# Simple 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

# 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 |

# 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 minimum allocation is from /20 to /22 depending on the RIR

  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

- The RIRs 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

  Consider using the Team Cymru or other reputable bogon BGP feed:

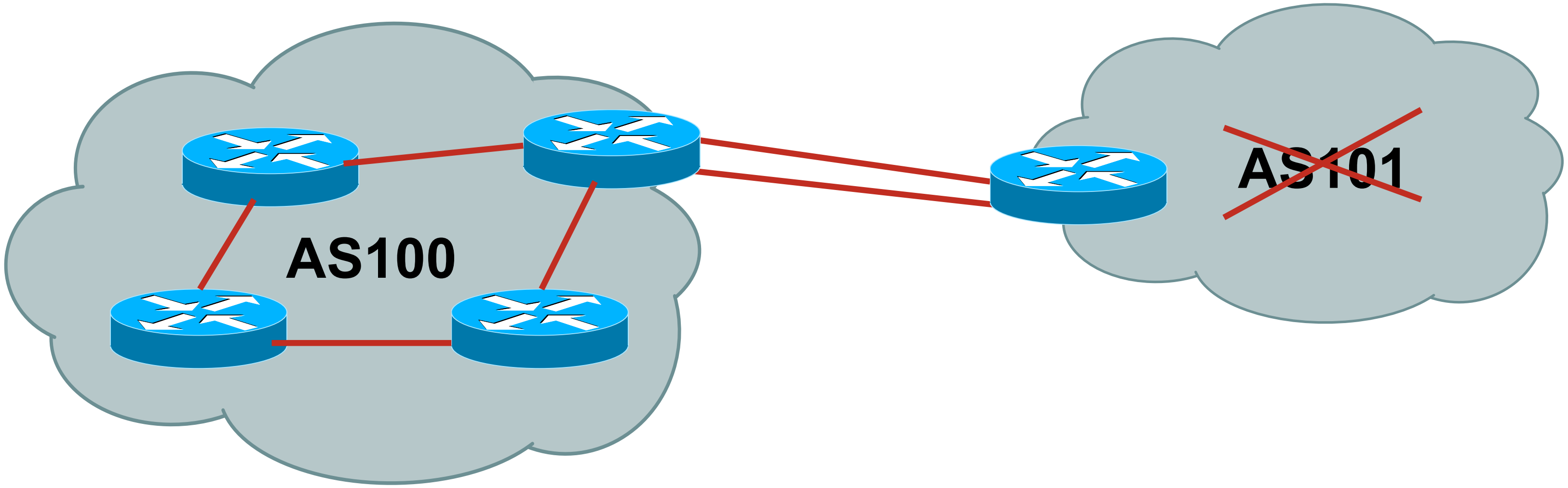
  http://www.team-cymru.org/Services/Bogons/routeserver.html

# Multihoming Options

# Multihoming Scenarios

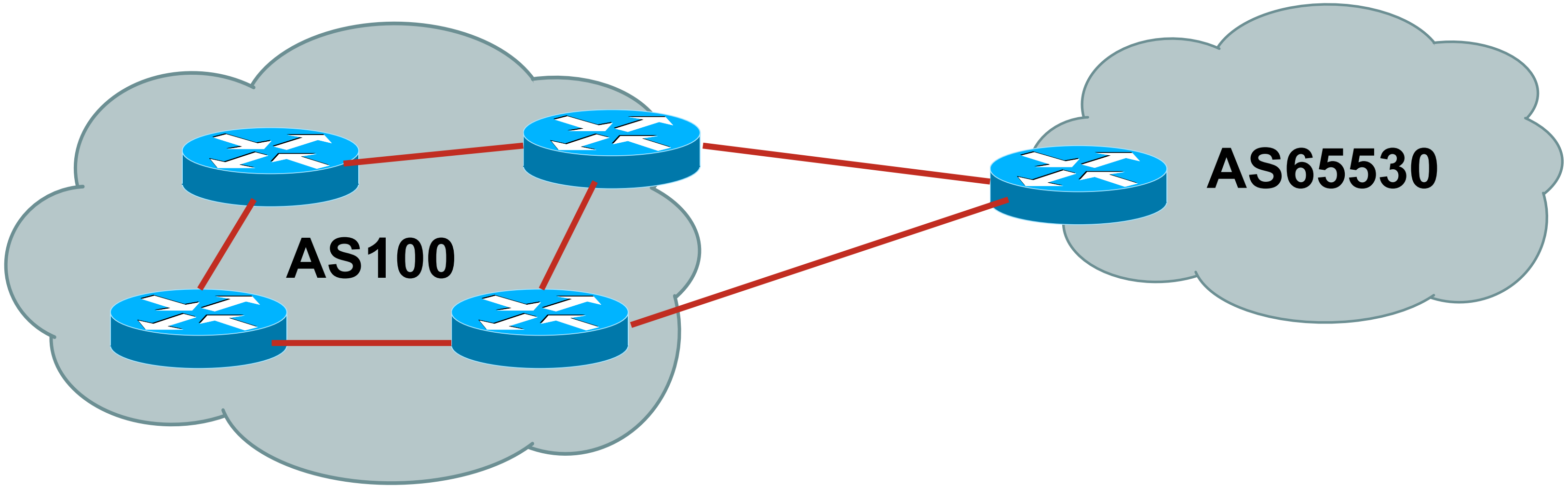
- Stub network
- Multi-homed stub network
- Multi-homed network
- Configuration Options

# 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

# 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

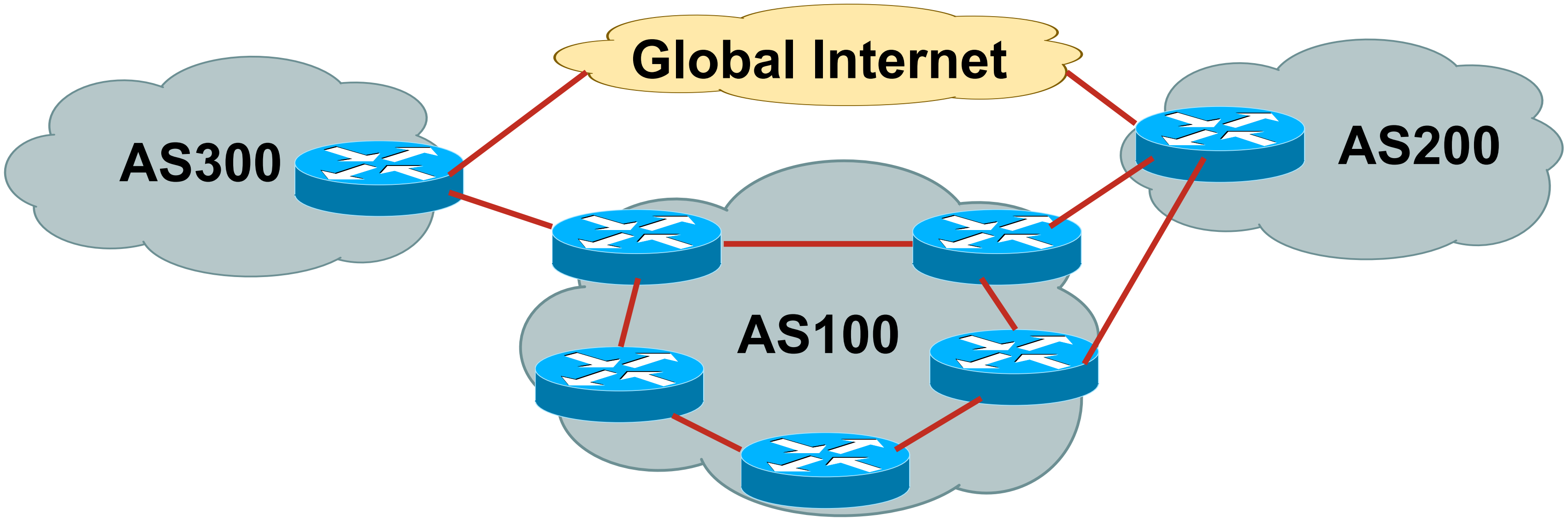
- As with RFC1918 address space, private ASNs are intended for internal use

