BGP Best Practices

Scalable Infrastructure Workshop
AfNOG 2010
Configuring BGP

Where do we start?
IOS Good Practices

- ISPs should start off with the following BGP commands as a basic template:
  
  ```
  router bgp 64511
  bgp deterministic-med
  distance bgp 200 200 200
  no synchronization
  no auto-summary
  ```
  
  Replace with public ASN

- Make ebgp and ibgp distance the same

- If supporting more than just IPv4 unicast neighbours

  ```
  no bgp default ipv4 unicast
  ```

  is also very important and required
BGP in Cisco IOS is permissive by default. Configuring BGP peering without using filters means:

- All best paths on the local router are passed to the neighbour
- All routes announced by the neighbour are received by the local router
- Can have disastrous consequences

Good practice is to ensure that each eBGP neighbour has inbound and outbound filter applied:

```
router bgp 64511
    neighbour 1.2.3.4 remote-as 64510
    neighbour 1.2.3.4 prefix-list as64510-in in
    neighbour 1.2.3.4 prefix-list as64510-out out
```
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
  - design goal is to **minimise** number of prefixes in IGP to aid scalability and rapid convergence
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/IGP model used in ISP networks

- Model representation

![Diagram of BGP/IGP model](image)
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

Quality, not Quantity!
Aggregation

- ISPs receive address block from Regional Registry or upstream provider
- **Aggregation** means announcing the address block only, not subprefixes
- Aggregate should be generated internally
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 fine-tuning multihoming
  - And even then care and frugality is required – don’t announce more subprefixes than absolutely necessary
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’ minimum allocation size is now at least a /21 or /22
  - no real reason to see anything much longer than a /22 prefix in the Internet
  - BUT there are currently ~168000 /24s!
The Internet during AfNOG 2009 (April 2009)

- Internet Routing Table Statistics
  - BGP Routing Table Entries: 288336
  - Prefixes after maximum aggregation: 136251
  - Unique prefixes in Internet: 140888
  - Prefixes smaller than registry alloc: 142536
  - /24s announced: 150651
    - only 5797 /24s are from 192.0.0.0/8
  - ASes in use: 31224
The Internet Today (May 2010)

- Current Internet Routing Table Statistics
  - BGP Routing Table Entries: 321324
  - Prefixes after maximum aggregation: 147948
  - Unique prefixes in Internet: 155831
  - Prefixes smaller than registry alloc: 154125
  - /24s announced: 168259
    - only 5730 /24s are from 192.0.0.0/8
  - ASes in use: 33989
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
Efforts to Improve Aggregation: The CIDR Report

- Also computes the size of the routing table assuming ISPs performed optimal aggregation
- Website allows searches and computations of aggregation to be made on a per AS basis
  - Flexible and powerful tool to aid ISPs
  - Intended to show how greater efficiency in terms of BGP table size can be obtained without loss of routing and policy information
  - Shows what forms of origin AS aggregation could be performed and the potential benefit of such actions to the total table size
  - Very effectively challenges the traffic engineering excuse
Aggregation Potential
Importance of Aggregation

- Size of routing table
  - Memory is no longer the problem
  - Routers can be specified to carry 1 million prefixes

- Convergence of the Routing System
  - This is a problem
  - Bigger table takes longer for CPU to process
  - BGP updates take longer to deal with

- BGP Instability Report tracks routing system update activity
  - [http://bgpupdates.potaroo.net/instability/bgpupd.html](http://bgpupdates.potaroo.net/instability/bgpupd.html)
### The BGP Instability Report

The BGP Instability Report is updated daily. This report was generated on 12 May 2010 06:10 (UTC+1000)

#### 50 Most active ASes for the past 7 days

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<th>% Prefixes</th>
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Aggregation: Summary

- Aggregation on the Internet could be **MUCH** better
  - 35% saving on Internet routing table size is quite feasible
  - Tools are available
  - Commands on the router are not hard
  - CIDR-Report webpage

- RIPE Routing WG aggregation recommendation
  - RIPE-399 — www.ripe.net/docs/ripe-399.html
Receiving Prefixes
Receiving Prefixes from downstream peers

- ISPs should only accept prefixes which have been assigned or allocated to their downstream peer

- For example
  - downstream has 100.50.0.0/20 block
  - should only announce this to peers
  - peers should only accept this from them
Receiving Prefixes:
Cisco IOS

