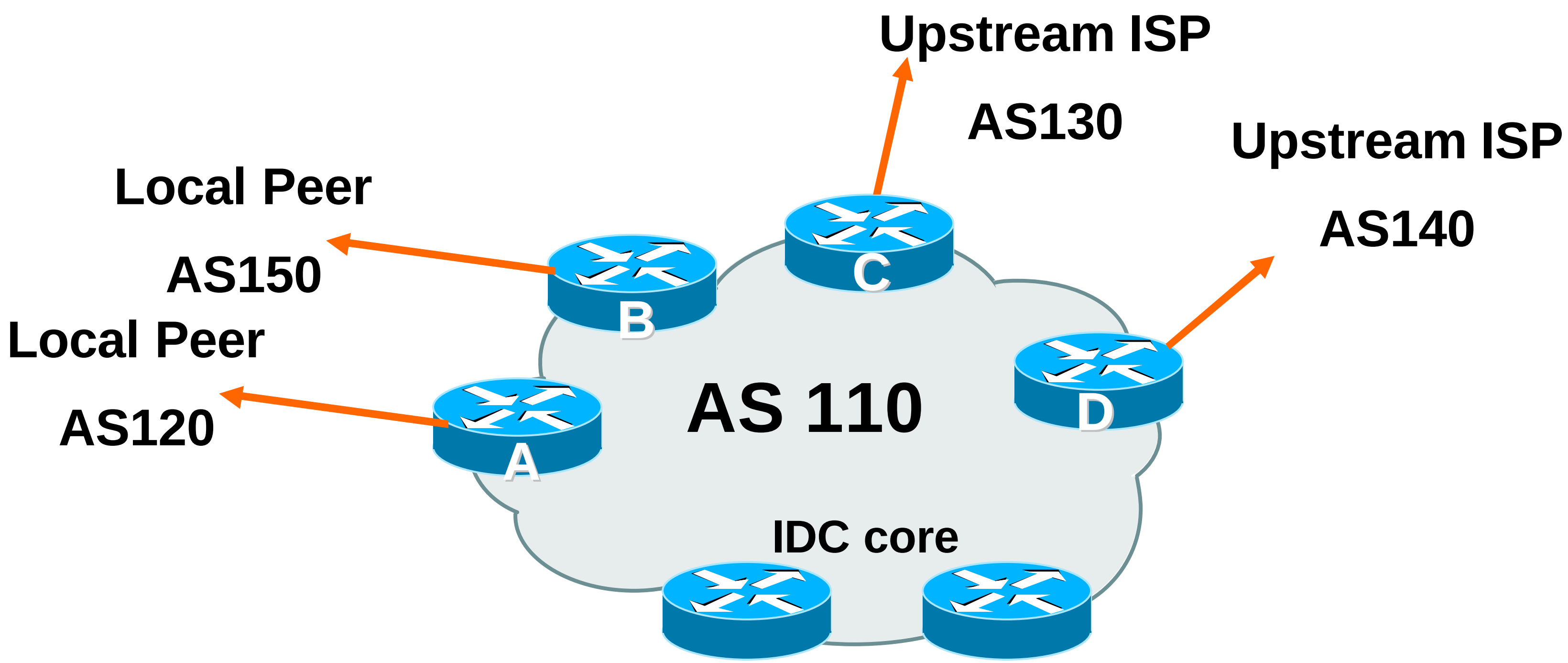
IDC Multihoming

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

- **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

- **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

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- **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

- **Why Multihome?**
- **Definition & Options**
- **Preparing the Network**
- **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!

