BGP Multihoming

ISP/IXP Workshops

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?

Multihoming Definition

- 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

Multihoming

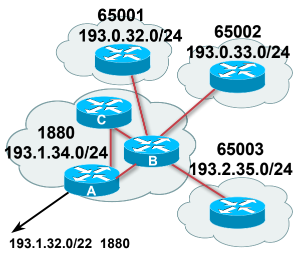
- The scenarios described here apply equally well to end sites being customers of ISPs and ISPs being customers of other ISPs
- Implementation detail may be different
  - end site → ISP   ISP controls config
  - ISP1 → ISP2   ISPs share config

AS Numbers

- An Autonomous System Number is required by BGP
- Obtained from upstream ISP or Regional Registry (RIR)
  - AfriNIC, 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

- 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

- Assumptions:
  - prefix-lists are used throughout
  - easier/better/faster than access-lists
- Three BASIC Principles
  - 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 /21
  - 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

- Some ISPs publish their minimum allocation sizes per /8 address block
  - AfriNIC: www.afrinic.net/docs/policies/afpol-v4200407-000.htm
  - APNIC: www.apnic.net/db/min-alloc.html
  - ARIN: www.arin.net/reference/ip_blocks.html
  - LACNIC: lacnic.net/en/registro/index.html
  - RIPE NCC: www.ripe.net/ripe/docs/smallest-alloc-sizes.html
  - Note that AfriNIC only publishes its current minimum allocation size, not the allocation size for its address blocks
- 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

- 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

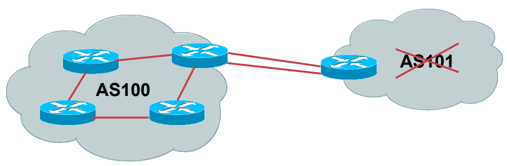
Cisco Systems

Multihoming Options

Multihoming Scenarios

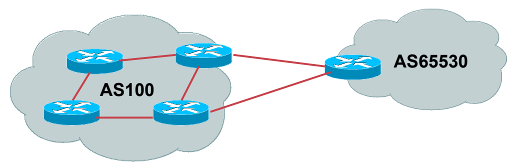
- Stub network
- Multi-homed stub network
- Multi-homed network
- Configuration Options

Stub Network



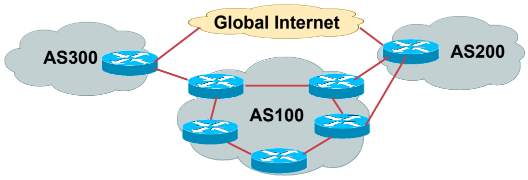
- No need for BGP
- Point static default to upstream ISP
- Upstream ISP advertises stub network
- Policy confined within upstream ISP's policy

Multi-homed Stub Network



- 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

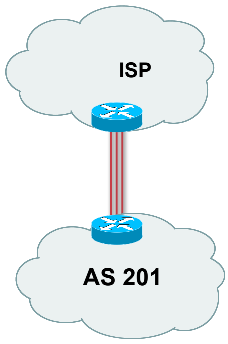
Multi-Homed Network



- 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

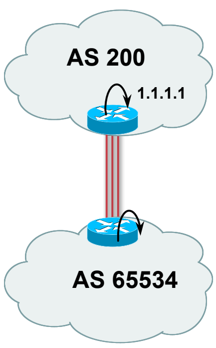
- Several options
  - ebgp multihop
  - bgp multipath
  - cef loadsharing
  - bgp attribute manipulation



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

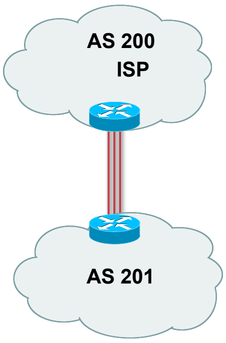
- Try and avoid use of ebgp-multihop unless:
  - It's absolutely necessary –or–
  - Loadsharing across multiple links
- Many ISPs discourage its use, for example:

> 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
bgp multi path

- Three BGP sessions required
- limit of 6 parallel paths

```
router bgp 201
 neighbor 1.1.2.1 remote-as 200
 neighbor 1.1.2.5 remote-as 200
 neighbor 1.1.2.9 remote-as 200
 maximum-paths 3
```

