

Service Provider Multihoming



BGP Traffic Engineering

Service Provider Multihoming

- ❑ 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
 - Some edge ISPs try and do this too
- ❑ The original “Traffic Engineering”

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: Some Strategies

- ❑ Take the prefixes you need to aid traffic engineering
 - Look at NetFlow data for popular sites
- ❑ Prefixes originated by your immediate neighbours and their neighbours will do more to aid load balancing than prefixes from ASNs many hops away
 - Concentrate on local destinations
- ❑ Use default routing as much as possible
 - Or use the full routing table with care

Service Provider Multihoming

□ Examples

- One upstream, one local peer
- One upstream, local exchange point
- Two upstreams, one local peer
- Three upstreams, unequal link bandwidths

□ Require BGP and a public ASN

□ Examples assume that the local network has their own /19 address block

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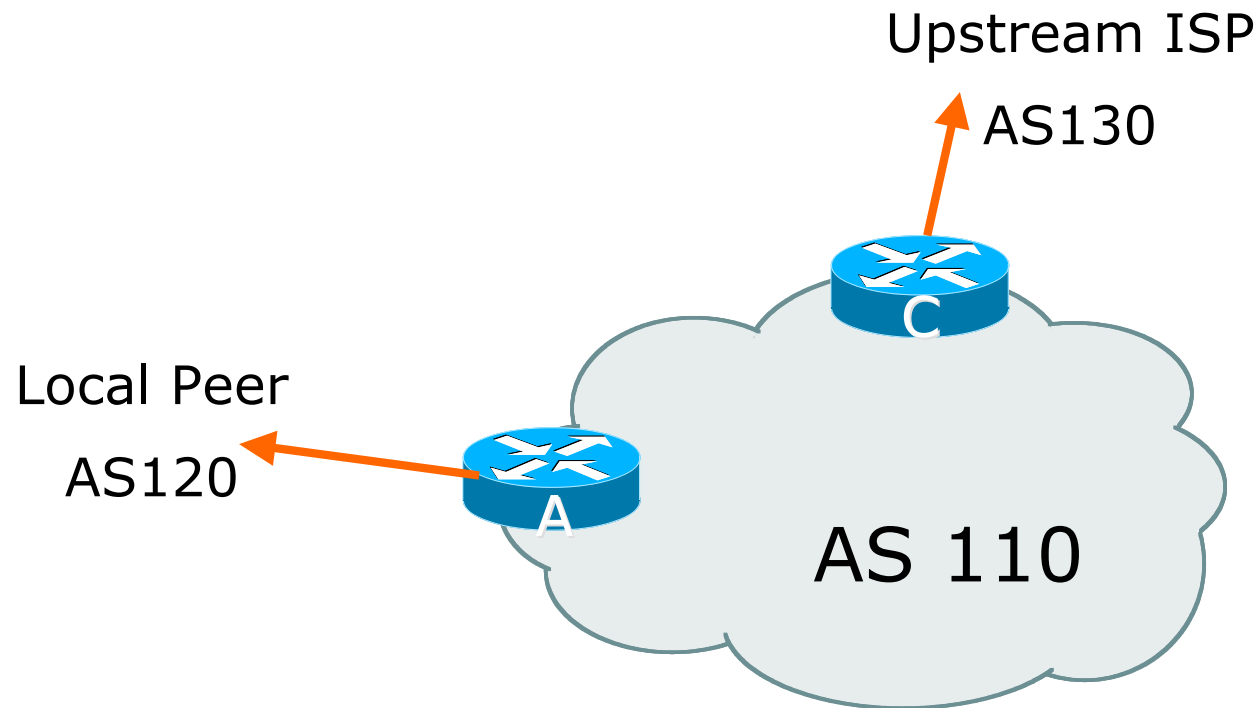