RFC1998

- **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**

RFC1998

Cisco.com

- **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
```

RFC1998

Cisco.com

- **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
```

RFC1998

Cisco.com

- **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
```

RFC1998

Cisco.com

- **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

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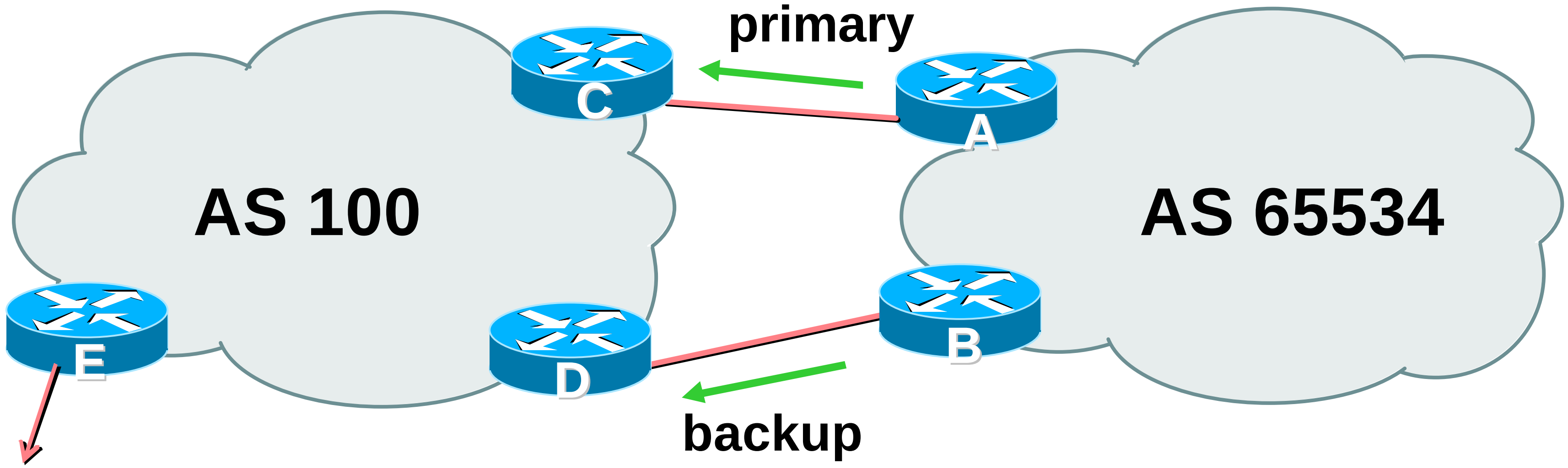
Two links to the same ISP

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)

- **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)

- **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)

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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 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)

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```
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)

- **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

- 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 E
Conne

```
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[...]
UUN[...]

```
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 Ig