  They should not be leaked to the public Internet

- Cisco IOS

```
neighbor x.x.x.x remove-private-AS
```

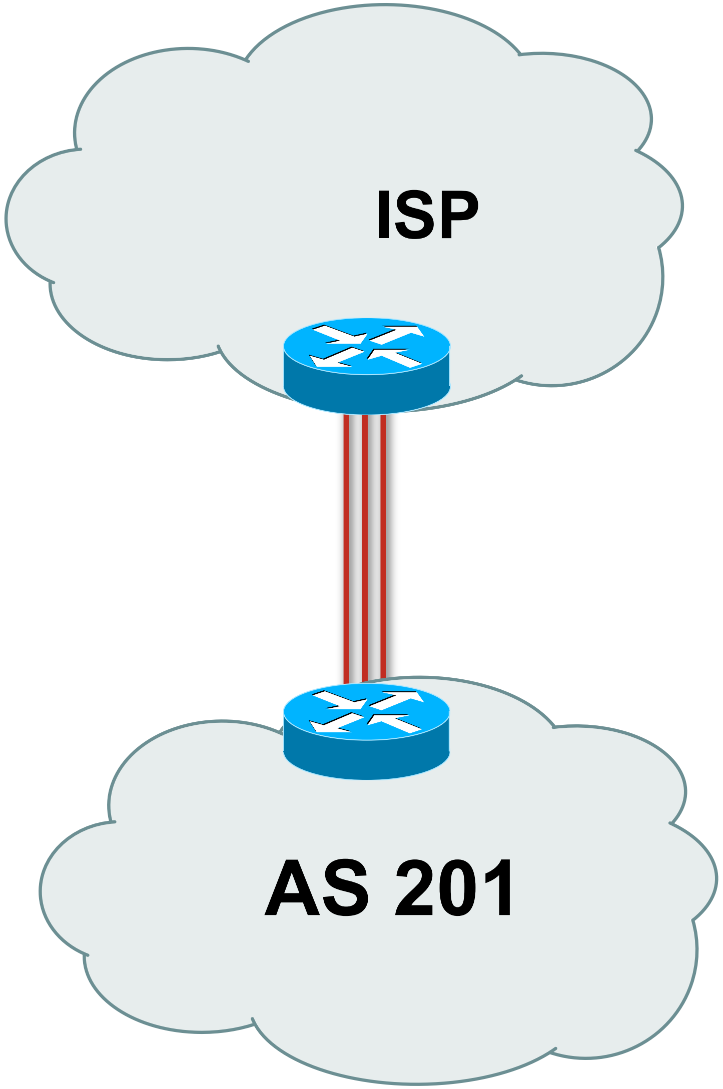
# Multi-homed Network



- 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

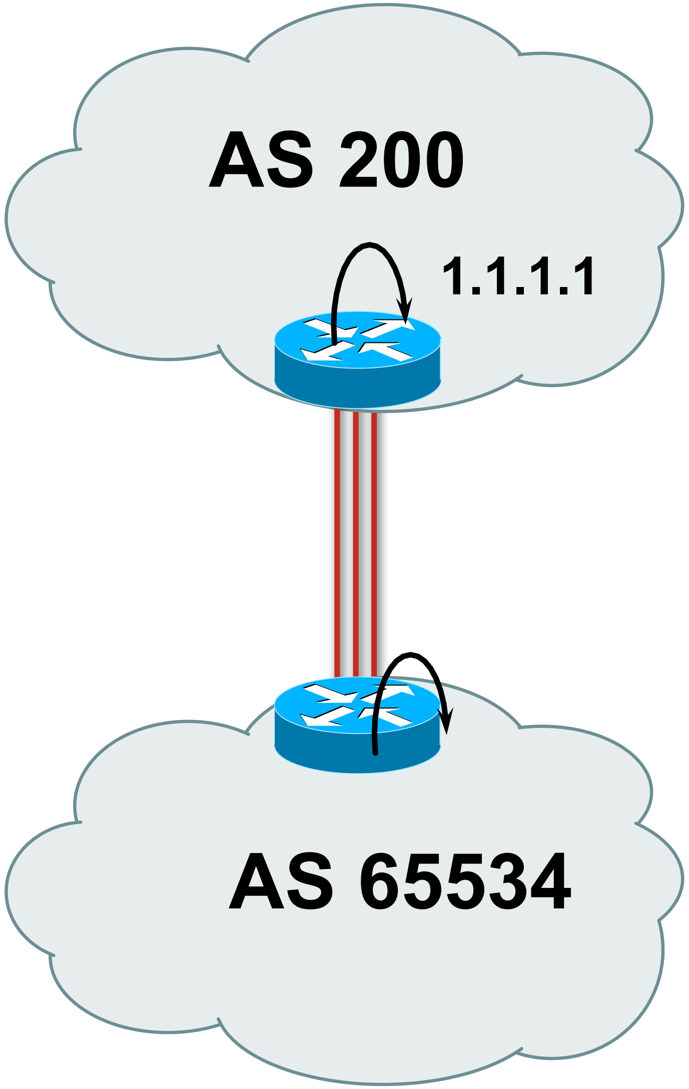
- Use eBGP multihop

  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

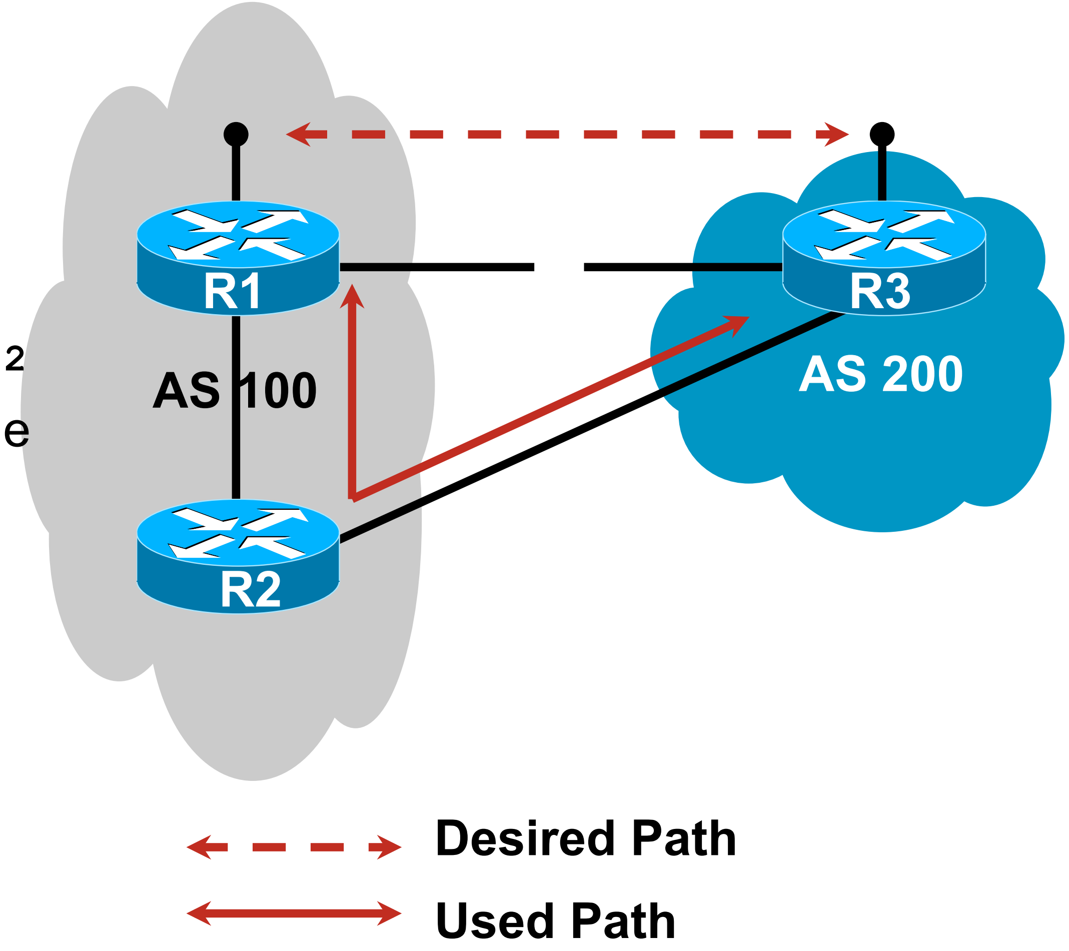
- One eBGP-multihop gotcha:

  R1 and R3 are eBGP peers that are loopback peering

  Configured with:

  ```
  neighbor x.x.x.x ebgp-multihop 2
  ```

  If the R1 to R3 link goes down the session could establish via R2



# Multiple Sessions to an ISP – Example One

- Try and avoid use of ebgp-multihop unless:

  It’s absolutely necessary –or–

  Loadsharing across multiple links

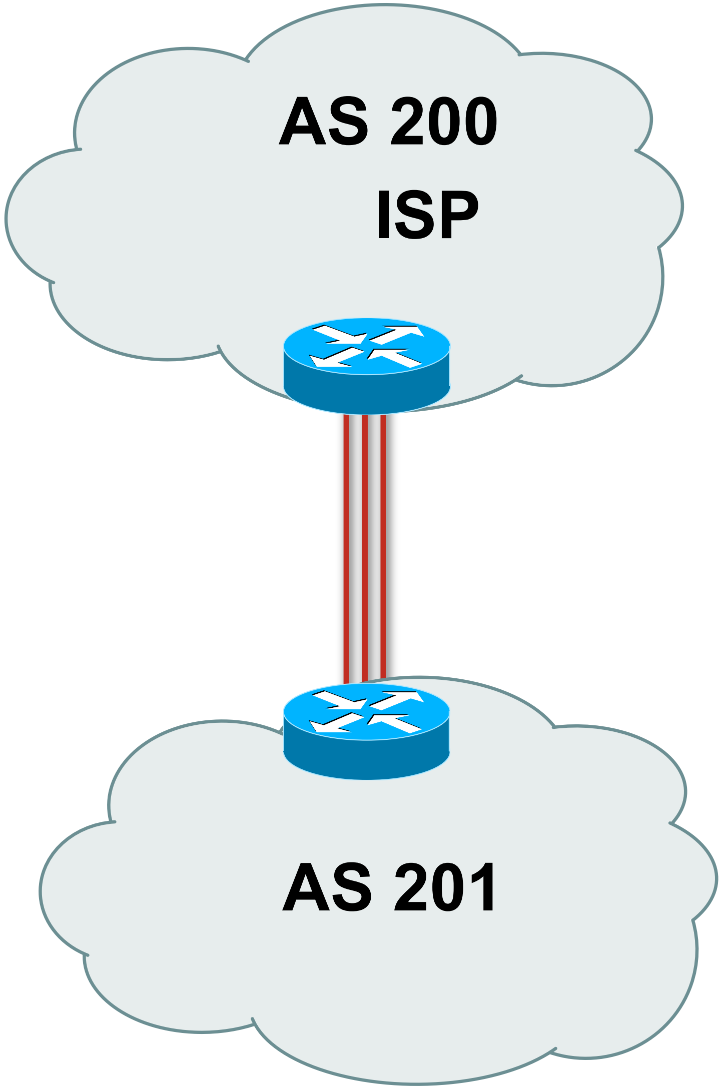
- Many ISPs discourage its use, for example:

**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
```



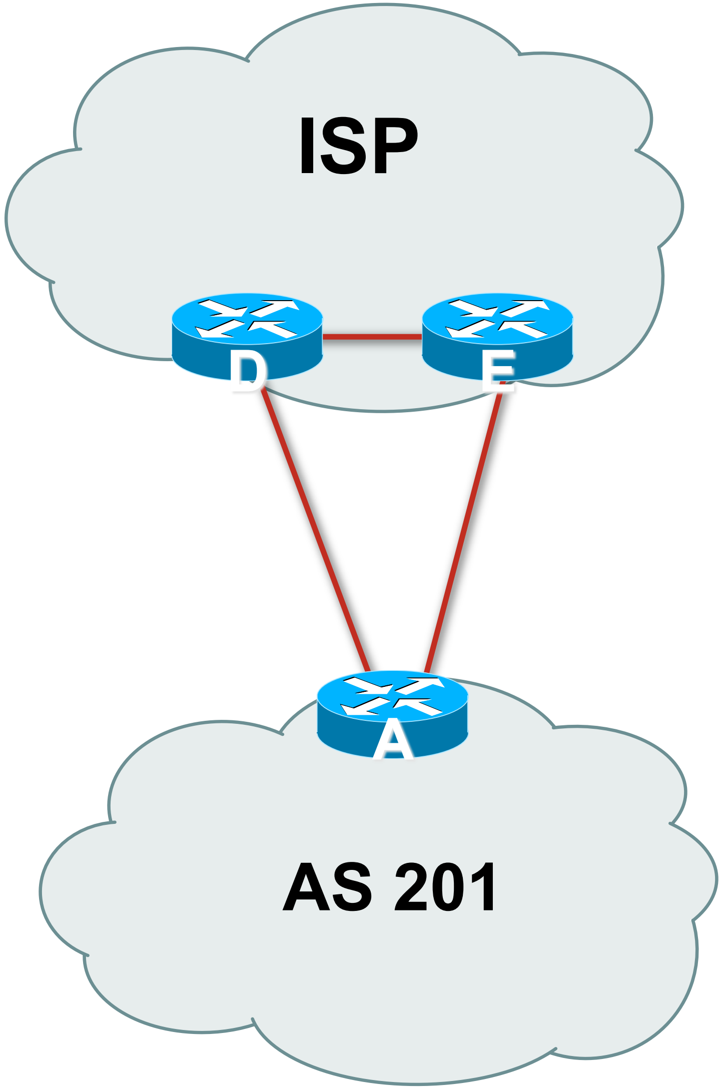
# Multiple Sessions to an ISP

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

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

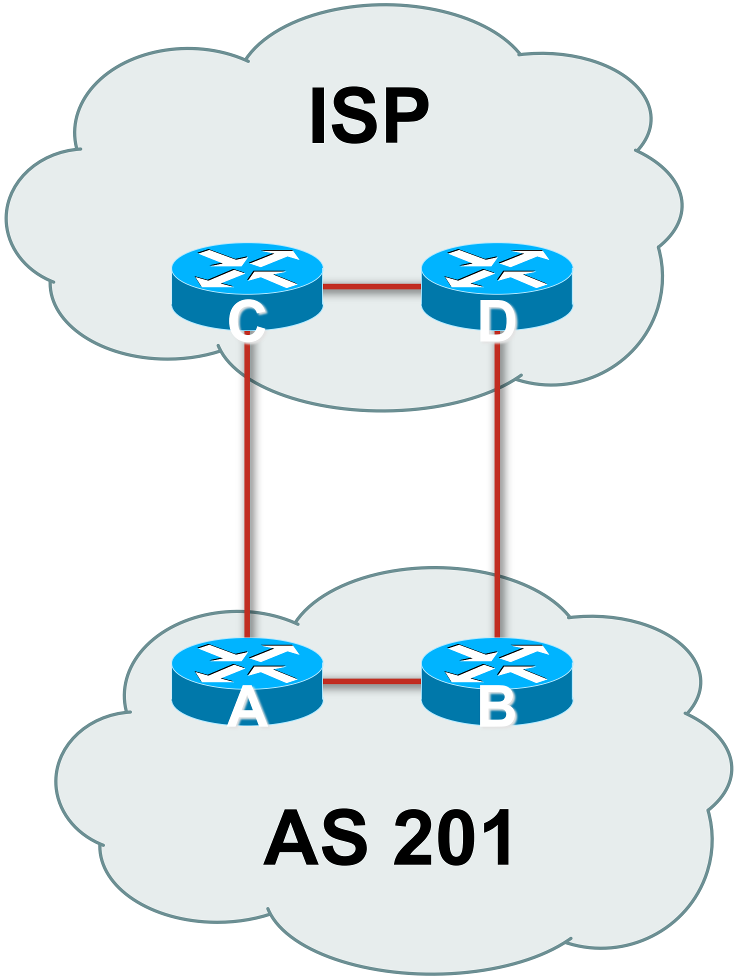
- Load share over the alternate paths

    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



# Basic Principles of Multihoming

**Let’s learn to walk before we try running…**

# The Basic Principles

- Announcing address space attracts traffic

  (Unless policy in upstream providers interferes)

- Announcing the ISP aggregate out a link will result in traffic for that aggregate coming in that link

- Announcing a subprefix of an aggregate out a link means that all traffic for that subprefix will come in that link, even if the aggregate is announced somewhere else

  The most specific announcement wins!

# The Basic Principles

- To split traffic between two links:

  Announce the aggregate on both links - ensures redundancy

  Announce one half of the address space on each link

  (This is the first step, all things being equal)

- Results in:

  Traffic for first half of address space comes in first link

  Traffic for second half of address space comes in second link

  If either link fails, the fact that the aggregate is announced ensures there is a backup path

# The Basic Principles

- The keys to successful multihoming configuration:

  Keeping traffic engineering prefix announcements independent of customer iBGP

  Understanding how to announce aggregates

  Understanding the purpose of announcing subprefixes of aggregates

  Understanding how to manipulate BGP attributes

  Too many upstreams/external paths makes multihoming harder (2 or 3 is enough!)

# IP Addressing & Multihoming

## How Good IP Address Plans assist with Multihoming

# IP Addressing & Multihoming

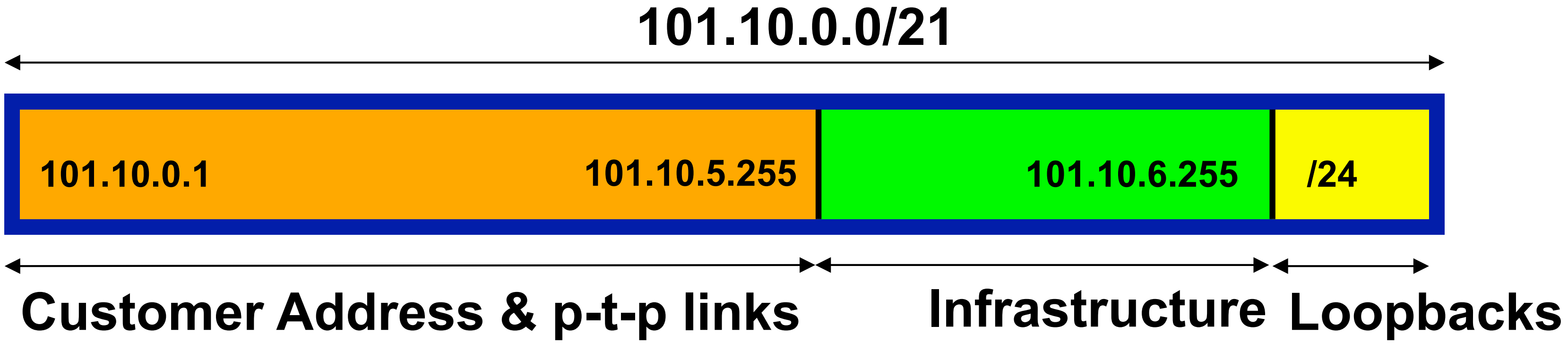
- IP Address planning is an important part of Multihoming
- Previously have discussed separating:

  Customer address space

  Customer p-t-p link address space

  Infrastructure p-t-p link address space

  Loopback address space