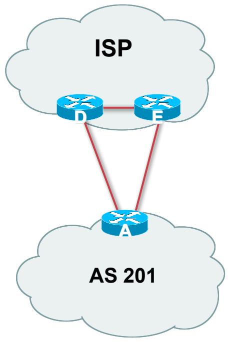


Multiple Sessions to an ISP

- Use eBGP multi-path to install multiple paths in IP table

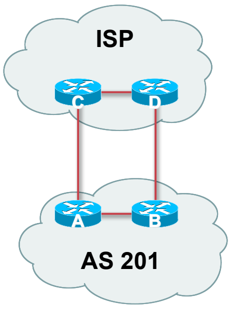
```
router bgp 201
 maximum-path <1-6>
```

- Load share over the alternate paths
  - per destination loadsharing



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
  - Point default towards one ISP
  - Learn selected prefixes from second ISP
  - Modify the number of prefixes learnt to achieve acceptable load sharing
- No magic solution



Preparing the network

Before we begin…

Preparing the Network

- We will deploy BGP across the network before we try and multihome
- BGP will be used therefore an ASN is required
- If multihoming to different ISPs, public ASN needed:
  - Either go to upstream ISP who is a registry member, or
  - Apply to the RIR yourself for a one off assignment, or
  - Ask an ISP who is a registry member, or
  - Join the RIR and get your own IP address allocation too (this option strongly recommended)!

Preparing the Network
Initial Assumptions

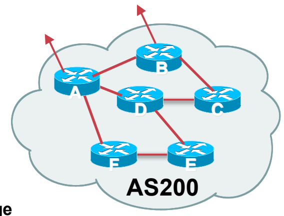
- The network is not running any BGP at the moment
  - single statically routed connection to upstream ISP
- The network is not running any IGP at all
  - Static default and routes through the network to do "routing"

Preparing the Network
First Step: IGP

- 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

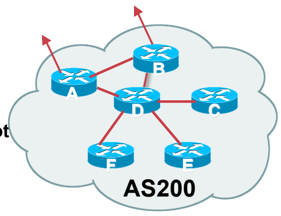
Preparing the Network
Second Step: iBGP

- 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)

- *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

- 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 BGP 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/static routes
  - Step 5: Restore BGP distance to greater than IGP distance
  - Step 6: Deployment of eBGP follows

Preparing the Network
Configuration – Before BGP

```
interface loopback 0
 ip address 121.10.255.1 255.255.255.255
!
interface serial 0/0
 ip address 121.10.0.1 255.255.255.252
!
interface serial 0/1
 ip address 121.10.0.5 255.255.255.252
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
 redistribute connected subnets     ! Point-to-point links
 redistribute static subnets        ! Customer networks
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
```

Add loopback configuration if not already there

Preparing the Network
Configuration – Steps 1 & 2

```
! interface and OSPF configuration unchanged
!
router bgp 100
 redistribute connected subnets route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
route-map point-to-point permit 5
 match ip address 1
 set community 100:1
!
access-list 1 permit 121.10.0.0 0.0.255.255
```

Add BGP and related configuration in red

Preparing the Network
Configuration – Steps 3 & 4

```
! interface configuration unchanged
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
!
router bgp 100
 redistribute connected route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 20 20 20       ! reduced BGP distance
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
...etc...
```

OSPF redistribution has been removed

Preparing the Network
Configuration – Step 5

```
! interface configuration unchanged
!
router ospf 100
 network 121.10.255.1 0.0.0.0 area 0
 passive-interface loopback 0
!
router bgp 100
 redistribute connected route-map point-to-point
 neighbor 121.10.1.2 remote-as 100
 neighbor 121.10.1.2 next-hop-self
 ...
 network 121.10.24.0 mask 255.255.252.0
 network 121.10.28.0 mask 255.255.254.0
 distance bgp 200 200 200    ! BGP distance restored
!
ip route 121.10.24.0 255.255.252.0 serial 0/0
ip route 121.10.28.0 255.255.254.0 serial 0/1
!
...etc...
```

