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”

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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**

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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!

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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**

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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**
- **Require BGP and a public ASN**
- **Examples assume that the local network has their own /19 address block**

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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

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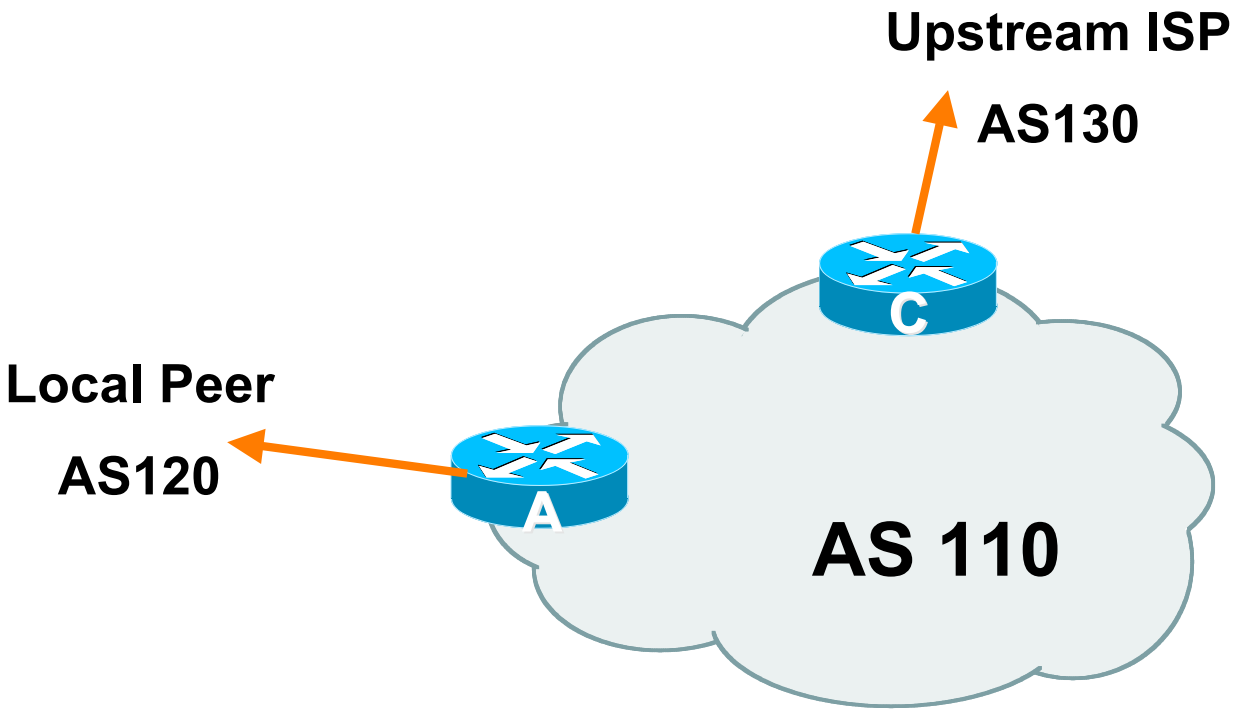
One Upstream, One Local Peer



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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**

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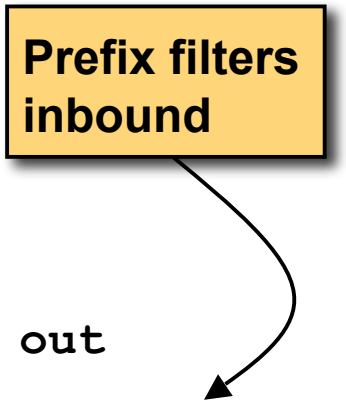
One Upstream, One Local Peer

- **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
```



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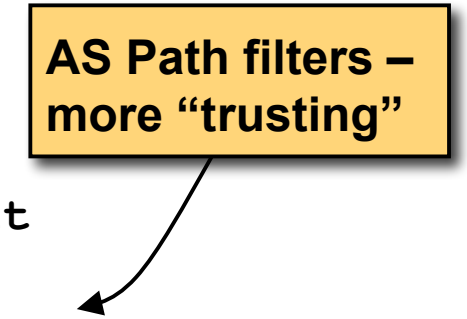
One Upstream, One Local Peer

- **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
```