One upstream, one local peer

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 the local peer originates

One Upstream, One Local Peer

❑ Router A Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.2 remote-as 120
  neighbor 122.102.10.2 prefix-list my-block out
  neighbor 122.102.10.2 prefix-list AS120-peer in
!
ip prefix-list AS120-peer permit 122.5.16.0/19
ip prefix-list AS120-peer permit 121.240.0.0/20
ip prefix-list my-block permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 null0 250
```

Prefix filters
inbound




One Upstream, One Local Peer

❑ Router A – Alternative Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.2 remote-as 120
  neighbor 122.102.10.2 prefix-list my-block out
  neighbor 122.102.10.2 filter-list 10 in
!
ip as-path access-list 10 permit ^(120_)+$
!
ip prefix-list my-block permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 null0
```

AS Path filters –
more “trusting”



One Upstream, One Local Peer

▣ Router C Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote-as 130
  neighbor 122.102.10.1 prefix-list default in
  neighbor 122.102.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 null0
```

One Upstream, One Local Peer

- ❑ 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

Aside:

Configuration Recommendations

❑ Private Peers

- The peering ISPs exchange prefixes they originate
- Sometimes they exchange prefixes from neighbouring ASNs too

❑ Be aware that the private peer eBGP router should carry only the prefixes you want the private peer to receive

- Otherwise they could point a default route to you and unintentionally transit your backbone

Service Provider Multihoming

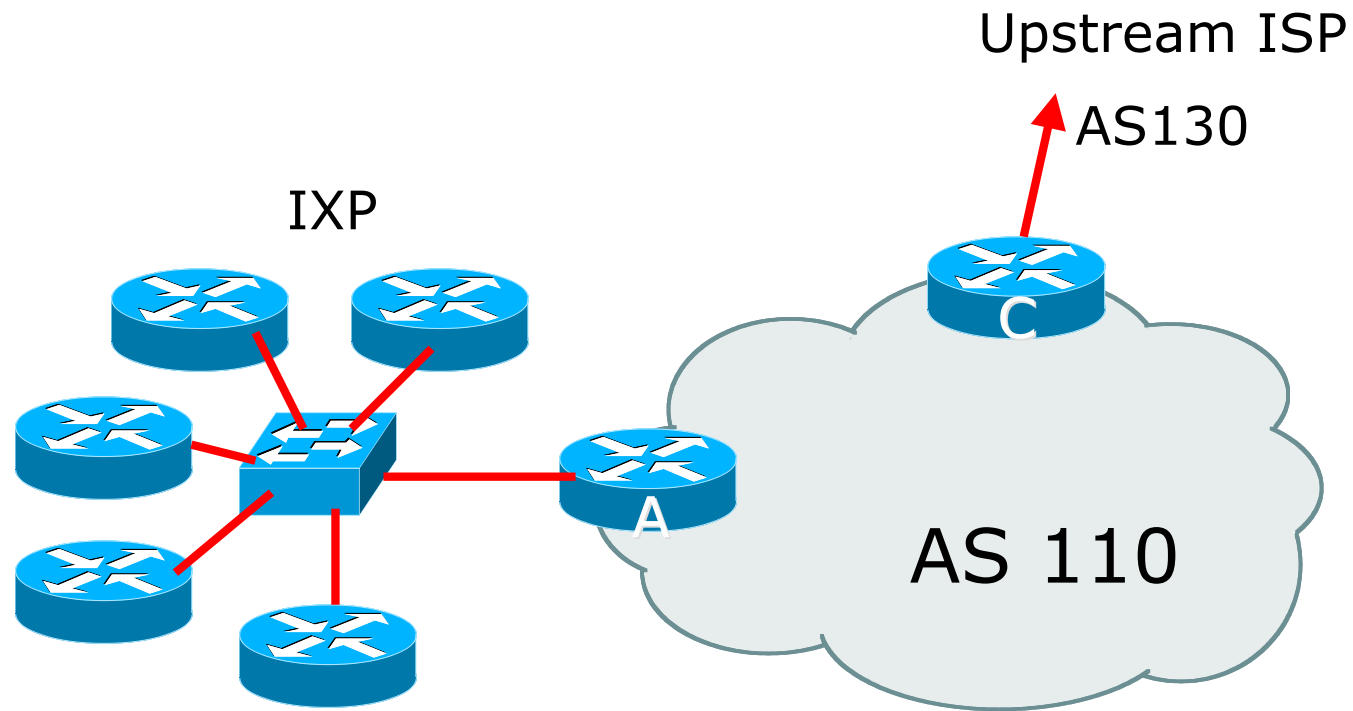


One upstream, Local Exchange
Point

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
- ❑ This example is a scaled up version of the previous one

One Upstream, Local Exchange Point



One Upstream, Local Exchange Point

- ❑ 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 originated by IXP peers

One Upstream, Local Exchange Point

▣ Router A Configuration