# IP Addressing & Multihoming

- ISP Router loopbacks and backbone point to point links make up a small part of total address space

  And they don't attract traffic, unlike customer address space

- Links from ISP Aggregation edge to customer router needs one /30

  Small requirements compared with total address space

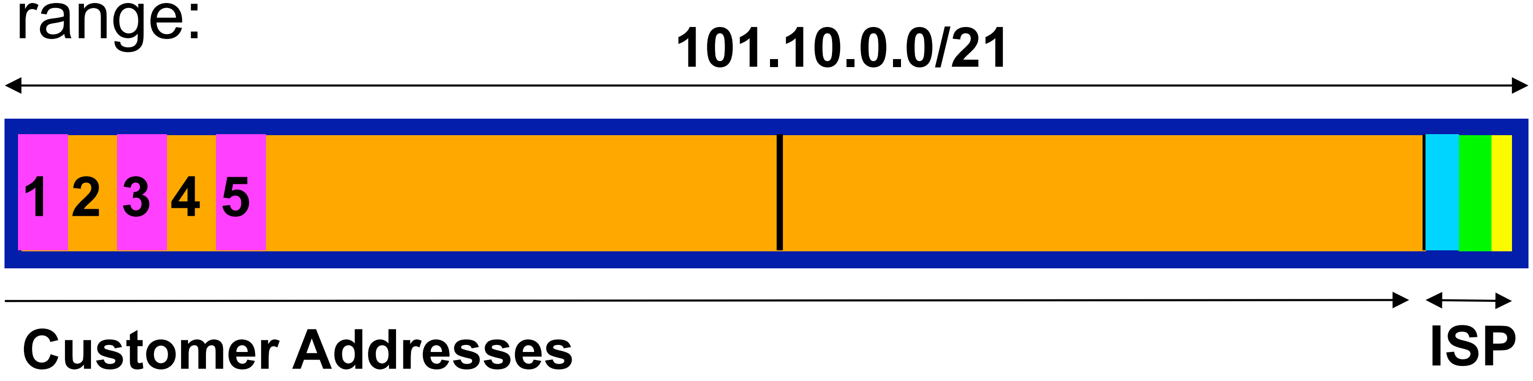
  Some ISPs use IP unnumbered

- Planning customer assignments is a very important part of multihoming

  Traffic engineering involves subdividing aggregate into pieces until load balancing works

# Unplanned IP addressing

- ISP fills up customer IP addressing from one end of the range:



- Customers generate traffic

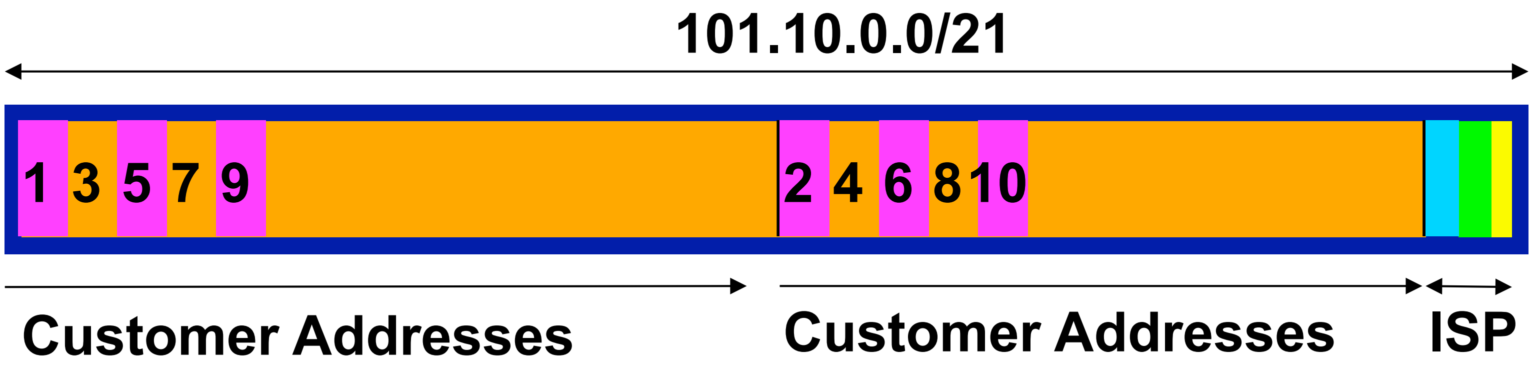
  Dividing the range into two pieces will result in one /22 with all the customers, and one /22 with just the ISP infrastructure the addresses

  ⇒No loadbalancing as all traffic will come in the first /22

  ⇒Means further subdivision of the first /22 = harder work

# Planned IP addressing

- If ISP fills up customer addressing from both ends of the range:



- Scheme then is:

  First customer from first /22, second customer from second /22, third from first /22, etc

- This works also for residential versus commercial customers:

  Residential from first /22

  Commercial from second /22

# Planned IP Addressing

- This works fine for multihoming between two upstream links (same or different providers)
- Can also subdivide address space to suit more than two upstreams

  Follow a similar scheme for populating each portion of the address space

- Don’t forget to always announce an aggregate out of each link

# Basic Multihoming

**Let’s try some simple worked examples…**

# 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
  - Assume that the network which is multihoming has a /19 address block

# 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

## 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

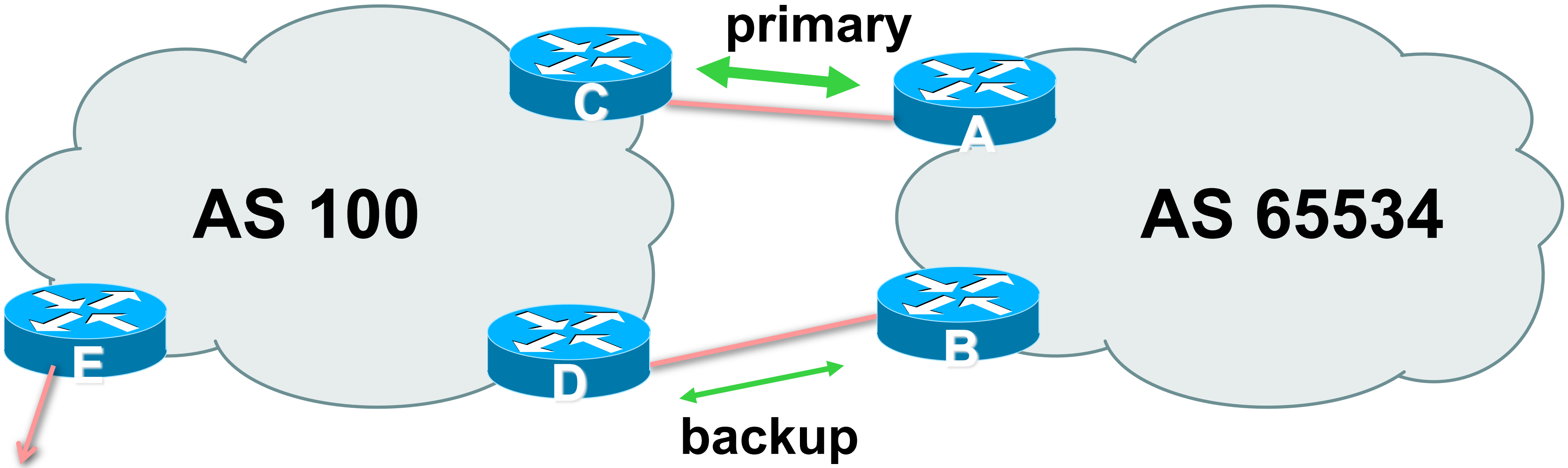
- Can use BGP for this

  use a private AS (ASNs in range 64512 to 65534)

- 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 (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
!
ip route 121.10.0.0 255.255.224.0 null0
```

