



BGP Best Current Practices

ISP/IXP Workshops



Recommended IOS Releases

Which IOS??

Which IOS?

- **IOS is a feature rich and highly complex router control system**
- **ISPs should choose the IOS variant which is most appropriate for the intended application**
- **There is an exclusive service provider train in IOS**
 - This is 12.0S, supporting 7200, 7500, 10000 and 12000**
 - Images also available for 2500, 2600, 3600 and 4500, but are completely unsupported**
- **There is a service provider image in most IOS releases**
 - This is the image with –p– in its name, for example:**
 - c7200-p-mz.122-8.T1 and c2600-p-mz.121-14**
 - The –p– image is IP-only plus ISIS/CLNS**

Which IOS?

- **12.n – for example 12.2**

This means the IOS is a mainline image

NO new features

ONLY bug fixes

The aim is stability!

- **12.nT – for example 12.2T**

This means the IOS is the technology release

NEW features

Bug fixes

Avoid unless you need the feature!

12.3 IOS release images

- **12.3 is the old “mainline” train**
 - Originated from 12.2T, currently at 12.3(15)**
 - Bug fix release only – aiming for stability**
 - Supports more platforms and has more features than 12.2 or 12.1**
- **12.3T was the old “technology train”**
 - new features introduced in IOS 12.3**
 - Last release was 12.3(14)T2**
- **Available on CCO, supported by TAC**

12.4 IOS release images

- **12.4 is the current “mainline” train**
 - Originated from 12.3T, currently at 12.4(1a)**
 - Bug fix release only – aiming for stability**
 - Supports more platforms and has more features than 12.3**
- **12.4T is the current “technology train”**
 - new features introduced in IOS 12.4**
 - As yet there is no 12.4T release**
- **Available on CCO, supported by TAC**

IOS images for ISPs

- **12.0S is the release for all ISPs**
For 7200, 7500, 10000 and GSR/12000 only
Currently at 12.0(31)S
- **12.2S is a new ISP release**
For 7x00 series (x = 2, 3, 5 and 6)
Combines 12.0S and 12.1E enhancements
Currently at 12.2(25)S4
- **Available on CCO, supported by TAC**



What is BGP for??

What is an IGP not for?

BGP versus OSPF/ISIS

- **Internal Routing Protocols (IGPs)**
examples are ISIS and OSPF
used for carrying **infrastructure** addresses
NOT used for carrying Internet prefixes or
customer prefixes

BGP versus OSPF/ISIS

- **BGP used internally (iBGP) and externally (eBGP)**
- **iBGP used to carry**
 - some/all Internet prefixes across backbone**
 - customer prefixes**
- **eBGP used to**
 - exchange prefixes with other ASes**
 - implement routing policy**

BGP versus OSPF/ISIS

- **DO NOT:**
 - distribute BGP prefixes into an IGP**
 - distribute IGP routes into BGP**
 - use an IGP to carry customer prefixes**
- **YOUR NETWORK WILL NOT SCALE**



Aggregation

Aggregation

- **Aggregation means announcing the address block received from the RIR to the other ASes connected to your network**
- **Subprefixes of this aggregate *may* be:**
 - Used internally in the ISP network**
 - Announced to other ASes to aid with multihoming**
- **Unfortunately too many people are still thinking about class Cs, resulting in a proliferation of /24s in the Internet routing table**

Configuring Aggregation – Cisco IOS

- **ISP has 101.10.0.0/19 address block**
- **To put into BGP as an aggregate:**

```
router bgp 100
```

```
network 101.10.0.0 mask 255.255.224.0
```

```
ip route 101.10.0.0 255.255.224.0 null0
```

- **The static route is a “pull up” route**

more specific prefixes within this address block ensure connectivity to ISP’s customers

“longest match lookup”

Aggregation

- **Address block should be announced to the Internet as an aggregate**
- **Subprefixes of address block should NOT be announced to Internet unless **special** circumstances (more later)**
- **Aggregate should be generated internally**
Not on the network borders!