```
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 IS
Leve

```
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
- Preparing the Network
- Connecting to the same ISP
- Connecting to different ISPs
- Service Provider Multihoming
- Using Communities
- Case Study

Cisco.com

Case Study

First Visit

Case Study – Requirements (1)

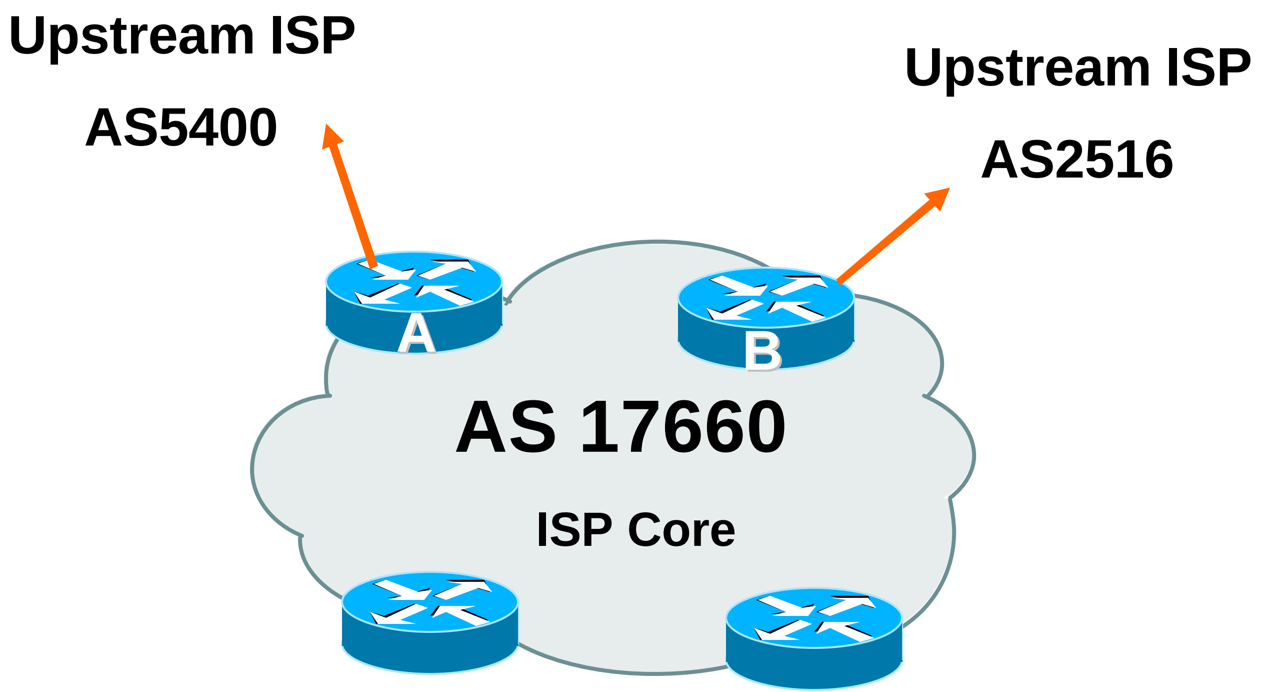
Cisco.com

- **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)

- **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



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