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

Basic Multihoming

Let's learn to walk before we try running…

Basic Multihoming

- No frills multihoming
- Will look at two cases:
  - Multihoming with the same ISP
  - Multihoming to different ISPs
- Will keep the examples easy
  - Understanding easy concepts will make the more complex scenarios easier to comprehend

Basic Multihoming

- This type is most commonplace at the edge of the Internet
  - Networks here are usually concerned with inbound traffic flows
  - Outbound traffic flows being "nearest exit" is usually sufficient
- Can apply to the leaf ISP as well as Enterprise networks

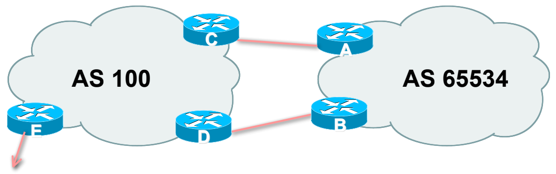
Two links to the same ISP

Basic – No Redundancy

Two links to the same ISP

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

Two links to the same ISP



- AS100 proxy aggregates for AS 65534

Two links to the same ISP

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

  basic inbound loadsharing

- Example has no practical use, but demonstrates the principles

Two links to the same ISP

- Router A Configuration

```
router bgp 65534
 network 121.10.0.0 mask 255.255.240.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```


Two links to the same ISP

- Router B Configuration

```
router bgp 65534
 network 121.10.0.0 mask 255.255.240.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```


Two links to the same ISP

- Router C Configuration

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/20
ip prefix-list default permit 0.0.0.0/0
```


Two links to the same ISP

- Router D Configuration

```
router bgp 100
 neighbor 122.102.10.5 remote-as 65534
 neighbor 122.102.10.5 default-originate
 neighbor 122.102.10.5 prefix-list Customer in
 neighbor 122.102.10.5 prefix-list default out
!
ip prefix-list Customer permit 121.10.16.0/20
ip prefix-list default permit 0.0.0.0/0
```

Two links to the same ISP

- Router E is AS100 border router
  - removes prefixes in the private AS from external announcements
  - implements the proxy aggregation for the customer prefixes

Two links to the same ISP

- Router E Configuration

```
router bgp 100
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 filter-list 1 out
!
ip route 121.10.0.0 255.255.224.0 null0
!
ip as-path access-list 1 deny ^65534$
ip as-path access-list 1 permit ^$
```

- Private AS still visible inside AS100

Two links to the same ISP

- **Big Problem**:
  - no backup in case of link failure
- /19 address block not announced
- AS Path filtering "awkward"
  - easier to use bgp command
  - `neighbor x.x.x.x remove-private-AS`

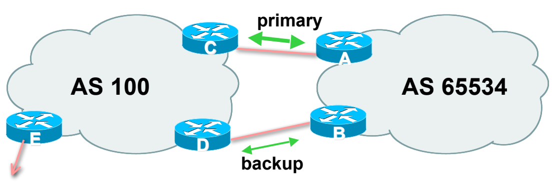
Two links to the same ISP

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 an E1, backup might be 64kbps

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



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

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

- **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)

- **Router A Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 description RouterC
 neighbor 122.102.10.2 prefix-list aggregate out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
!
```


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

- **Router B Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 description RouterD
 neighbor 122.102.10.6 prefix-list aggregate out
 neighbor 122.102.10.6 route-map routerD-out out
 neighbor 122.102.10.6 prefix-list default in
 neighbor 122.102.10.6 route-map routerD-in in
!
..next slide
```


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

```
ip prefix-list aggregate permit 121.10.0.0/19
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)

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

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19
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 122.102.10.5 remote-as 65534
 neighbor 122.102.10.5 default-originate
 neighbor 122.102.10.5 prefix-list Customer in
 neighbor 122.102.10.5 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19
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 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customer out
!
ip prefix-list Customer permit 121.10.0.0/19
```

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

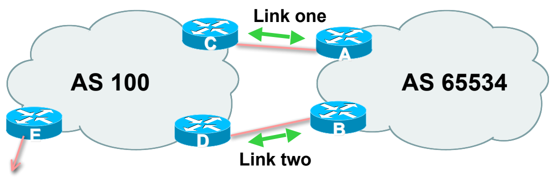
Two links to the same ISP

With Redundancy and 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



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

Loadsharing to the same ISP (with redundancy)

- **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 (with redundancy)

- **Router A Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
ip prefix-list routerC permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```

Loadsharing to the same ISP (with redundancy)

- **Router B Configuration**

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
ip prefix-list routerD permit 121.10.0.0/19
!
ip route 121.10.16.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```


Loadsharing to the same ISP (with redundancy)

- **Router C Configuration**