Announcing Aggregate – Cisco IOS

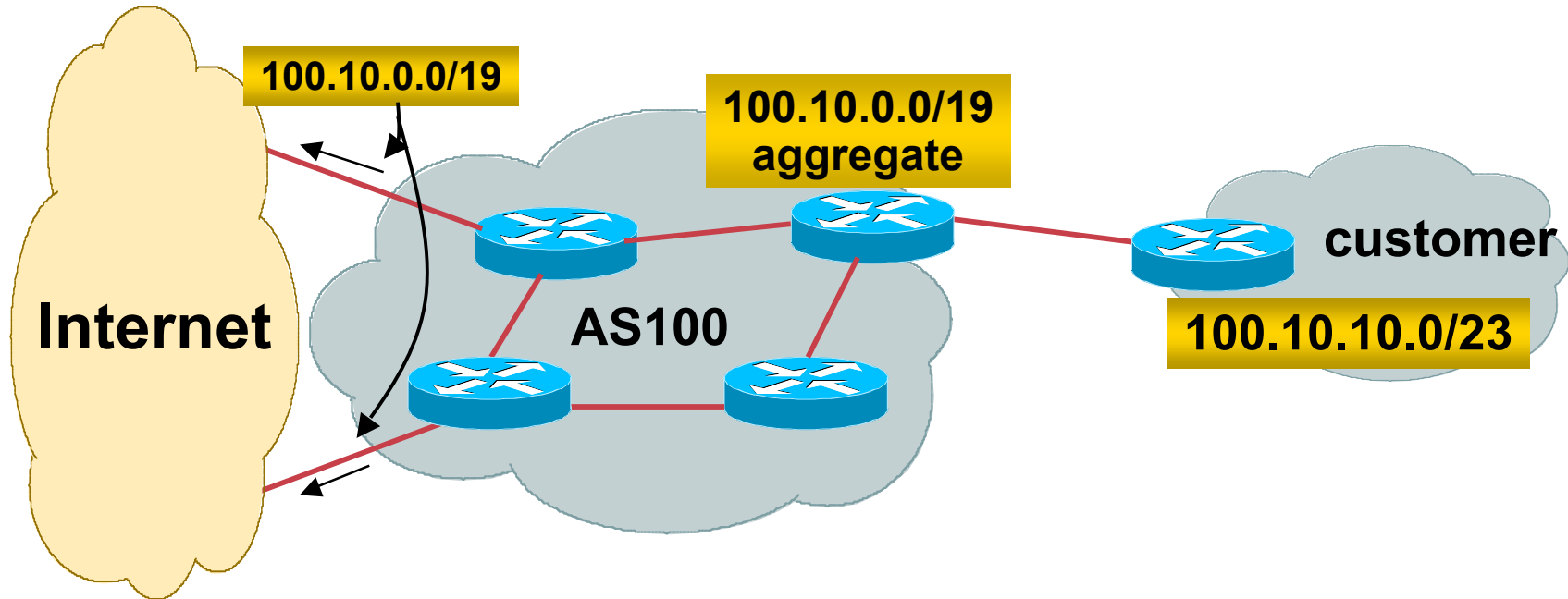
- **Configuration Example**

```
router bgp 100
  network 101.10.0.0 mask 255.255.224.0
  neighbor 102.102.10.1 remote-as 101
  neighbor 102.102.10.1 prefix-list out-filter out
!
ip route 101.10.0.0 255.255.224.0 null0
!
ip prefix-list out-filter permit 101.10.0.0/19
ip prefix-list out-filter deny 0.0.0.0/0 le 32
```


Announcing an Aggregate


- **ISPs who don't and won't aggregate are held in poor regard by community**
- **Registries publish their minimum allocation size**
 - Anything from a /20 to a /22 depending on RIR**
 - Different sizes for different address blocks**
- **No real reason to see anything longer than a /22 prefix in the Internet**
 - BUT there are currently >90000 /24s!**