- **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

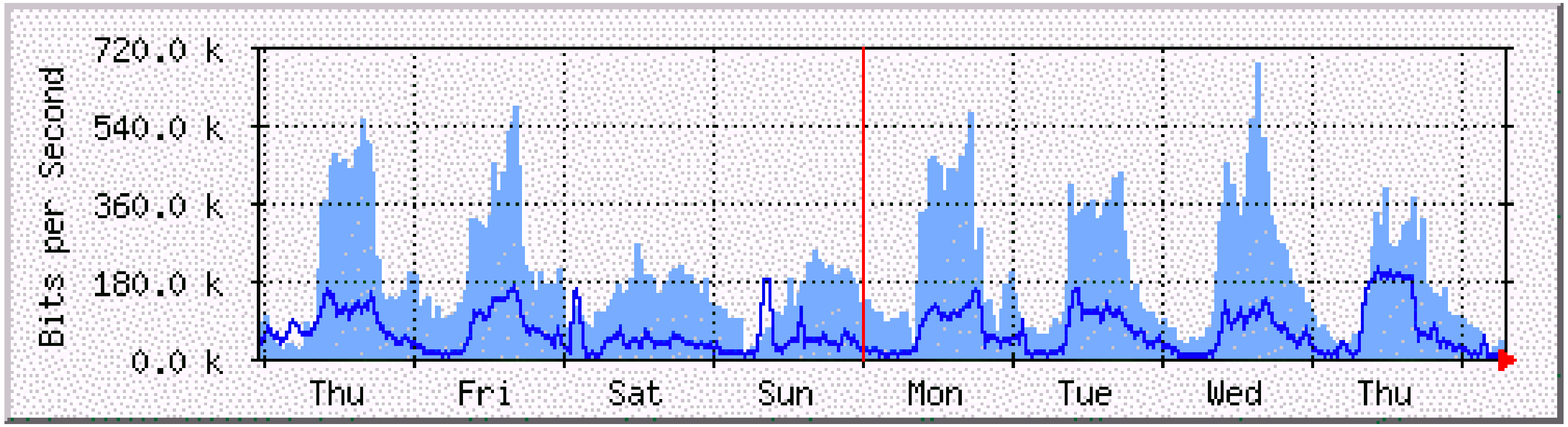
- **First cut:**
  - **Requested default from AS2516**
  - **Requested full routes from AS5400**
- **Then looked at my Routing Report**
  - **Picked the top 5 ASNs and created a filter-list**
    - **If 701, 1, 7018, 1239 or 7046 are in AS-PATH, prefixes are discarded**
    - **Allowed prefixes originated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

Case Study – Outbound Loadsharing

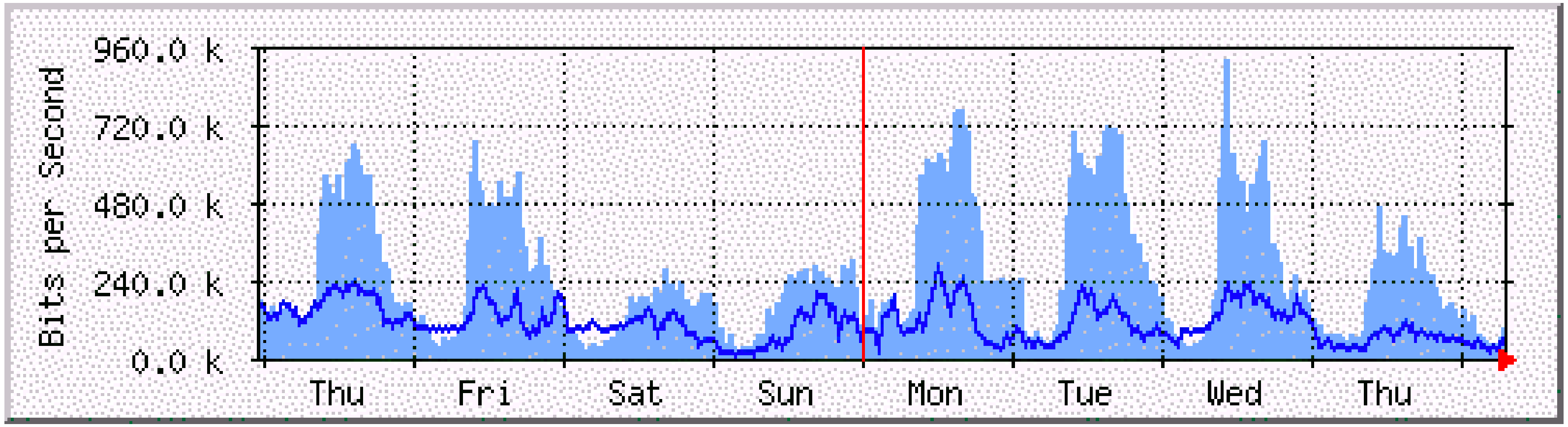
- **Refinement**
  - 32000 prefixes quite a lot, seeing more outbound traffic on the AS5400 path