```
interface fastethernet 0/0
  description Exchange Point LAN
  ip address 120.5.10.1 mask 255.255.255.224
  ip verify unicast reverse-path
!
router bgp 110
  neighbor ixp-peers peer-group
  neighbor ixp-peers prefix-list my-block out
  neighbor ixp-peers remove-private-AS
  neighbor ixp-peers route-map set-local-pref in
...next slide
```

One Upstream, Local Exchange Point

```
neighbor 120.5.10.2 remote-as 100
neighbor 120.5.10.2 peer-group ixp-peers
neighbor 120.5.10.2 prefix-list peer100 in
neighbor 120.5.10.3 remote-as 101
neighbor 120.5.10.3 peer-group ixp-peers
neighbor 120.5.10.3 prefix-list peer101 in
neighbor 120.5.10.4 remote-as 102
neighbor 120.5.10.4 peer-group ixp-peers
neighbor 120.5.10.4 prefix-list peer102 in
neighbor 120.5.10.5 remote-as 103
neighbor 120.5.10.5 peer-group ixp-peers
neighbor 120.5.10.5 prefix-list peer103 in
...next slide
```

One Upstream, Local Exchange Point

```
!  
ip prefix-list my-block permit 121.10.0.0/19  
ip prefix-list peer100 permit 122.0.0.0/19  
ip prefix-list peer101 permit 122.30.0.0/19  
ip prefix-list peer102 permit 122.12.0.0/19  
ip prefix-list peer103 permit 122.18.128.0/19  
!  
route-map set-local-pref permit 10  
  set local-preference 150  
!
```

One Upstream, Local Exchange

- ❑ Note that Router A does not generate the aggregate for AS110
 - If Router A becomes disconnected from backbone, then the aggregate is no longer announced to the IX
 - BGP failover works as expected
- ❑ Note the inbound route-map which sets the local preference higher than the default
 - This ensures that local traffic crosses the IXP
 - (And avoids potential problems with uRPF check)

One Upstream, Local Exchange Point

❑ Router C Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote-as 130
  neighbor 122.102.10.1 prefix-list default in
  neighbor 122.102.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 null0
```


One Upstream, Local Exchange Point

- ❑ Note Router A configuration
 - Prefix-list higher maintenance, but safer
 - uRPF on the IX facing interface
 - No generation of AS110 aggregate
- ❑ IXP traffic goes to and from local IXP, everything else goes to upstream

Aside:

IXP Configuration Recommendations

- ❑ IXP peers
 - The peering ISPs at the IXP exchange prefixes they originate
 - Sometimes they exchange prefixes from neighbouring ASNs too
- ❑ Be aware that the IXP border router should carry only the prefixes you want the IXP peers to receive and the destinations you want them to be able to reach
 - Otherwise they could point a default route to you and unintentionally transit your backbone
- ❑ If IXP router is at IX, and distant from your backbone
 - Don't originate your address block at your IXP router