Aggregation – Example

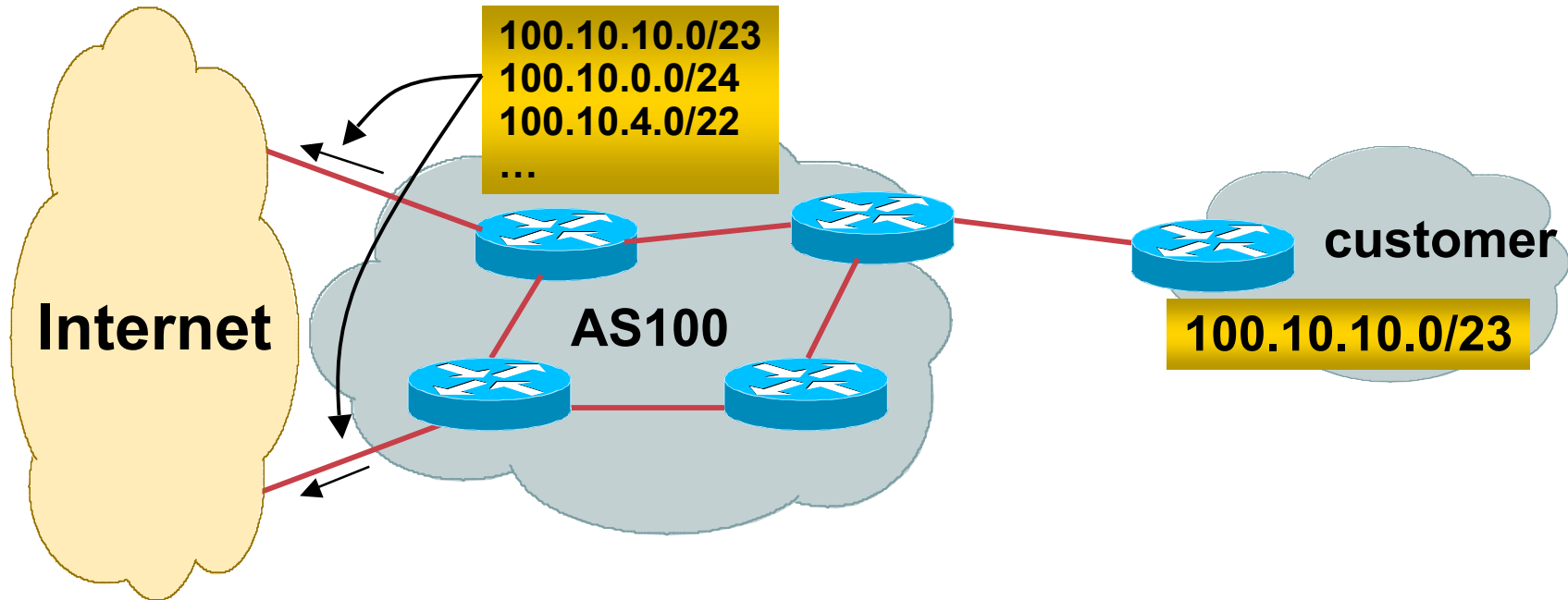


- **Customer has /23 network assigned from AS100's /19 address block**
- **AS100 announced /19 aggregate to the Internet**

Aggregation – Good Example

- **Customer link goes down**
their /23 network becomes unreachable
/23 is withdrawn from AS100's iBGP
 - **/19 aggregate is still being announced**
no BGP hold down problems
no BGP propagation delays
no damping by other ISPs
- 
- **Customer link returns**
 - **Their /23 network is visible again**
The /23 is re-injected into AS100's iBGP
 - **The whole Internet becomes visible immediately**
 - **Customer has Quality of Service perception**

Aggregation – Example



- **Customer has /23 network assigned from AS100's /19 address block**
- **AS100 announces customers' individual networks to the Internet**

Aggregation – Bad Example

- **Customer link goes down**
 - Their /23 network becomes unreachable
 - /23 is withdrawn from AS100's iBGP
- **Their ISP doesn't aggregate its /19 network block**
 - /23 network withdrawal announced to peers
 - starts rippling through the Internet
 - added load on all Internet backbone routers as network is removed from routing table

- **Customer link returns**
 - Their /23 network is now visible to their ISP
 - Their /23 network is re-advertised to peers
 - Starts rippling through Internet
 - Load on Internet backbone routers as network is reinserted into routing table
 - Some ISP's suppress the flaps
 - Internet may take 10-20 min or longer to be visible
 - Where is the Quality of Service???

Aggregation – Summary

- **Good example is what everyone should do!**
 - Adds to Internet stability**
 - Reduces size of routing table**
 - Reduces routing churn**
 - Improves Internet QoS for **everyone****
- **Bad example is what too many still do!**
 - Why? Lack of knowledge?**

The Internet Today (June 2005)

- **Current Internet Routing Table Statistics**

| | |
|---|---------------|
| BGP Routing Table Entries | 165559 |
| Prefixes after maximum aggregation | 95442 |
| Unique prefixes in Internet | 79379 |
| Prefixes smaller than registry alloc | 78267 |
| /24s announced | 90447 |
| only 5717 /24s are from 192.0.0.0/8 | |
| ASes in use | 19872 |