  - Traffic was very asymmetric
    - out through AS5400, in through AS2516
  - Added the next 3 ASNs from the Top 20 list
    - 209, 2914 and 3549
  - Now seeing 14000 prefixes
  - Traffic is now evenly 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

- **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

- **ISP wants:**

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

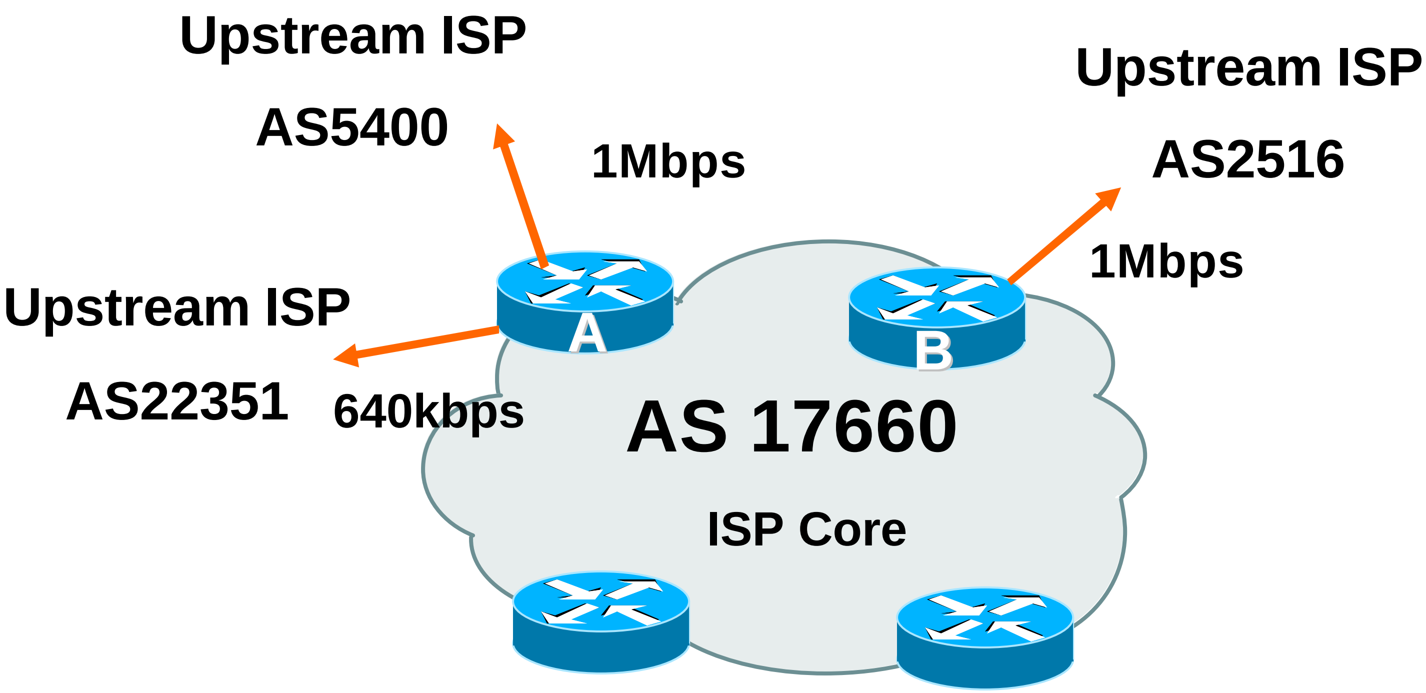
  Still want symmetric routing and equal link utilisation in and out (as close as possible)

    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