Service Provider Multihoming

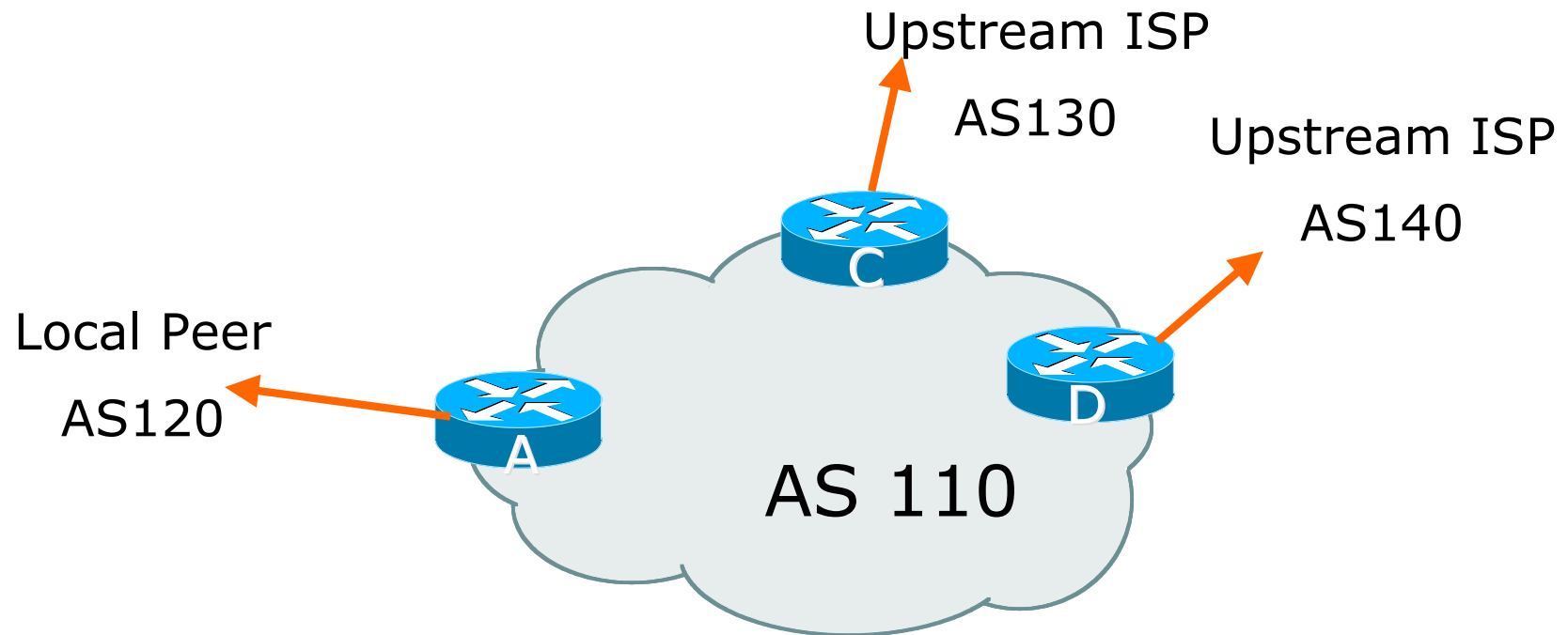


Two upstreams, one local peer

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 originated by local peer
- ❑ Note separation of Router C and D
 - Single edge router means no redundancy
- ❑ Router A
 - Same routing configuration as in example with one upstream and one local peer

Two Upstreams, One Local Peer

❑ Router C Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote-as 130
  neighbor 122.102.10.1 prefix-list default in
  neighbor 122.102.10.1 prefix-list my-block out
!
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 null0
```

Two Upstreams, One Local Peer

❑ Router D Configuration

```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.5 remote-as 140
  neighbor 122.102.10.5 prefix-list default in
  neighbor 122.102.10.5 prefix-list my-block out
!
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 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

- 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

❑ Router C Configuration

```
router bgp 110
```

```
network 121.10.0.0 mask 255.255.224.0
```

```
neighbor 122.102.10.1 remote-as 130
```

```
neighbor 122.102.10.1 prefix-list rfc1918-deny in
```

```
neighbor 122.102.10.1 prefix-list my-block out
```

```
neighbor 122.102.10.1 route-map AS130-loadshare in
```

```
!
```


```
ip prefix-list my-block permit 121.10.0.0/19
```

```
! See www.cymru.com/Documents/bogon-list.html
```

```
! ...for "RFC1918 and friends" list
```

```
...next slide
```