# 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
!
ip route 121.10.0.0 255.255.224.0 null0
!
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

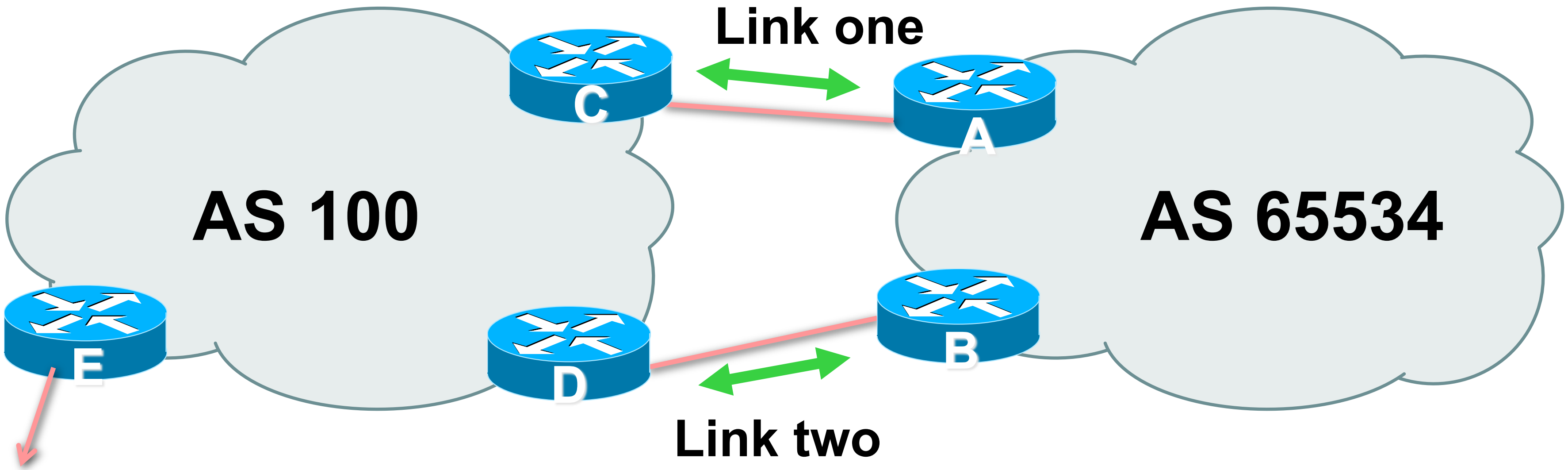
## With Redundancy and Loadsharing

# 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

# 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

- Address space comes from

  both upstreams or

  Regional Internet Registry

- Configuration concepts very similar

# Inconsistent-AS?

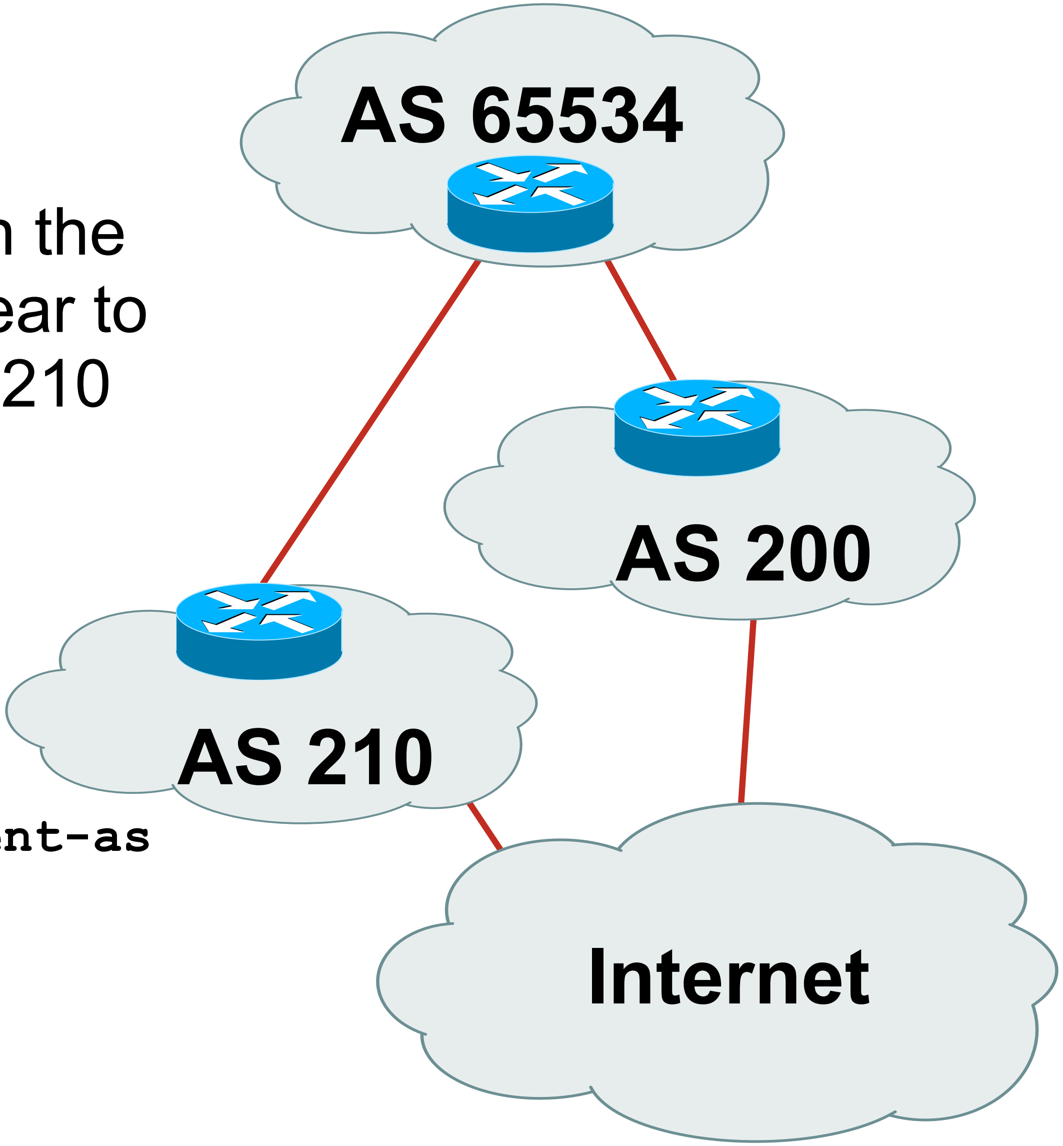
- Viewing the prefixes originated by AS65534 in the Internet shows they appear to be originated by both AS210 and AS200