Efforts to improve aggregation

- **The CIDR Report**

Initiated and operated for many years by Tony Bates

Now combined with Geoff Huston's routing analysis

www.cidr-report.org

Results e-mailed on a weekly basis to most operations lists around the world

Lists the top 30 service providers who could do better at aggregating



Receiving Prefixes

Receiving Prefixes

- **There are three scenarios for receiving prefixes from other ASNs**
 - Customer talking BGP**
 - Peer talking BGP**
 - Upstream/Transit talking BGP**
- **Each has different filtering requirements and need to be considered separately**

Receiving Prefixes: From Customers

- **ISPs should only accept prefixes which have been assigned or allocated to their downstream customer**
- **If ISP has assigned address space to its customer, then the customer **IS** entitled to announce it back to his ISP**
- **If the ISP has **NOT** assigned address space to its customer, then:**

Check in the four RIR databases to see if this address space really has been assigned to the customer

The tool: **whois -h whois.apnic.net x.x.x.0/24**

Receiving Prefixes: From Customers

- Example use of whois to check if customer is entitled to announce address space:

```
pfs-pc$ whois -h whois.apnic.net 202.12.29.0
inetnum:      202.12.29.0 - 202.12.29.255
netname:      APNIC-AP-AU-BNE
descr:        APNIC Pty Ltd - Brisbane Offices + Servers
descr:        Level 1, 33 Park Rd
descr:        PO Box 2131, Milton
descr:        Brisbane, QLD.
country:      AU
admin-c:      HM20-AP
tech-c:       NO4-AP
mnt-by:       APNIC-HM
changed:      hm-changed@apnic.net 20030108
status:       ASSIGNED PORTABLE
source:       APNIC
```

Portable – means its an assignment to the customer, the customer can announce it to you

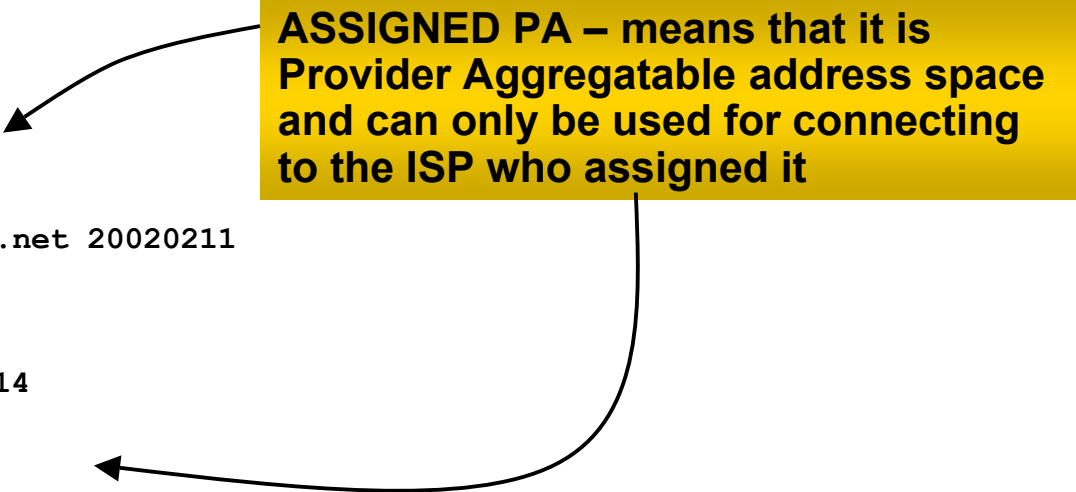
Receiving Prefixes: From Customers

- Example use of whois to check if customer is entitled to announce address space:

```
$ whois -h whois.ripe.net 193.128.2.0
inetnum:      193.128.2.0 - 193.128.2.15
descr:        Wood Mackenzie
country:      GB
admin-c:      DB635-RIPE
tech-c:       DB635-RIPE
status:       ASSIGNED PA
mnt-by:       AS1849-MNT
changed:      davids@uk.uu.net 20020211
source:       RIPE

route:        193.128.0.0/14
descr:        PIPEX-BLOCK1
origin:       AS1849
notify:       routing@uk.uu.net
mnt-by:       AS1849-MNT
changed:      beny@uk.uu.net 20020321
source:       RIPE
```

**ASSIGNED PA – means that it is
Provider Aggregatable address space
and can only be used for connecting
to the ISP who assigned it**