```
router bgp 100
 neighbor 122.102.10.1 remote-as 65534
 neighbor 122.102.10.1 default-originate
 neighbor 122.102.10.1 prefix-list Customer in
 neighbor 122.102.10.1 prefix-list default out
!
ip prefix-list Customer permit 121.10.0.0/19 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 (with redundancy)

- **Router E Configuration**

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customer out
!
ip prefix-list Customer permit 121.10.0.0/19
```

- **Private AS still visible inside AS100**

Loadsharing to the same ISP (with redundancy)

- **Default route for outbound traffic?**

  Use default-information originate for the IGP and rely on IGP metrics for nearest exit

  e.g. on router A:

```
router ospf 65534
 default-information originate metric 2 metric-type 1
```


Loadsharing to the same ISP (with redundancy)

- **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

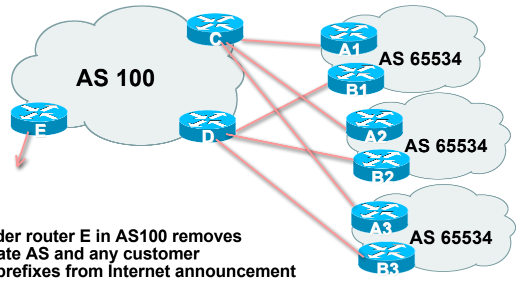
Multiple Dualhomed Customers

(RFC2270)

Multiple Dualhomed Customers (RFC2270)

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

Multiple Dualhomed Customers (RFC2270)



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

Multiple Dualhomed Customers (RFC2270)

- 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 (RFC2270)

- Router A1 Configuration

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.2 remote-as 100
 neighbor 122.102.10.2 prefix-list routerC out
 neighbor 122.102.10.2 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
ip prefix-list routerC permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.240.0 null0
ip route 121.10.0.0 255.255.224.0 null0
```


Multiple Dualhomed Customers (RFC2270)

- Router B1 Configuration

```
router bgp 65534
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 122.102.10.6 remote-as 100
 neighbor 122.102.10.6 prefix-list routerD out
 neighbor 122.102.10.6 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
ip prefix-list routerD permit 121.10.0.0/19
!
ip route 121.10.0.0 255.255.224.0 null0
ip route 121.10.16.0 255.255.240.0 null0
```


Multiple Dualhomed Customers (RFC2270)

- 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 122.102.10.1 peer-group bgp-customers
 neighbor 122.102.10.1 description Customer One
 neighbor 122.102.10.1 prefix-list Customer1 in
 neighbor 122.102.10.9 peer-group bgp-customers
 neighbor 122.102.10.9 description Customer Two
 neighbor 122.102.10.9 prefix-list Customer2 in
```

Multiple Dualhomed Customers (RFC2270)

```
 neighbor 122.102.10.17 peer-group bgp-customers
 neighbor 122.102.10.17 description Customer Three
 neighbor 122.102.10.17 prefix-list Customer3 in
!
ip prefix-list Customer1 permit 121.10.0.0/19 le 20
ip prefix-list Customer2 permit 121.16.64.0/19 le 20
ip prefix-list Customer3 permit 121.14.192.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- Router C only allows in /19 and /20 prefixes from customer block

Multiple Dualhomed Customers (RFC2270)

- Router D 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 122.102.10.5 peer-group bgp-customers
 neighbor 122.102.10.5 description Customer One
 neighbor 122.102.10.5 prefix-list Customer1 in
 neighbor 122.102.10.13 peer-group bgp-customers
 neighbor 122.102.10.13 description Customer Two
 neighbor 122.102.10.13 prefix-list Customer2 in
```


Multiple Dualhomed Customers (RFC2270)