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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
```


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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**

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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**

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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

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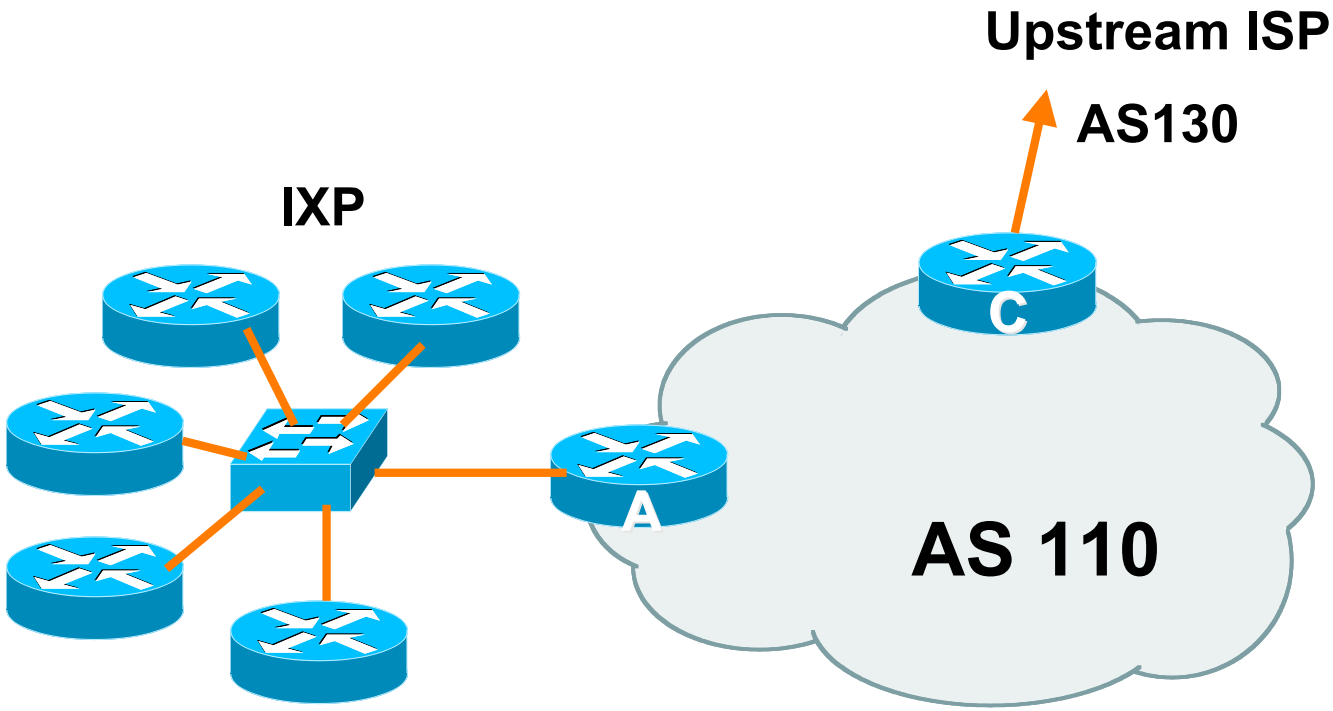
One Upstream, Local Exchange Point



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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**

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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
```


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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
```


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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
!
```


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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)**

