# 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.*n*T – 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
```





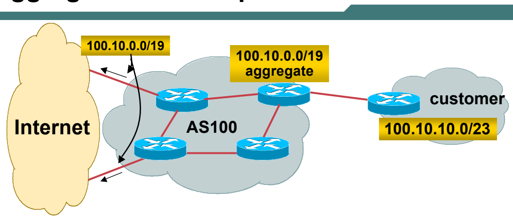
## Announcing an Aggregate

- 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

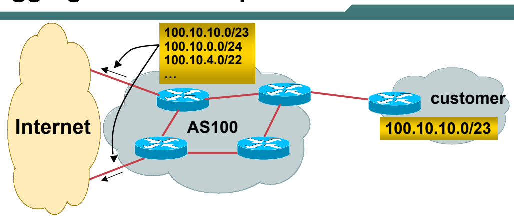
## Aggregation – Good Example

- 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





CISCO SYSTEMS

## 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



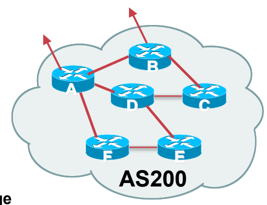
## Preparing the Network
## IGP (cont)

- 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

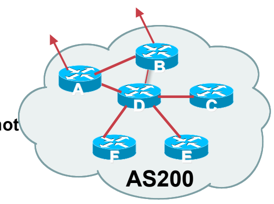
- Second step is to configure the local network to use iBGP
- iBGP can run on
  - all routers, or
  - a subset of routers, or
  - just on the upstream edge
- *iBGP must run on all routers which are in the transit path between external connections*






## 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