```
 neighbor 122.102.10.21 peer-group bgp-customers
 neighbor 122.102.10.21 description Customer Three
 neighbor 122.102.10.21 prefix-list Customer3 in
!
ip prefix-list Customer1 permit 121.10.0.0/19 le 20
ip prefix-list Customer2 permit 121.16.64.0/19 le 20
ip prefix-list Customer3 permit 121.14.192.0/19 le 20
ip prefix-list default permit 0.0.0.0/0
```

- Router D only allows in /19 and /20 prefixes from customer block

Multiple Dualhomed Customers (RFC2270)

- Router E Configuration
  - assumes customer address space is not part of upstream's address block

```
router bgp 100
 neighbor 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 remove-private-AS
 neighbor 122.102.10.17 prefix-list Customers out
!
ip prefix-list Customers permit 121.10.0.0/19
ip prefix-list Customers permit 121.16.64.0/19
ip prefix-list Customers permit 121.14.192.0/19
```

- Private AS still visible inside AS100

Multiple Dualhomed Customers (RFC2270)

- 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 122.102.10.17 remote-as 110
 neighbor 122.102.10.17 prefix-list my-aggregate out
!
ip prefix-list my-aggregate permit 121.8.0.0/13
```


Multihoming Summary

- Use private AS for multihoming to upstream
- Leak subprefixes to upstream only to aid loadsharing
- Upstream Router E configuration is uniform across all scenarios

Basic Multihoming

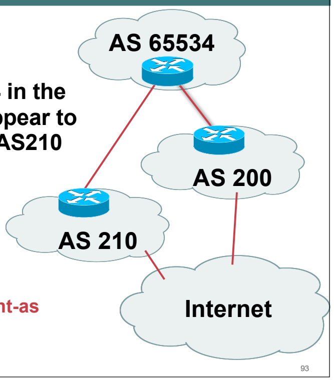
Multihoming to Different ISPs

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?

- 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



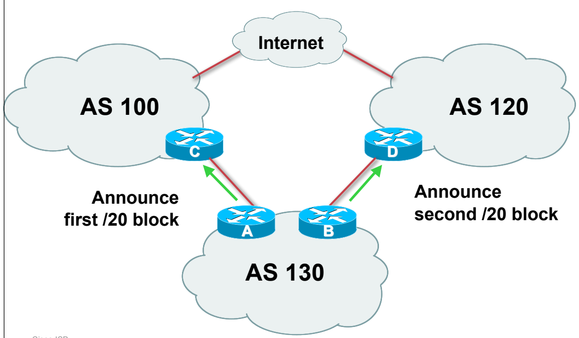
Two links to different ISPs

Basic – No Redundancy

Two links to different ISPs (no redundancy)

- Example for PI space
  - ISP network, or large enterprise site
- Split /19 and announce as two /20s, one on each link
  - basic inbound loadsharing

Two links to different ISPs (no redundancy)



Two links to different ISPs (no redundancy)

- Router A Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list routerC out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerC permit 121.10.0.0/20
```


Two links to different ISPs (no redundancy)

- Router B Configuration

```
router bgp 130
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list routerD out
 neighbor 120.1.5.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
ip prefix-list routerD permit 121.10.16.0/20
```


Two links to different ISPs (no redundancy)

- Router C Configuration

```
router bgp 100
 neighbor 121.10.1.1 remote-as 130
 neighbor 121.10.1.1 default-originate
 neighbor 121.10.1.1 prefix-list AS130cust in
 neighbor 121.10.1.1 prefix-list default-out out
!
```

- Router C only announces default to AS 130
- Router C only accepts AS130's prefix block

Two links to different ISPs (no redundancy)

- Router D Configuration