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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
```


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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**

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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**

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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**

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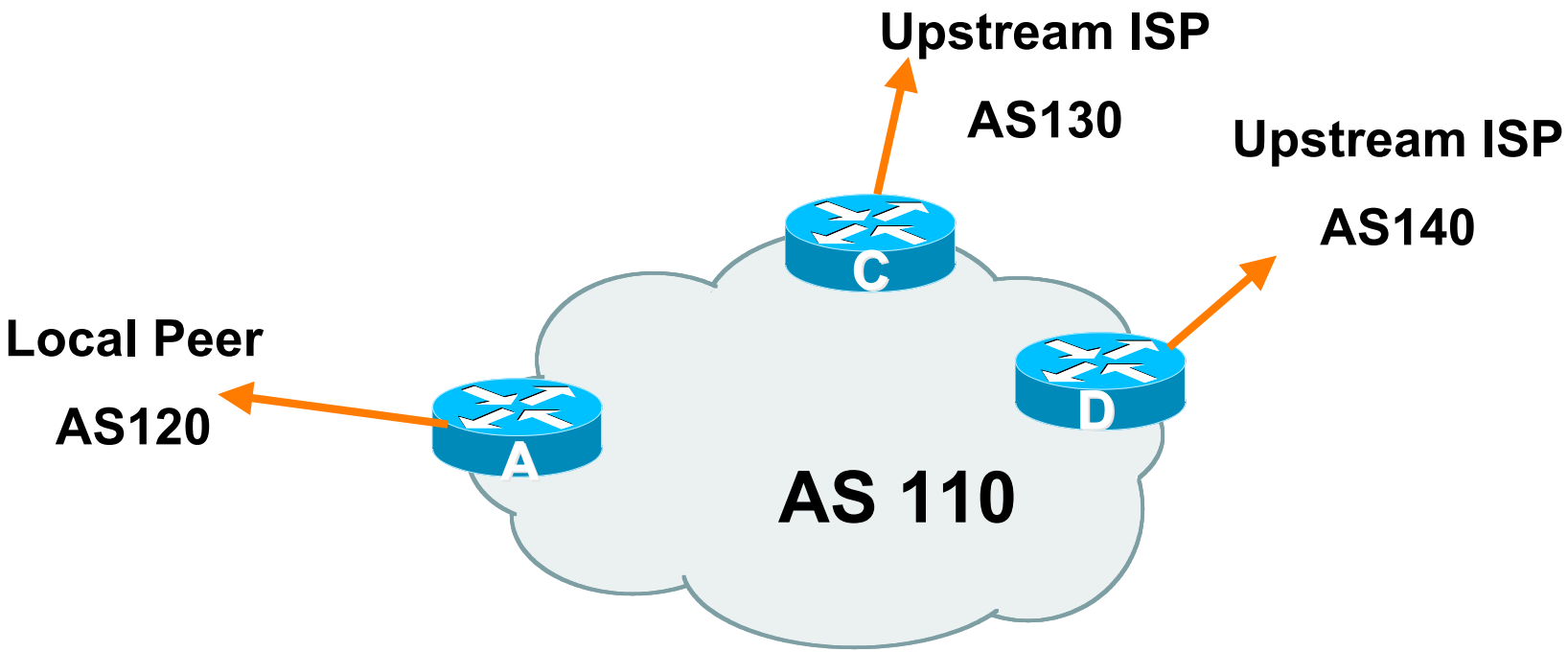
Two Upstreams, One Local Peer



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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

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Two Upstreams, One Local Peer

- **Router A**

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

  Same hardware configuration

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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
```


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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
```


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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

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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!**

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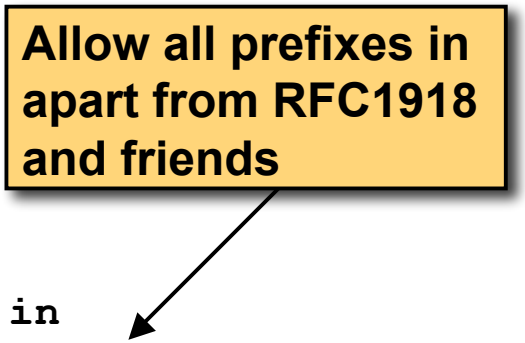
Two Upstreams, One Local Peer
Full Routes

- **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
```



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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
!
```


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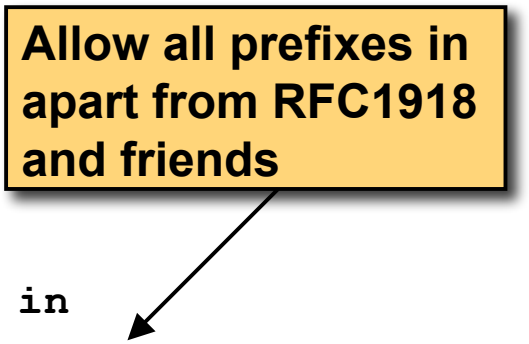
Two Upstreams, One Local Peer
Full Routes

- **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
```



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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**

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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**

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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**

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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

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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
!
```


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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
```


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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

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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**

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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**