Receiving Prefixes from customer: Cisco IOS

- **For Example:**

downstream has 100.50.0.0/20 block

should only announce this to upstreams

upstreams should only accept this from them

- **Configuration on upstream**

```
router bgp 100
```

```
neighbor 102.102.10.1 remote-as 101
```

```
neighbor 102.102.10.1 prefix-list customer in
```

```
!
```

```
ip prefix-list customer permit 100.50.0.0/20
```

Receiving Prefixes: From Peers

- **A peer is an ISP with whom you agree to exchange prefixes you originate into the Internet routing table**

Prefixes you accept from a peer are only those they have indicated they will announce

Prefixes you announce to your peer are only those you have indicated you will announce

Receiving Prefixes: From Peers

- **Agreeing what each will announce to the other:**

Exchange of e-mail documentation as part of the peering agreement, and then ongoing updates

OR

Use of the Internet Routing Registry and configuration tools such as the IRRToolSet

www.isc.org/sw/IRRToolSet/

Receiving Prefixes from peer: Cisco IOS

- **For Example:**

peer has 220.50.0.0/16, 61.237.64.0/18 and 81.250.128.0/17
address blocks

- **Configuration on local router**

```
router bgp 100
  neighbor 102.102.10.1 remote-as 101
  neighbor 102.102.10.1 prefix-list my-peer in
!
ip prefix-list my-peer permit 220.50.0.0/16
ip prefix-list my-peer permit 61.237.64.0/18
ip prefix-list my-peer permit 81.250.128.0/17
ip prefix-list my-peer deny 0.0.0.0/0 le 32
```

Receiving Prefixes: From Upstream/Transit Provider

- **Upstream/Transit Provider is an ISP who you pay to give you transit to the **WHOLE** Internet**
- **Receiving prefixes from them is not desirable unless really necessary**
 - special circumstances – see later**
- **Ask upstream/transit provider to either:**
 - originate a default-route**
 - OR***
 - announce one prefix you can use as default**

Receiving Prefixes: From Upstream/Transit Provider

- **Downstream Router Configuration**

```
router bgp 100
  network 101.10.0.0 mask 255.255.224.0
  neighbor 101.5.7.1 remote-as 101
  neighbor 101.5.7.1 prefix-list infilter in
  neighbor 101.5.7.1 prefix-list outfilter out
!
ip prefix-list infilter permit 0.0.0.0/0
!
ip prefix-list outfilter permit 101.10.0.0/19
```

Receiving Prefixes: From Upstream/Transit Provider

- **Upstream Router Configuration**

```
router bgp 101
  neighbor 101.5.7.2 remote-as 100
  neighbor 101.5.7.2 default-originate
  neighbor 101.5.7.2 prefix-list cust-in in
  neighbor 101.5.7.2 prefix-list cust-out out
!
ip prefix-list cust-in permit 101.10.0.0/19
!
ip prefix-list cust-out permit 0.0.0.0/0
```

Receiving Prefixes: From Upstream/Transit Provider

- **If necessary to receive prefixes from any provider, care is required**

don't accept RFC1918 *etc* prefixes

<ftp://ftp.rfc-editor.org/in-notes/rfc3330.txt>

don't accept your own prefixes

don't accept default (unless you need it)

don't accept prefixes longer than /24

- **Check Project Cymru's list of "bogons"**

<http://www.cymru.com/Documents/bogon-list.html>

Receiving Prefixes

```
router bgp 100
  network 101.10.0.0 mask 255.255.224.0
  neighbor 101.5.7.1 remote-as 101
  neighbor 101.5.7.1 prefix-list in-filter in
!
ip prefix-list in-filter deny 0.0.0.0/0 ! Block default
ip prefix-list in-filter deny 0.0.0.0/8 le 32
ip prefix-list in-filter deny 10.0.0.0/8 le 32
ip prefix-list in-filter deny 101.10.0.0/19 le 32 ! Block local prefix
ip prefix-list in-filter deny 127.0.0.0/8 le 32
ip prefix-list in-filter deny 169.254.0.0/16 le 32
ip prefix-list in-filter deny 172.16.0.0/12 le 32
ip prefix-list in-filter deny 192.0.2.0/24 le 32
ip prefix-list in-filter deny 192.168.0.0/16 le 32
ip prefix-list in-filter deny 224.0.0.0/3 le 32 ! Block multicast
ip prefix-list in-filter deny 0.0.0.0/0 ge 25 ! Block prefixes >/24
ip prefix-list in-filter permit 0.0.0.0/0 le 32
```