```
router bgp 120
 neighbor 120.1.5.1 remote-as 130
 neighbor 120.1.5.1 default-originate
 neighbor 120.1.5.1 prefix-list AS130cust in
 neighbor 120.1.5.1 prefix-list default-out out
!
```

- Router D only announces default to AS 130
- Router D only accepts AS130's prefix block

Two links to different ISPs (no redundancy)

- **Big Problem**:

  no backup in case of link failure
- /19 address block not announced

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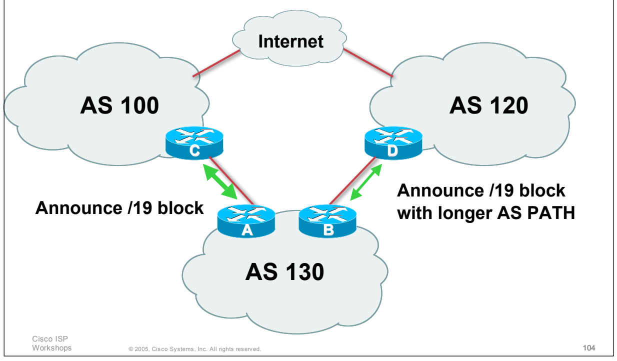
Two links to different ISPs

One link primary, the other link backup only

Two links to different ISPs (one as backup only)

- 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)



Two links to different ISPs (one as backup only)

- Router A Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list aggregate out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list aggregate permit 121.10.0.0/19
ip prefix-list default permit 0.0.0.0/0
```


Two links to different ISPs (one as backup only)

- Router B Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list aggregate out
 neighbor 120.1.5.1 route-map routerD-out out
 neighbor 120.1.5.1 prefix-list default in
 neighbor 120.1.5.1 route-map routerD-in in
!
ip prefix-list aggregate permit 121.10.0.0/19
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

Cisco Systems

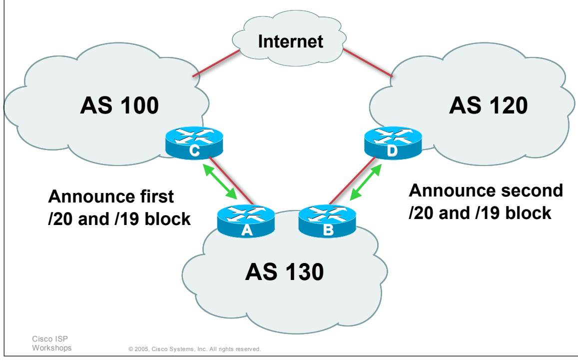
Two links to different ISPs

With Redundancy

Two links to different ISPs (with redundancy)

- 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 redundancy)



Two links to different ISPs (with redundancy)

- Router A Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.0.0 mask 255.255.240.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list firstblock out
 neighbor 122.102.10.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list firstblock permit 121.10.0.0/20
ip prefix-list firstblock permit 121.10.0.0/19
```


Two links to different ISPs (with redundancy)

- Router B Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list secondblock out
 neighbor 120.1.5.1 prefix-list default in
!
ip prefix-list default permit 0.0.0.0/0
!
ip prefix-list secondblock permit 121.10.16.0/20
ip prefix-list secondblock permit 121.10.0.0/19
```


Two links to different ISPs (with loadsharing)

- 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…!

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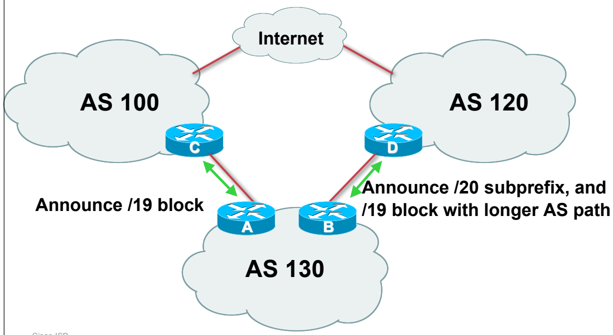
Two links to different ISPs

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 121.10.0.0 mask 255.255.224.0
 neighbor 122.102.10.1 remote-as 100
 neighbor 122.102.10.1 prefix-list default in
 neighbor 122.102.10.1 prefix-list aggregate out
!
ip prefix-list aggregate permit 121.10.0.0/19
```


Loadsharing with different ISPs

- Router B Configuration

```
router bgp 130
 network 121.10.0.0 mask 255.255.224.0
 network 121.10.16.0 mask 255.255.240.0
 neighbor 120.1.5.1 remote-as 120
 neighbor 120.1.5.1 prefix-list default in
 neighbor 120.1.5.1 prefix-list subblocks out
 neighbor 120.1.5.1 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 121.10.0.0/19 le 20
ip prefix-list aggregate permit 121.10.0.0/19
```


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

Cisco Systems

BGP Multihoming

ISP/IXP Workshops