- Configuration Example 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
  ip prefix-list customer deny 0.0.0.0/0 le 32
  ```
Receiving Prefixes from upstream peers

- Not desirable unless really necessary
  - special circumstances
- Ask upstream to either:
  - originate a default-route
  - announce one prefix you can use as default
Receiving Prefixes from upstream peers

- **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 infilt in
  neighbor 101.5.7.1 prefix-list outfilt out

  ip prefix-list infilt permit 0.0.0.0/0
  ip prefix-list infilt deny 0.0.0.0/0 le 32

  ip prefix-list outfilt permit 101.10.0.0/19
  ip prefix-list outfilt deny 0.0.0.0/0 le 32
  ```
Receiving Prefixes from upstream peers

- 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-in deny 0.0.0.0/0 le 32
  !
  
  ip prefix-list cust-out permit 0.0.0.0/0
  ip prefix-list cust-out deny 0.0.0.0/0 le 32
  ```
Receiving Prefixes from upstream peers

- If necessary to receive prefixes from upstream provider, care is required
  - don’t accept RFC1918 etc prefixes
  - don’t accept your own prefix
  - don’t accept default (unless you need it)
  - don’t accept prefixes longer than /24
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

  ! Block default
  ip prefix-list in-filter deny 0.0.0.0/0
  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
```
Generic ISP BGP prefix filter

- This prefix-list MUST be applied to all external BGP peerings, in and out!
- RFC5735 lists many special use addresses
- Check Team Cymru’s bogon pages
  - http://www.cymru.com/Bogons
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:

```plaintext
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
Configuration Tips
Templates

- Good practice to configure templates for everything
  - Vendor defaults tend not to be optimal or even very useful for ISPs
  - ISPs create their own defaults by using configuration templates
  - Sample iBGP and eBGP templates follow for Cisco IOS
BGP Template – iBGP peers

```
router bgp 100
neighbor internal peer-group
neighbor internal description ibgp peers
neighbor internal remote-as 100
neighbor internal update-source Loopback0
neighbor internal next-hop-self
neighbor internal send-community
neighbor internal version 4
neighbor internal password 7 03085A09
neighbor 1.0.0.1 peer-group internal
neighbor 1.0.0.2 peer-group internal
```
BGP Template – iBGP peers

- Use peer-groups
- iBGP between loopbacks!
- Next-hop-self
  - Keep DMZ and point-to-point out of IGP
- Always send communities in iBGP
  - Otherwise accidents will happen
- Hardwire BGP to version 4
  - Yes, this is being paranoid!
- Use passwords on iBGP session
  - Not being paranoid, some ISPs consider this VERY necessary
Router B:
router bgp 100
network 10.60.0.0 mask 255.255.0.0
neighbor external peer-group
neighbor external remote-as 200
neighbor external description ISP connection
neighbor external remove-private-AS
neighbor external version 4
neighbor external prefix-list ispout out ! “real” filter
neighbor external filter-list 1 out ! “accident” filter
neighbor external route-map ispout out
neighbor external prefix-list ispin in
neighbor external filter-list 2 in
neighbor external route-map ispin in
neighbor external password 7 020A0559
neighbor external maximum-prefix 220000 [warning-only]
neighbor 10.200.0.1 peer-group external
! ip route 10.60.0.0 255.255.0.0 null0 254
BGP Template – eBGP peers

- Remove private ASes from announcements
  - Common omission today

- Use extensive filters, with “backup”
  - Use as-path filters to backup prefix-lists
  - Use route-maps for policy

- Use password agreed between you and peer on eBGP session

- Use maximum-prefix tracking
  - Router will warn you if there are sudden increases in BGP table size, bringing down eBGP if desired
More BGP “defaults”

- Log neighbour changes
  - Log neighbour changes
  - `bgp log-neighbor-changes`

- Enable deterministic MED
  - `bgp deterministic-med`
  - Otherwise bestpath could be different every time BGP session is reset

- Make BGP admin distance higher than any IGP
  - `distance bgp 200 200 200`
Configuration Tips Summary

- Use configuration templates
- Standardise the configuration
- Anything to make your life easier, network less prone to errors, network more likely to scale
- It’s all about scaling – if your network won’t scale, then it won’t be successful
Summary – BGP BCP

- Initial Configuration
- BGP versus IGP
- Aggregation
- Sending & Receiving Prefixes
- Injecting Prefixes into iBGP
- Configuration Tips