Receiving Prefixes

- **Paying attention to prefixes received from customers, peers and transit providers assists with:**
 - The integrity of the local network**
 - The integrity of the Internet**
- **Responsibility of all ISPs to be good Internet citizens**

CISCO SYSTEMS



Prefixes into iBGP

Injecting prefixes into iBGP

- **Use iBGP to carry customer prefixes**
don't use IGP
- **Point static route to customer interface**
- **Use BGP network statement**
- **As long as static route exists (interface active), prefix will be in BGP**

Router Configuration: network statement

- **Example:**

```
interface loopback 0
  ip address 215.17.3.1 255.255.255.255
!
interface Serial 5/0
  ip unnumbered loopback 0
  ip verify unicast reverse-path
!
ip route 215.34.10.0 255.255.252.0 Serial 5/0
!
router bgp 100
  network 215.34.10.0 mask 255.255.252.0
```

Injecting prefixes into iBGP

- **interface flap will result in prefix withdraw and reannounce**
 - use “ip route...permanent”
- **many ISPs use redistribute static rather than network statement**
 - only use this if you understand why

Router Configuration: redistribute static

- **Example:**

```
ip route 215.34.10.0 255.255.252.0 Serial 5/0
!
router bgp 100
  redistribute static route-map static-to-bgp
<snip>
!
route-map static-to-bgp permit 10
  match ip address prefix-list ISP-block
  set origin igp
<snip>
!
ip prefix-list ISP-block permit 215.34.10.0/22 le 30
!
```

Injecting prefixes into iBGP

- **Route-map ISP-block can be used for many things:**
 - setting communities and other attributes
 - setting origin code to IGP, etc
- **Be careful with prefix-lists and route-maps**
 - absence of either/both means all statically routed prefixes go into iBGP



Scaling the network

How to get out of carrying all prefixes in IGP

Why use BGP rather than IGP?

- **IGP has Limitations:**

The more routing information in the network

Periodic updates/flooding “overload”

Long convergence times

Affects the core first

Policy definition

Not easy to do

Preparing the Network

- **We want to deploy BGP now...**
- **BGP will be used therefore an ASN is required**
- **If multihoming to different ISPs is intended in the near future, a public ASN should be obtained:**
 - 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

- **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 IGP

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

Preparing the Network IGP (cont)

- **Be prudent deploying IGP – keep the Link State Database Lean!**

Router loopbacks go in IGP

Backbone WAN point to point links go in IGP

(In fact, any link where IGP dynamic routing will be run should go into IGP)

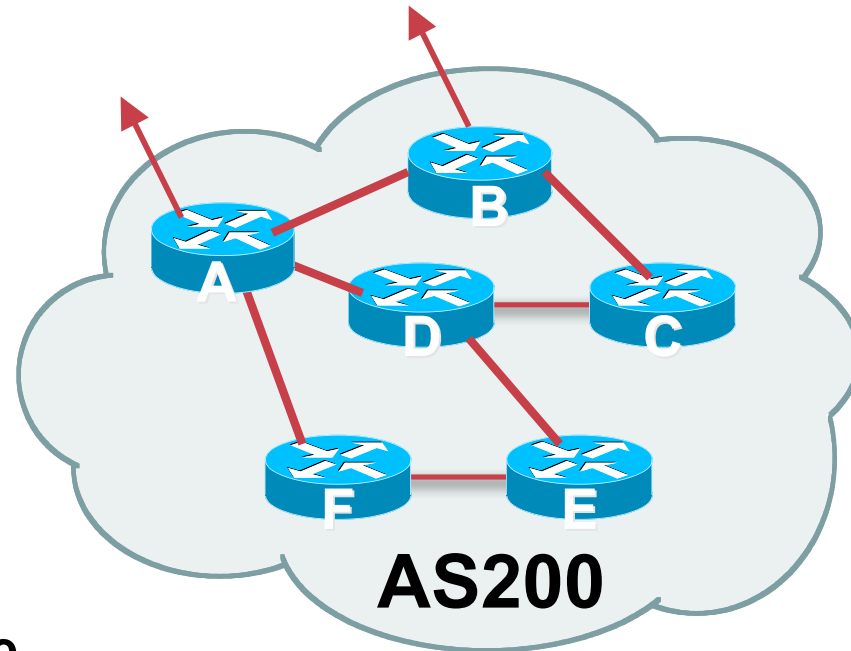
Summarise on area/level boundaries (if possible) – i.e. think about your IGP address plan