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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
```


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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]+$
!
```


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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
!
```


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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**

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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
```


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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

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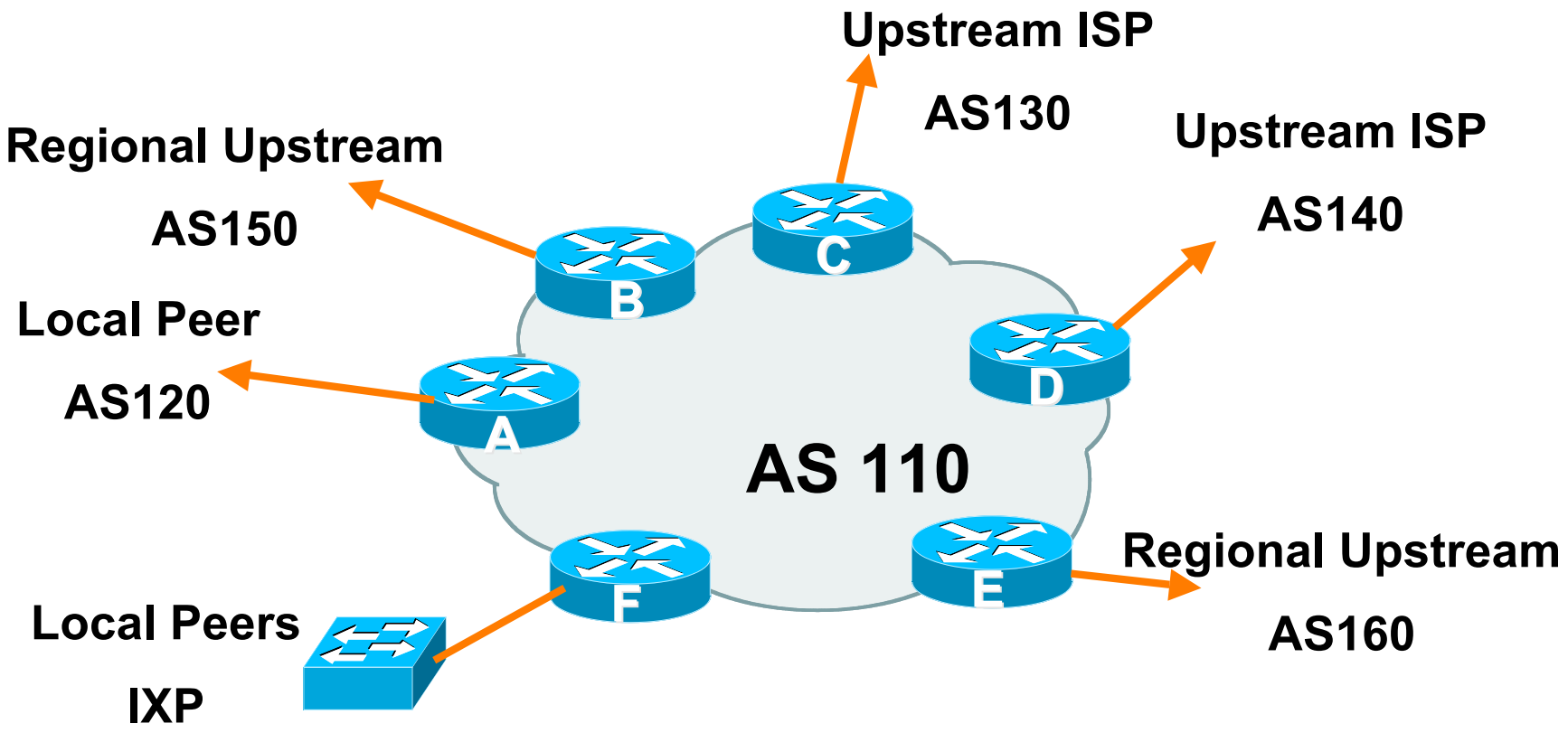
Tier-1 & Regional Upstreams, Local Peers



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Tier-1 & Regional Upstreams, Local Peers

- 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

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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**

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Tier-1 & Regional Upstreams, Local Peers Detail

- **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**

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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**

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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**

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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**

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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

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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**

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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**

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Service Provider Multihoming

BGP Traffic Engineering