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

- **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

- **Results:**

  Around 35000 prefixes from AS5400

  Around 2000 prefixes from AS22351

  Around 200kbps on both the AS5400 and AS2516 links

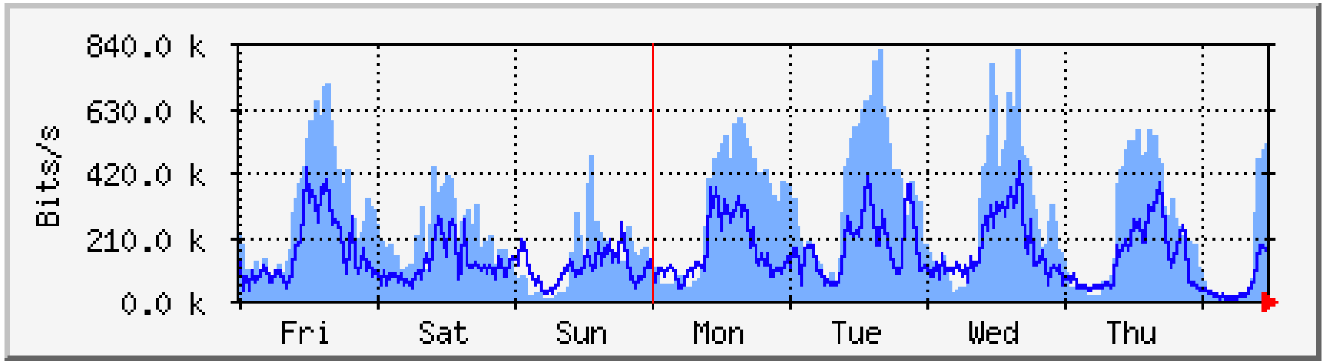
  Around 50kbps on the AS22351 link

  Outbound traffic fluctuates quite substantially based on time of day

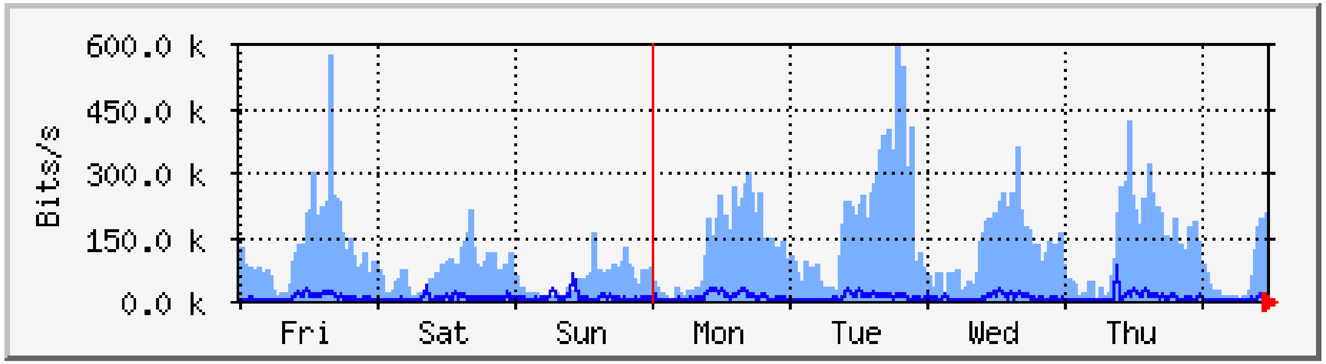
- **Status:**

  Situation left pending monitoring by the ISP's NOC

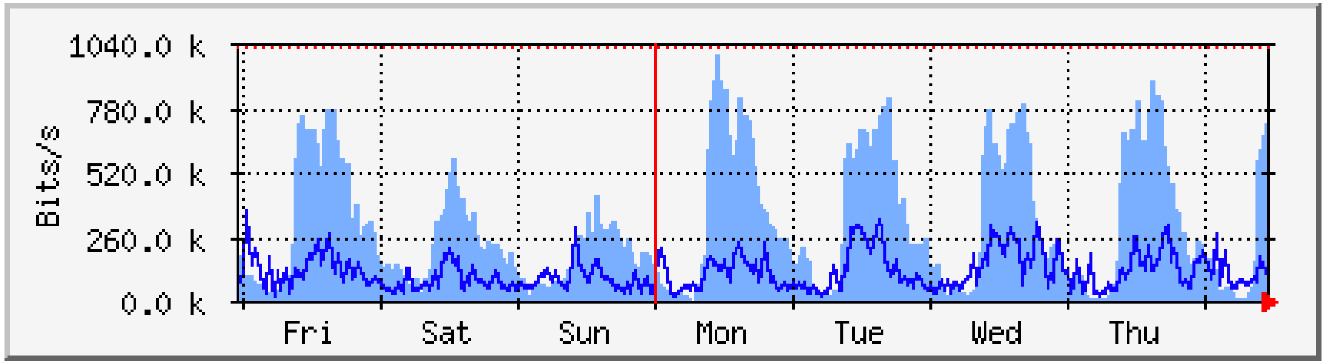
Case Study