Allow all prefixes in
apart from RFC1918
and friends



Two Upstreams, One Local Peer

Full Routes

```
ip route 121.10.0.0 255.255.224.0 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

❑ Router D Configuration

```
router bgp 110
```

```
network 121.10.0.0 mask 255.255.224.0
```

```
neighbor 122.102.10.5 remote-as 140
```

```
neighbor 122.102.10.5 prefix-list rfc1918-deny in
```

```
neighbor 122.102.10.5 prefix-list my-block out
```

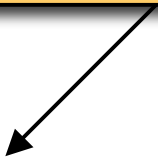
```
!
```

```
ip prefix-list my-block permit 121.10.0.0/19
```

```
! See www.cymru.com/Documents/bogon-list.html
```

```
! ...for "RFC1918 and friends" list
```

Allow all prefixes in
apart from RFC1918
and friends



Two Upstreams, One Local Peer

Full Routes

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

Two Upstreams, One Local Peer

Full Routes

- 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: Strategy

- ❑ Ask one upstream for a default route
 - Easy to originate default towards a BGP neighbour
- ❑ Ask other upstream for a full routing table
 - Then filter this routing table based on neighbouring ASN
 - E.g. want traffic to their neighbours to go over the link to that ASN
 - Most of what upstream sends is thrown away
 - Easier than asking the upstream to set up custom BGP filters for you

Two Upstreams, One Local Peer


Partial Routes

❑ Router C Configuration


```
router bgp 110
  network 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote-as 130
  neighbor 122.102.10.1 prefix-list rfc1918-nodef-deny in
  neighbor 122.102.10.1 prefix-list my-block out
  neighbor 122.102.10.1 filter-list 10 in
  neighbor 122.102.10.1 route-map tag-default-low in
!
```

...next slide

Allow all prefixes
and default in; deny
RFC1918 and friends



AS filter list filters
prefixes based on
origin ASN



Two Upstreams, One Local Peer

Partial Routes

```
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 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 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.5 remote-as 140
  neighbor 122.102.10.5 prefix-list default in
  neighbor 122.102.10.5 prefix-list my-block out
!
ip prefix-list my-block permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 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 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote-as 130
  neighbor 122.102.10.1 prefix-list rfc1918-deny in
  neighbor 122.102.10.1 prefix-list my-block out
  neighbor 122.102.10.1 filter-list 10 in
!
```

...next slide

Two Upstreams, One Local Peer

Partial Routes

```
ip prefix-list my-block permit 121.10.0.0/19
! See www.cymru.com/Documents/bogon-list.html
! ...for "RFC1918 and friends" list
!
ip route 121.10.0.0 255.255.224.0 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 121.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.5 remote-as 140
  neighbor 122.102.10.5 prefix-list deny-all in
  neighbor 122.102.10.5 prefix-list my-block out
!
ip prefix-list deny-all deny 0.0.0.0/0 le 32
ip prefix-list my-block permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 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

Aside:

Configuration Recommendation

- ❑ When distributing internal default by iBGP or OSPF
 - Make sure that routers connecting to private peers or to IXPs do **NOT** carry the default route
 - Otherwise they could point a default route to you and unintentionally transit your backbone
 - Simple fix for Private Peer/IXP routers:
`ip route 0.0.0.0 0.0.0.0 null0`