  This is NOT bad

  Nor is it illegal

- IOS command is

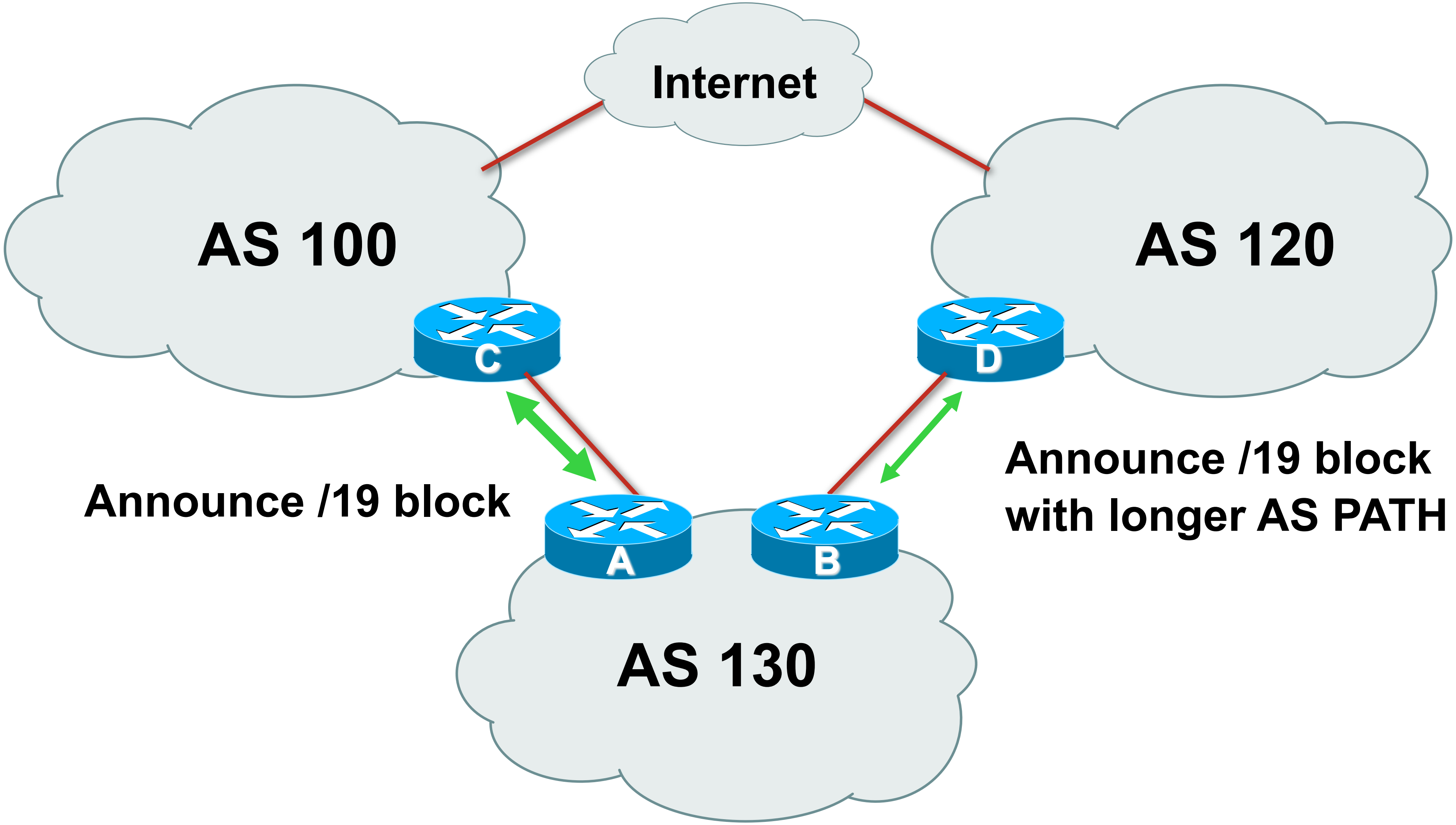
  ```
  show ip bgp inconsistent-as
  ```