Preparing the Network IGP (cont)

- **Routes which don't go into the IGP include:**
 - Dynamic assignment pools (DSL/Cable/Dial)**
 - Customer point to point link addressing**
 - (using next-hop-self in iBGP ensures that these do NOT need to be in IGP)**
 - Static/Hosting LANs**
 - Customer assigned address space**
 - Anything else not listed in the previous slide**

Preparing the Network 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***



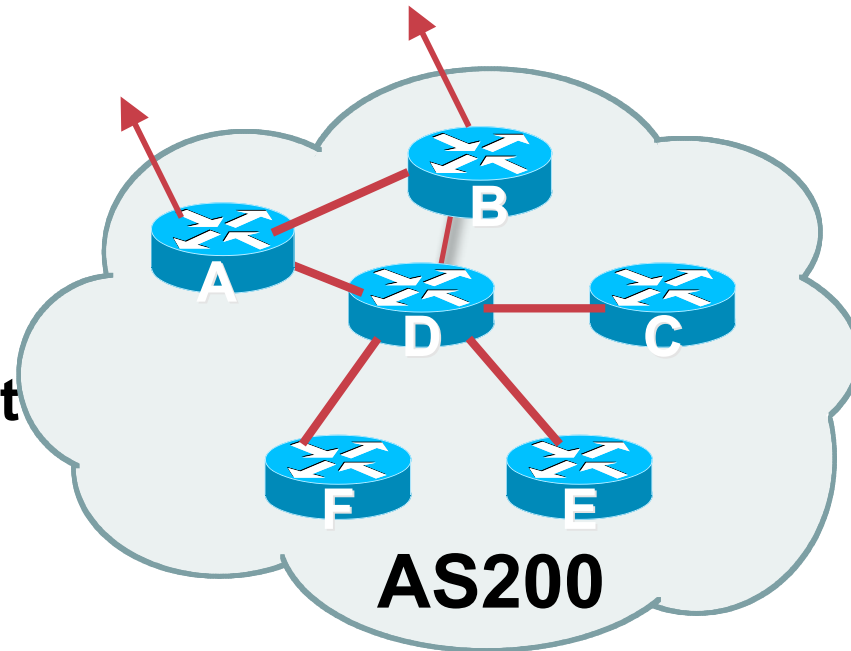
Preparing the Network iBGP (Transit Path)

- *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 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, the 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**

Will it be full routes everywhere, or partial, or some mix?

- **iBGP scaling technique**

Community policy?

Route-reflectors?

Techniques such as peer templates?

Preparing the Network

iBGP Implementation

- Then deploy iBGP:

Step 1: Introduce iBGP mesh on chosen routers

make sure that iBGP distance is greater than IGP distance

Use **distance bgp 200 200 200**

Step 2: Install “customer” prefixes into iBGP

Check! Does the network still work?

Step 3: Carefully remove the static routing for the prefixes now in IGP and iBGP

Check! Does the network still work?

Step 4: Deployment of eBGP follows

Preparing the Network iBGP Implementation

Install “customer” prefixes into iBGP?

- **Customer assigned address space**
 - Network statement/static route combination**
 - Use unique community to identify customer assignments**
- **Customer facing point-to-point links**
 - Redistribute connected routes through filters which only permit point-to-point link addresses to enter iBGP**
 - Use a unique community to identify point-to-point link addresses (these are only required for your monitoring system)**
- **Dynamic assignment pools & local LANs**
 - Simple network statement will do this**
 - Use unique community to identify these networks**

Preparing the Network

iBGP Implementation

Carefully remove static routes?

- **Work on one router at a time:**
 - Check that static route for a particular destination is also learned either by IGP or by iBGP**
 - If so, remove it**
 - If not, establish why and fix the problem**
 - (Remember to look in the RIB, not the FIB!)**
- **Then the next router, until the whole PoP is done**
- **Then the next PoP, and so on until the network is now dependent on the IGP and iBGP you have deployed**

Preparing the Network Completion

- **Previous steps are NOT flag day steps**

Each can be carried out during different maintenance periods, for example:

Step One on Week One

Step Two on Week Two

Step Three on Week Three

And so on

And with proper planning will have NO customer visible impact at all

Preparing the Network Configuration Summary

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



BGP Best Current Practices

ISP/IXP Workshops