Service Provider Multihoming



Three upstreams, unequal
bandwidths

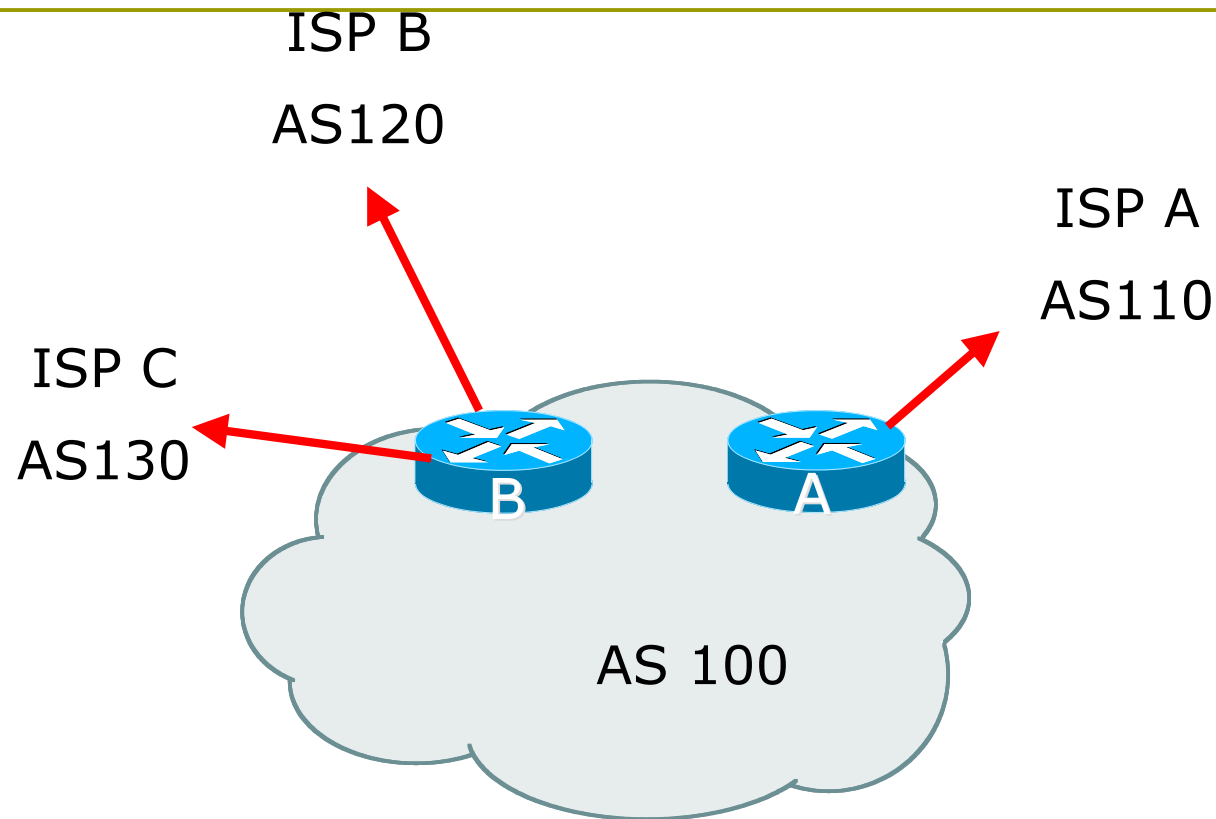
Three upstreams, unequal bandwidths

- Autonomous System has three upstreams
 - 16Mbps to ISP A
 - 8Mbps to ISP B
 - 4Mbps to ISP C
- What is the strategy here?
 - One option is full table from each
 - 3x 320k prefixes \Rightarrow 960k paths
 - Other option is partial table and defaults from each
 - How??

Strategy

- ❑ Two external routers (gives router redundancy)
 - Do **NOT** need three routers for this
- ❑ Connect biggest bandwidth to one router
 - Most of inbound and outbound traffic will go here
- ❑ Connect the other two links to the second router
 - Provides maximum backup capacity if primary link fails
- ❑ Use the biggest link as default
 - Most of the inbound and outbound traffic will go here
- ❑ Do the traffic engineering on the two smaller links
 - Focus on regional traffic needs

Diagram



- ❑ Router A has 16Mbps circuit to ISP A
- ❑ Router B has 8Mbps and 4Mbps circuits to ISPs B&C

Outbound load-balancing strategy

- ❑ Available BGP feeds from Transit providers:
 - Full table
 - Customer prefixes and default
 - Default Route
- ❑ These are the common options on Internet today
 - Very rare for any provider to offer anything different
 - Very rare for any provider to customise BGP feed for a customer