MRTG Graphs



Router A to AS5400



Router A to AS22351



Router B to AS2516

Case Study
Configuration Router A

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```
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

- **Solution**

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

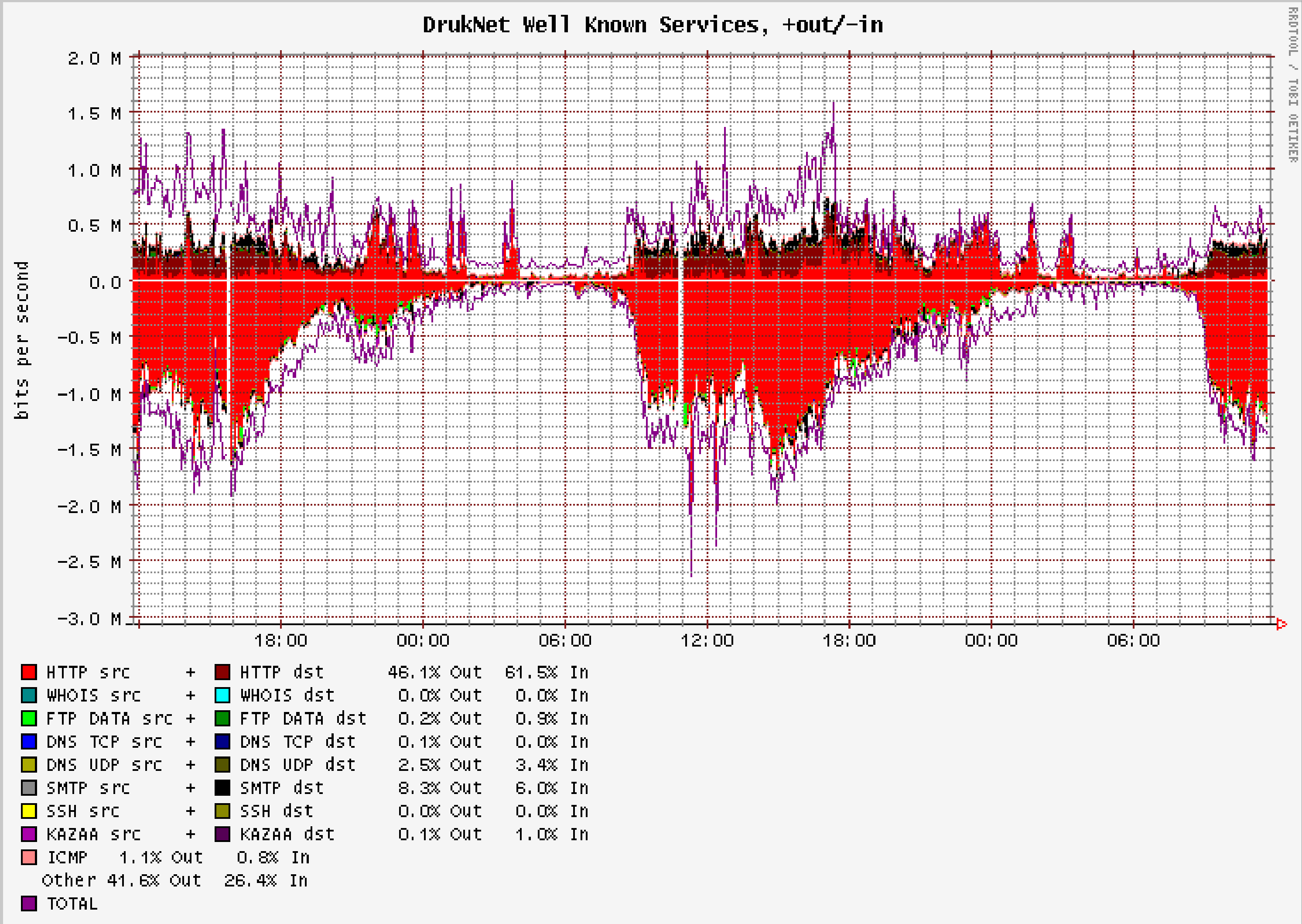
  Inbound and outbound ACLs on border routers had tcp/1214 filters added

```
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



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 & 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