# Two links to different ISPs

## One link primary, the other link backup only

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



Announce /19 block

Announce /19 block with longer AS PATH

# 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)

- 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
!
ip route 121.10.0.0 255.255.224.0 null0
```

# 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

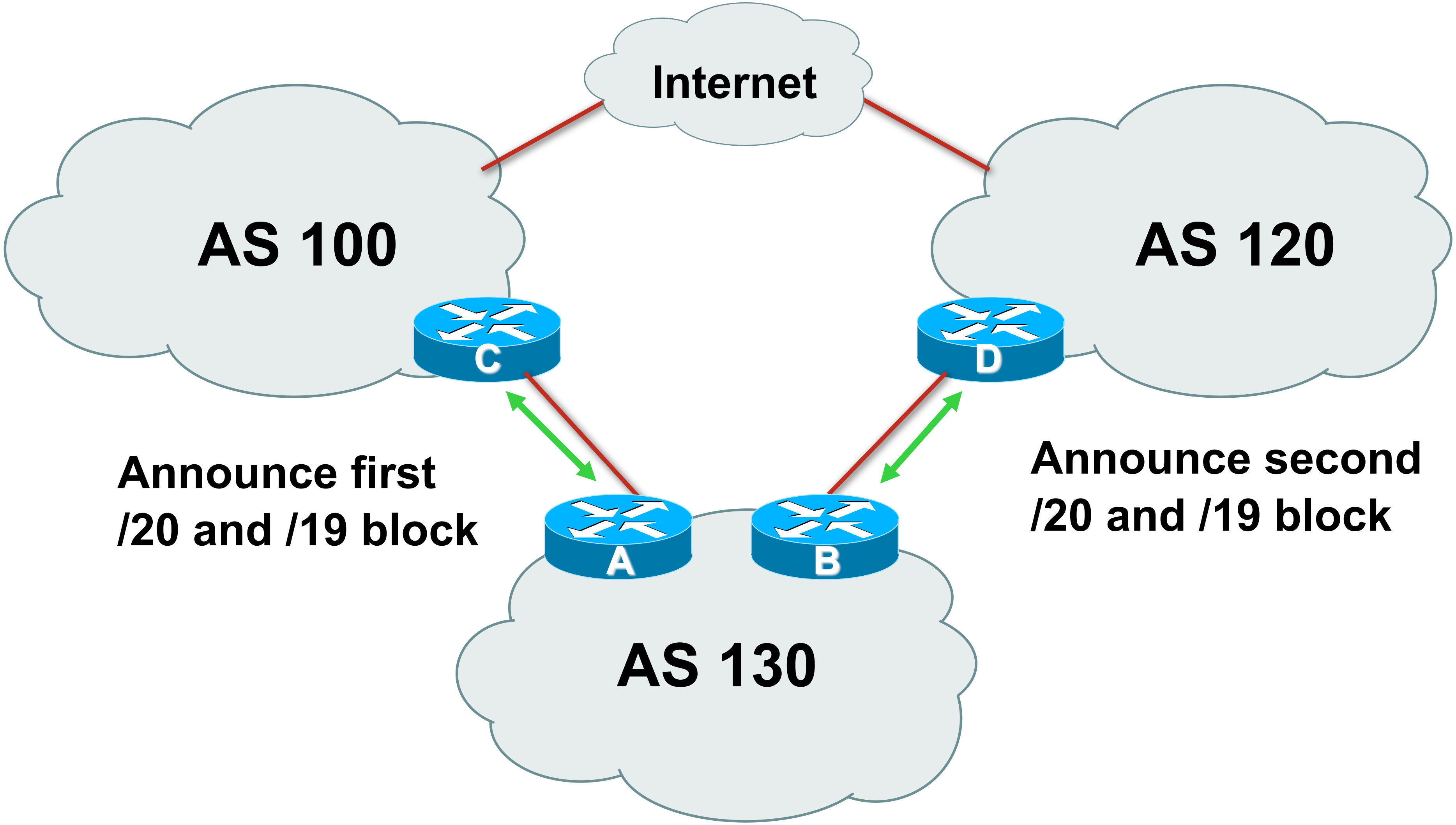
  (Useful when two competing ISPs agree to provide mutual backup to each other)

- But it shows the basic concepts of using local-prefs and AS-path prepends for engineering traffic in the chosen direction

# Two links to different ISPs

## With Redundancy and Loadsharing

# Two links to different ISPs (with loadsharing)



Announce first
/20 and /19 block

Announce second
/20 and /19 block

# Two links to different ISPs (with loadsharing)

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

  basic inbound loadsharing

- When one link fails, the announcement of the /19 aggregate via the other ISP ensures continued connectivity

# Two links to different ISPs (with loadsharing)

- 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 loadsharing)

- 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

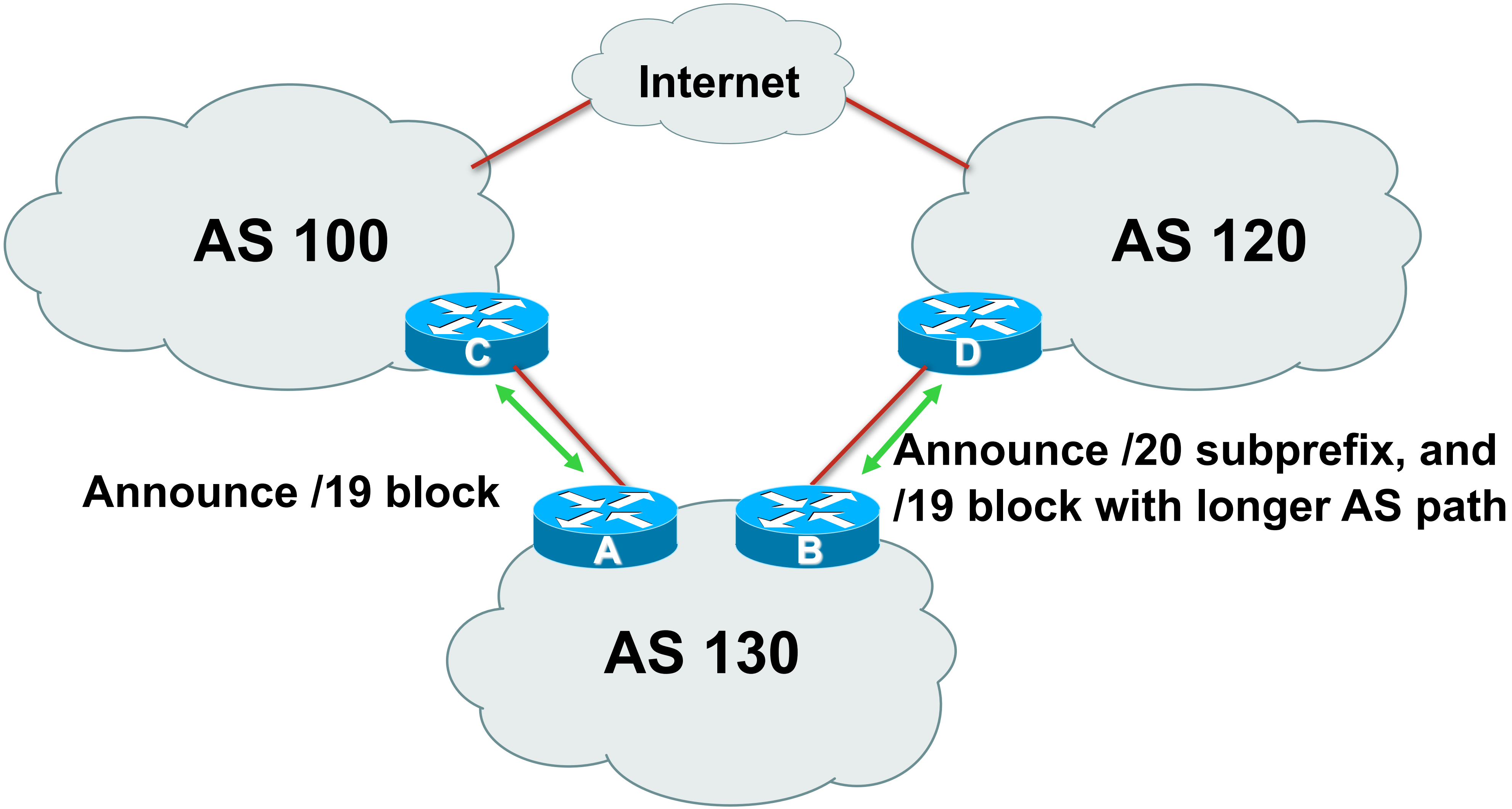
  Start with a simple concept

  And build on it…!

# Two links to different ISPs

## More Controlled Loadsharing

# Loadsharing with different ISPs



Announce /19 block

Announce /20 subprefix, and /19 block with longer AS path

# 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

- 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
ip prefix-list default permit 0.0.0.0/0
!
ip route 121.10.0.0 255.255.224.0 null0
```

# 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

# Summary

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- Previous examples dealt with simple case
- Load balancing inbound traffic flow
  - Achieved by modifying outbound routing announcements
  - Aggregate is always announced
- We have not looked at outbound traffic flow
  - For now this is left as “nearest exit”

# Simple Multihoming

ISP/IXP Workshops