Outbound load-balancing strategy

- ❑ Accept only a default route from the provider with the **largest** connectivity, ISP A
 - Because most of the traffic is going to use this link
- ❑ If ISP A won't provide a default:
 - Still run BGP with them, but discard all prefixes
 - Point static default route to the upstream link
 - Distribute the default in the IGP
- ❑ Request the full table from ISP B & C
 - Most of this will be thrown away
 - ("Default plus customers" is not enough)

Outbound load-balancing strategy

- ❑ How to decide what to keep and what to discard from ISPs B & C?
 - Most traffic will use ISP A link — so we need to find a good/useful subset
- ❑ Discard prefixes transiting the global transit ISPs
 - Global transit ISPs generally appear in most non-local or regional AS-PATHs
- ❑ Discard prefixes with ISP A's ASN in the path
 - Makes more sense for traffic to those destinations to go via the link to ISP A

Outbound load-balancing strategy

□ Global Transit ISPs include:

209	Qwest	3549	Global Crossing
701	VerizonBusiness	3356	Level 3
1239	Sprint	3561	Savvis
1668	AOL TDN	7018	AT&T
2914	NTT America		

ISP B peering Inbound AS-PATH filter

```
ip as-path access-list 1 deny _209_  
ip as-path access-list 1 deny _701_  
ip as-path access-list 1 deny _1239_  
ip as-path access-list 1 deny _3356_  
ip as-path access-list 1 deny _3549_  
ip as-path access-list 1 deny _3561_  
ip as-path access-list 1 deny _2914_  
ip as-path access-list 1 deny _7018_  
!  
ip as-path access-list 1 deny _ISPA_ ←  
ip as-path access-list 1 deny _ISPC_  
!  
ip as-path access-list 1 permit _ISPB$  
ip as-path access-list 1 permit _ISPB_[0-9]+$  
ip as-path access-list 1 permit _ISPB_[0-9]+_[0-9]+$  
ip as-path access-list 1 permit _ISPB_[0-9]+_[0-9]+_[0-9]+$  
ip as-path access-list 1 deny .*
```

Don't need ISPA and
ISPC prefixes via ISPB

Outbound load-balancing strategy: ISP B peering configuration

- ❑ Part 1: Dropping Global Transit ISP prefixes
 - This can be fine-tuned if traffic volume is not sufficient
 - (More prefixes in = more traffic out)
- ❑ Part 2: Dropping prefixes transiting ISP A & C network
- ❑ Part 3: Permitting prefixes from ISP B, their BGP neighbours, and their neighbours, and their neighbours
 - More AS_PATH permit clauses, the more prefixes allowed in, the more egress traffic
 - Too many prefixes in will mean more outbound traffic than the link to ISP B can handle

Outbound load-balancing strategy

- ❑ Similar AS-PATH filter can be built for the ISP C BGP peering
- ❑ If the same prefixes are heard from both ISP B and C, then establish proximity of their origin ASN to ISP B or C
 - e.g. ISP B might be in Japan, with the neighbouring ASN in Europe, yet ISP C might be in Europe
 - Transit to the ASN via ISP C makes more sense in this case

Inbound load-balancing strategy

- ❑ The largest outbound link should announce just the aggregate
- ❑ The other links should announce:
 - a) The aggregate with AS-PATH prepend
 - b) Subprefixes of the aggregate, chosen according to traffic volumes to those subprefixes, and according to the services on those subprefixes
- ❑ Example:
 - Link to ISP B could be used just for Broadband/Dial customers — so number all such customers out of one contiguous subprefix
 - Link to ISP C could be used just for commercial leased line customers — so number all such customers out of one contiguous subprefix

Router A: eBGP Configuration Example

```
router bgp 100
  network 100.10.0.0 mask 255.255.224.0
  neighbor 122.102.10.1 remote 110
  neighbor 122.102.10.1 prefix-list default in
  neighbor 122.102.10.1 prefix-list aggregate out
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list aggregate permit 100.10.0.0/19
!
```


Router B: eBGP Configuration Example

```
router bgp 100
  network 100.10.0.0 mask 255.255.224.0
  neighbor 120.103.1.1 remote 120
  neighbor 120.103.1.1 filter-list 1 in
  neighbor 120.103.1.1 prefix-list ISP-B out
  neighbor 120.103.1.1 route-map to-ISP-B out
  neighbor 121.105.2.1 remote 130
  neighbor 121.105.2.1 filter-list 2 in
  neighbor 121.105.2.1 prefix-list ISP-C out
  neighbor 121.105.2.1 route-map to-ISP-C out
!
ip prefix-list aggregate permit 100.10.0.0/19
!
...next slide
```

Router B: eBGP Configuration

Example

```
ip prefix-list ISP-B permit 100.10.0.0/19
ip prefix-list ISP-B permit 100.10.0.0/21
!
ip prefix-list ISP-C permit 100.10.0.0/19
ip prefix-list ISP-C permit 100.10.28.0/22
!
route-map to-ISP-B permit 10
  match ip address prefix-list aggregate
  set as-path prepend 100
!
route-map to-ISP-B permit 20
!
route-map to-ISP-C permit 10
  match ip address prefix-list aggregate
  set as-path prepend 100 100
!
route-map to-ISP-C permit 20
```

/21 to ISP B
"dial customers"

/22 to ISP C
"biz customers"

e.g. Single
prepend on ISP B
link

e.g. Dual prepend
on ISP C link

What about outbound backup?

□ We have:

- Default route from ISP A by eBGP
- Mostly discarded full table from ISPs B&C

□ Strategy:

- Originate default route by OSPF on Router A (with metric 10) — link to ISP A
- Originate default route by OSPF on Router B (with metric 30) — links to ISPs B & C
- Plus on Router B:
 - Static default route to ISP B with distance 240
 - Static default route to ISP C with distance 245
- When link goes down, static route is withdrawn

Outbound backup: steady state

- Steady state (all links up and active):
 - Default route is to Router A — OSPF metric 10
 - (Because default learned by eBGP \Rightarrow default is in RIB \Rightarrow OSPF will originate default)
 - Backup default is to Router B — OSPF metric 20
 - eBGP prefixes learned from upstreams distributed by iBGP throughout backbone
 - (Default can be filtered in iBGP to avoid “RIB failure error”)

Outbound backup: failure examples

- ❑ Link to ISP A down, to ISPs B&C up:
 - Default route is to Router B — OSPF metric 20
 - (eBGP default gone from RIB, so OSPF on Router A withdraws the default)
- ❑ Above is true if link to B or C is down as well
- ❑ Link to ISPs B & C down, link to ISP A is up:
 - Default route is to Router A — OSPF metric 10
 - (static defaults on Router B removed from RIB, so OSPF on Router B withdraws the default)

Other considerations

- ❑ Default route should not be propagated to devices terminating non-transit peers and customers
- ❑ Rarely any need to carry default in iBGP
 - Best to filter out default in iBGP mesh peerings
- ❑ Still carry other eBGP prefixes across iBGP mesh
 - Otherwise routers will follow default route rules resulting in suboptimal traffic flow
 - Not a big issue because not carrying full table

Router A: iBGP Configuration Example

```
router bgp 100
  network 100.10.0.0 mask 255.255.224.0
  neighbor ibgp-peers peer-group
  neighbor ibgp-peers remote-as 100
  neighbor ibgp-peers prefix-list ibgp-filter out
  neighbor 100.10.0.2 peer-group ibgp-peers
  neighbor 100.10.0.2 prefix-list ibgp-filter out
  neighbor 100.10.0.3 peer-group ibgp-peers
  neighbor 100.10.0.3 prefix-list ibgp-filter out
!
ip prefix-list ibgp-filter deny 0.0.0.0/0
ip prefix-list ibgp-filter permit 0.0.0.0/0 le 32
!
```

Three upstreams, unequal bandwidths:

Summary

- ❑ Example based on many deployed working multihoming/loadbalancing topologies
- ❑ Many variations possible — this one is:
 - Easy to tune
 - Light on border router resources
 - Light on backbone router infrastructure
 - Sparse BGP table \Rightarrow faster convergence

Service Provider Multihoming



BGP Traffic Engineering